Stay away from math? Data literacy and math anxiety in seventh-grade students

Undvik matte? Dataläskunnighet och matteångest hos elever i årskurs 7

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The term data literacy has been defined as "the ability to collect, manage, evaluate, and apply data, in a critical manner" and the concept speaks for an important skill in today's information-rich digital landscape. The educational system is a key factor in supporting students in their quest of strengthening this ability. The following thesis aims to investigate how student performance related to data literacy, and more specifically proportional reasoning, may be affected by mathematical- and less-mathematical visual framing. In this context, framing can be interpreted as providing different kinds of scaffolding. The reasoning behind using less-mathematical framing is to possibly alleviate some of the emotional resistance that students can experience towards mathematics, a phenomenon known as math anxiety (MA). Related to this, Swedish students' attitudes and feelings towards mathematics are also investigated. A study using seventh-grade students ($N = 114$) is described which found no significant difference between the two variations of framing on eight questions targeting proportionality. However, students with the less-mathematical framing did generally perform better, although marginally. In addition, the results found that around 10% of students report frequent feelings of fear and nervousness when thinking about mathematics. Moreover, students tend to use words with negative connotations (such as boring, difficult, and tiresome) when asked to describe mathematics using their own words. With the prevalence of MA and perceived negativity surrounding mathematics, future pedagogical interventions targeting data literacy might indeed benefit from being separated from traditional mathematical characteristics.

1 Introduction

In today's day and age, data is everywhere. Its presence in various aspects of life affects how we live and how we make decisions (Wolff, Gooch, Montaner, Rashid, & Kortuem, 2016). From this stem the need for a solid understanding of how to interact with data in order to make correct interpretations and reach the right conclusions that are based upon it. The skill to navigate through different aspects of data efficiently and confidently is related to the concept of data literacy. Data literacy is becoming more established as a concept, and as an operationalised skill in various contexts, including educational settings where increasing attention is being brought to the importance of applied knowledge. More work is, however, needed for investigating how pedagogical interventions are best designed in order to be effective and suitable for as many as possible. This is especially true in regards to younger students around the age of 12-13, as they represent an age group that seemingly has not been studied as much in relation to the concept of data literacy in comparison to older students or adults. In addition, children of this age presumably have a smartphone and/or computer of some sort where the access to information is endless. Yet, their ability to think critically about what they come across in relation to data might not, understandably, be as fully developed as the one of an adult's. It is therefore important to "catch" and target this younger group to support them proactively. Although the ability to think critically and more nuanced typically increases with age, it should also be noted that adults are seemingly not particularly good at being data literate either (Ridsdale et al., 2015).

The increased presence online through different forms of technology results in a flow of information that is greater than probably ever before (Rideout, 2016). With this comes the importance of being able to understand and interact with different forms of data. In addition, the younger generation is growing up into a technological landscape that stresses the need for such competence to be brought to attention and action early. Data literacy has been defined as "the ability to collect, manage, evaluate and apply data, in a critical manner" (Ridsdale et al., 2015, p. 11) and is a multifaceted concept. Being data literate requires understanding of how arguments are valued against each other, which is often a reflection of proportional reasoning. Continuing to investigate how students best are supported in developing their understanding of this is therefore of importance. Proportionality is in some aspects central to making decisions, both big and small, in every-day situations (Peters et al., 2006). Put differently, it is the capacity to make comparisons in relative (multiplicative) rather than absolute (additive) terms (Fielding-Wells, Dole, & Makar, 2014). Previous studies have suggested that this particular type of reasoning and recognising proportional situations are something students generally struggle with (Boyer, Levine, & Huttenlocher, 2008; Hilton, Hilton, Dole, & Goos, 2016; Van Dooren, De Bock, Hessels, Janssens, & Verschaffel, 2005). A screening study aiming to explore the current data literacy skills in Swedish students (in grade six) also found support for this claim, that proportionality, and more specifically proportional reasoning, is one of the aspects of data literacy students appear to find the most challenging (Tärning, Ternbland, Haake, & Gulz, 2023). Based on this finding, proportionality was used as the starting point when creating the material for the current study.

The relevance and importance of data literacy appears to be evident and it is without doubt a valuable and necessary skill. In addition, with an increasing data-dependent workforce, data literacy is a skill needed through all stages of life (OECD, 2019; Ridsdale et al., 2015). This implies that being data literate is of importance, not only to the rising generation, but to society as a whole. The challenge ahead is to examine how to best teach this skill and what the best strategies for effective learning are. There have been several approaches to this, such as using an activity-based approach where students interact with data as part of a more creative process (Bhargava, Kadouaki, Bhargava, Castro, & D'Ignazio, 2016; Williams, Deahl, Rubel, & Lim, 2014; Wolff, Wermelinger, & Petre, 2019). Moreover, data literacy is often combined with statistics and mathematics to be part of a larger inquiry process as a way of working across subjects taught in schools. The potentially problematic aspect of doing so is that some students experience an emotional resistance towards the subject of mathematics, sometimes to the extent of having what is called math anxiety (MA). The concept of MA will be explained further in a later section. Due to data literacy being a concept that is applicable across a range of subjects and not purely a mathematical skill, it might be beneficial to separate pedagogical interventions from a traditional mathematical context in order to provide the best learning conditions for as many students as possible.

In this study, a first step is taken into investigating how the visual presentation (framing) of questions targeting data literacy, and more specifically proportional reasoning, may affect student performance. This is done through the use of traditional mathematical characteristics (e.g., with emphasis on number and tables) in a mathematical condition and non-traditional mathematical characteristics (e.g., by including images, using different layouts, and a somewhat richer narrative) in a less-mathematical condition. In addition, the second aim of the study is to investigate what attitude Swedish seventh-grade students have towards mathematics, with the possibility to explore the prevalence of math anxiety in the targeted age group. Math anxiety has been defined as "feelings of fear, apprehension, tension, or dread when faced with math, or even the prospect of math" (Ashcraft, 2002). Interestingly, this phenomenon has not been observed, to the same extent, in relation to any other subject taught in schools (Dowker, Sarkar, & Looi, 2016) which means that MA is one of the most prevalent academic anxieties (O'Hara, Kennedy, Naoufal, & Montreuil, 2022). Hence, there appears to be something particular about mathematics.

By altering the way questions are visually presented to students, there is a possibility that the mathematical resistance some students experience can be avoided, or at least reduced. Meaning, that it might be easier to target students with pedagogical activities aiming to strengthen data literacy-skills using a less-mathematical approach. In educational settings, using a similar strategy to facilitate learning is related to the concept of scaffolding. Scaffolding can take many different shapes, but central to all is the idea of temporarily modifying a task until the students master it themselves without the initial support. The concept has its origin in work from Bruner and colleagues (1976) and Vygotsky (1978). What all scaffolding strategies have in common is that they are temporary and made to be removed once students advance their understanding. In the following study, the visual presentation (framing) can be interpreted as providing different kinds of scaffolding, used to promote students' learning processes.

The novelty resides in the attempt of trying to remove mathematical characteristics from proportional reasoning (and by extension, an aspect of data literacy) which is not exclusively a mathematical skill and see what effect it may have on student performance. Again, in the current context, it is hypothesised that there might be benefits to separating pedagogical activities targeting data literacy from a purely mathematical context.

The thesis will be presented with the following structure: firstly a theoretical background of relevant literature will be given for the concepts of data literacy and math anxiety together with a short section of the Swedish educational system's current approach to the topic. This is followed by a detailed description of the methodology of the current study before the results are presented. The final section discusses the implications from the findings as well as some directions for future research.

Proportional reasoning

Data literacy is currently discussed in different contexts including corporate, educational, and research settings. The broad application of the term results in slightly different definitions depending on what aspect of the concept that is being emphasised. Hence, being data literate reflects the competence to interact with data in various stages, from the way it was gathered to the way it is applied, and used in argumentation Ridsdale et al. (2015). In a more educational context, Deahl (2014, p. 41) proposes the definition of data literacy as being: "the ability to understand, find, collect, interpret, visualise, and support arguments using quantitative and qualitative data". This definition by Deahl (2014) puts more emphasis on the ability to understand how to argue with data and how different arguments are weighed and compared to each other. Mandinach and Gummer (2013) propose a similar definition of data literacy as being "the ability to understand and use data effectively to inform decisions" (p. 30). This, how arguments hold in relation to each other, can be related to proportional reasoning and is the aspect of data literacy that the current investigation will focus on. Proportional reasoning is referring to the use of ratios in situations involving comparisons of quantities (Hilton et al., 2016) and younger students often struggle with the transition of shifting from additive to multiplicative thinking (see, e.g., Larson, 2013; Boyer et al., 2008) or, on the other end, tend to overuse proportionality, even in situations when it is not applicable (see, e.g., Van Dooren et al., 2005). While additive thinking is more concerned with the quantity itself and consequential sums and differences rather than its value in relation to other quantities, multiplicative thinking is about understanding how the quantity relates to others in terms of multiplication and division (Hilton et al., 2016). In more general terms, proportional reasoning requires the sense of co-variation and the ability to make comparisons in relative terms (Fielding-Wells et al., 2014). To illustrate with an example; in order to make juice, water and concentrate needs to be mixed. One recipe calls for 3 dl of concentrate to be mixed with 12 dl of water while another calls for 5 dl of concentrate and 20 dl of water to be mixed. Using additive thinking (in absolute terms) someone is likely to say that the second recipe makes for a stronger juice as it contains a higher quantity of concentrate, without considering the amount of water in the different cases. On the other hand, someone using a more relative perspective is more likely to see that the two recipes make an equally concentrated juice. This, as the ratio of concentrate to water is identical in both recipes. A similar example is given in Larson (2013).

An alternative definition of the concept data literacy was presented by D'Ignazio and Bhargava as "the ability to read, work with, analyze and argue with data as part of a larger inquiry process" (2016, p. 84). What all the given definitions have in common is the tendency for a hierarchical structure that involves themes such as identifying, understanding, operating on, and using data (D'Ignazio & Bhargava, 2016). With data literacy being a multifaceted concept, there is additional room for a variation of approaches and strategies when designing learning activities targeting the skill. It is common to make the connection between such activities and the teaching of math and statistics. Generally, data refers to a group of numbers in specific contexts, giving them meaning beyond their abstract representation (Cobb & Moore, 1997). The study of data is originally strongly connected to statistics. However, as the field of data science continues to emerge, it relates to several other fields through the combination of the disciplines mathematics, statistics, and computer science (Ow-Yeong, Yeter, & Ali, 2023). From a student perspective, data is most often introduced as statistics through the subject of mathematics, beginning as early as in kindergarten around age five (Ow-Yeong et al., 2023). The areas of data, mathematics, and statistics certainly overlap and are strongly connected, Gould (2017) even suggests that the definition of statistical literacy should incorporate and entail more aspects of data literacy as the need has grown for modern students to be educated statistical consumers and producers.

Moreover, data literacy is continuously gaining more attention and becoming more explicitly incorporated into educational contexts. Yet, it is clear that continuing to develop and improve pedagogical activities targeting data literacy will be important in the coming future. Before then, we need to investigate how students are best supported when it comes to becoming data literate. It is therefore useful to gain more understanding of how this could be done more effectively, and in a way that is suitable for as many students as possible. An idea is that with the known (and quite prevalent) presence of MA, it might be useful to separate pedagogical interventions targeting data literacy from a purely mathematical context, for several reasons. Not only can it alleviate some of the resistance that stems from MA, but also highlight the important ability to apply data literacy across a range of topics and contexts that are not only mathematical. Naturally, some aspects of data literacy are strongly related to statistics, but it is important to note that it is not a purely mathematical skill. Data might have better quality or higher value due to the way it was produced for instance. This can be explained by the fact that being data literate also includes understanding of the scientific method, scientific thinking and the way (good) science and knowledge are produced. In other words, this aspect is closely related to arguing with data and understanding why an argument is (or should be) chosen in favour of another, similar in many cases to proportional reasoning.

Data literacy in education

With the ever-increasing flow of information that is facing the younger generation, they not only need to interact with data, but they also need to be able to determine if the data in itself is trustworthy and if there are good reasons to believe the implications that arise from it. The increased presence of data in our society requires a more advanced understanding of how to interact and handle data in an effective way. Moreover, it is of importance for each individual to feel comfortable and confident in one's ability to make correct interpretations when making a decision or evaluating different aspects of data. Thus, promoting data literacy can be viewed as a way of promoting self-efficacy for citizens (Pangrazio & Sefton-Green, 2020). The concept of self-efficacy was introduced by Bandura (1977) and is the idea of having faith in one's own ability and capability in a specific situation or task, and that it can be successfully accomplished. In addition, not being data literate can lead to misinterpretations and misinformation which, in turn, is detrimental to a democratic society.

The educational system has a prominent role in making sure that students get the support they need to develop this skill, as the general assumption is that creating data literate societies begin in schools (Vahey, Yarnall, Patton, Zalles, & Swan, 2006; Wolff et al., 2016). In most cases (including Sweden), however, data literacy is not explicitly stated in the syllabus but instead, incorporated across curricula for different subjects including mathematics, social sciences, and natural sciences. It is, however, expressed in the mission statement for the Swedish elementary school (Lgr22, 2022 p. 7, translation by the author) that:

> “Students should be able to navigate and act in a complex reality with a vast flow of information and increased digitalisation at a fast rate of change. Skills and methods to interact with- and use new knowledge are therefore important. It is also necessary for students to develop their ability to critically review information, facts, and relationships in order to understand the consequences of different outcomes.”

To integrate data literacy across subjects seems to be a common approach, yet, the risk with doing so is that it might not allow for the coverage to be comprehensive enough (Gebre, 2022). It could also be argued that the broad application of the skill should be utilised by educational systems, to use the phrasing by Deahl: "schools should embrace and value data literacy curricula because of their interdisciplinary and exploratory nature, not in spite of it" (Deahl, 2014, p. 56). Related to the broad application of the skill and different disciplinary areas, central to data literacy is, again, to understand how data is used in argumentation and reasoning. It is therefore of importance that the way data literacy is taught allows for the integration from learning to living and that students can apply their knowledge to their own life and every-day situations (Gebre, 2022). In addition, Deahl (2014) argues that building data literacy in communities is not about mastering a single skill, but rather to foster the understanding and competence that will best empower individuals in their interaction with data. Ultimately, as with any literacy, the road towards becoming data literate should be seen as an ongoing process (Pangrazio & Sefton-Green, 2020).

Math anxiety

Mathematics is present through different forms in our everyday life. From a young age it is a central aspect of education, and we use our mathematical skills in many situations that require decision-making. It is known that many people find mathematics challenging and elements of it difficult, in addition to there being specific learning disabilities related to mathematics (Dowker et al., 2016). A phenomenon relating more to emotional aspects of the perceived challenges with mathematics is math anxiety (MA). MA has been defined by (Richardson and Suinn, 1972, p. 551) as “a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in [. . .] ordinary life and academic situations” and by (Ashcraft, 2002, p. 181) as “feelings of fear, apprehension, tension, or dread when faced with math, or even the prospect of math”. It is important to note that experiencing a bit of nervousness before writing a math exam is not a direct example of MA, to experience real anxiety and feelings of fear, however, is. It has been suggested that MA is the most common of the academic anxieties (Luttenberger, Wimmer, & Paechter, 2018; O’Hara et al., 2022) with an estimated prevalence of approximately 30% of 15-year-olds experiencing feelings of nervousness, helplessness, and tension when being confronted with doing a mathematical task (Cassady, 2010). It is, however, difficult to say anything too definite about the prevalence of MA due to the vast differences in methodology, measurement, and participants in documented studies investigating this phenomenon.

Math anxiety has been shown to be detrimental to learning in many ways (Demedts, Reynvoet, Sasanguie, & Depaepe, 2022; Dowker et al., 2016; Luttenberger et al., 2018; O’Hara et al., 2022). It should be noted, however, that MA is not necessarily always associated with low performance. Historically, MA has been further divided into subcategories to distinguish between different variations, such as learning MA and evaluation MA (O’Hara et al., 2022). Here, learning MA refers to anxiety occurring during/in anticipation of learning mathematics whereas evaluation MA refers to anxiety during or in anticipation of evaluation, such as before a quiz or a test. A possible result of MA in situations of evaluation is that cognitive resources are primarily used for regulation of the emotional response, leaving less resources available for the task at hand (Brunyé et al., 2013). The two different types of MA have been shown to be affected differently by individual- and environmental factors (O’Hara et al., 2022). In general, the feeling of anxiety appears to be higher in situations involving evaluation (Hart & Ganley, 2019). An additional differentiation can be made between state MA (temporary and situation-specific) and trait MA (stable characteristic of an individual) where findings suggest that both types seem to have an effect (but not to the same extent) on math performance (Demedts et al., 2022). The distinction between different variations of MA is valuable, not only to deepen the understanding of the phenomenon, but also to develop strategies for targeting different aspects of it. Another factor known to influence MA is gender, with the tendency for the self-reported prevalence of MA to be higher among girls and females (Devine, Hill, Carey, & Szűcs, 2018; Hart & Ganley, 2019; Luttenberger et al., 2018; Van Mier, Schleepen, & Van den Berg, 2019).

In the current context and following study, it is by no means suggested that the solution to deal with math anxiety is by avoidance and to remove all learning materials from a mathematical context. However, the ways to further investigate MA and how it can be reduced is outside the scope for this thesis. Here, MA is simply highlighted as a concept that can possibly influence students’ ability to interact with learning material targeting data literacy.

Hypotheses and purpose

This thesis aims to explore how we can combine previous knowledge of the challenges with supporting students in their quest of becoming data literate with the known phenomenon of math anxiety. In addition to MA being an uncomfortable experience, as pointed out by Dowker et al. (2016), these emotions and attitudes towards mathematics act as barriers to learning. This is done to investigate whether future pedagogical activities targeting data literacy could possibly benefit from being separated from stereotypical mathematical characteristics, and the traditional way mathematical questions are usually presented. The hypothesis is that students will perform better when the learning material does not "look like" mathematics, partly due to what is known about MA. The two research questions for the current investigation can therefore be phrased in the following manner:

RQ1: How does mathematical vs. less-mathematical framing affect student performance on questions related to proportional reasoning?

RQ2: What attitudes and feelings do Swedish seventh-grade students experience toward mathematics?

2 Method

Participants

A total of 114 students, all in seventh-grade, from two different public schools in the south of Sweden participated in the study. The participants were between the ages of 13 and 14 (54 boys and 60 girls). No personal information about the participants was retrieved. All participants were kept anonymous.

Materials and conditions

Due to the novel nature of the topic of investigation together with the lack of cohesive research targeting data literacy pedagogy (Gebre, 2022; Wolff et al., 2019) there were no fully tested or evaluated resources available for further use in the following study. This is a result from the fact that the exploration and evolution of data literacy interventions are still very much ongoing. In addition, with data literacy being a wide and multifaceted concept, it was necessary to limit the scope and focus a more specific element, also due to the restricted time-frame available. In this case, that specific element was proportional reasoning. In the current context, proportional reasoning was incorporated in the form of evaluating arguments that have elements of proportionality in them, and does therefore not refer to the mathematical tradition per se. The created testing material consists of students having to value arguments against each other based on a given statement, and not perform any complex calculations for instance.

In order to investigate the first research question (RQ1), a differentiation had to be made between two conditions: one mathematical and one less-mathematical. There were many different routes that could be taken to accomplish this, one possibility would be to create a more elaborate pedagogical intervention that runs over a longer period of time and involves the application of other learning strategies such as storytelling for example. Storytelling has been associated with many beneficial outcomes in education and proven to be an effective strategy to promote learning, partly through the positive effect it appears to have on student engagement (Comay, 2020; Willingham, 2009). The use of stories often allows for increased coherence, and embedding information in a narrative can support both conceptual memory as well as the general understanding (Comay, 2020). In addition, both mathematics and storytelling share the element of being driven by internal logic (Comay, 2020). The advantages of using storytelling in education are also supported by the work of Willingham, who suggests that the human mind is drawn to stories, he even states that: “the human mind seems exquisitely tuned to understand and remember stories—so much so that psychologists sometimes refer to stories as "psychologically privileged", meaning that they are treated differently in memory than other types of material” (Willingham, 2009, p. 85). From a more emotional perspective, storytelling seems to be a good way to motivate and engage learners (Comay, 2020). Hence, constructing more elaborate pedagogical strategies for incorporating storytelling into teaching different aspects of data literacy might be a fruitful future direction. This direction would, however, require more time and commitment from schools, teachers, and students. Again, due to the limited time frame, it was decided to focus on framing and the visual presentation of the questions in the testing material. Elements of storytelling were incorporated when possible, such as when providing more context with a somewhat richer narrative in the less-mathematical condition.

Measure of proportional reasoning

The material with questions relating to proportional reasoning was created in two versions, separated by the presence (or absence) of traditionally mathematical features, elements, and characteristics in the visual presentation. Hence, framing here refers to the way the questions were visually presented to participants. In order to keep the differentiation between the conditions straightforward and clear, they will be referred to as the mathematical condition (M) and the less-mathematical condition (LM). From the work of Hilton and colleagues (2016), a similar structure was adopted to create eight multiple-choice style questions (see appendix for the complete set of questions for both conditions). For each question, some situational context is provided together with a given statement. The task is to first decide if the statement is true or false based on the given information, before supporting the decision by selecting one of four alternatives for justification, meaning *why* the statement is true or false in relation to the given information. This structure was chosen for several reasons. For one, it is a way of getting the students to reflect on their own answer and way of reasoning. Secondly, if they answer incorrectly, it provides a clue to where or in what way their way of reasoning falls short.

In the mathematical condition, the questions were presented in a way that is stereotypical for mathematical learning materials, such as math books, sometimes including simple visual representations and graphs (see figure 1). For the mathematical framing, the focus was put on numbers, other contextual words were limited, and the questions often included a simple table with relevant numbers.

	The sunflower's height
Day 0	0 cm
Day 6	10 cm

A sunflower has grown to be almost 3.5 m tall. After 6 days, the sunflower was only 10 cm tall.
It took more than 6 months for the sunflower reach its current height.

True or **False**

Because (choose the best option):

a) After exactly 6 months, the sunflower is only 3 meters tall.

b) It takes 60 days for the sunflower to reach a height of 1 meter.

c) It takes less than 6 months for the sunflower to grow 3.5 meters tall.

d) The sunflower grows less than 10 cm in a week.

Figure 1. Example of question with mathematical framing, translated into English.

In the less-mathematical condition, the questions were framed in a way *not* be associated with a math book or other traditional mathematical contexts (see figure 2). Such strategies included the use of layouts that are more common in newspapers or websites, as these represent examples of other contexts that students are familiar with but do not necessarily associate with mathematics. The less-mathematical framing also included more imagery relating to the context of the question but that did not contain any additional information needed to answer the question, such as pictures or colourful illustrations. Relating back to storytelling, this creates a stronger narrative made up of the richer contextual details.

Melker's sunflower can almost touch the sky

Melker, 7.5 years old and has grown a sunflower that has reached a height of almost 3.5 meters. "It is fun to grow things", Melker says who also grows carrots in his garden. It has, however, taken some time for the sunflower to grow to its current size. After 6 days, the sunflower was only 10 cm tall.
It took more than 6 months for the sunflower to reach its current height.

True or **False**

Because (choose the best option):

a) After exactly 6 months, the sunflower is only 3 meters tall.

b) It takes 60 days for the sunflower to reach a height of 1 meter.

c) It takes less than 6 months for the sunflower to grow 3.5 meters tall.

d) The sunflower grows less than 10 cm in a week.

Figure 2. Example of question with less-mathematical framing, translated into English.

To clarify, the content and phrasing of the statements (as well as the four multiple-choice alternatives) are identical in both framing conditions. Thus, it is only the visual presentation that is being manipulated. This is to ensure that the versions are equal in terms of difficulty and knowledge needed. The central idea is only to "remove" the questions from the typical context of educational literature and present them in a way that is not necessarily associated with mathematics at all.

Measure of math anxiety

The second research question (RQ2) aimed to explore Swedish students' attitudes and feelings toward the subject of mathematics. This was investigated through having all participants (in both framing conditions) complete the same questionnaire about their experience with mathematics (see figure 3 below).

1. I think mathematics is fun

☐ Never ☐ Almost never ☐ Sometimes ☐ Often ☐ Almost always ☐ Always

2. I feel nervous when I think about mathematics

☐ Never ☐ Almost never ☐ Sometimes ☐ Often ☐ Almost always ☐ Always

3. I think mathematics is difficult

☐ Never ☐ Almost never ☐ Sometimes ☐ Often ☐ Almost always ☐ Always

4. I think mathematics is interesting

☐ Never ☐ Almost never ☐ Sometimes ☐ Often ☐ Almost always ☐ Always

5. I feel that I would like to learn more mathematics

☐ Never ☐ Almost never ☐ Sometimes ☐ Often ☐ Almost always ☐ Always

6. I understand when the teacher explains something to everyone in math class

☐ Never ☐ Almost never ☐ Sometimes ☐ Often ☐ Almost always ☐ Always

7. I feel afraid when I think about mathematics

☐ Never ☐ Almost never ☐ Sometimes ☐ Often ☐ Almost always ☐ Always

8. When I am about to take a math exam, I feel...

9. One word that describes mathematics for me is...

Figure 3. The MA-questionnaire completed by all participants, translated to English.

Although none of the questions explicitly ask about anxiety levels, it will be referred to as the MA-questionnaire. It consisted of nine questions about mathematics, seven of which were statements that participants responded to on a six-item scale ranging from "never" to "always". Having a six-item scale forces participants to choose an alternative of valence and is a way of avoiding collection of neutral answers. The statements were: "I think mathematics is fun", "I feel nervous when I think about mathematics", "I think mathematics is difficult", "I think mathematics is interesting", "I would like to learn more mathematics", "I understand when the teacher explains a mathematical problem or calculation in class", and "I feel scared when thinking about mathematics". To avoid potential framing effects or bias, the statements included both positive and negative feelings and attitudes towards the subject of mathematics. The two statements most relevant to MA are the ones asking about experienced nervousness and fear when thinking about mathematics. The last two questions in the questionnaire asked students to give a written response, in free-text form, to the statements "When I am about to take a math exam, I feel. . . " and "A word that describes mathematics for me is. . . ".

All statements were intentionally written in a neutral tone, trying to not be leading in any way. The statements included in the questionnaire were partially adapted and translated from the Mathematical Anxiety Rating Scale (MARS) that was developed by Richardson and Suinn (1972) and has been used in previous research. In the MARS questionnaire, however, participants are asked to respond to statements on a four-item scale ranging from "low anxiety" to "high anxiety". Hence, it explicitly asks the respondent to rate their levels of anxiety in relation to different statements about mathematics. The decision to not ask the students to rate their anxiety level in the current study was made to allow more aspects of a possible perceived resistance towards mathematics to be included, as some students might experience a more emotional (e.g., an uneasy feeling) or cognitive (e.g., "I couldn't do it last time so I don't want to do it again") avoidance towards mathematics that is not related to- or expressed in the form of anxiety per se. In addition, previous studies indicate that younger participants might not be as familiar with the term anxiety and what it entails, and that an alternative term such as "worry" might be more useful (Punaro & Reeve, 2012). The same study by Punaro and Reeve (2012) let participants use facial expressions to convey their emotional response. In their study, however, participants were younger (around age 9). In this case, it was decided that the participants were presumably old enough to comprehend the written options.

Procedure

The data collection began with the researchers introducing themselves and explaining the purpose of their visit. All students were then verbally informed that participation was voluntary and was not in any way connected to their grades or regular teacher. They were, however, encouraged to still do their best during the session. The level of subject knowledge (meaning a categorical assessment on a four-point scale: very low, low, average, high) for mathematics was provided by the teachers and obtained for each participant. This was done to get a more nuanced insight to the students' mathematical skills than it would have been, had only the participants' grades been reported for instance. This information was kept anonymous through the use of a coding system that allowed for identification of participants when the data was later analysed. For the six classes that participated in the study, half of the students in each class were allocated to each framing condition. This was done as a way to eliminate any possible influential factors that might be unique to a certain class or teacher which, in turn, could result in between-group differences. The data was collected with students in the same class sitting all together in their regular classroom. Before being handed the material (the proportional reasoning questions and the MA-questionnaire in the same booklet) participants were briefly informed about the structure of the questions together with some instructions, which were to first read the question, then decide if the statement is true or false, and finally to choose *one* of the four alternatives (a, b, c, or d) by circling the answers. Participants were also instructed to answer the questions independently, without discussing amongst each other. The proportional reasoning questions were completed prior to the MA-questionnaire. When the material was handed out, the researchers tried to allocate the two different conditions evenly among gender and placement in the classroom (yet, otherwise randomly), in addition to making sure that students sitting directly next to each other were given the same version of the questions. This was done to avoid the possible distraction of students seeing that the person next to them had questions that looked different from their own. It took students around 15 minutes to complete the material in its entirety. During the session, the researchers observed and were available for any questions or clarifications. This was, however, rarely needed. The data was collected over a time span of one week. All text in the material was written in Swedish.

Pilot

The created material was pilot-tested using 29 participants (10 boys and 19 girls) from a sixth-grade class (students aged 12 and 13), in a school unrelated to the project and primary data collection. This was done to evaluate the difficulty level of the questions as well as to see how the general structure of the material worked in a classroom setting. 14 participants were allocated to the experimental condition with less-mathematical framing and 15 participants to the condition with mathematical framing. All participants also completed the MA-questionnaire after they were finished with the proportionality questions. The overall take-away was that the difficulty level of the questions were suitable for the targeted age group, meaning, that they understood the questions but did not find them too easy. After the testing, some word choices and phrasings were changed in the material, together with other minor adjustments to the formatting. In addition, the pilot indicated that there indeed seemed to be a difference in student performance between the two conditions as participants in the less-mathematical condition consistently performed better compared to participants in the mathematical condition. However, no further analyses of the results were performed, as the purpose was solely to test the created material.

Ultimately, the pilot also acted as a good motivator for continuing the investigation in the chosen direction.

3 Results

The statistical analyses were conducted using R (version 4.1.3) with RStudio.

Student performance

The analyses in the following section were calculated based on the responses from 96 participants (50 boys and 46 girls) to the questions targeting proportional reasoning, with 48 students in each condition. Responses were excluded in cases where they were incomplete, or it was observed during the data collection that it was obvious that the student was unfocused and did not read the questions at all, only putting down answers at random. The results were analysed using a point system where one point was given for each correct answer. Hence, one point was awarded for the correct identification of true or false and another point was awarded for the correct justification, making two points the maximum for each question, and 16 points the maximum number of points in total for all of the eight questions combined.

For seven of the eight questions (the exception being the question number one), the experimental condition with less-mathematical framing performed better, although marginally (see figure 4). Thus, using an independent samples t-test, there was no significant effect found for the less-mathematical framing, $t(93)=1.63$, $p=.1063$, on student performance, despite the less-mathematical condition ($M=10.5$, $SD=3.2$) continuously having higher scores compared to the mathematical condition ($M=9.48$, $SD=2.9$).

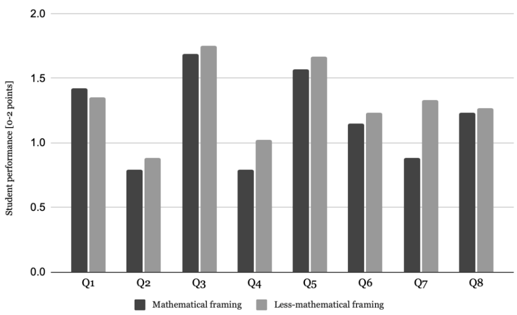

Figure 4. Student performance as the average amount of points for each question in both framing conditions.

Furthermore, as demonstrated in figure 4, there were some variation in performance for the different questions, with question two and question four being the seemingly most challenging ones for both conditions, as they have the lowest scores. Question seven had the highest mean difference between the two groups with 0.88 ($SD=0.76$) being the average points for the mathematical condition and 1.33 ($SD=0.56$) being the average points for the less-mathematical condition. In addition, question seven is the only case where a significant difference $t(86)=3.3625$, $p=<.005$ between the conditions was found. Question four does also indicate a more noticeable mean difference between the conditions with an average of 0.81 ($SD=0.87$) points for the mathematical condition and 1.02 ($SD=0.76$) for the less-mathematical condition. These, more substantial differences, can be due to a variation of factors, such as the influence of included images or preconceptions that would possibly apply to some of the contextual aspects of the questions. This will be explored in more detail in the next section.

	Mathematical		Less-mathematical				
Q	*M*	*SD*	*M*	*SD*	*p*	*t*	*df*
1	1.42	0.77	1.35	0.78	.694	-0.39	94
2	0.79	0.9	0.88	0.93	.658	0.44	94
3	1.69	0.51	1.75	0.48	.540	0.61	94
4	0.79	0.88	1.02	0.76	.173	1.37	92
5	1.54	0.71	1.67	0.66	.376	0.89	94
6	1.15	0.8	1.23	0.86	.623	0.49	94
7	0.88	0.76	1.33	0.56	$<$.005	3.36	86
8	1.23	0.76	1.27	0.76	.784	0.27	94

Table 1. Comparison of the average scores for both framing conditions, to each question.

Unfortunately, the assessments for subject knowledge in mathematics were not provided by some of the teachers, resulting in missing values for 46 students. This made it impossible to further investigate how the level of mathematical subject knowledge could have a possible effect on student performance, as the information was not provided for 48% of the participants.

Math Anxiety

For the MA-questionnaire, responses from 114 participants were collected and analysed. The higher number of participants is due to a higher number of completed responses. All participants filled in the MA-questionnaire seemingly focused, even students who did not want (or care) to complete the proportional reasoning questions. As the two research questions are investigated in parallel to each other, it was decided to include as many of the questionnaire-responses as possible. The findings suggest that students generally do not perceive mathematics as fun (with 81% of students stated that they never, almost never or only sometimes find math fun) nor particularly interesting (82% of students stated that they never, almost never, or only sometimes find math interesting). The majority of students also reported that they find math to be somewhat challenging with 62% of students stated that they sometimes or often find mathematics difficult. This claim can be further strengthened by the two final complementary free-text answers, and is in line with prior expectations. The statements' most relevant in regards to MA are the ones that ask students about experienced nervousness and fear when thinking about mathematics. For nervousness, 8% of students report that they often, almost always, or always feel nervous when thinking about mathematics (see figure 5). In addition, there is a considerable percentage of students (37%) that report that they sometimes feel nervous when thinking about math. Nervousness associated with mathematics is to be somewhat expected, especially in regards to evaluation-MA in the scenario of being faced with a mathematical problem or test O'Hara et al. (2022). It should be noted that the MA-questionnaire does not ask students about a specific situation but their overall, and general perception.

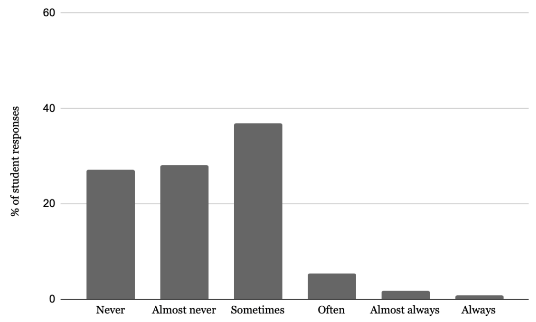

Figure 5. Student responses (%) to the statement "I feel nervous when I think about mathematics".

In terms of experienced fear, 57% of students report that they never feel afraid when thinking about mathematics. Moreover, 10% of students report that they often, almost always or always experience feelings of fear when thinking about the subject of mathematics (see figure 6).

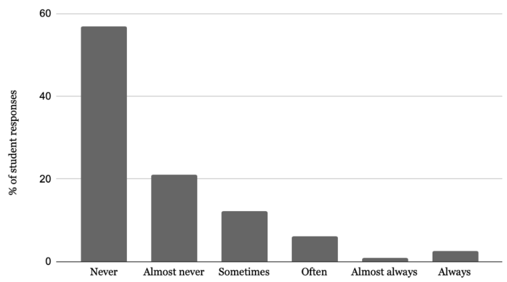

Figure 6. Student responses (%) to the statement "I feel afraid when I think about mathematics".

The two final questions in the MA-questionnaire ask students to finish the statements "When I am about to take a math exam, I feel..." and "One word that describes mathematics for me is..." in free-text form. Before writing a math exam, students most frequently report that they feel nervous (52), stressed (18), tired (5), confident (4), or tense (3). When asked to describe their perception of mathematics with one word, the most frequent responses were boring (29), difficult (11), problem-solving (11), interesting (7), or tiresome (5). Occasionally, more positive words were used such as important (4) and fun (2). Yet, less frequent responses also included even more negative words such as pointless (2), hatred (2), terrible (1), and anxiety (1).

4 Discussion

The aim of the study was to investigate whether framing in the form of visual presentation of proportional reasoning questions (with more or less emphasis on traditional mathematical characteristics) had an effect on student performance. This was combined with a questionnaire to explore Swedish seventh-grade students' general experience and attitude towards the subject of mathematics. The results highlight several meaningful observations. Even though the findings do not demonstrate any significant difference in performance between the two framing conditions, they do suggest that students generally do not have a particularly positive attitude toward mathematics, and separating data literacy interventions from a mathematical context might result in more engagement and interest from students. The MA-questionnaire indicate that in terms of perceived fear and nervousness, less than 10% of students (9.6% and 7.9% for fear and nervousness, respectively) report that they often, almost always or always do experience these feelings when thinking about mathematics. These results can be interpreted as two-sided. On the one hand, previous studies investigating MA typically found higher numbers regarding the prevalence (see e.g., Cassady (2010)) than the ones suggested in the current study. On the other hand, the results from the MA-questionnaire highlight that there is indeed a group of students who experience significant nervousness and fear in relation to the subject of mathematics. This further strengthens the call for MA to be taken into consideration when designing pedagogical interventions or future learning material that is not explicitly intended for mathematics. Although the majority of students appear to have a "healthy" or neutral relationship with mathematics, it is also clear that some students do not. This minority needs to be acknowledged and further supported as MA has been shown to be negatively correlated to mathematical achievement (Barroso et al., 2021). Another possible consequence of MA, beside it being an unpleasant experience, is the impact on future career choices. A longitudinal study by Ahmed (2018) found that adolescents with consistently low levels of MA were 7.4 times more likely to later be pursuing a career (i.e., being employed) in STEM (science, technology, engineering and mathematics) when compared to adolescents showing consistently high levels of MA. In this light it should also be noted that MA is has been found to either remain at the same level or increase with time (Ahmed, 2018; Dowker et al., 2016), making it important for future directions to target younger students with supporting actions.

In regards to the proportional reasoning-questions; in two cases, (question number four and seven) students in the less-mathematical condition performed substantially better. In both cases, the questions were presented in a way often found in newspapers, with one question having the layout of a typical advertisement for a product and the other question having the layout of an article. Possible preconceptions and connotations of being more critical towards ads and larger headlines which are made to be alluring and "selling" might have influenced this. Hence, there might be a tendency to read more carefully and be more attentive to details when suspecting that the content is typically made to be persuasive. This is, however, entirely speculative.

One question (number two) had the lowest average score for both conditions and involved a typical situation of proportionality where one must understand the reasoning of the relation between a part and the whole when the quantity varies. These results are in line with previous findings of how students typically struggle with this type of thinking (Boyer et al., 2008; Fielding-Wells et al., 2014; Larson, 2013; Van Dooren et al., 2005). In both conditions, less than half of the students (35% in M and 46% in LM) correctly identified that the given statement in this case was false. A similar proportion (38% in M and 42% in LM) of students correctly identified the justification (alternative C in this case). Taking a closer look at the responses it is clear that many students did not correctly identify the situation as one of proportionality and used absolute (additive) instead of relative (multiplicative) thinking, as alternative A was the other highly frequent answer (50% in M and 42% in LM). Similarly to the juice example mentioned previously, students tend to compare two absolute quantities with each other, not taking into consideration their relation with other values, resulting in an erroneous way of reasoning. In order to make the correct interpretation and successfully answer the question, they must compare the relationship between two quantities, rather than viewing each as independent of the other. Larson (2013) pin the tendency for students to struggle with this to the fact that proportional reasoning requires a significant shift in thinking. Hence, students might recognise the elements of proportionality in one situation, but not when it is being set in another. Here, the eight questions were all put in a different context that allows for students' previous knowledge to be used and utilised when solving the task. This, more complex way of thinking and reasoning is essential for data literacy in the broader sense as the skill entails a deeper, and more nuanced understanding of the provided information. The same problem relates to Willingham's explanation to why critical thinking is difficult to teach effectively, through the idea of surface-structure and deep-structure of understanding Willingham (2008). Meaning, when a student is presented with a problem, their mind interprets the information in light of the previous knowledge and in the context it is being provided (Willingham, 2008). The ability to look past this, initial context, and use deep-structure knowledge that have a broader range of application is essential in order to become data literate and a critical thinker. The reason being that critical thinking as well as scientific thinking (that is also central to data literacy) is not a skill per se, nor something that be acquired and deployed regardless of context (Willingham, 2008). Hence, creating cohesive learning strategies for data literacy is also one of the challenges ahead.

Returning to the current study, in the less-mathematical condition, the framing often included images, photos or pictures along the presented questions. They did not, however, provide any additional information that could be used to solve the task. The purpose of such visuals in this case was to create a more casual and inviting visual presentation that steered away from stereotypical association to mathematics. It could be argued that such imagery instead acts counterproductive as distractions and imposing extraneous cognitive load on participants. The efficient use of media in an educational context has been investigated and a proposed multimedia effect has been suggested, meaning when pictures are added to illustrate or replace part of the problem text, problem-solving performance is enhanced (Hu, Chen, Li, & Huang, 2021). Thus, a reverse multimedia effect could possibly be expected when "distracting" imagery is included in the problem text (Herrlinger, Höffler, Opfermann, & Leutner, 2017). This could be related to the coherence principle in the Multimedia Learning Theory (Moreno & Mayer, 1999) which claims that visual effects should be eliminated when they do not add to the task at hand. Including extraneous material might result in redundancy which require unnecessary allocation of cognitive resources that could be used in a better, and more efficient way (Mayer & Fiorella, 2014; Mayer & Moreno, 2003). Moreover, the same idea could be related to question number one which was the only case where a higher average score was found for the mathematical condition. The content of the specific question circled around a recipe of a chocolate dessert with an additional image of the finished product included in the less-mathematical condition. The image could have acted as a distraction and seductive detail that drew attention from the text which resulted in less focus and cognitive resources being put on the task at hand, producing a higher score in the condition where the image was excluded. On the other hand, having elements in the less-mathematical condition to be somewhat distracting was the plan and, in some aspects, intentional. Moving forward, the balance between "useful" distraction and it being in the way of effective learning need to be further investigated. A meta-analysis by Hu et al. (2021) investigated the multimedia effect in problem solving, yet, the results for the effects of decorative pictures were not sufficient for reliable interpretations.

Ultimately, teaching data literacy is a complex process that requires the integration of multiple skills across a variation of subjects and continuous effort in order to produce data literate individuals. It is of importance to empower individuals and create well-informed societies in a landscape that is heavily influenced by data. Research regarding how to best support students of all ages and the role of educational systems in effective learning strategies for data literacy is currently ongoing and it is evident that more work will be needed in the future.

Limitations and future directions

This study was a first step to exploring the possible connection between MA and the design of data literacy learning material, resulting in useful insights as well as aspects of possible improvements. One major limitation in regards to the proportionality questions is the unfortunate fact that previous subject knowledge levels were not obtained for a large number of students. This is indeed limiting the study as it was a factor intended to be integrated into the analyses of the produced results. Another limitation is that the different versions of framing were not evaluated prior to the data collection, only the questions and the material in its entirety. Doing so would have been beneficial in regards to the validity and to possibly strengthen the claim that the different framing conditions really are perceived by the students as being more- or less mathematical.

In addition, the MA-questionnaire has limitations in its construction that need to be taken into consideration. For one, most of the statements ask students about a more general attitude or approach toward mathematics. Thus, they are not situation-specific. It is possible that asking more specified questions about real-life scenarios, or having participants respond in real-time right before an exam would produce more accurate results. As always, when using self-reported data, one must also be cautious about potential influencing factors stemming from social desirability that might affect the validity of the questionnaire. Moreover, the fact that the MA-questionnaire was filled in subsequently to the proportional reasoning questions might also have affected the students' responses to the questionnaire. Some students might have had a feeling that they performed badly on the proportionality questions which could have influenced their response to be more negative. Naturally, the opposite could also be true. Some students might have had a great and positive feeling after the proportionality questions that might have influenced their response to the MA-questionnaire. A possible improvement could therefore be to not hand out the proportional reasoning questions and the MA-questionnaire simultaneously.

In regards to other possible improvements, one would be to differentiate between male and female responses when analysing the findings from the MA-questionnaire, given what is known about gender differences in relation to the concept (Cassady, 2010). Another improvement would be to further explore the connection between MA and student performance in the two different conditions. In this study, the two inquires were investigated in parallel to each other and the collected data did not combine the two lines of interest. To further explore this would be interesting, as previous findings suggest that MA often, but not always, appear to be negatively correlated with performance and math achievement (Barroso et al., 2021).

Conclusions

In this investigation there was no significant difference found for student performance in the different framing conditions. However, students presented with less-mathematical framing did generally score higher, although marginally. This could indicate that there might be benefits to be found though further investigations that use more elaborately designed interventions, such as having an even more distinct separation from traditional mathematical contexts. In addition, students do not appear to have a particularly positive attitude towards mathematics, and there are perhaps other positive effects to gain such as increased engagement and interest when removing future pedagogical interventions or strategies targeting data literacy from purely mathematical traditions.

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Appendix

Below are the proportional reasoning questions used in the data collection. They are presented in Swedish and the formatting has been modified. The less-mathematical framing is presented first, immediately followed by the mathematical before the shared statement (italicized) and multiple-choice options.

Question 1.

Less-mathematical framing:

Klara vill fira chokladbollens dag genom att baka och letar upp ett recept. Tyvärr har hon bara 100g smör hemma. *Om hon anpassar receptet ovan och använder den mängd smör hon har, kommer hon behöva använda 3 dl havregryn.*

Mathematical framing:

Chokladbollar
150g smör
1,5 dl strösocker
3 msk kakao
1 tsk vaniljsocker
3 msk kaffe (eller vatten)
4,5 dl havregryn

Om man utgår från receptet ovan men bara har 100g smör behöver man minska mängden havregryn till 3 dl.

Sant eller **Falskt**

Därför att (välj det bästa alternativet):
a) Om hon/man använder 50g mindre smör, behöver hon/man använda 0,5 dl mindre havregryn.
b) Om hon/man minskar smöret med en tredjedel måste hon/man minska havregrynen med en tredjedel.
c) Hon/man behöver inte ändra mängden havregryn.
d) Det ska alltid vara mer havregryn än smör.

Question 2.

Less-mathematical framing:

Mathematical framing:

I tabellen visas omröstningen för en klassaktivitet i årskurs 5 och årskurs 6

Årskurs	Åka till stranden	Gå på bio	Totalt
Årskurs 5	8	14	22
Årskurs 6	7	6	13

Att åka till stranden är mer populärt bland eleverna i årskurs 5 än årskurs 6.

Sant eller **Falskt**

Därför att (välj det bästa alternativet):
a) Fler elever i årskurs 5 väljer att åka till stranden än i årskurs 6.
b) Bara sex elever i årskurs 6 väljer att gå på bio.
c) Mer än hälften av eleverna i årskurs 6 väljer att åka till stranden och mindre än hälften av eleverna i årskurs 5 väljer att åka till stranden.
d) Fler elever i årskurs 5 väljer att gå på bio än i årskurs 6.

Question 3.

Less-mathematical framing:

Mathematical framing:

Stapeldiagrammet nedan visar de fem mest populära idrotterna bland barn och unga i Sverige.

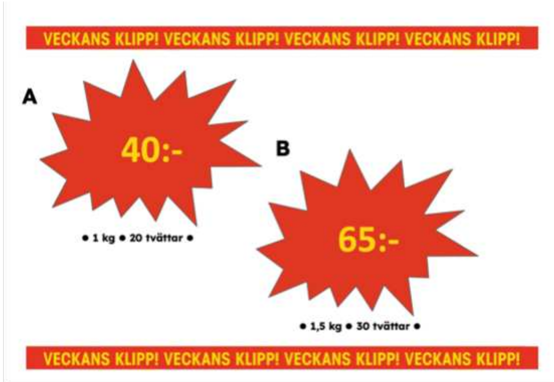
Det är fler ungdomar som spelar fotboll än alla de fyra andra sporterna tillsammans.

Sant eller **Falskt**

Därför att (välj det bästa alternativet):
a) Stapeln för fotboll är längst.
b) Det är nästan lika många som spelar innebandy och ishockey.
c) Lägger man ihop staplarna för de andra sporterna skulle den vara kortare än den för fotboll.
d) Fotboll är den roligaste sporten.

Question 4.

Less-mathematical framing:



Mathematical framing:

Tvättmedel A	Tvättmedel B
• 40 kronor	• 65 kronor
• 1 kg	• 1.5 kg
• 20 tvättar	• 30 tvättar

Tvättmedel A är det bästa köpet.

Sant eller **Falskt**

Därför att (välj det bästa alternativet):
a) Tvättmedel A kostar minst.
b) Tvättmedel B kostar mer, men det räcker till 10 tvättar mer.
c) Kostnaden per tvätt är lägre.
d) Det är ingen skillnad mellan alternativen.

Question 5.

Less-mathematical framing:

Mathematical framing:

	Tid	Sträcka
Människa	1 h	5 km
Sengångare	1 h	250 m

Sengångaren är världens långsammaste däggdjur. I tabellen visas hur långt en sengångare och människa går på en timma.

Om en sengångare går dubbelt så fort skulle den vara hälften så snabb som en människa.

Sant eller **Falskt**

Därför att (välj det bästa alternativet):
a) Om sengångaren går dubbelt så fort är den lika snabb som en människa.
b) Sengångaren kommer fortfarande vara långsammare än en människa.
c) Då skulle det ta 1 timma för sengångaren att gå 2500m.
d) En människa kommer alltid att vara snabbare än ett djur.

Question 6.

Less-mathematical framing:

Melker, 7,5 år har odlat en solros som har blivit nästan 3,5 meter hög. ”Det är roligt att odla” säger Melker som även har morötter i sin pallkrage. Men det har tagit tid för solrosen att bli så stor, efter 6 dagar hade solrosen växt 10 cm.

Mathematical framing:

	Solrosens höjd
Dag 0	0 cm
Dag 6	10 cm

En solros har blivit nästan 3,5 m hög, efter 6 dagar hade solrosen växt 10 cm.

Det tog över ett halvår för Melkers solros att växa sig så hög som den är på bilden/Det tog över ett halvår för solrosen att växa sig så hög som den är nu.

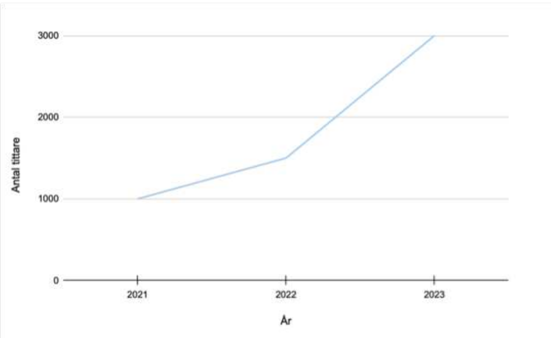
Sant eller **Falskt**

Därför att (välj det bästa alternativet):
a) Efter ett halvår är solrosen bara 3 meter hög.
b) Det tar 60 dagar för solrosen att bli 1 meter hög.
c) Det tar mindre än ett halvår för solrosen att bli 3,5 meter hög.
d) Solrosen växer mindre än 10 cm på en vecka.

Question 7.

Less-mathematical framing:

Mathematical framing:



Linjediagrammet nedan visar tittatantalet för ett populärt TV program. I tidningen finns rubriken ”Många tittade på populära programmet – antalet ökade med 200% på ett år”.

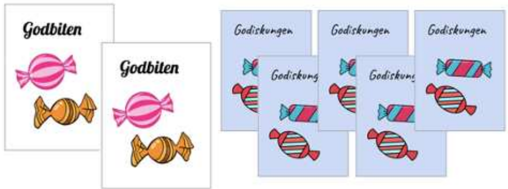
Det som står i tidningsrubriken stämmer.

Sant eller **Falskt**

Därför att (välj det bästa alternativet):
a) Det var flest som såg programmet år 2023.
b) Antalet ökade med 100% mellan år 2022 och 2023.
c) Det var lika många som såg programmet 2021 och 2022.
d) Det går inte att säga.

Question 8.

Less-mathematical framing:



Milla går till affären för att köpa godis. Det finns två märken att välja mellan: Godbiten och Godiskungen. 2 påsar Godbiten kostar 6 kronor. 5 lika stora påsar från Godiskungen kostar 20 kronor.

Mathematical framing:

Milla går till affären för att köpa godis. Det finns två märken att välja mellan: Godbiten och Godiskungen. 2 påsar Godbiten kostar 6 kronor. 5 lika stora påsar från Godiskungen kostar 20 kronor.

Man får mer godis för pengarna om man väljer att köpa Godiskungen.

Sant eller **Falskt**

Därför att (välj det bästa alternativet):
a) Godiskungen är alltid dyrare.
b) Godbiten är billigare per påse.
c) 6 kronor är mindre än 20 kronor, därför är Godbiten billigare.
d) Det ingen skillnad i pris mellan Godbiten och Godiskungen.