

# Are Digital Technology-based Mathematics Content and Teachers' Teaching Styles Determinants of Students' Mathematics Anxiety?

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## Abstract

Mathematics anxiety remains a persistent problem affecting students' learning outcomes at the secondary school level. Mathematics anxiety is an affective factor that significantly influences students' success in learning mathematics. The level of mathematics anxiety is seen as the result of the interaction between various internal and external factors, including the characteristics of the learning content and the teacher's teaching style. This study aims to analyze the interaction between mathematics content and the teacher's teaching style in predicting students' levels of mathematics anxiety. The study used an ex post facto design involving 64 students, consisting of 32 grade XI science students and 32 grade XI social students. Data were collected through a mathematics content test and a validated mathematics anxiety questionnaire. Data analysis was conducted using a two-way ANOVA test to examine the main effects and interactions between independent variables on mathematics anxiety. The results of the analysis showed a significant interaction between digital technology-based mathematics content and the teacher's teaching style on students' levels of mathematics anxiety [ $p < 0.05$ ]. This finding indicates that variations in mathematics anxiety are not determined by a single factor, but by a combination of content characteristics and the teacher's pedagogical approach. Implications: The results of this study provide an empirical basis for the development of adaptive and evidence-based mathematics learning strategies to reduce students' mathematics anxiety.

**Keywords:** Digital Technology, Mathematical Anxiety, Mathematics Content, Teacher Style.

## Introduction

Mathematics plays a very important role in education from elementary school to college. Mathematical knowledge is useful for developing reasoning skills and is very useful for solving everyday problems. However, in its application in schools, there are factors of mathematical content and teacher's teaching style that can trigger students' anxiety about mathematics.

Mathematical content and a teacher's teaching style play complementary roles in enhancing students' mathematical understanding. Successful delivery of mathematical content depends heavily on the teacher's teaching style. Teachers who are able to connect mathematical concepts to real-world situations, use active learning methods, and provide opportunities for students to think critically will help them develop a deeper understanding of mathematical concepts. Therefore, an effective teaching style can bridge students' difficulties in understanding abstract mathematical content, making learning more

engaging and meaningful, and eliminating student anxiety.

## Mathematics Anxiety

Math anxiety generally stems from a student's previous negative experiences with math content or math teachers. Math anxiety is not a learning disability, but it interferes with an individual's ability to learn math and hinders a student's ability to understand and participate in math (1). Mathematics anxiety is an uncomfortable feeling, such as fear or tension, that occurs when a person is faced with a mathematical problem or situation. This feeling can interfere with a person's ability to process numbers and solve math problems (2). Mathematics anxiety generally stems from students' previous negative experiences with mathematics content or with the teaching style of mathematics teachers (3, 4). The teacher's teaching style is closely related to the delivery of content, interactions, and personality traits of the

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teacher when teaching. An interesting teaching style of the teacher encourages student participation, and increases student learning motivation. An authoritarian and unfriendly teaching style of the teacher towards students will hinder student achievement and interest in learning (5).

Math anxiety experienced by students can reduce their concentration, self-confidence, and thinking skills. Ultimately, this anxiety has a significant impact on student achievement and a tendency to avoid learning mathematics (6). Therefore, anxiety needs to be managed through teacher support, a safe learning environment, a gradual learning approach, and strengthening emotional regulation so that students can learn mathematics more positively and effectively.

### **Mathematics Content**

Mathematics content in schools encompasses a variety of concepts, principles, and skills designed to develop students' logical, analytical, and creative thinking abilities. Each level of education increases in depth and complexity, from understanding basic concepts to applying them to real-world situations.

At higher grade levels, mathematics material becomes increasingly difficult and complex (7). Therefore, students are required to understand more abstract concepts, the relationships between concepts, and higher-order thinking skills such as reasoning, generalization, and problem-solving (8).

Mathematics content that generally causes anxiety in students is abstract, requires a high level of conceptual understanding, and involves complex calculations and formal symbols (9). Topics such as algebra, spatial geometry, trigonometry, and word problems that require logical reasoning often cause anxiety because students find it difficult to relate these concepts to real-world situations. Furthermore, the pressure to find the right answer and the fear of making calculation errors also exacerbate learning anxiety. Therefore, the presentation of mathematics content needs to be designed in a contextual, interactive, and gradual manner so that students can understand concepts meaningfully and feel more confident in learning.

Currently, digital resources have developed rapidly and are utilized in the development of mathematics learning content (10, 11). Digital

technology-based mathematics content includes interactive videos, games, digital comics, digital books, and so on (12, 13). The use of digital technology encourages more interactive mathematics learning, improves understanding of mathematical concepts (14), and is very relevant to the needs of the current 21st century (15).

### **Teacher's Teaching Style**

The teaching style of mathematics teachers plays an important role in determining the level of students' understanding and learning motivation (16). Teachers who use interactive, creative, and contextual teaching styles can help students understand mathematical concepts more easily because learning feels meaningful and enjoyable (17).

A math teacher's teaching style plays a crucial role in determining students' understanding and motivation. Teachers who employ interactive, creative, and contextual teaching styles can help students grasp math concepts more easily because learning feels meaningful and enjoyable. Conversely, a teaching style that is rigid, monotonous, and focuses solely on procedures or outcomes can quickly lead to students becoming bored and losing interest in learning. When teachers adapt their teaching style to students' characteristics and needs, for example through discussions, educational games, or the use of visual media, students will be more motivated, more willing to ask questions, and more actively participate in the learning process.

Several studies have revealed a significant negative correlation between mathematics anxiety, math content, and self-concept (18, 19). Mathematics anxiety affects the decline in student learning achievement (20, 21). On the other hand, teacher behavior is a major factor contributing to mathematics anxiety in students (22). Researchers believe that many internal and external factors influence the math anxiety experienced by students. These influencing factors may interact with each other in determining the level of math anxiety. However, several research results from experts (18–22) have not investigated the interaction between these factors. In line with the unanswered gaps in research, both theoretically and pedagogically, this study was conducted specifically to answer the following research questions:

RQ1. Is there a significant difference in students'

mathematics anxiety between digital-based and paper-and-pencil mathematics content?

RQ2. Is there a significant difference in students' mathematics anxiety between digital-based and paper-and-pencil mathematics content?

RQ3. Is there a significant interaction between mathematics content type and teaching style in predicting students' mathematics anxiety?

The results of this study are expected to help teachers understand and identify factors that interact with one another in students' mathematics anxiety.

**Table 1:** Learning Activities Based on Teacher's Teaching Style

Class	Learning Activities	Math Content	Teacher's teaching style
XI - Science	Learning I	Content A (digital technology-based)	Technological Teaching Style (TTS)
	Learning II	Content B (paper and pencil-based)	Classical Teaching Style (CTS)
XI - Social	Learning I	Content A (digital technology-based)	Technological Teaching Style (TTS)
	Learning II	Content B (paper and pencil-based)	Classical Teaching Style (CTS)

This study employed an ex post facto design with a  $2 \times 2$  factorial approach, as described in Table 1. The first factor was the type of mathematics content, consisting of digital technology-based content and paper and pencil-based content, while the second factor was the teacher's teaching style, classified as Technology Teaching Style (TTS) and Classical Teaching Style (CTS). The combination of these two factors resulted in four analysis groups: Digital-TTS, Digital-CTS, Paper-TTS, and Paper-CTS, with mathematics anxiety as the dependent variable.

### Research Samples

The number of research samples was 64 students, consisting of class XI-science = 32 students, and XI-social = 32 students, where major is used as a grouping variable. In both classes, students received mathematics learning taught by senior teachers in the first lesson and intern teachers in the second lesson. Senior teachers have a classical teaching style (CTS). Intern teachers have a technological teaching style (TTS). Both teachers take turns teaching in both classes. In the first lesson, the teacher presents mathematics content assisted by digital technology (content A) and in the second lesson, the teacher presents paper and pencil-based mathematics content (content B).

### Data Collection

Data collection through a survey questionnaire with a Likert scale of 1-5. The questionnaire

## Methodology

This research explores data from past events to identify causal factors without providing any special treatment to the variables being studied.

### Research Design

This quantitative research is ex post facto, which is research conducted after an event or incident has occurred (23). This study aims to see the effects of a phenomenon and test the cause and effect relationship (24).

contains a survey of mathematical content (10 items) and teacher's teaching style (20 items). The mathematics anxiety instrument was developed from research results that have a high level of validity and reliability (20). The tool to measure the level of mathematics anxiety was developed by Cheng (25).

### Data Analysis

Data analysis was conducted using descriptive and inferential statistics. To test interactions between variables, a two-way ANOVA statistical test was used. The two-way ANOVA statistical test is useful for testing the main effects of each factor and the interaction effect between mathematics content and teacher teaching style at a significance level of  $\alpha = 0.05$ . To maintain the direction and consistency of the research, Table 2 presents the alignment between the research questions, research variables, and statistical analyses used.

## Results

A survey was conducted to obtain information about students' opinions on mathematical content. Students gave answers (through responses) on a Likert scale of 1-5. The survey results are presented in Table 3.

Looking at Table 2, students' interest in digital technology-based mathematics content (content A) is higher than students' interest in paper and pencil-based mathematics content (content B).

**Table 2:** Alignment of Research Questions, Variables, and Statistical Analysis

Research Question (RQ)	Independent Variable(s)	Dependent Variable	Statistical Analysis
<b>RQ1.</b> Is there a significant difference in students' mathematics anxiety between digital-based and paper-and-pencil mathematics content?	Type of mathematics content (digital-based vs paper-and-pencil)	Mathematics anxiety	Two-way ANOVA (main effect of content)
<b>RQ3.</b> Is there a significant interaction between mathematics content type and teaching style in predicting students' mathematics anxiety?	Teaching style (TTS vs CTS); Academic track (science vs social science)	Mathematics anxiety	Two-way ANOVA (main effect of teaching style; control factor: academic track)
<b>RQ3.</b> Is there a significant interaction between mathematics content type and teaching style in predicting students' mathematics anxiety?	Mathematics content × Teaching style	Mathematics anxiety	Two-way ANOVA (interaction effect)

**Table 3:** Statistical Description of Students' Anxiety Towards Mathematical Content

Class	Content	Mean Score	Interest in Math Content	Anxiety Score	Anxiety Criteria
X-Science	Content B	22.53	Low	57.062	High
	Content A	45.06	High	44.125	Medium
X-Social	Content B	24.25	Low	62.500	High
	Content A	43.81	High	46.624	Medium

Meanwhile, the level of anxiety of science and social studies students towards mathematics content (content A) is in the "moderate" category

and towards mathematics content (content B) is in the "high" category. The following is Table 4 to describe data on students' anxiety towards the teacher's teaching style.

**Table 4:** Statistical Description of Students' Anxiety Towards the Teacher's Teaching Style

Class	Teacher's Teaching Style	Mean Score	Interest in Teaching Style	Anxiety Score	Anxiety Criteria
X-Science	(CTS)	58.74	Medium	63.200	High
	(TTS)	79.05	High	45.125	Medium
X-Social	(CTS)	45.93	Low	67.250	High
	(TTS)	76.12	High	41.000	Medium

Table 4 shows that students in science and social studies classes have high learning interest when learning mathematics with the teacher's teaching style (TTS). However, students experience higher levels of mathematics anxiety when students learn with the teacher's teaching style (CTS) than with the teacher's teaching style (TTS). The difference in mathematics anxiety towards the teacher's teaching style is supported by the statistical

comparison test in Table 5.

Results of Table 5, the output of the homogeneity of variance test obtained a Sig. value of  $0.79 > 0.05$ , which means that the variance of anxiety data based on teacher teaching style (CTS) and (TTS) has a homogeneous variance. Meanwhile, based on the output in the equal variances assumed section, it has a Sig. (2-tailed) value of  $0.029 < 0.05$ , so  $H_0$  is rejected and  $H_a$  is accepted.

**Table 5:** Comparative Test Results

		Levene's Test for Equality of Variances				t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Sig. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Math Anxiety	Equal var. assumed	6.24	.079	-4.117	62	0.029	-9.3342	2.5918	-17.8724	-0.8215
	Equal var. not assumed			-4.983	54.05	0.025	-9.3342	2.6973	-17.8975	-0.9502

Thus, it is said that there is a significant difference between students' anxiety scores towards the teacher's teaching style (CTS) and (TTS), with an average difference value of -9.3342.

In the final step to answer the research question, the researcher conducted a two-way ANOVA statistical test to test for interactions between research variables. The test results are displayed in Table 6.

**Table 6:** Tests of Between-Subjects Effects

Source	Type III Sum of Square	df	Mean Square	F	Sig.
Corrected Model	6553.779 <sup>a</sup>	5	1924.400	79.329	< .002
Intercept	139021.069	1	139021.069	9278.772	< .001
Content	8.240	1	8.240	.578	.484
Teaching Style	5547.669	2	2732.483	184.941	< .001
Content * Teaching Style	233.108	2	105.169	7.531	.002
Error	6208.750	58			
Total	95319.000	64			
Corrected Total	7554.938	63			

R Squared = .893 (Adjusted R Squared = .871)  
 Dependent variable: Math Anxiety

Table 6 shows that the Sig. level of  $0.002 < 0.05$  results in  $H_0$  being rejected. Therefore, it is concluded that there is a significant interaction between mathematical content and teacher teaching style in determining students' levels of mathematical anxiety. The interaction between mathematical content and teaching style in determining levels of mathematical anxiety is reinforced by Figure 1 below.

The graph in Figure 1 shows an interaction due to the intersection of the lines between mathematics content and teacher teaching style. Mathematics content A elicits lower anxiety than content B. Mathematics anxiety tends to increase based on the mathematics content. Meanwhile, teaching with a CTS style elicits higher anxiety than teaching with a TTS style. Mathematics anxiety related to teacher's teaching style tends to decrease in line with the implementation of the TTS style.

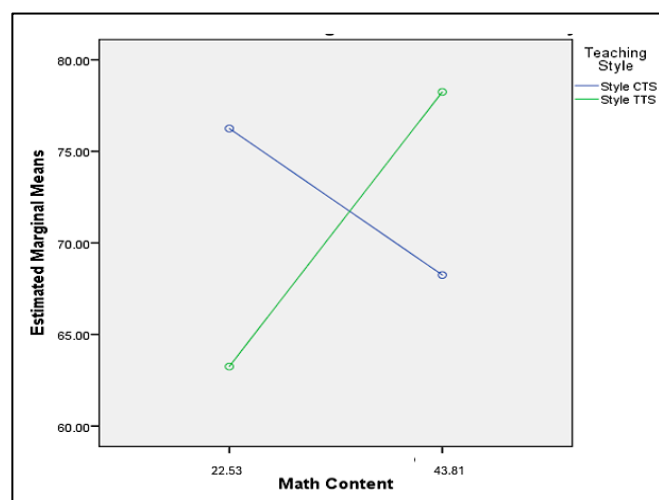
### Discussion

The phenomenon of mathematics anxiety in students is a feeling of anxiety, worry, or fear experienced by students when faced with mathematics (21). Mathematics anxiety can arise

due to the influence of factors from within and outside the individual (26). External influences of the individual include mathematical content factors and the teacher's teaching style in the classroom.

Based on the data analysis in Figure 1, it shows that the interaction between mathematical content and the teacher's teaching style is a determining factor in students' levels of math anxiety. In other words, the level of math anxiety in a person is determined by the level of interaction between mathematical content and the teacher's teaching style.

Table 2 implies that difficult paper and pencil-based mathematics material (material B) does not attract students' interest in learning, thus increasing students' anxiety (27). Meanwhile, mathematics content packaged through interactive digital technology can reduce anxiety, attract interest in learning, and increase students' understanding of mathematical concepts (28). The correlation between mathematics content and mathematics anxiety shows that the higher the level of difficulty of the content (paper and pencil form), the higher the mathematics anxiety experienced by students and vice versa.



**Figure 1:** Interaction between Mathematical Content and Teacher's Teaching Style

Teaching style is related to the teacher's strategy when teaching which can have an influence on student learning outcomes (29). Ineffective teacher teaching style (CTS) can trigger math anxiety in students. Teachers with teaching style (TTS) using math content packaged in the form of digital comics, games, and interactive learning videos can create a comfortable learning environment for students.

In general, the classical teaching style (CTS) causes boredom and passive students when learning because teachers only rely on delivering paper and pencil-based mathematics content. In the CTS teaching style, the role of the teacher is more dominant than the students. However, if the teacher applies a technology-based teaching style (TTS) where mathematics content is presented in the form of digital comics, games, or interactive videos, it will have an impact on increasing student participation and interest in learning (28).

The results of this study indicate that the TTS teacher's teaching style can reduce mathematics anxiety in science and social science students, especially when combined with digital technology-based mathematics content. The use of digital technology-based multimedia (visual) in the teacher's teaching style (TTS) can increase curiosity and help students understand mathematical concepts well (10, 28). Students feel comfortable in class with TTS teachers so that students are more active in asking questions and participating in learning. On the other hand, the use of digital technology-based media can affect the reduction of student anxiety in mathematics learning. The correlation between teacher teaching style and mathematics anxiety shows that the higher the variation in digital technology-based teaching styles, the lower the level of mathematics anxiety experienced by students.

The teaching style of technological teachers combined with the presentation of digital-based content can increase student learning participation and reduce math anxiety. However, if teachers teach in a classical (conventional) style that provides doctrines and only provides information to students (teacher - centered) it causes students to get bored and their interest in learning decreases. Related to their function as teachers, educators and mentors, various roles are needed from teachers who always describe the expected behavioral patterns in their various

interactions that can motivate students to continue learning. Teachers must ensure that in learning there is no condition of math anxiety for students. In some cases, the teacher's teaching style affects student anxiety. The anxiety experienced by students will affect students' cognitive, emotional, and behavioral (3).

The interaction between mathematics content and teacher teaching style is also significant in determining the level of mathematics anxiety. Research shows that teaching style (TTS) effectively reduces students' mathematics anxiety by utilizing digital technology-based mathematics content. Conversely, if teachers use ineffective teaching styles (CTS) (such as only teaching traditionally) and irrelevant mathematics content, students' mathematics anxiety will increase.

In general, the classical teaching style (CTS) leads to boredom and passive learning. In CTS, the teacher plays a more dominant role than the students. However, if teachers adopt a technology-based teaching style (TTS), they can actively engage students in the learning process and increase their motivation.

The relationship between a teacher's teaching style, mathematical content, and math anxiety is closely intertwined in the learning process. A teacher's interactive, engaging, and adaptive teaching style can help students understand math content often considered difficult and abstract, such as algebra, geometry, or problem-solving. Conversely, a rigid, memorization-oriented teaching style can reinforce students' negative perceptions of math, thereby inducing anxiety and lowering their self-confidence. Therefore, successful mathematics learning depends not only on mastery of the material but also on the teacher's ability to create a positive and supportive learning environment to reduce students' math anxiety (3, 4).

The findings of this study have significant pedagogical implications for mathematics learning practices in secondary schools. The significant interaction between digital technology-based mathematics content and teachers' teaching styles suggests that efforts to reduce students' mathematics anxiety cannot be achieved through content modification or pedagogical approaches alone. Teachers need to design mathematics learning by combining contextual, digitally supported content selection with an adaptive,

interactive, and affective-focused teaching style. This approach requires teachers to focus not only on mastery of the material but also on presentation methods and learning interactions that can create an emotionally safe learning environment. Thus, the appropriate integration of digital content and teaching styles has the potential to reduce mathematics anxiety while increasing student engagement and learning outcomes.

Theoretically, the results of this study reinforce the view that mathematics anxiety is a multidimensional construct influenced by the dynamic interaction between learning and pedagogical factors. The finding of an interaction effect between mathematics content and teachers' teaching styles provides empirical support for a conceptual model that positions students' affective factors as the result of a contextual and relational learning process, rather than as merely individual attributes. This study also expands the study of mathematics anxiety by demonstrating that content characteristics, particularly those based on digital technology, have theoretical significance when linked to teachers' teaching approaches. Therefore, this study emphasizes the importance of an interactional approach in developing mathematics learning theories that simultaneously integrate cognitive, pedagogical, and affective aspects.

## Conclusion

Math anxiety is a complex problem influenced by many factors, including the teacher's teaching style and the mathematics content. By understanding the relationship between these factors, teachers can develop more effective teaching strategies to help students overcome math anxiety and improve their mathematics achievement. The conclusion of this study is (a) Digital technology-based mathematics content has a lower effect on mathematics anxiety compared to paper and pencil-based mathematics content; (b) The technology teacher teaching style (TTS) has an impact on reducing mathematics anxiety in students in all science and social science majors compared to the classical teacher teaching style (CTS); and (c) There is a strong interaction between digital technology-based mathematics content and teacher teaching style in determining the level of students' mathematics anxiety. In this case, digital technology-based mathematics

content and technology-based teacher teaching style (TTS) can reduce students' mathematics anxiety. Conversely, paper and pencil-based mathematics content and classical teaching style (CTS) significantly impact students' mathematics anxiety.

These findings emphasize the importance of selecting appropriate mathematics content and implementing an adaptive and contextual teaching style in mathematics learning. Furthermore, the results of this study provide an empirical contribution to the development of evidence-based pedagogical practices to reduce mathematics anxiety in secondary education.

A limitation of this study lies in the use of an ex post facto design with a limited sample size, which prevents strong causal inferences between variables. Future research is recommended to use experimental or quasi-experimental designs with larger samples and to examine the role of mediating variables such as mathematics self-efficacy or moderating variables such as students' gender and academic background.

## Abbreviations

ANOVA: Analysis of Variance, CTS: Classical Teaching Style, TTS: Technological Teaching Style.

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## Author Contributions

Imam Kusmaryono: conceptualization, methodology, supervision, final alignment, Widya Kusumaningsih: field data collection, report writing, discussion of research results.

## Conflict of Interest

The authors have no conflicts of interest to declare.

## Data Availability

The data supporting the findings of this study are available from the corresponding author and are accessible upon reasonable request for academic purposes.

## Declaration of Artificial Intelligence (AI) Assistance

The authors declare that this manuscript was not written in part or in whole using artificial intelligence (AI).

## Ethics Approval

This research adheres to established ethical guidelines and has received university approval to conduct this work honestly and ethically. The parties involved (school principals, teachers, and students) have voluntarily agreed to participate.

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