The effect of worked examples and extra help on math anxiety and equation learning in French-speaking Belgium

American Journal of Education and Learning
Vol. 10, No. 2, 226-248, 2025
e-ISSN:2518-6647

(Corresponding Author)

Sara JACMART[1]
Laetitia Dragone[2]
Gaëtan Temperman[3]
Bruno De Lièvre[4]

[1,2,3,4]*University of Mons, Belgium.*
[1]*Email:* Sara.Jacmart@alumni.umons.ac.be
[2]*Email:* laetitia.dragone@umons.ac.be
[3]*Email:* gaetan.temperman@umons.ac.be
[4]*Email:* bruno.delievre@umons.ac.be

ABSTRACT

This study examined the effectiveness of worked examples as a teaching strategy to improve students' performance in mathematics and to reduce their level of anxiety. This instructional approach was implemented during a mathematics course to teach equation solving to 47 students in the second year of secondary school in French-speaking Belgium, where both high levels of mathematics anxiety and low performance in equation solving had been observed. The study also explored the impact of adding extra support that detailed each step of the worked examples on these two variables. Only one of the two groups was given the opportunity to access these additional explanations through QR codes. Pre- and post-experimental observations were conducted in order to assess the effect of this practice on both variables. The results showed that worked examples, whether accompanied by additional help or not, had a significant positive effect on students' mathematical performance. However, no significant effect on mathematics-related anxiety was observed in either group. Moreover, the addition of extra support did not result in any significant difference in terms of reducing anxiety or improving performance when compared to the use of worked examples alone. Thus, the study confirms that worked examples can efficiently support equation solving even without the addition of extra help.

Keywords: *Anxiety, Extra help, Mathematics, Performance, Worked example, Equation solving.*

DOI: 10.55284/ajel.v10i2.1603
Citation | JACMART, S., Dragone, L., Temperman, G., & Lièvre, B. D. (2025). The effect of worked examples and extra help on math anxiety and equation learning in French-speaking Belgium. *American Journal of Education and Learning, 10*(2), 226–248.

Funding: This study received no specific financial support.
Institutional Review Board Statement: The study involved minimal risk and followed ethical guidelines for social science fieldwork. Formal approval from an Institutional Review Board was not required under the policies of the University of Mons, Belgium. Informed verbal consent was obtained from all participants, and all data were anonymized to protect participant confidentiality
Transparency: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.
History: Received: 20 June 2025/ Revised: 4 September 2025/ Accepted: 24 September 2025/ Published: 10 October 2025
Publisher: Online Science Publishing

Highlights of this paper

- Worked examples significantly improved students' performance in solving equations in a French-speaking Belgian secondary school.
- No significant effect was found on mathematics anxiety, regardless of the presence or absence of extra support.
- Additional step-by-step support did not enhance performance or reduce anxiety and may have added unnecessary cognitive load, suggesting that worked examples alone are effective and more practical to implement in classrooms.

1. INTRODUCTION

Mathematics anxiety has long been a concern in global education (Luttenberger, Wimmer, & Paechter, 2018). According to Gunderson, Park, Maloney, Beilock, and Levine (2018), this phenomenon is a widespread problem affecting all age groups. International research findings, such as those from the Programme for International Student Assessment (PISA), support this finding, revealing that a considerable number of 15-year-olds experience anxiety about mathematics (Organisation for Economic Co-operation and Development, 2014a). Ten years later, the results of the 2022 PISA survey highlighted persistent and more significant anxiety than previously in French-speaking Belgium (Baye et al., 2023).

Furthermore, Beilock and Maloney (2015) add that mathematics anxiety cannot be ignored as it negatively impacts academic performance. Indeed, numerous studies have shown a negative relationship between mathematics anxiety and mathematical performance, meaning that higher anxiety is associated with lower achievement (Organisation for Economic Co-operation and Development, 2014b; Ramirez, Chang, Maloney, Levine, & Beilock, 2016).

Regarding student performance in French-speaking Belgium, results from the 2022 Secondary Education First-Degree Certificate (CE1D) reveal that only 48.9% of participating students passed the examination, highlighting rather poor outcomes (Wallonia-Brussels Federation, 2023a). Equations, in particular, stand out among the problematic topics. Indeed, out of the six items evaluating this skill, only one achieved a success rate exceeding 50%. This observation is particularly concerning, as it implies that more than half of the students lack proficiency in these essential mathematical competencies.

This literature review highlights two issues: mathematics anxiety and students' difficulties in solving equations.

To address this second issue, the literature suggests the strategy of worked examples. Indeed, results from previous research indicate that worked examples can positively impact student performance (Barbieri, Booth, Begolli, & McCann, 2021) and reduce anxiety levels (Algarni, Birrell, & Porter, 2012). However, Mesghina, Vollman, Trezise, and Richland (2024) did not observe a significant effect of worked examples on learners' mathematics anxiety levels.

In this context, the present research aims to explore the effectiveness of worked examples as a pedagogical strategy to enhance student performance in equation-solving tasks. It also aims to provide more information about the effect of this practice on mathematics anxiety.

In addition, we extend our field of investigation by providing learners with additional help that explains each step of the worked example. This extra help aims to assess whether these complementary explanations enhance the positive effect of the worked examples on student performance and whether they affect mathematics anxiety.

It is important to highlight that the strategy of worked examples is still underrepresented in the French-language literature and remains largely unknown to teachers (Barbieri et al., 2021). Thus, the aim of this research is also to share and promote this practice with those involved in French-language teaching.

2. THEORETICAL BACKGROUND

2.1. Math Anxiety

It is widely recognized in the literature that a significant number of students and adults experience mathematics anxiety (Luttenberger et al., 2018). Mathematics anxiety has been defined by Richardson and Suinn (1972) as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551). Results from the PISA surveys also highlight this issue. Indeed, reports from the 2012 study indicated that more than 50% of 15-year-old adolescents feel anxious when performing mathematics-related tasks (Organisation for Economic Co-operation and Development, 2014a). More recently, findings from the 2022 survey have highlighted persistent and even higher levels of anxiety compared to 2012 among students in French-speaking Belgium (Baye et al., 2023). However, 15-year-old adolescents are not the only ones affected by this substantial anxiety. Recent studies have shown that mathematics anxiety can begin as early as childhood (Harari, Vukovic, & Bailey, 2013; Ramirez, Gunderson, Levine, & Beilock, 2013). For instance, research conducted by Ramirez et al. (2013) indicates that mathematics anxiety may already manifest by the age of six.

2.1.1. Causes

In their article, Luttenberger et al. (2018) identified various factors contributing to mathematics anxiety. These can be personal or environmental. Personal factors relate directly to the individual, such as initial knowledge or gender, whereas environmental factors are educational or cultural values.

Regarding personal factors, it has been shown that girls are more anxious in mathematics than boys (Baye et al., 2023). This difference is attributed to girls internalizing negative stereotypes about their mathematical abilities, consequently increasing their anxiety (Justicia-Galiano, Martín-Puga, Linares, & Pelegrina, 2023). Moreover, Luttenberger et al. (2018) highlight that children with dyscalculia are more prone to developing substantial anxiety toward mathematics due to the learning difficulties associated with this disorder. Finally, a general predisposition toward anxiety can also explain math anxiety (Papousek et al., 2011).

Regarding environmental factors, Luttenberger et al. (2018) explain that children are often influenced by the attitudes toward mathematics displayed by individuals they perceive as models. For example, teachers who experience mathematics anxiety and openly express it in front of their students may inadvertently transfer this anxiety to their classroom (Lin, Durbin, & Rancer, 2016). Furthermore, an individual's cultural background may also influence anxiety levels. According to PISA studies, mathematics anxiety varies significantly between Asian and Western European countries (Lee, 2009; Organisation for Economic Co-operation and Development, 2014b). Wiseman and Zhao (2022) suggest this discrepancy could stem from higher parental expectations in Asian countries compared to Western European nations. Indeed, Huberty (2009) notes that high parental expectations regarding academic performance may lead to increased anxiety in children.

2.1.2. Impacts

The literature review conducted by Luttenberger et al. (2018) identified several impacts of mathematics anxiety, notably affecting students' mathematical performance, educational choices, and learning behaviors.

Firstly, numerous studies have demonstrated a negative correlation between mathematics anxiety and student performance in mathematics (Foley et al., 2017). In other words, higher levels of mathematics anxiety are associated with lower academic achievement in this discipline (Ashcraft & Krause, 2007). International findings from the PISA surveys further confirm this negative relationship (Organisation for Economic Co-operation and Development, 2014a).

One explanation for this negative correlation is that highly anxious students tend to avoid mathematics-related activities and situations, which limits their opportunities to develop skills and build confidence in the subject. Choe, Jenifer, Rozek, Berman, and Beilock (2019) provided experimental evidence that math-anxious learners tend to avoid cognitively demanding mathematical tasks, even when these tasks offer higher rewards. In their study, participants with high levels of math anxiety consistently chose easier, low-reward math problems over more challenging ones. This calculated avoidance reduces learners' engagement with challenging math tasks, which can slow down the development of their skills and negatively impact their long-term achievement.

One second explanation provided by Ashcraft and Kirk (2001) emphasizes the detrimental impact of mathematics anxiety on working memory. High levels of anxiety can lead to intrusive thoughts focused on performance, diverting attention away from the task, overloading working memory resources, and ultimately preventing learners from fully concentrating. Thus, the cognitive load imposed by anxiety explains the observed decline in mathematics performance.

Secondly, it has been shown that students experiencing mathematics anxiety often avoid selecting mathematics courses in secondary school and university. They also tend to avoid disciplines closely linked to mathematics, such as science, technology, and engineering (Ashcraft & Moore, 2009).

Finally, students with significant mathematics anxiety are likely to exhibit various negative learning behaviors. They tend to dedicate less effective time and effort to their math homework, often procrastinating, rushing through assignments, or leaving them incomplete (Song, Li, Quintero, & Wang, 2023). However, homework allows students to regularly review what they have learned and practice problem-solving at their own rhythm, which supports the consolidation and deeper integration of their learning. These negative behaviors, therefore, limit the benefits of homework and contribute to weaker academic performance in mathematics.

2.2. Learning of Equation Solving

Learning algebra is known to be difficult for learners (Demonty, 2013; Oliveira, Rhéaume, & Geerts, 2017). These difficulties are observed in particular when solving equations (Cortes & Kavafian, 1999; Jupri, Drijvers, & van den Heuvel-Panhuizen, 2014; Wallonia-Brussels Federation, 2023a).

In French-speaking Belgium, algebra instruction begins in the first year of secondary school and aims to solve and verify first-degree equations with one unknown (Wallonia-Brussels Federation, 2010). This skill is assessed at the end of the second year through the CE1D mathematics examination. The 2022 exam results highlighted poor performance in this particular skill area. Indeed, out of the six questions focused on solving equations, five had a success rate below 50% (Wallonia-Brussels Federation, 2023a). These results are concerning, as they imply that over half of the students lack proficiency in this essential competency. However, this skill is an essential prerequisite for the following year, when more advanced equations are introduced (Wallonia-Brussels Federation, 2023b).

To explain and understand these low performance levels, the literature examines the errors students make and the difficulties they encounter. Cortes and Kavafian (1999) authored an article classifying these errors. On the one hand, some errors may be conceptual, meaning students apply incorrect mathematical rules. On the other hand, errors can result from a lack of verification. This oversight often occurs when students solve equations hastily or omit intermediate steps. Besides these two interpretations, the authors categorized the identified errors into five distinct groups, presented in Table 1.

Table 1. Classification of errors made when solving equations (Cortes & Kavafian, 1999).

Categories	Sub-categories	Examples

Errors concerning the concept of equation and unknown		$-x = 5$ (Example 1)
Errors in identical algebraic transformations in both members of the equation	Errors in additive transformations	$5t - 50 = 125$ $5t - 50 + 50 = 125$ $5t = 125$ (Example 2) $-37 = 6v + 65$ $37 + 65 = 6v + 65 - 65$ (Example 3) $-37 = 6v + 65$ $37 + 65 = 6v$ (Example 4)
	Errors in multiplicative transformations	$11x + 30 = 14x$ $\frac{11x}{11} + 30 = 14x$ (Example 5) $-9y = 99$ $y = \frac{99}{9}$ (Example 6) $84y = -35$ $y = \frac{84}{-35}$ (Example 7)
Errors concerning the choice of priority operation	Errors relating to the priority of multiplication over addition and subtraction	$5t - 50 = 125$ $-45t = 125$ (Example 8)
	Errors concerning the priority of addition and subtraction over division	$-4z + z = -76$ $\frac{-4z}{4} + z = \frac{-76}{4}$ (Example 9)
Errors in writing a new equation: lack of control	Omission or incorrect entry of a term in the new equation	$-37 = 6v + 65$ $6v + 65 = -65$ (Example 10)
	Omission of a minus sign in the new equation	$\frac{-3x}{3} = \frac{86}{3}$ $x = \frac{86}{3}$ (Example 11)
	Arbitrary introduction of a minus sign in the new equation	-9y = 99 $y = \frac{-99}{-9}$ (Example 12)
Errors in numerical calculations	Errors concerning relative numbers	$-56 - 20 = -36$ (Example 13)
	Errors in mental calculations	$125 - 39 = 96$ (Example 14)

Firstly, concerning errors related to the concepts of equations and unknowns, the authors explain that many students stop solving when they obtain an equation in which the unknown is preceded by a minus sign. For example, they leave '-x = 5' and do not indicate the final expression 'x = -5' (example 1).

Among the errors related to algebraic transformations, the authors identified mistakes concerning both additive and multiplicative transformations. In the first case, students sometimes apply a transformation to only one side of the equation, as shown in Example 2. It is also common to observe cases where different transformations are applied to each side for instance, adding a term on one side while subtracting it on the other (Example 3). In addition to these two conceptual errors, it can happen that these transformations are not explicitly indicated and that the sign of the term placed in the other member is not modified, as shown in Example 4.

In the second case, it is not unusual for students to divide only one of the terms in the equation, as in example 5, or to make one transformation on one member and a different one on the other (example 6). A final error mentioned by these authors is illustrated by example 7. Learners may reverse the numerator and denominator at the end of the solution.

Another category of conceptual error relates to the choice of priority operation. These errors are due to a failure to respect the priority of multiplication over addition and subtraction. In concrete terms, these errors can be illustrated when, as in example 8, a student adds an algebraic expression and an independent term. The errors in the second sub-category are due to a failure to respect the priority of addition and subtraction over division. In example 9, two terms were first divided by 4 instead of '-4z + z'.

In addition, the next category refers to errors due to lack of control. When solving an equation, students may forget a term in the new step or write a term incorrectly (example 10). It is also not uncommon to see a negative sign added (example 12) or forgotten (example 11).

Finally, the last category of errors relating to the absence of control concerns the numerical calculations carried out during solving. Several subtypes may appear: errors concerning operations with integers (example 13) and those resulting from mental calculations (example 14).

In conclusion, there is a wide variety of errors that can be made by learners when solving equations. Even the most successful learners are not immune to making mistakes (Cortes & Kavafian, 1999). Indeed, it is not uncommon for them to make mistakes due to the lack of control. Pupils, regardless of their level, are therefore inclined to make mistakes easily, which could explain their results for this skill in CE1D mathematics. With the aim of reducing the occurrence of these errors and facilitating learning, our research focused on exploring pedagogical strategies to facilitate the teaching of equations. This review of the literature led to the strategy of worked examples.

2.3. Worked Examples

2.3.1. Principles and Rules

To facilitate the learning of algebra, the literature recommends that teachers implement this practice instead of directly offering learners a series of tasks to solve individually (Booth, Lange, Koedinger, & Newton, 2013; Booth, McGinn, Young, & Barbieri, 2015; Smith, Closser, Ottmar, & Chan, 2022). This strategy aims to submit a completed task to students, ask them to read it, and then present them with a similar task to solve (Booth, Oyer, et al., 2015; Rodiawati & Retnowati, 2019).

To make this strategy effective, Rodiawati and Retnowati (2019) explain certain principles to be observed when implementing it. The example worked must include clear, step-by-step explanations, highlight relevant information and avoid containing superfluous elements. Retnowati, Ayres, and Sweller (2017) also state that it is best to have students work individually on these tasks, as they have shown that collaboration can hinder learning.

2.3.2. Types of Worked Examples

One of the most frequently used approaches is to present the learner with a worked example and then ask them to explain it. However, this method can take different forms (Booth, McGinn, et al., 2015). For example, it is possible to gradually reduce the level of help provided from one example to the next as the learner progresses (Booth, Oyer, et al., 2015; Grobe, 2015). Thus, the examples worked are less and less developed. The first example is complete, and the next includes all the solution steps except one, which the student has to complete. The examples that follow contain fewer and fewer steps, and the learner is expected to complete them. This approach is supposed to facilitate the transition from worked examples to autonomous task solving. Furthermore, Grobe (2015) argues that, eventually, students should be able to solve exercises independently, which implies abandoning complete worked examples at some point in the learning process. According to her, one method of achieving this goal is to adopt this type of worked examples.

Another application of this strategy is to offer examples whose resolution is incorrect, either in addition to or instead of the correct examples (Booth, McGinn, et al., 2015). To be useful, these incorrect examples must illustrate a mistake frequently made by students. Booth, Oyer, et al. (2015) encourage teachers to incorporate this variant into their teaching because the use of incorrect examples facilitates understanding of concepts and correct application of procedures, thus reducing the likelihood of learners repeating this error later. However, these authors specify that it is essential for learners to have the necessary prior knowledge before offering them this type of task.

Finally, a last approach involves the simultaneous presentation of two examples in order to compare them (Booth, McGinn, et al., 2015). Several combinations are possible, but (Booth, McGinn, et al., 2015) considers the most effective approach to be comparing two different and correct solutions to the same problem in order to identify the most effective strategy.

According to them, this comparison is relevant from a pedagogical point of view because it allows students to have several methods for solving a problem and to choose the one that is most appropriate depending on the context.

2.3.3. Research Results Regarding Performance and Anxiety

Numerous studies have shown the positive effect of using worked examples on learners' performance compared to problem solving (Barbieri et al., 2021; Barbieri, Miller-Cotto, Clerjuste, & Chawla, 2023; Booth, Oyer, et al., 2015). These results can be explained by the fact that worked examples guide students directly to the appropriate procedures and therefore require a lower cognitive load than that required during problem solving (Booth, Oyer, et al., 2015). Moreover, when students solve a task on their own, they have to find the appropriate procedures to put in place to solve it, which can give rise to the emergence of ineffective or erroneous strategies and encourage their retention (Sweller, 1999, cited by Booth, McGinn, et al. (2015). Recently, Barbieri et al. (2021) introduced the worked examples strategy to teach equation solving. An experimental group was taught equations based on correct, incorrect, and incomplete worked examples. The control group, on the other hand, learned the equations through problem solving. The study revealed that the subjects in the experimental group made more progress than those in the control group.

A few studies have also been conducted to measure the effect of worked examples on anxiety in mathematics lessons. Firstly, Algarni et al. (2012) collected testimonies from learners who had used this strategy. They said that their anxiety had decreased. However, no questionnaire was administered to measure the anxiety of these students before and after the experiment. The simple testimony of the students is therefore not sufficient to affirm that worked examples reduce students' anxiety towards the mathematics course. More recently, Mesghina et al. (2024) conducted another study in the context of a pandemic to see whether using this strategy reduced students' anxiety in mathematics. It was found that there was no significant difference between the anxiety of the control group and that of the experimental group. However, the authors are convinced that mathematics anxiety was affected by the worked examples.

To summarize, the studies investigating the effect of worked examples on mathematics anxiety are still limited and lead to different conclusions. The first study relies solely on student testimonies to explain that worked examples helped to reduce their anxiety. The second, conducted in the specific context of a pandemic, revealed no significant difference between the anxiety of the experimental group and that of the control group. Researchers are nevertheless convinced that this strategy had an impact on anxiety. These results underline the need for further research. This is why our study aims to shed light on the relationship between worked examples and students' anxiety about mathematics.

3. METHODOLOGY

3.1. Sample

The research sample includes 47 pupils in the second year of secondary school in French-speaking Belgium, with an average age of 13. They come from the same school and follow the same mathematics course. This was a casual sample (Harmegnies & Huet, 2016). The students were chosen because the researcher was also their teacher. The selection criterion was therefore their availability. The experiment took place during scheduled class time, and the subjects were not informed of their participation in it, which helped to limit the appearance of a Hawthorne effect (Harmegnies & Huet, 2016).

These 47 participants were divided into two experimental groups: 21 participants had the opportunity to access additional support, while 26 did not. The teacher-researcher delivered the same pedagogical content to both groups, aiming to avoid potential biases linked to the facilitator effect (Harmegnies & Huet, 2016).

The experiment took place in their usual classroom and at the times scheduled in their timetable. In addition, the researcher was the students' regular teacher. This study was therefore conducted under real, authentic conditions, which gives it a high degree of ecological validity (Harmegnies & Huet, 2016).

3.2. Instructional Design

The instructional design was divided into two parts, spread over three 50-minute periods.

3.2.1. Skill

Solving first-degree equations with one unknown is a skill that was developed during this research (Wallonia-Brussels Federation, 2010).

3.2.2. Instructional Scenario

The first part of the experiment was to introduce the method for solving equations of the type $ax + b = cx + d$. To introduce the method, the students were given an example worked by ChatGPT, an artificial intelligence. They were asked to analyse this solution in order to deduce the different steps involved in solving an equation of this type. The students were initially asked to do this individually, and then to share their reasoning with the class. It should be noted that the learners had already studied equations last year and had worked on equations of the type $ax = b$, $a + x = b$, and $ax + b = c$. They had therefore benefited from this prior knowledge. Moreover, they were reminded of these concepts before the introduction of this new type.

After being introduced to the new content, the class was given an exercise session to practice the procedure. To do so, the worked example strategy using the fading procedure was employed. Several sets of exercises were provided to expose students to varying levels of difficulty they might encounter. Learners completed these exercises individually and consulted the teacher in case of misunderstanding.

One of the two experimental groups was given the opportunity to receive extra help if they so desired. In this way, each fully worked example was presented with a QR code that students could scan to obtain more detailed explanations from the Microsoft Math Solver application.

3.3. Experimental Procedure

3.3.1. Experimental Design

The aim of this research was to measure the effect of the presence or absence of extra help on pupils' performance and anxiety in mathematics. A design with pre- and post-experimental observations (O1 X O2) was therefore set up (Table 2). Participants were first given two pre-tests to measure their initial equation-solving skills and their level of anxiety about the maths lesson. Then, the experimental treatment consisting of presenting activities in the form of worked examples was applied. Finally, two post-tests similar to the pre-tests were administered to the learners after this treatment in order to measure the effect of the independent variable on their performance and anxiety.

Table 2. Experimental design.

VI	Experimental design		
Experimental groups			
	Pre-tests	**Learning sequence**	**Post-tests**
Extra help	O_1	X	O_2
No extra help			

3.3.2. Variables

In this study, the extra help serves as the independent variable. It was deliberately manipulated and includes two distinct levels: its presence or absence. Each experimental group was exposed to one level of this variable.

The independent variable was manipulated to assess its effects on two dependent variables. The first relates to student performance and refers to individual progress. The second concerns students' perceptions, specifically the evolution of their anxiety toward mathematics.

3.3.3. Instruments

- **Pre-tests**

As a first step, a test was administered to all participants before the experimental treatment in order to measure their prior knowledge of equation solving (Appendix 1). This test consisted of four items taken from previous CE1D mathematics examinations (Wallonia-Brussels Federation, 2023a), specifically requiring students to solve four equations of the form ax + b = cx + d. The tests were scored using an evaluation table (Appendix 2) to ensure objective scoring. This table was developed based on the correction guides published annually for the CE1D exams, which provide teachers with standardized marking criteria (Wallonia-Brussels Federation, 2023b).

The scores obtained by each participant were then compared to determine whether the groups were statistically equivalent in terms of their initial knowledge of the targeted skill.

Secondly, participants completed another test to assess their initial level of anxiety for the mathematics lesson. The Mathematics Anxiety Scale adapted for a secondary school audience (Mahmood & Khatoon, 2011), was used (see Appendix 5). This scale contains 14 items, 7 of which are positive and 7 negative. They are all assessed using a 5-point Likert scale ranging from 1 'strongly disagree' to 5 'strongly agree'. This instrument has a Cronbach's alpha of 0.87, indicating excellent internal reliability, i.e., the scale's ability to measure what it is intended to measure (Taber, 2018).

The maths anxiety score is obtained by inverting the positive items and adding up the individual scores for each item. The score can therefore be between 14 and 70, and the higher the number, the greater the students' anxiety about mathematics. The researchers established that an average of 42 corresponds to a moderate level of anxiety. A score above this indicates that the student is more anxious than average.

Each test begins with the same researcher reading out the instructions to both groups. The students are given the opportunity to ask questions if they do not understand anything. If necessary, the researcher can repeat the instructions.

- **Post-test**

Immediately after the experimental treatment, participants completed two additional tests designed to gather data similar to that of the pre-tests.

The first aimed to assess students' skills in solving equations. To this end, it included items similar to those in the pre-test but arranged in a different order (Appendix 3). These changes were made to prevent any contamination effect from the pre-test on the post-test (Harmegnies & Huet, 2016). Once again, grading was carried out using an evaluation rubric (Appendix 4).

The second post-test involved administering the same questionnaire developed by Mahmood and Khatoon (2011), with the only difference being the rearrangement of item order (see Appendix 6). Similar to the pre-tests, the researcher verbally states the instructions before the post-tests are administered to each group, giving learners the opportunity to ask questions if they are confused. If necessary, these instructions can be reiterated by the researcher.

Each learner's individual performance on the pre- and post-tests is then compared to assess their progress. The observed differences between pre- and post-test scores are calculated for each participant using the relative gain formula.

$$Relative\ gain = 100.\left(\frac{Post-Pre}{Max-Pre}\right) \qquad (1)$$

Equation 1: Relative gain (D'Hainaut, 1975).

However, if the post-test score is lower than the pre-test score, it is necessary to calculate a relative loss (D'Hainaut, 1975).

$$\boxed{Relative\ loss = 100 \cdot \left(\frac{Post-Pre}{Pre}\right)} \qquad (2)$$

Equation 2: Relative loss (D'Hainaut, 1975).

3.4. Research Questions

3.4.1. Research Questions Related to Student Progress in Mathematics

1) Does the pedagogical approach contribute to significant improvement in student performance?
2) Does students' progress differ based on the presence or absence of additional support?
3) Is there a correlation between students' initial level and their progress?

3.4.2. Research Questions Relating to Perception (Anxiety)

4) What is the overall impact of the instructional intervention on students' level of mathematics anxiety?
5) Does the level of student anxiety differ based on the presence or absence of additional support?

3.4.3. Questions Related to the Process (Number of Requests for Help)

6) Is there a correlation between the number of help requests and students' progress in mathematics?
7) Is there a correlation between the number of help requests and students' level of mathematics anxiety?

4. RESULTS

The data collected during the experiment are analyzed in this section to address the research questions. Data were collected anonymously by assigning a number to each participant, thereby preventing any personal identification. The results are first analyzed at the descriptive level and then at the inferential level using the JASP software. Table 3 presents the research questions along with the corresponding statistical tests used to answer them.

Table 3. Choice of statistical tests for each research question.

Statistical tests	Wilcoxon	Mann-Whitney	Spearman's rank correlation
Research questions	Q1 ; Q4	Q2 ; Q5	Q3 ; Q6 ; Q7

Before addressing the research questions, we first examined whether the data followed a normal distribution. We also verified whether the groups were statistically equivalent. Additionally, the reliability of the pre-test was assessed.

4.1. Data Distribution Analysis

The Shapiro-Wilk statistical test was conducted to determine whether the datasets used in the analysis followed a normal distribution. Since all p-values were below the threshold of 0.05, the null hypothesis stating that both groups' data follow a normal distribution was rejected. Therefore, non-parametric statistical tests were selected for the subsequent analysis of the experiment.

4.2. Statistical Comparison of Groups

As a reminder, the study involved 47 participants. Twenty-one had the opportunity to use additional help if they wished, while 26 did not have access to it. Before carrying out any comparisons, it is essential to verify whether the groups are statistically equivalent. Table 4 presents the descriptive statistics comparing the two groups' pre-test scores.

Table 4. Descriptive statistics: Group comparison.

Pre-test scores – Extra help group			Pre-test scores – No extra help group		
N	m (%)	σ	N	m (%)	σ
21	3.17	10.03	26	4.81	10.05

4.2.1. Descriptive Statistics

The two groups show fairly similar average results for the initial level of learners. This closeness between the mean percentage score (m%) and standard deviations (σ) suggests that the two groups are identical. This means that they have similar initial knowledge of equation solving.

Moreover, these very low averages are consistent with students' difficulties in solving equations, as identified in the literature (Jupri et al., 2014; Wallonia-Brussels Federation, 2023a). Learners' resolutions contain errors identified by Cortes and Kavafian (1999), such as the omission of a negative sign in the new equation.

4.2.2. Inferential Statistics

To verify that the groups are statistically equivalent and to generalize the results, the Mann-Whitney test for independent samples was applied.

Table 5. Inferential statistics: group comparison.

Mann-Whitney test for independent samples	W	p
Pre-test	241	0.303

Table 5 shows that the two groups are statistically equivalent. Indeed, there were no significant differences between them, as the p-value was greater than 0.05 (p=0.303).

4.3. Reliability of the Mathematics Pre-Test

The results of the pre-test are also used to measure its reliability. Therefore, a Cronbach's alpha coefficient was calculated using the formula below. k is the number of items, $\sigma^2{}_X$ is the variance of the total score and $\sigma^2{}_{Y_i}$ is the variance of item i (Cronbach, 1951).

$$\boxed{\alpha = \frac{k}{k-1} \cdot \left(1 - \frac{\sum_{i=1}^{k} \sigma^2{}_{Y_i}}{\sigma^2{}_X}\right)} \qquad (3)$$

Équation 3: Reliability analysis of the pre-test.

Table 6. Reliability analysis of the equation pre-test.

	k	$\sigma^2{}_X$	$\sum_{i=1}^{k} \sigma^2{}_{Y_i}$	α
Equations pre-test	4	1.43	0.38	0.97

Table 6 shows a Cronbach's alpha coefficient of 0.97 for the reliability analysis. According to Taber (2018), this value means that the reliability of the test is excellent. Therefore, we can state that this test represents a reliable assessment instrument, demonstrating its ability to consistently measure the equation-solving skills of the subjects in the sample.

4.4. Investigating Mathematics Progress Across the Entire Sample

Q1. Does the pedagogical approach contribute to significant improvement in student performance?

Table 7. Descriptive Statistics: progress in mathematics for the entire sample.

Pre-test score			Post-test score			Relative gains	
m (%)	**CV**	**N**	**m (%)**	**CV**	**N**	**m (%)**	**N**
4.08	244	47	71.63	41	47	71.07	47

4.4.1. Descriptive Statistics

Several observable elements in Table 7 seem to indicate that the program had a positive effect on participants' progress. First of all, the participants went from an average of 4.08% in the pre-test to an average of 71.63% in the post-test. Secondly, their average gain was 71.07%, far exceeding the minimum gain of 30% proposed by D'Hainaut (1975) for learning to be considered significant. Finally, the heterogeneity rate fell from 245% at pre-test to 41% at post-test, reflecting a significant reduction in the initial gaps between learners.

4.4.2. Inferential Statistics

In order to verify that the subjects' progress was statistically significant, a Wilcoxon paired-samples test was performed (Table 8). This test revealed a significant difference between the pre-test scores and the post-test scores for the sample as a whole ($p<.001$). Consequently, the instructional design had a significant effect on student progress.

Table 8. Inferential Statistics: progress in mathematics for the entire sample.

Wilcoxon signed-rank test for paired samples	W	p
Pre-test - Post-test	1035	< 0.001

4.5. Investigating Students' Progress in Mathematics According to the Independent Variable

Q2. Does students' progress differ based on the presence or absence of additional support?

Table 9. Descriptive statistics: Students' progress in mathematics according to the presence or absence of extra help.

« Extra help » group (N = 21)					« No help » Group (N = 26)				
Gains (%)	m (%)		CV		Gains (%)	m (%)		CV	
	Pre-test	Post-test	Pre-test	Post-test		Pre-test	Post-test	Pre-test	Post-test
73.01	3.17	73.41	316	32	69.49	4.81	70.19	209	48

4.5.1. Descriptive Statistics

Table 9 provides some information about the two experimental groups. Firstly, the group that received extra help obtained a mean score of 3.17% in the pre-test and a mean score of 73.41% in the post-test. Students who had the opportunity to use this extra help improved by an average of 73.01%. The other group obtained a starting average of 4.81% and an average of 70.19% for the post-test. On average, these subjects improved by 69.49%. These initial results show slight differences between the average post-test scores and the average relative gains of the two groups.

The table then provides further details on the heterogeneity rate. A decrease in the heterogeneity rate was observed in both groups, suggesting a reduction in the initial gaps. However, it should be noted that this reduction is more pronounced for the group that received the extra help.

At this stage, the advantage would be given to the group that benefited from the additional aid, although these variations are small.

4.5.2. Inferential Statistics

In order to generalize the results obtained from the descriptive analysis, the Mann-Whitney test was conducted on the relative gains between the pre-test and post-test in mathematics.

Table 10. Inferential statistics: Effect of extra help support on students' progress in mathematics.

Mann-Whitney test for independent samples	W	p
Relative gains: Pre-test - Post-test	254	0.698

Table 10 shows that there were no significant differences between the two groups in terms of their progress in the target skill. In conclusion, neither method (presence or absence of help) guarantees better progress than the other.

4.6. Correlation Between Students' Progress and Their Pre-Test Score on Equations

Q3. Is there a correlation between students' initial level and their progress?

4.6.1. Statistical Analyses

To answer this research question, a Spearman correlation coefficient was calculated between the relative gains and the scores obtained in the pre-test on the equations. Table 11 reports these results.

Table 11. Correlation between relative gains and students' initial level on the mathematics test.

Correlation	Spearman's rank correlation	p
Relative gains versus pre-test math	0.101	0.501

The values obtained indicate that there is no link between students' initial level and their progress.

4.7. Perception of the Entire Sample

Q4. What is the overall impact of the instructional intervention on students' level of mathematics anxiety?

4.7.1. Descriptive Statistics

Table 12 shows the progress of anxiety in the sample as a whole. These perceptions are collected at pre- and post-test, allowing a relative gain to be calculated.

Table 12. Descriptive Statistics: progression of students' math anxiety.

Pre-test score			Post-test score			Relative gains/loss	
m (/70)	**CV**	**N**	**m (/70)**	**CV**	**N**	**m(%)**	**N**
34.12	39.2	47	34.06	38.36	47	-0.31	47

The results show very little change in student anxiety. The mean score for the pre-test was 34.12, and the mean score for the post-test was 34.06, indicating a slight decrease. Anxiety, therefore, decreased between the two measurements, but the change was minor. We thus assume that there are no significant differences.

Table 13. Inferential statistics: progression of students' mathematics anxiety.

Wilcoxon paired samples	W	p
Pre-test anxiety - Post-test anxiety	428	0.979

4.7.2. Inferential Statistics

Table 13 presents the results of the Wilcoxon test for paired samples, which confirm that there are no significant differences between anxiety measured at pre-test and post-test. In other words, the teaching system has no significant effect on students' anxiety for the maths lesson.

4.8. Participants' Perception According to the Independent Variable

Q5. Does the level of student anxiety differ based on the presence or absence of additional support?

4.8.1. Descriptive Statistics

Table 14 shows the progression of maths anxiety in each group.

Table 14. Descriptive statistics: progression of students' mathematics anxiety based on whether support was provided or not.

« Extra help » group (N = 21)					« No help » group (N = 26)				
Relative gains/loss (%)	**m (/70)**		**CV**		**Relative gains/loss (%)**	**m (/70)**		**CV**	
	Pre-test	Post-test	Pre-test	Post-test		Pre-test	Post-test	Pre-test	Post-test
0.75	37.76	37.9	35.55	35	-1.17	31.19	30.96	41.18	39.7

According to the descriptive statistics presented in the table, the anxiety of the "no extra help" group decreased, while that of the other group increased. However, it is important to point out that these variations are very slight and therefore do not allow us to conclude with certainty that there is a significant difference between these two groups.

4.8.2. Inferential Statistics

A Mann-Whitney test for independent samples was used to compare learners' gains in anxiety in order to determine whether these were significantly different.

Table 15. Inferential Statistics: progression of math anxiety according to support received.

Wilcoxon signed-rank test for paired samples	W	p
Relative gains anxiety	302	0.542

Table 15 indicates that the observed differences are not statistically significant. Indeed, the p-value obtained (0.542) is greater than 0.05. Consequently, we can conclude that the presence or absence of help did not have a significant impact on students' anxiety levels.

4.9. Correlation Between the Number of Extra Help and Students' Progress

Q6. Is there a correlation between the number of help requests and students' progress in mathematics?

4.9.1. Statistical Analyses

To measure the strength of the link between the number of aids used and pupils' progress in mathematics, a Spearman's rank correlation was calculated. The values obtained are presented in Table 16.

Table 16. Correlation between relative gains and the number of help requests.

Correlation	Spearman's rank correlation	p
Relative gains vs. number of help requests	-0.309	0.173

The values shown in Table 16 indicate that there is no correlation between the number of aids requested by the pupils and their progress.

4.10. Correlation Between the Number of Extra Help and Students' Anxiety

Q7. Is there a correlation between the number of help requests and students' level of mathematics anxiety?

4.10.1. Statistical Analyses

To measure the strength of the correlation between the number of helps requested and the students' level of anxiety, a Spearman's rank correlation was conducted.

Table 17. Correlation between the number of help requests and students' initial level of mathematics anxiety.

Correlation	Spearman's rank correlation	p
Number of help requests vs. pre-test anxiety	0.068	0.768

The values shown in Table 17 suggest that there is no correlation between the number of extra helps requested by learners and their level of anxiety for the mathematics lesson. There is therefore no link between these two variables.

5. CONCLUSION AND DISCUSSION

This research aimed to evaluate the effect of worked examples and the addition of extra help on learners' mathematical anxiety and their performance in solving equations. This experiment was carried out in two classes in the second year of secondary school to learn equation solving. Twenty-one subjects were given the opportunity to use extra help if they wished, and twenty-six were not.

Firstly, the results of the mathematics pre-test revealed a very low initial mastery of the skill of solving equations. This initial finding is in line with the observations made by Cortes and Kavafian (1999), Wallonia-Brussels Federation (2023a), and Jupri et al. (2014), who highlight the difficulties students encounter in solving equations and the errors they frequently make.

Secondly, following the results obtained by Barbieri et al. (2021), a significant effect of worked examples on learners' performance was observed. Consequently, we can conclude that the introduction of worked examples contributes to the learning of equations.

However, no significant difference was found between the pre- and post-tests measuring anxiety, suggesting that this teaching method, although beneficial in improving learners' results in mathematics, does not influence anxiety related to this subject. This observation is in line with that of Mesghina et al. (2024), who found no significant effect of this strategy on students' anxiety towards the mathematics lesson.

Finally, the presence of additional help detailing each step of the worked example proposed to the students did not show significant differences between the two groups in terms of their performance and anxiety. These results suggest that the presence or absence of extra help does not significantly affect students' performance and anxiety in mathematics when the worked examples strategy is applied. One possible explanation is that the additional support may have introduced unnecessary cognitive load. Although the extra explanations were intended to clarify each step of the worked example, they may have overloaded students' working memory by presenting too much information at once. According to Cognitive Load Theory (Sweller, 1988), such additional explanations can distract learners from core concepts and interfere with the processing of relevant information in working memory. Rather than supporting learning, the extra guidance may have disrupted the efficiency of cognitive processing (Chandler & Sweller, 1991). It is therefore possible that some students chose to ignore the additional help, perceiving it as unnecessary or even burdensome. The effectiveness of the worked examples is therefore sufficiently strong not to require extra help. This simplifies the implementation of this approach for teachers.

6. LIMITATIONS AND PERSPECTIVES

One of the limitations of this research concerns the duration of the experiment. The subjects were exposed to the practice of worked examples during only three 50-minute sessions. It would be interesting to extend the period during which this teaching strategy was applied in order to determine whether the students' anxiety changed significantly under these conditions.

Secondly, the research population consisted of 47 subjects, all students in their second year of secondary school. To generalize the findings on anxiety, further studies could be conducted with a larger and more diverse sample. For example, research could be carried out with learners who have been identified as experiencing high math anxiety.

In addition, it would also be interesting to evaluate the effect of the practice of worked examples on students' long-term retention. This could be done by means of a delayed post-test, administered several weeks after the experiment, in order to determine whether the skills acquired thanks to the worked examples persist in the students or whether they tend to fade over time. Such an approach would provide valuable information about the long-term effectiveness of worked examples as a teaching strategy.

Finally, although quantitative surveys have not shown a significant effect on anxiety, Algarni et al. (2012) and Mesghina et al. (2024) defend the idea that students' anxiety towards mathematics is positively impacted when the worked examples strategy is used. To explore the insights of these researchers further, implementing a qualitative analysis could be beneficial. This approach would provide valuable data on students' perceptions, offering a deeper understanding of the effect of solved examples on students' anxiety about mathematics. Specifically, this method could include interviews with students and teachers involved in the experiment.

REFERENCES

Algarni, A., Birrell, C., & Porter, A. (2012). *Evaluating the use of worked examples and problem solving methods in teaching mathematics for ESL students at the tertiary level.* Paper presented at the Fifth Annual ASEARC Conference, Wollongong.

Ashcraft, M. H., & Kirk, E. P. (2001). The relationships among working memory, math anxiety, and performance. *Journal of Experimental Psychology: General*, *130*(2), 224–237. https://psycnet.apa.org/doi/10.1037/0096-3445.130.2.224

Ashcraft, M. H., & Krause, J. A. (2007). Working memory, math performance, and math anxiety. *Psychonomic Bulletin & Review*, *14*(2), 243–248. https://doi.org/10.3758/BF03194059

Ashcraft, M. H., & Moore, A. M. (2009). Mathematics anxiety and the affective drop in performance. *Journal of Psychoeducational Assessment*, *27*(3), 197-205. https://doi.org/10.1177/0734282908330580

Barbieri, C. A., Booth, J. L., Begolli, K. N., & McCann, N. (2021). The effect of worked examples on student learning and error anticipation in algebra. *Instructional Science*, *49*(4), 419-439. https://doi.org/10.1007/s11251-021-09545-6

Barbieri, C. A., Miller-Cotto, D., Clerjuste, S. N., & Chawla, K. (2023). A meta-analysis of the worked examples effect on mathematics performance. *Educational Psychology Review*, *35*(1), 11. https://doi.org/10.1007/s10648-023-09745-1

Baye, A., Bricteux, S., Crépin, F., Demonty, I., Hindryckx, G., Matoul, A., & Quittre, V. (2023). Performance of 15-year-olds in mathematics, science and reading at the end of the health crisis: Results of PISA 2022 in the Wallonia-Brussels Federation. *Les cahiers des Sciences de l'Éducation*, *46*, 1-105.

Beilock, S. L., & Maloney, E. A. (2015). Math anxiety: A factor in math achievement not to be ignored. *Policy Insights from the Behavioral and Brain Sciences*, *2*(1), 4-12. https://doi.org/10.1177/2372732215601438

Booth, J. L., Lange, K. E., Koedinger, K. R., & Newton, K. J. (2013). Using example problems to improve student learning in algebra: Differentiating between correct and incorrect examples. *Learning and Instruction*, *25*, 24-34. https://doi.org/10.1016/j.learninstruc.2012.11.002

Booth, J. L., McGinn, K. M., Young, L. K., & Barbieri, C. (2015). Simple practice doesn't always make perfect: Evidence from the worked example effect. *Policy Insights from the Behavioral and Brain Sciences*, *2*(1), 24-32. https://doi.org/10.1177/2372732215601691

Booth, J. L., Oyer, M. H., Paré-Blagoev, E. J., Elliot, A. J., Barbieri, C., Augustine, A., & Koedinger, K. R. (2015). Learning algebra by example in real-world classrooms. *Journal of Research on Educational Effectiveness*, *8*(4), 530-551. https://doi.org/10.1080/19345747.2015.1055636

Chandler, P., & Sweller, J. (1991). Cognitive load theory and the format of instruction. *Cognition and Instruction*, *8*(4), 293-332. https://doi.org/10.1207/s1532690xci0804_2

Choe, K. W., Jenifer, J. B., Rozek, C. S., Berman, M. G., & Beilock, S. L. (2019). Calculated avoidance: Math anxiety predicts math avoidance in effort-based decision-making. *Science Advances*, *5*(11), eaay1062. https://doi.org/10.1126/sciadv.aay1062

Cortes, A., & Kavafian, N. (1999). Principles that guide thought in solving equations. *Petit x*, (51), 47-73.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, *16*(3), 297-334. https://doi.org/10.1007/BF02310555

D'Hainaut, L. (1975). *From the ends to the objectives of education* (4th ed.). Bruxelles, Belgique: Labor-Nathan.

Demonty, I. (2013). Better understanding students' difficulties in elementary algebra: Perspectives on the non-certifying external assessment system in the Wallonia-Brussels Federation. *Education & Training, e-298-01*, 51-61.

Foley, A. E., Herts, J. B., Borgonovi, F., Guerriero, S., Levine, S. C., & Beilock, S. L. (2017). The math anxiety-performance link: A global phenomenon. *Current Directions in Psychological Science, 26*(1), 52-58. https://doi.org/10.1177/0963721416672463

Grobe, C. S. (2015). Fostering modeling competencies: Benefits of worked examples, problems to be solved, and fading procedures. *European Journal of Science and Mathematics Education, 3*(4), 364-375. https://doi.org/10.30935/scimath/9444

Gunderson, E. A., Park, D., Maloney, E. A., Beilock, S. L., & Levine, S. C. (2018). Reciprocal relations among motivational frameworks, math anxiety, and math achievement in early elementary school. *Journal of Cognition and Development, 19*(1), 21-46. https://doi.org/10.1080/15248372.2017.1421538

Harari, R. R., Vukovic, R. K., & Bailey, S. P. (2013). Mathematics anxiety in young children: An exploratory study. *The Journal of Experimental Education, 81*(4), 538-555. https://doi.org/10.1080/00220973.2012.727888

Harmegnies, B., & Huet, K. (2016). *Experimental methodology*. Mons, Belgium: University of Mons.

Huberty, T. J. (2009). Test and performance anxiety. *Principal Leadership, 10*(1), 12–16.

Jupri, A., Drijvers, P., & van den Heuvel-Panhuizen, M. (2014). Student difficulties in solving equations from an operational and a structural perspective. *International Electronic Journal of Mathematics Education, 9*(1), 39-55. https://doi.org/10.29333/iejme/280

Justicia-Galiano, M. J., Martín-Puga, M. E., Linares, R., & Pelegrina, S. (2023). Gender stereotypes about math anxiety: Ability and emotional components. *Learning and Individual Differences, 105*, 102316. https://doi.org/10.1016/j.lindif.2023.102316

Lee, J. (2009). Universals and specifics of math self-concept, math self-efficacy, and math anxiety across 41 PISA 2003 participating countries. *Learning and Individual Differences, 19*(3), 355-365. https://doi.org/10.1016/j.lindif.2008.10.009

Lin, Y., Durbin, J. M., & Rancer, A. S. (2016). Perceived instructor argumentativeness, verbal aggressiveness, and classroom communication climate in relation to student state motivation and math anxiety. *Communication Education, 66*(3), 330-349. https://doi.org/10.1080/03634523.2016.1245427

Luttenberger, S., Wimmer, S., & Paechter, M. (2018). Spotlight on math anxiety. *Psychology Research and Behavior Management, 11*, 311-322. https://doi.org/10.2147/PRBM.S141421

Mahmood, S., & Khatoon, T. (2011). Development and validation of the mathematics anxiety scale for secondary and senior secondary school students. *British Journal of Arts and Social Sciences, 2*(2), 169-179.

Mesghina, A., Vollman, E., Trezise, K., & Richland, L. E. (2024). Worked examples moderate the effect of math learning anxiety on children's math learning and engagement during the COVID-19 pandemic. *Journal of Educational Psychology, 116*(2), 173–194. https://doi.org/10.1037/edu0000795

Oliveira, I., Rhéaume, S., & Geerts, F. (2017). Learning Algebra: Procedures and difficulties encountered in problem solving. *Nouveaux Cahiers de la Recherche en Education, 20*(3), 156-180.

Organisation for Economic Co-operation and Development. (2014a). *Key findings from PISA 2012: What 15-year-olds know and what they can do with what they know*. France: OECD Publishing.

Organisation for Economic Co-operation and Development. (2014b). *PISA 2012 results: Students ready to learn (Volume III): Engagement, motivation, and self-image*. Paris, France: OECD Publishing.

Papousek, I., Ruggeri, K., Macher, D., Paechter, M., Heene, M., Weiss, E. M., . . . Freudenthaler, H. H. (2011). Psychometric evaluation and experimental validation of the statistics anxiety rating scale. *Journal of Personality Assessment, 94*(1), 82-91. https://doi.org/10.1080/00223891.2011.627959

Ramirez, G., Chang, H., Maloney, E. A., Levine, S. C., & Beilock, S. L. (2016). On the relationship between math anxiety and math achievement in early elementary school: The role of problem solving strategies. *Journal of Experimental Child Psychology, 141*, 83-100. https://doi.org/10.1016/j.jecp.2015.07.014

Ramirez, G., Gunderson, E. A., Levine, S. C., & Beilock, S. L. (2013). Math anxiety, working memory, and math achievement in early elementary school. *Journal of Cognition and Development, 14*(2), 187-202. https://doi.org/10.1080/15248372.2012.664593

Retnowati, E., Ayres, P., & Sweller, J. (2017). Can collaborative learning improve the effectiveness of worked examples in learning mathematics? *Journal of educational psychology, 109*(5), 666–679.

Richardson, F. C., & Suinn, R. M. (1972). The mathematics anxiety rating scale: Psychometric data. *Journal of Counseling Psychology, 19*(6), 551–554. https://doi.org/10.1037/h0033456

Rodiawati, A., & Retnowati, E. (2019). How to design worked examples for learning patterns in Mathematics. *Journal of Physics: Conference Series, 1320*, 012045. https://doi.org/10.1088/1742-6596/1320/1/012045

Smith, H., Closser, A. H., Ottmar, E., & Chan, J. Y. C. (2022). The impact of algebra worked example presentations on student learning. *Applied Cognitive Psychology, 36*(2), 363-377. https://doi.org/10.1002/acp.3925

Song, S., Li, T., Quintero, M., & Wang, Z. (2023). The link between math anxiety and math achievement: The role of afterschool learning. *Journal of Numerical Cognition, 9*(3), 418–432. https://doi.org/10.5964/jnc.11325

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science, 12*(2), 257–285. https://doi.org/10.1207/s15516709cog1202_4

Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education, 48*(6), 1273-1296. https://doi.org/10.1007/s11165-016-9602-2

Wallonia-Brussels Federation. (2010). *Skills bases: mathematical training*. Belgium: Wallonia-Brussels Federation.

Wallonia-Brussels Federation. (2023a). *CE1D mathematics 2023*. Brussels, Belgium: Wallonia-Brussels Federation.

Wallonia-Brussels Federation. (2023b). *Teacher's file and correction guide: CE1D mathematics 2023*. Brussels, Belgium: Wallonia-Brussels Federation.

Wiseman, A. W., & Zhao, X. (2022). Parents' expectations for the educational attainment of their children: A cross-national study using PIRLS 2011. *Prospects, 52*(1), 79-100. https://doi.org/10.1007/s11125-020-09460-7

APPENDIX.

Appendix 1. Equation pre-test.

SOLVE the following equations by writing out all your steps. Any fractional solutions must be written in irreducible form.

1 $9 + 3x = x + 7$	2 $2x - 28 = 12 - 6x$
3 $13 + 17x = 3x - 2$	4 $2x + 6 = 3x + 9$

Appendix 2. Pre-test scoring rubric.

Question 1	**Correct method and answer: $x = -1$ (3 pts)** • **Correct method but only one error in numerical calculation or absence of final answer (2 pts)** • **One error in method* but consistency elsewhere and presence of a final answer (1 pt)** • **The method is correct (with at least one correct application of a property of the equations) but not complete (1 pt).** ***An error of method: incorrect application of equations or rules of algebraic calculation.**	**0-1-2-3**
Question 2	Correct method and answer: $x = 5$ (3 pts) • Correct method but only one error in numerical calculation or absence of final answer (2 pts) • One error in method* but consistency elsewhere and presence of a final answer (1 pt) • The method is correct (with at least one correct application of a property of the equations) but not complete (1 pt). *An error of method: incorrect application of equations or rules of algebraic calculation.	**0-1-2-3**
Question 3	Correct method and answer: $x = -\frac{15}{14}$ (3 pts) • Correct method but only one error in numerical calculation or absence of final answer (2 pts) • One error in method* but consistency elsewhere and presence of a final answer (1 pt) • The method is correct (with at least one correct application of a property of the equations) but not complete (1 pt). *An error of method: incorrect application of equations or rules of algebraic calculation.	**0-1-2**
Question 4	Correct method and answer: $x = -3$ (3 pts) • Correct method but only one error in numerical calculation or absence of final answer (2 pts) • One error in method* but consistency elsewhere and presence of a final answer (1 pt) • The method is correct (with at least one correct application of a property of the equations) but not complete (1 pt). *An error of method: incorrect application of equations or rules of algebraic calculation.	**0-1-2**

Appendix 3. Equation post-test.

SOLVE the following equations should be solved by writing out all your steps. Any fractional solutions must be expressed in irreducible form.

1 $2x + 6 = 3x + 9$	2 $9 + 3x = x + 7$
3 $2x - 28 = 12 - 6x$	4 $13 + 17x = 3x - 2$

Appendix 4. Post-test scoring rubric.

Question 1	**Correct method and answer: $x = -3$ (3 pts)** • Correct method but only one error in numerical calculation or absence of final answer (2 pts) • One error in method* but consistency elsewhere and presence of a final answer (1 pt) • The method is correct (with at least one correct application of a property of the equations) but not complete (1 pt). *An error of method: incorrect application of equations or rules of algebraic calculation.	**0-1-2-3**
Question 2	Correct method and answer: $x = -1$ (3 pts) • Correct method but only one error in numerical calculation or absence of final answer (2 pts) • One error in method* but consistency elsewhere and presence of a final answer (1 pt) • The method is correct (with at least one correct application of a property of the equations) but not complete (1 pt). *An error of method: incorrect application of equations or rules of algebraic calculation.	**0-1-2-3**
Question 3	Correct method and answer: $x = 5$ (3 pts) • Correct method but only one error in numerical calculation or absence of final answer (2 pts) • One error in method* but consistency elsewhere and presence of a final answer (1 pt) • The method is correct (with at least one correct application of a property of the equations) but not complete (1 pt). *An error of method: incorrect application of equations or rules of algebraic calculation.	**0-1-2-3**
Question 4	Correct method and answer: $x = -\frac{15}{14}$ (3 pts) • Correct method but only one error in numerical calculation or absence of final answer (2 pts) • One error in method* but consistency elsewhere and presence of a final answer (1 pt) • The method is correct (with at least one correct application of a property of the equations) but not complete (1 pt). *An error of method: incorrect application of equations or rules of algebraic calculation.	**0-1-2-3**

Appendix 5. Anxiety pre-test.

Number :

Age : Gender :

This questionnaire focuses specifically on learning mathematics.
Please indicate the extent to which you agree with each statement by selecting the answer that best reflects your opinion.
There are **no right or wrong answers** — simply respond based on your own thoughts and feelings.
Your answers will remain **entirely confidential**, and **no judgment will be made**.
Thank you for answering as honestly as possible.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
	1	2	3	4	5
I feel happy and excited in a math class as compared to any other class.	○	○	○	○	○
Math is most dreaded subject for me.	○	○	○	○	○
Math makes me feel comfortable and easy.	○	○	○	○	○
My mind goes blank when teacher asks math questions.	○	○	○	○	○
Math is one of my favorite subjects.	○	○	○	○	○
I would prefer math as one of my subjects in higher studies.	○	○	○	○	○
Solving math problems is always pleasant for me.	○	○	○	○	○
Math doesn't scare me at all.	○	○	○	○	○
I feel worried before entering the math class.	○	○	○	○	○
I am afraid to ask questions in math class.	○	○	○	○	○
Math is a headache for me.	○	○	○	○	○
I am always afraid of math exams.	○	○	○	○	○
I feel nervous when I am about to do math homework.	○	○	○	○	○
I find math interesting.	○	○	○	○	○

Appendix 6. Anxiety post-test.

Number :

Age : Gender :

This questionnaire focuses specifically on learning mathematics.

Please indicate the extent to which you agree with each statement by selecting the answer that best reflects your opinion.

There are **no right or wrong answers** — simply respond based on your own thoughts and feelings.

Your answers will remain **entirely confidential**, and **no judgment will be made**.

Thank you for answering as honestly as possible.

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
	1	**2**	**3**	**4**	**5**
Math makes me feel comfortable and easy.	○	○	○	○	○
Math is most dreaded subject for me.	○	○	○	○	○
I feel worried before entering the math class.	○	○	○	○	○
I find math interesting.	○	○	○	○	○
Math is one of my favorite subjects.	○	○	○	○	○
I am always afraid of math exams.	○	○	○	○	○
Solving math problems is always pleasant for me.	○	○	○	○	○
I feel nervous when I am about to do math homework.	○	○	○	○	○
I feel happy and excited in a math class as compared to any other class.	○	○	○	○	○
I would prefer math as one of my subjects in higher studies.	○	○	○	○	○
Math is a headache for me.	○	○	○	○	○
I am afraid to ask questions in math class.	○	○	○	○	○
Math doesn't scare me at all.	○	○	○	○	○
My mind goes blank when the teacher asks math questions.	○	○	○	○	○