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# Mathematical mindset shift: reducing math anxiety and enhancing attitudes in secondary school students through growth mindset intervention

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**ABSTRACT**

This study examines the effectiveness of a growth mindset intervention (GMI) in improving mathematical mindset, reducing math anxiety, and enhancing attitudes toward mathematics among secondary school students. A true-experimental design was employed, involving 69 Form Two students from secondary schools in Kedah, Malaysia. Participants were randomly assigned to a treatment group (n=35) or a control group (n=34). Data were analyzed using multivariate analysis of covariance (MANCOVA). The results revealed significant differences in math anxiety (p=0.000) and attitudes toward math (p=0.000) between the treatment and control groups after controlling for covariates (math scores and gender). However, no significant difference was observed in mathematical mindset between groups (p=0.292). Within the treatment group, significant improvements were noted in mathematical mindset (p=0.001), math anxiety (p=0.000), and attitudes toward math (p=0.000), while the control group showed no significant changes across these variables. Students in the treatment group experienced reduced math anxiety and improved attitudes toward math following the intervention. These findings suggest that GMI is an effective strategy for mitigating math anxiety and fostering positive attitudes toward mathematics, providing valuable insights for educators seeking to improve students' learning experiences and outcomes.



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## 1. INTRODUCTION

Mathematics plays a central role in science, technology, engineering, and mathematics (STEM) education because it develops essential abilities such as logical reasoning, analytical thinking, and problem-solving across various fields of study [1]. It also contributes significantly to students' academic development and future career opportunities; particularly as modern workplaces increasingly require strong quantitative and analytical capabilities [2]. Beyond its relevance to employment, mathematics supports the development of higher-order cognitive skills that enable individuals to make informed decisions and address real-life challenges effectively [3]. Owing to its broad importance, mathematics remains a compulsory subject at both primary and secondary levels of education in many countries.

However, despite its importance, mathematics is frequently viewed by students as complex and intimidating, often resulting in low achievement, avoidance behaviors, and reduced interest in learning [4], [5]. These difficulties are commonly linked to limited conceptual understanding, low self-confidence, and external expectations related to academic success [6], [7]. Such conditions may lead to negative emotional responses, particularly mathematics anxiety, which can significantly restrict students' participation and performance [8]. This issue is not limited to a single context but is observed globally, including in Malaysia, where enrollment in Science streams at the secondary level decreased from 48% in 2012 to 44% in 2018. Similarly, only 37% of tertiary students pursued mathematics- and science-related programs compared with 63% in arts and humanities [9], [10]. These trends indicate the urgent need to address both intellectual and emotional barriers that influence students' engagement with mathematics.

Traditional educational interventions have primarily focused on strengthening students' mathematical knowledge and technical skills, with less emphasis placed on psychological factors such as beliefs, attitudes, and perceptions toward learning mathematics [11]. One psychological approach that has gained attention is the growth mindset intervention (GMI), which promotes the belief that mathematical ability can be developed through effort and persistence rather than being fixed [12], [13]. Although research has demonstrated the general benefits of growth mindset in education, empirical evidence examining its simultaneous impact on mindset, anxiety, and attitudes within secondary mathematics education remains limited [14]. Therefore, this study examines the effectiveness of a GMI in enhancing students' attitudes toward mathematics, reducing mathematics anxiety, and strengthening mathematical mindset. By doing so, the study provides further empirical evidence regarding the effectiveness of psychologically based interventions in improving students' learning experiences.

Research has increasingly explored how individuals' beliefs about ability influence their reactions to academic challenges [15]. Students who adopt a fixed mindset tend to view their mathematical ability as predetermined and unchangeable [16]. Consequently, they often avoid difficult tasks, experience fear of failure, and demonstrate limited strategies for coping with challenges [17]. Such beliefs may contribute to lower academic performance and defensive learning behaviors, as success is often perceived solely in terms of obtaining correct answers rather than engaging in the learning process.

In contrast, students who adopt a growth mindset believe that their abilities can improve through effort, practice, and persistence. These students are generally more willing to accept challenging tasks and perceive difficulties as opportunities to develop their skills [18]. When growth mindset principles are encouraged in educational and home environments, students typically show higher motivation and greater perseverance in learning activities [3]. They also become more receptive to feedback and view mistakes as part of the learning process rather than as indicators of failure [19]. Understanding the influence of mindset on learning therefore plays an important role in shaping students' academic experiences. Encouraging students to embrace challenges and learn from errors can strengthen self-confidence and promote meaningful learning [20]. Hence, educating students about the differences between growth and fixed mindsets and their consequences is essential for fostering positive learning behaviors.

Mathematics anxiety refers to feelings of tension or apprehension that interfere with an individual's ability to perform mathematical tasks effectively. Students experiencing mathematics anxiety often demonstrate low confidence in their abilities and encounter difficulties when solving mathematical problems. International evidence indicates that approximately 30% of students across 65 countries report high levels of mathematics anxiety [21]. Studies conducted in Malaysia similarly reveal that students experience moderate levels of mathematics anxiety, which may worsen without appropriate intervention [22], [23]. Research further suggests that mathematics anxiety affects individuals across different age groups and negatively influences both academic achievement and psychological well-being [24]. If not addressed, persistent anxiety may lead to long-term negative attitudes toward mathematics, highlighting the importance of early intervention.

Previous studies have consistently shown that increased levels of mathematics anxiety are associated with reduced motivation, lower enjoyment, and poorer academic performance [25], [26]. Concerns regarding mathematics performance among Malaysian students have also been highlighted by the Ministry of Education Malaysia in its efforts to improve national education outcomes. Evidence from the Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA) indicates a decline in students' mathematics achievement over time. In the PISA 2022 assessment, Malaysian students scored 409 in mathematics, representing a decrease from 440 in 2018. Similar declines were observed in reading and science performance. These findings highlight the need for effective strategies to address both emotional and academic challenges in mathematics learning.

Attitude refers to an individual's learned tendency to respond positively or negatively toward a particular subject, influencing thoughts, feelings, and behaviors. In mathematics education, students' attitudes may shape their level of interest, willingness to engage in learning activities, perceptions of their own ability, and views regarding the importance of mathematics [27]. Previous research has identified several key elements of attitudes toward mathematics, including motivation, enjoyment, self-confidence, and perceived value [28]. Similar findings have been reported in studies involving students from different educational contexts, which identified emotional disposition, perceptions of mathematics, and perceived competence as key components influencing students' attitudes [29]. Research conducted by TIMSS further emphasized students' enjoyment, perceived value, and confidence as important indicators of their attitudes toward mathematics [30]. Despite differences in terminology, most studies describe attitudes toward mathematics through three common dimensions: liking mathematics, valuing mathematics, and confidence in mathematical ability.

Students' attitudes toward mathematics are not fixed and may change over time [31]. Positive attitudes have been shown to enhance students' engagement and learning outcomes, whereas negative attitudes may hinder academic performance. Empirical evidence suggests that students who demonstrate positive attitudes toward mathematics are more likely to participate actively in learning activities, perceive the subject as valuable, and achieve higher academic performance [32]. These findings are further supported by research indicating that cognitive and emotional factors jointly influence success in mathematics [33]. Therefore, students' attitudes represent an important factor that should be considered when developing effective educational strategies.

This study focuses on addressing the challenges experienced by secondary school students in mathematics learning, particularly mathematics anxiety and negative attitudes toward the subject. Many students struggle with fear and low confidence in mathematics, often influenced by fixed beliefs about their abilities, which limit their engagement and performance. Through the implementation of a GMI, this study investigates whether encouraging adaptive beliefs about learning can reduce mathematics anxiety, enhance students' attitudes toward mathematics, and strengthen their mathematical mindset. The study examines three research questions:

- Does participation in a seven-week GMI reduce mathematics anxiety among Malaysian secondary school students compared to those receiving conventional instruction?
- Does the intervention improve students' attitudes toward mathematics, including enjoyment, motivation, self-confidence, and perceived value?
- Does participation in the intervention promote a stronger growth mindset regarding mathematical ability?

The findings are expected to provide insights for educators regarding the role of psychological factors in mathematics learning and support the integration of growth mindset approaches into teaching practices and curriculum development.

## 2. METHOD

### 2.1. Research design

The study employed a true-experimental design involving 69 secondary school students from two schools in Malaysia. Participants were randomly assigned to either a treatment group (35 students) or a control group (34 students). A primary limitation of this study is the relatively small sample size (N=69). While sufficient for an initial exploratory investigation, quantitative research methods often recommend larger sample sizes, with benchmarks frequently cited at over 100 participants, to ensure greater statistical power and more robust generalization of results. A sample size of 69 may lack the power necessary to reliably detect small to moderate effect sizes for the GMI, particularly when using a multivariate analysis like multivariate analysis of covariance (MANCOVA) with multiple variables, thus increasing the potential risk of a Type II error where the true effect is missed [34]. Furthermore, the limited sample size, drawn from only two schools, restricts the representativeness of the sample and consequently limits the generalizability of the findings to the broader, diverse population of Malaysian secondary students, meaning the results should be interpreted with caution regarding their wider applicability.

The treatment group underwent a seven-week GMI designed to shift their perceptions of mathematics from fixed to growth-oriented, reduce anxiety, and foster positive attitudes. The intervention included structured lessons based on established theories of mindset and cognitive restructuring, while the control group continued with their regular mathematics curriculum. Pre- and post-tests were conducted using questionnaires to measure changes in mathematical mindset, math anxiety, and attitudes toward mathematics. All participants were Form Two students (14 years old) involved in enrichment maths classes in their respective schools. Prior to random assignment, students across three eligible Form Two classes were screened for eligibility based on several criteria: participants had to be 14 years old, exhibit low to moderate levels of pre-existing maths anxiety (to allow potential for change), and provide signed consent forms indicating their voluntary participation.

### 2.2. Instruments

The questionnaire of growth mindset, maths anxiety and attitude towards maths were translated into Malay by two translators and were then back translated by two other translators, which ensured that the meanings of the Malay version are in line with the English version. All scaled were scored so that higher scores represented higher levels of the variable. In order to make sure the validity and reliability of the instrument, content validity was conducted. The experts need to examine items that will be used either suitable or consistent with the aim of the study. The expert reviewed each questionnaire item to show whether it measures the content area [35]. Face validity also was conducted to ensure the validity. The existing questionnaire is in English and was translated into Malay by two language teachers educated in both English and Bahasa Malaysia. Back-to-back translations were conducted by another two language teachers involved in the initial translation phase [36]. The questionnaire underwent a pilot test study on the same population from an external setting. A total of 35 respondents of Form Two were randomly selected from the nearest secondary school. The Cronbach's alpha of each questionnaire was 0.80 and above.

#### 2.2.1. Growth mindset

The study utilized the Implicit Theory of Intelligence Scale to evaluate students' implicit beliefs in mathematics learning. The Revised Implicit Theories of Intelligence Scale, as modified by Castella and Byrne [37] from Dweck's [38] original version, served as the basis. This revised version specifically gauges students' beliefs regarding their capacity to shape their own intelligence. Moreover, the items from Dweck *et al.* [39] instrument were adapted to align with the context of mathematics. Comprising eight questions, the instrument measures an individual's growth mindset (4 items) and fixed mindset (4 items) using a five-point Likert scale. The reliability of this measure ranged from .87 to .90.

#### 2.2.2. Maths anxiety

The mathematics anxiety scale (MAS) with 21-items are bidimensional with two subcategories which are learning mathematics anxiety (LMA) and perception of difficulty and motivation (PDM). Both LMA and PDM were derived by considering items that measure the relevant constructs [40]. Responses were made on a five-point Likert-type scale. The reliability for this measure was 0.90.

#### 2.2.3. Attitude towards maths

The Short Form of the attitudes toward mathematics inventory (ATMI) was developed by Lim and Chapman [41], as a revision of the original 40-item ATMI created by Tapia and Marsh [42]. This refined version comprises 19 items, categorized into four subscales which are enjoyment (5 items), motivation (4 items), self-confidence (5 items), and value (5 items). The items are constructed using a five-point Likert scale, requiring students to respond accordingly. The reliability of this measure is reported to be 0.93, indicating a high level of consistency [43].

### 2.3. Module intervention

This module was derived from a preceding module on the growth mindset in mathematics created by Joe Boaler, known as thecubed.org. The collaboration of contents between Stanford's Project for Education Research That Scales (PERTS) research center (2016), were embedded in the module [44]. The primary objective of the intervention is to transform research findings into practical solutions for educators to implement in their classrooms. Additionally, reference was made to previous theories related to growth mindset and cognitive restructuring. Students in the treatment group underwent instruction in growth mindset through seven lessons, without detracting from their regular mathematics instruction time. To ensure scalability, our intervention was developed by revising past GMI to align with the perspectives, concerns, and reading levels of Form Two students from government secondary school in Malaysia. This process involved pilot test and small group testing to make sure the instruction was understandable.

### 2.4. Procedure of data collection

Some ethical aspects such as anonymity and confidentiality were considered in this study. The questionnaire is anonymous as students are not required to identify by name. Questionnaire data are aggregated, and as a result, no individual of students could be identified. The consent forms were given to the students who participated in the study. Only the students who agreed to participate could join the intervention.

The researcher administered the pretest and posttest during the students' advisory period. In contrast to the comparison group, students in the treatment group received the GMI during their usual advisory period. The study was carried out in three separate phases but interconnected for seven weeks were described as: pre-test, intervention, and post-test.

- Pre-test: one week before the intervention, administer a pre-test questionnaire to all s to collect baseline data on their attitudes towards math, mathematical mindset, and math anxiety. The researcher will ensure s complete the questionnaire individually using paper and pencil.
- Intervention: the GMI was implemented over a period of seven weeks, consisting of seven sessions lasting for 60 minutes for treatment group.

– Post-test: a week after the intervention, administer a post-test questionnaire to all respondents to assess changes in their attitudes towards math, mathematical mindset, and math anxiety. Respondents need to complete the questionnaire individually using paper and pencil. The summary of data collection is shown in Table 1.

Table 1. Summary of data collection procedure

| Week | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
|---|---|---|---|---|---|---|---|---|---|
| Topic | | Topic 1 | Topic 2 | Topic 3 | Topic 4 | Topic 5 | Topic 6 | Topic 7 | |
| | Pre-test | | | | | | | | Post-test |
| Treatment | | | | | GMI | | | | |
| Control | | | | | Existing module | | | | |

## 2.5. Data analysis

The process of analysing statistical data involves two types of statistics which are descriptive statistics analysis that refers to the description of an event by presenting the study data in the form of a simple measurement technique and inferential type statistics which in the form of summarisation towards research population (descriptive and inferential). Descriptive statistics that were used in this study involves the mean and standard deviation while inferential testing involves MANCOVA analysis. MANCOVA was used because the researcher intended to control the covariate variables (gender and maths's scored) that would affect the result of pre-test and post-test. To perform this analysis, The statistical package for the social sciences (SPSS) software version 26.0 is used. To ensure there was no bias between the treatment and control groups, a homogeneity test was conducted between groups by comparing the pre-test result using MANCOVA. The result shows no significant difference between control and treatment groups at a baseline.

# 3. RESULTS

## 3.1. Demographic of respondents

The intervention involved an initial 35 students in the treatment group and 34 students in the control group. All participants initially met the study's inclusion criteria. At the conclusion of the intervention, 34 students from the treatment group and 31 students from the control group successfully completed all modules and post-intervention assessments. Prior to statistical analysis, data cleaning and screening procedures were conducted. Two respondents were subsequently removed due to extreme outlier values in their questionnaire responses, which could significantly skew data distribution. The final dataset for analysis comprised 69 respondents.

As shown in Table 2, the treatment group comprised 25 females (71.4%) and 10 males (28.6%), while the control group consisted of 19 females (55.9%) and 15 males (44.1%). Regarding mathematics grades, most participants in both the treatment (51.4%) and control (67.6%) groups fell within the 0-39 range. This demographic overview indicates a relatively low baseline academic performance level among the student cohort, suggesting a general need for interventions aimed at improvement.

Table 2. Respondents' profile

| Group | | Profile | Frequency | Percentage |
|---|---|---|---|---|
| Treatment | Gender | Male | 10 | 28.6 |
| | | Female | 25 | 71.4 |
| | | Total | 35 | 100 |
| | Grade | 100-80 | 2 | 5.8 |
| | | 79-60 | 5 | 14.7 |
| | | 59-40 | 9 | 28.5 |
| | | 39-0 | 18 | 51.4 |
| | | Total | 35 | 100 |
| Control | Gender | Male | 15 | 44.1 |
| | | Female | 19 | 55.9 |
| | | Total | 34 | 100 |
| | Grade | 100-80 | 0 | 0 |
| | | 79-60 | 4 | 14.7 |
| | | 59-40 | 5 | 17.7 |
| | | 39-0 | 23 | 67.6 |
| | | Total | 34 | 100 |

### 3.2. The differences between control and treatment groups before the intervention

To assess for pre-existing differences in mathematical mindset, math anxiety, and attitude toward math between the control and treatment groups, a one-way MANCOVA was conducted using pre-test scores, with gender and initial math grades as covariates. Prior to the MANCOVA, Box's M test was performed to check the assumption of homogeneity of variance-covariance matrices. Table 3 shows that the Box's M test was not statistically significant (M=4.472, p=0.642>0.05). This result confirms the homogeneity of variance-covariance matrices among the dependent variables across the independent variable levels, thus satisfying an assumption for conducting the one-way MANCOVA. Therefore, one-way MANCOVA tests can be performed to see the difference in student's mathematical mindset, maths anxiety and attitude towards maths between pre-test scores. As shown in Table 4, the Wilks' Lambda value (λ=0.979), F(3, 69)=0.446, p=0.721 (p>0.05) indicates no statistically significant differences in the combined dependent variables (mathematical mindset, math anxiety, and attitude toward math) between the treatment and control groups at baseline. This suggests that the groups were comparable before the intervention commenced.

Table 3. Box' M test of pre-test score for mathematical mindset, maths anxiety, and attitude towards maths between treatment and control group

| Box's M | F-value | df1 | df2 | Sig. |
|---|---|---|---|---|
| 4.472 | 0.709 | 6 | 32446.584 | 0.642 |

Table 4. Wilks' lambda value for mathematical mindset, maths anxiety, and attitude towards maths

| Effect | Wilks' Lambda Value | F Value | DF between groups | DF in group | Sig |
|---|---|---|---|---|---|
| Group | 0.979 | 0.446 | 3 | 69 | 0.721 |

### 3.3. The differences between pre-test and post-test of the control and treatment groups

Analysis was conducted to find the significant difference within the groups (pre-test and post-test) of mathematical mindset, maths anxiety and attitude towards maths for treatment and control groups. However, the final sample after the intervention reduce from 69 to 65 students. Table 5 shows the result of each variable for the treatment and control groups.

The one-way MANCOVA results reveal statistically significant improvements from pre-test to post-test for the treatment group across all three variables: mathematical mindset (F(1,59)=12.587, p=0.001), math anxiety (F(1,59)=18.014, p<0.001), and attitude toward math (F(1,59)=20.534, p<0.001). Conversely, the control group showed no statistically significant differences between pre-test and post-test for any of the variables (p>0.05 for all). These findings indicate that participation in the intervention significantly improved the treatment group's mathematical mindset, reduced their math anxiety, and enhanced their attitudes towards learning mathematics.

Table 6 shows the descriptive analysis of each variable for the treatment and control group after controlling the mean score of the gender and students' math grade. For the treatment group, mean scores for mathematical mindset and attitude toward math increased from pre-test to post-test, while the mean score for math anxiety showed a notable decrease. This observed decline in math anxiety suggests a reduction in the average level of anxiety experienced by students following the intervention.

Table 5. One-way MANCOVA of mathematical mindset, maths anxiety, and attitude towards maths within groups (pre and post-test)

| t | Variables | Type III sum of squares | df | Mean square | F | Sig. |
|---|---|---|---|---|---|---|
| Treatment | Mathematical mindset | 3.359 | 1 | 3.359 | 12.587 | 0.001 |
| | Maths anxiety | 4.200 | 1 | 4.200 | 18.014 | 0.000 |
| | Attitude towards maths | 2.407 | 1 | 2.407 | 20.534 | 0.000 |
| Control | Mathematical mindset | 0.157 | 1 | 0.157 | 0.627 | 0.344 |
| | Maths anxiety | 0.210 | 1 | 0.210 | 0.796 | 0.111 |
| | Attitude towards maths | 0.064 | 1 | 0.064 | 0.474 | 0.494 |

### 3.4. The differences between control and treatment groups after the intervention

Table 7 shows the Wilk's λ value for mathematical mindset, maths anxiety, and attitude towards maths. There was a statistically significant difference in mathematical mindset, maths anxiety, and attitude towards maths based on a treatment and control groups, F (3, 59)=2.935, p<.041; Wilk's λ =0.870. This result demonstrated that the intervention gives an impact to the students. Table 8 presents the post-test of one-way MANCOVA results.

Table 6. Descriptive analysis between pre and post-test of the control and treatment groups

| Variables | Group | | Mean | SD | Total |
|---|---|---|---|---|---|
| Maths anxiety | Treatment | Pre-test | 3.13 | 0.444 | 35 |
| | | Post-test | 2.62 | 0.514 | 34 |
| | Control | Total | 2.89 | 0.540 | 69 |
| | | Pre-test | 3.16 | 0.276 | 34 |
| Attitude towards maths | Treatment | Post-test | 3.00 | 0.392 | 31 |
| | | Total | 3.08 | 0.343 | 65 |
| | | Pre-test | 3.18 | 0.0316 | 35 |
| | | Post-test | 3.56 | 0.366 | 34 |
| | | Total | 3.37 | 0.389 | 69 |
| | | Pre-test | 3.20 | 0.272 | 34 |
| | | Post-test | 3.27 | 0.449 | 31 |
| | | Total | 3.24 | 0.366 | 65 |

Note: the pre-test number of students 69 reduce to 65 for the post-test

Table 7. Wilks' lambda value for mathematical mindset, maths anxiety, and attitude towards maths

| Effect | Wilks' Lambda value | F Value | DF between groups | DF in group | Sig |
|---|---|---|---|---|---|
| Group | 0.870 | 2.935 | 3 | 59 | 0.041 |

Table 8. One-way MANCOVA of mathematical mindset, maths anxiety, and attitude towards maths between treatment and control group

| Dependent variable | Type III sum of squares | df | Mean square | F | Sig. |
|---|---|---|---|---|---|
| Mathematical mindset | .338 | 1 | 0.338 | 1.13 | 0.292 |
| Maths anxiety | 1.744 | 1 | 1.744 | 6.51 | 0.013 |
| Attitude towards maths | 1.315 | 1 | 1.315 | 7.72 | 0.007 |

The one-way MANCOVA results for post-test scores revealed no statistically significant difference between the treatment and control groups for mathematical mindset ($F(1, 59)=1.13$, $p=0.292$). However, significant differences were observed for math anxiety ($F(1, 59)=6.51$, $p=0.013$) and attitude toward math ($F(1, 59)=7.72$, $p=0.007$). These findings indicate that the GMI significantly reduced math anxiety and improved students' attitudes toward mathematics in the treatment group compared to the control group. Although there was no statistically significant between-group difference in mathematical mindset at post-test, the within-group analysis showed meaningful improvement in mathematical mindset within the treatment group from pre-test to post-test. Overall, these results demonstrate that GMI effectively addresses emotional and attitudinal barriers to math learning.

## 4. DISCUSSION

This study examined the effectiveness of a GMI in enhancing mathematical mindset, reducing mathematics anxiety, and improving attitudes toward mathematics among secondary school students. The findings reveal differential effects across cognitive and affective domains, suggesting that mindset interventions may influence students' emotional and motivational responses more readily than their core belief structures.

### 4.1. Mathematical mindset

The absence of significant between-group differences in mathematical mindset indicates that belief restructuring may require sustained exposure and reinforcement. Previous research suggests that mindset development is a gradual psychological process shaped by continuous learning experiences and contextual influences [45], [46]. The significant within-group improvement observed in the treatment group nevertheless indicates that the intervention initiated early cognitive changes, supporting earlier findings that brief interventions can activate adaptive learning beliefs and motivation [47], [48]. These results suggest that short-term interventions may serve as an initial catalyst for mindset change, although longer implementation periods may be necessary to produce robust group-level effects.

### 4.2. Mathematics anxiety

In contrast, the intervention produced a significant reduction in mathematics anxiety, demonstrating that affective responses may be more immediately responsive to psychological interventions. This finding supports existing research showing that students' emotional engagement with mathematics is strongly influenced by instructional experiences and classroom environment. Given the well-established relationship between mathematics anxiety and reduced academic performance [49], the observed reduction suggests that GMI may improve learning outcomes by minimizing psychological barriers. The findings consistent with prior intervention studies reporting that structured educational approaches can effectively reduce mathematics anxiety and improve academic engagement [50].

### 4.3. Attitudes toward mathematics

The intervention also significantly improved students' attitudes toward mathematics, indicating increased confidence and positive perceptions of learning. This result supports prior studies emphasizing the role of psychological and contextual factors in shaping students' learning attitudes [51], [52]. In addition, student-centered and engaging instructional strategies can enhance learners' self-efficacy and support the development of a growth mindset. In this study, the GMI encouraged students to view challenges as opportunities for learning, making their experiences more meaningful [48]. As a result, students developed more positive beliefs about their abilities, which contributed to improved attitudes toward mathematics. Positive attitudes toward mathematics are associated with increased motivation and engagement, which in turn contribute to improved academic outcomes [18]. These findings highlight the interconnected relationship between students' beliefs, emotions, and learning behaviors in mathematics education.

## 5. CONCLUSION

This study provides empirical evidence that GMI can effectively improve students' affective engagement in mathematics learning, particularly by reducing mathematics anxiety and promoting positive attitudes toward mathematics. Although significant changes in mathematical mindset were not observed at the group level, the intervention demonstrated potential in initiating gradual belief development while producing immediate emotional and motivational benefits. This study provides experimental evidence on the effectiveness of a GMI in reducing mathematics anxiety and supporting positive learning beliefs among secondary school students.

The findings suggest that mindset-based interventions may produce immediate improvements in affective outcomes, particularly in reducing mathematics anxiety, while changes in core belief structures such as mathematical mindset may require longer exposure. This highlights the importance of considering both cognitive and affective dimensions when evaluating the effectiveness of educational interventions. Conducted within the Malaysian secondary education context, this study contributes empirical insights into the application of psychologically informed strategies in mathematics learning. By fostering adaptive attitudes and reducing anxiety, GMI can enhance students' engagement, resilience, and overall learning experiences in mathematics. These findings offer practical implications for educators and policymakers seeking evidence-based approaches to support students' success in mathematics and STEM-related fields. Future research should examine the long-term impact of mindset interventions through longitudinal designs, larger samples, and diverse educational settings.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

## CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

## DATA AVAILABILITY

All underlying data supporting the study's findings are fully presented within the article itself.

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