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Beliefs, Attitudes, and Practices of High School Teachers in Handling Students' Errors: Implications for Error-Tolerant Mathematics Classrooms

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Abstract

Proper handling of students' errors in mathematics provides teaching and learning opportunities. Anchored in the Professional Error Competence Model developed by Wuttke and Siefried, this study investigated junior high school teachers' beliefs, attitudes, and practices in handling students' errors in their Mathematics class. The study employed a descriptive-correlational design and surveyed one hundred three Mathematics teachers from public secondary schools in Camarines Sur. A researcher-made survey questionnaire was used to gather the necessary data. All statistical analyses on the data collected, such as weighted mean, Pearson's r, and Canonical Correlation Analysis were done using SPSS (version 21). The findings show that respondents frequently employed error detection, correction, and prevention strategies. It also demonstrates that both beliefs and attitudes correlated significantly with respondents' error-handling practices. The study further reveals that the respondents' attributes (age, sex, educational attainment, field of specialization, number of years in teaching mathematics, and seminars attended) contribute to their practices, beliefs, and attitudes in error handling. However, it is noted that as respondents grow older and gain more teaching experiences in Mathematics, certain error-handling practices, beliefs, and attitudes appear to diminish. It is therefore recommended that the frequency of error handling activities that facilitate learning should be increased further in a Mathematics class. School administrators should organize training programs that highlight the critical role of error handling in the learning process. They should also embark on benchmarking activities, mentoring, and coaching to expose teachers to error-handling strategies that promote an error-tolerant mathematics classroom where students have numerous opportunities to learn. Moreover, schools should provide students with opportunities to evaluate their teachers' practices in handling errors. Finally, future researchers should perform actual observations on error handling practices to learn more about them in the classroom setting. They may also look into how teachers deal with errors in online education.

Keywords: Attitudes, Attributes, Beliefs, Error-handling practices, Error-tolerant mathematics classrooms

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INTRODUCTION

Mathematics plays a vital role in people's lives in all areas of life. It has a crucial and distinctive role in human societies, and it is a critical component of humanity's overall development (Yadav, 2019). For instance, Mathematics teaches students to think critically and develop problem-solving skills, which they can apply in school and in today's challenging world. It is also regarded as the gateway to national progress because it is responsible for technological innovations and advancements that improve our lives (Science Education Institute-Department of Science and Technology & Philippine Council of Mathematics Teacher Education, 2011).

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However, studies reveal that Mathematics remains a complex subject for many students, as evidenced by students' low mathematics performance in class (e.g., Jameel & Ali, 2016; Suleiman & Hammed, 2019; Capuno et al., 2019). Additionally, the difficulty can be seen in students' poor performance on national and international achievement tests. For instance, the National Achievement Test (NAT) revealed a significant decline in students' mathematics performance between 2016 and 2017 (Ager, 2019). This poor performance is further attested by the result of the assessment for Mathematics and Science for Grade 4 pupils conducted by The International Mathematics and Science Study (TIMSS) in 2019, which showed that Filipino children ranked last out of 58 participating countries around the globe (Baclig, 2020). Only 19% of Filipino pupils achieved the low intermediate benchmark in Mathematics, indicating that only a small percentage have some basic mathematical knowledge. This subpar performance in the early years impacts the students' later academic achievement. Studies show that the acquisition of early mathematics competencies is predictive of students' high school mathematics performance (Watts et al., 2014; Watts et al., 2018; Goldhaber et al., 2021).

Several studies at the middle school and early high school levels have shown that many students have trouble learning mathematical concepts and procedures (Yetkin, 2003; Maguire, 2012; Sakinah Nuraini et al., 2018). The high rate of mathematical errors in schools reveals this struggle with mathematics among students (Elbrink, 2008; Lai, 2012; Riccomini, 2016). According to Barlow et al. (2018), students may even develop misconceptions- faulty views or opinions established due to prior misunderstandings or incorrect thinking-that would impede their future mathematics learning. Maguire (2012) added that many scholars agree that misconceptions can be very tough to undo and are resilient to external and internal remediations. For example, in his study, plenty of students in elementary school develop a simplistic interpretation of equivalence, and some carry over this misconception to middle school, high school, and college. Hence, many students exit elementary school underprepared to tackle the more rigorous mathematics curriculum of secondary education, which often results in poor performance.

There are factors involved as to why some students perform poorly in Mathematics. Suleiman and Hammed (2019) point to the lack of qualified Mathematics teachers, ineffective teaching methodology, and students' poor socioeconomic background causing failure in secondary schools. Similarly, Jameel and Ali (2016) claim that an inadequate number of exercises and drills, which affect students' acquisition of concrete and abstract mathematical concepts, and the strictness in Mathematics instruction are the primary causes of students' low achievement.

Another factor that may influence students' performance in mathematics is how teachers respond to students' errors (Heinze, 2005). Heinze and Reiss (2007) state that handling errors can help students learn, but teachers frequently overlook this learning opportunity. Studies (Wiens, 2007; Chamundeswari, 2014; Makhubele et al., 2015; Damla Gedik et al., 2017) have indicated that one way to address the problem of students' poor achievement in Mathematics is to investigate the errors that they frequently commit in Mathematics. According to Noche (2009), the information that teachers gain from exploring errors can aid them in enhancing their instruction and assessment. It further helps the teacher develop ideas for teaching priority, thereby preventing classroom errors (Riccomini, 2016). Without correcting the errors, students will build their mathematical knowledge on misunderstood concepts (Elbrink, 2008).

Unfortunately, only a few studies were done on error-handling (Heinze, 2005; Bray, 2011); hence, a study that will focus on this phenomenon is crucial. How teachers handle student errors that occur during lessons to create an "error-friendly" environment (the emotional component of professional competence) and to support the learning process through feedback (the cognitive component of professional competence) continue to draw attention among mathematics education researchers (Wuttke & Siefried, 2010). The study thereby proposed to explore junior high school teachers' beliefs, attitudes, and practices in handling learner errors. Specifically, this study aimed to realize the following objectives: (1) determine the common types of errors committed by students and dealt with by teachers; (2) determine the common practices of teachers in handling student errors (3) determine the beliefs of the teachers in handling students' errors: (4) determine the attitudes of the teachers in handling students' errors; (5) test the relationships of the teachers' practices, beliefs, and attitudes in handling students' errors; (6) examine what teachers' attributes are associated with their beliefs, attitudes, and common practices in handling students' errors. The study results have many curricular and instructional implications for Mathematics teaching and inputs for professional development training and mathematics educators' programs.

RESEARCH METHOD

This study is a quantitative, non-experimental, descriptive-correlational research focusing on the errors committed by students and dealt with by Mathematics teachers. The study was conducted in various public secondary schools of Camarines Sur's fourth congressional district. The respondents were the 103 junior school teachers from the five randomly chosen municipalities: San Jose, Caramoan, Sagnay, Tigaon, and Presentacion.

A survey questionnaire was developed to gather the needed data. The questionnaire was face validated by junior high school Mathematics teachers. Pilot testing was conducted, and reliability was tested using Cronbach's Alpha, which yielded acceptable alpha coefficients. Reliability coefficients were .92 for types of errors, .79 for practices in handling errors, and .71 for beliefs and attitudes.

Data gathered from the survey were encoded and analyzed using SPSS (version 21) and were analyzed using the following statistical tools: (a) Weighted mean was used to determine the common types of errors dealt with by teachers and their common practices, attitudes, and beliefs in handling the errors; (b) Pearson's r was used to examine the relationships between the teachers' practices, beliefs, and attitudes in handling students' errors; and (c) Canonical Correlation Analysis (CCA) was used to determine whether the teachers' attributes (age, sex, the field of specialization, educational attainment, number of years in teaching mathematics, and seminars attended) are associated with their beliefs, attitudes, and practices in handling errors.

RESULTS AND DISCUSSION

The following are the results of the data acquired to determine the most common errors made by students and the beliefs, attitudes, and practices of teachers in dealing with student errors in Mathematics classes:

Common types of students' errors dealt by mathematics teachers

Table 1 reveals that the three general types of errors are very common among students. Procedural errors were the most common, with a weighted mean of 3.83. This is followed by careless errors with a weighted mean of 3.69 and conceptual errors with a weighted mean of 3.69.

Table 1. Common types of students' errors dealt by the mathematics teachers

Common Types of Errors	M_w	Verbal Interpretation
Conceptual Errors	3.83	Very Often
Procedural Errors	3.82	Very Often
Careless/Slip Errors	3.69	Very Often
Overall	3.78	Very Often

The top three common types of conceptual errors are *miscalculation due to improper use of signs*, a *miscalculation in algebraic operations as a result of errors in combining like terms*, and *incorrect mathematical sentences when translating word problems*. The three common procedural errors include *incorrect procedure in solving operations on fractions*, *incorrect use of the rule*, and *incorrect cancellation of rational expressions*. The three common careless or slip errors are *incomplete answers in the problem (e. g., missing units, signs, or variables in the answer)*, an *incomplete solution process is required in the problem*, and the *wrong answer because directions were not followed correctly and incorrect answer since problems was not read carefully*.

In general, the students demonstrated incorrect execution of mathematical steps in a mathematical process. Students failed to select and apply appropriate procedures when solving problems, and somewhere along the way, they performed basic mathematical operations incorrectly. Because mathematics involves multi-step problem solving, this is alarming because if a student makes a single procedural error, the rest of their work and the final solution will be incorrect. This finding is consistent with Makhubele et al. (2015), who report that procedural errors often occur in mathematics class. Brown and Skow (2016) explain that such errors occur when students do not correctly apply mathematical rules or properties (i.e., the formula or step-by-step procedure for solving a problem). The student has developed all the basic mathematics concepts but has not mastered the underlying mathematical processes to perform the math correctly (Makhubele et al., 2015; Barlow et al., 2018).

One of the most frequently encountered procedural errors is a failure to perform fraction operations. Performing fractions operations is a fundamental skill in mathematics that students must master during their early years of schooling. However, many students struggle with fractions as they fail to grasp the procedures and algorithms that go along with them (Gagani & Diano, 2019). If students do not understand how fractions work, their ability to learn higher-level mathematics courses such as Algebra, Geometry, and Calculus will be impacted. According to Rushton (2018), Brown and Skow (2016), and Bentley and Bossé, (2018), students make fractional errors because they struggle in finding the common denominator for addition and subtraction and have difficulties with multiplication and division. Lestiana et al. (2017) demonstrate that students could not perform accurate fraction operations because they generalized a previously learned procedure and misapplied it to compare two fractions. For instance, it is shown that most of the students in the study already knew about the cross-multiplication strategy to compare two fractions, as the teacher told them about the strategy. As a result, some erroneously generalized that this strategy can be applied besides fractions.

As to conceptual errors, the respondents report that the common error among their students is miscalculation due to improper use of signs. The same result was found in the study of Rushton (2018), who reports that algebraic operations are often carried out incorrectly due to improper signs. For example, the respondents typically made sign mistakes when shifting terms across the equation by addition or subtraction(e.g., making a positive term negative or vice versa). This is in line with the findings of Lim et al. (2019), who found that students made conceptual errors when applying real-number properties due to a lack of understanding of the lesson. Also, the most frequent error made by respondents was to interchange the inequality symbols. Khalid and Embong's (2019) examination further reveals how students make integer operations mistakes. They concluded that the most significant challenge for teachers is explaining the idea of operational symbols and negative signs. Students always make errors because they treat the negative sign and the subtraction symbol as the same. The researchers claim that students' most common errors and misconceptions arise from a lack of knowledge of the subject.

As to careless or slip errors, most students make the common error of providing an incomplete answer to the problem. For instance, students usually omit units, signs, and variables from their final answer. The odds of making such careless errors in mathematics are high, as it requires precise answers. Wiens (2007) substantiates this result by demonstrating how students are susceptible to careless errors. Their study revealed that the student found the solution, but they did not include the label that goes along with it in the problem context. They specifically omitted a percentage symbol from their answer. However, Goldman (2021) argues that labeling students' work as careless is not constructive feedback because it obscures the source of the problem and precludes the teachers from aiding students in resolving it. He believes that there are various reasons for students' math errors, and labeling them as "careless" may mean missing an opportunity to help them learn.

Common practices of mathematics teachers in handling students' errors

Table 2 shows that the three general classifications of respondents' practices were marked as very often (4.04). Error prevention gained the highest weighted mean of 4.10. It is followed by error correction with a weighted mean of 4.03 and error detection with 4.00.

Table 2. Common practices of mathematics teachers in handling students' errors

Practices	M_w	Verbal Interpretation
Error Detection	4.00	Very Often
Error Correction	4.03	Very Often
Error Prevention	4.10	Very Often
Overall	4.04	Very Often

The top three error detection practices are *I review the answers of my students to see if there are errors committed in the solution*, *I analyze the written responses of my students to determine the types of errors committed*, and *I collect a sample of written works of my students such as quizzes, seat works, and assignments to look for error patterns*. The top three error correction techniques used by respondents are: *I recognize the errors of my students*, *I provide corrective feedback in students' written works such as quizzes, periodical exams, seatwork, and homework*, and *I involve the whole class in correcting their errors*. The respondents' error prevention practices are *I tell my students to read the directions carefully in tests or any performance tasks*, *I show how the problem is solved and pinpoint their incorrectness*, and *I discuss difficult topics from simple to complex*.

Based on the study's findings, it can be inferred that the respondents can identify errors that occurred in their mathematics class each time. They use various error detection strategies, including checking students' answers, identifying errors in students' written responses, and getting a sample of students' written work. It is essential in teaching and learning to recognize errors in a mathematics class. Riccomini (2016) states that identifying errors helps teachers determine where their students' errors lie to give better instruction to address the errors. Inspecting errors also allows students to identify and correct them and make sound reasoning behind their correct answers (Barlow et al., 2018).

As to error correction, the findings revealed that respondents correct students' errors most of the time. Some of the error correction strategies they use frequently are to alert students when they make an error, provide feedback on assignments, and involve the entire class in finding and correcting mistakes. Multiple studies support the idea that students can benefit from the learning opportunity of the error correction process (Rushton, 2018; Gardee & Brodie, 2015; Bray, 2011; Rach et al., 2013). So, teachers should refrain from creating the impression that specific errors are prohibited, which would foster error-handling activities in the class to be productive (Heinze, 2005).

This study's results are consistent with findings from Bray (2011), indicating that the teacher integrates students into the correction process. This was also found in Gardee and Bordie's (2015) study, in which the teacher called on students to correct their classmates' mistakes. The students will benefit from the feedback they receive if it comes to them right away. According to Barry (2008), giving feedback improved learning for the students, who immediately understood and rectified their mistakes. However, Shi (2017) argues that some teachers dislike explicit correction because they believe it will erode students' confidence in class. Thus, teachers must correct their students' errors appropriately.

The findings further reveal that teachers use error prevention strategies frequently. Some of these are carefully reading the directions during tests and performance tasks, illustrating how the problem is solved, explaining why they got it wrong, and discussing difficult topics from simple to complex. Students must follow test and performance task instructions to succeed in the learning process. As Dunham et al. (2020)mentioned, following instructions or failing to do so impairs general learning and proficiency acquisition. It was found in the study by Wiens (2007) that if students do not read test instructions, they are more likely to make careless errors. The teacher can take the students from simple to complex step-by-step to help them better comprehend the mathematics concepts and procedures.

According to Rezapour and Taghipour (2013), learners would better comprehend the lessons when teaching was done in a simple to complex manner. Another way to handle difficulty in learning mathematics is to demonstrate how the problem is solved and identify their learners' errors. Yet, according to Brown and Skow (2016), the teacher should only show the area where the student makes a mistake during the demonstration of problem-solving. For instance, the authors explained that if the student's error pattern is that she consistently misses the common denominator when adding and subtracting fractions, the teacher would provide the instruction and go over the underlying conceptual knowledge about finding the common denominator. Additionally, when explaining errors in a problem, the teacher may give multiple explanations to ensure that different children access the error in the most appropriate way (Hansen et al., 2020).

The findings corroborate Wuttke and Siefried's (2017) Professional Error Competence Model, which proposes that Mathematics teachers can develop error competence when they recognize that students can benefit from errors and that errors are essential components fostering an error-tolerant mathematics classroom conducive to successful learning. Further, these findings contribute to the growing body of knowledge on mathematics teachers' practices in handling student errors.

Beliefs of the mathematics teachers in the handling of students' errors

Based on Table 3, it shows that the beliefs related to error handling were somewhat true to the respondents (4.15). Table 3 shows that the beliefs related to error handling were somewhat true to the respondents (4.15). The top belief with the highest weighted mean: Errors students make should be accepted and corrected (4.67); causes of students' errors should be looked into (4.50), and students' errors are considered essential components in the learning process (4.40).

According to the findings, teachers acknowledged the critical role of students' errors in the learning process. They understand the value of accepting and correcting students' errors, as well as delving into the root causes of errors. Rather than penalizing or ignoring their students' errors, the teachers feel they can work constructively to understand the errors and provide reinforcement and necessary remediation.

Table 3. Beliefs of the mathematics teachers in handling students' errors

Beliefs	M_w	Verbal Interpretation
Errors students make should be accepted and corrected	4.67	Very true to me
Causes of students' errors should be looked into	4.50	Very true to me
Students' errors are considered essential components in the learning process	4.40	Very true to me
Individual correction of students' errors in their written tasks is significant	4.31	Very true to me
Students' errors are teachable moments	4.29	Very true to me
The occurrence of students' errors in class is natural	4.17	Somewhat true to me
Students could benefit from one another's errors	4.15	Somewhat true to me
Prevalence of errors in class could be a learning opportunity	3.95	Somewhat true to me
An error-tolerant classroom is a learning environment that accepts students' errors	3.62	Somewhat true to me
Investigation of error patterns in students' works is crucial in the teaching-learning process	3.39	Undecided/neutral
Average	4.15	Somewhat true to me

Ročāne (2015) supports these findings by stating that teachers should foster an environment where students feel comfortable making errors. However, it appears as though some teachers believe that students would be embarrassed to have their mistakes broadcast in the class that if students' errors receive increased attention, they will be confused (Bray, 2011). It is a risk a teacher takes when correcting students in oral communication that the student will be reluctant to try again in the future. According to Turling et al. (2012, cited in Wuttke & Siefried, 2017), teachers who hold such beliefs may see errors as hurdles to learning.

Attitudes of the mathematics teachers in handling students' errors

The data in Table 4 demonstrate that respondents agree on how helpful students' errors are to the learning process (4.03).

Table 4. Attitudes of the Mathematics teachers in handling students' errors

Attitudes	M_w	Verbal Interpretation
Constructive feedback on errors motivates the students to perform better	4.53	Strongly Agree
Appropriate strategies should be employed to address the types of errors	4.53	Strongly Agree
Appropriate remediation is necessary to respond to a particular type of error	4.51	Strongly Agree
Error analysis is the initial step to understanding the errors prevalent in the class	4.31	Strongly Agree
The use of students' errors in the educative process would improve the learning outcome	4.30	Strongly Agree
Error analysis is the first step in learning about the common errors in the class.	4.03	Agree
Proper handling of errors could address students' misconceptions about procedures and concepts	4.00	Agree
Discussion of errors in class would clarify the topics being tackled	3.82	Agree
Students discussing their incorrect solutions in class serves to demonstrate that mistakes should not be embarrassed about.	3.43	Agree
Correction of students' errors in class promotes students' self-confidence	2.80	Undecided/neutral
Average	4.03	Agree

The three attitude indicators that received the highest weighted mean were: constructive feedbacking of errors motivates the students to perform better (4.53); appropriate strategies should be employed to address the types of errors (4.53), and appropriate remediation is necessary to respond to a particular kind of error (4.51). However, the respondents were uncertain that correcting students' errors in class would help students feel more confident (2.80).

The findings above suggest that respondents are disposed to respond favorably to a particular error situation in a Mathematics class. They believe that constructive feedback is necessary to motivate the students and maximize learning outcomes. If feedback on errors is not performed appropriately, students may feel ashamed in class. This is why some teachers remain unsure whether correcting students' errors in class can increase students' confidence. Teachers may be concerned if their approach to addressing errors would negatively affect students. For instance, they may be afraid of embarrassing students by correcting errors before class.

Generally, the findings support the theory that the teacher saw the errors as an opportunity for learning (Turling et al., 2012, cited in Wuttke & Siefried, 2017). Like the teachers, the students had a similar outlook, believing that error-handling exercises should be incorporated into the class, as explained in some research (Kavaliauskienė & Anusienė, 2012; Zhu, 2010). The students were most interested in correcting every mistake they felt was conducive to helping them learn in their classes. However, according to Bargiel-Matusiewicz and Bargiel-Firlit (2009), some students associate making errors with guilt, and as a result, they use an avoidance technique to avoid ridicule when they make errors. This highlights the critical role of teachers in ensuring that students realize that errors are not to be seen negatively and that they should find ways to correct their students' errors without undermining their confidence.

Relationships between the practices, beliefs, and attitudes of the mathematics teachers in handling students' errors

As seen in Table 5, the overall practices demonstrated a positive correlation with beliefs ($r = .210$, 2-tailed $p <.05$), with the highest correlation coefficient found for error detection ($r = .345$, 2-tailed $p <.01$), which was followed by error prevention strategies ($r = .238$, 2-tailed $p <.05$), and finally error correction ($r = .210$, 2-tailed $p <.05$).

Certain beliefs were found significantly associated with all the three practices, such as: relationships between *errors students make should be accepted and corrected* and error detection ($r = .287$, 2-tailed $p <.01$), error correction ($r = .270$, 2-tailed $p <.01$), and error prevention ($r = .258$, 2-tailed $p <.01$); *students' errors are teachable moments* and error detection ($r = .331$, 2-tailed $p <.01$), error correction ($r = .280$, 2-tailed $p <.01$), and error prevention ($r = .240$, 2-tailed $p <.05$); and *prevalence of errors in class could be a learning opportunity* and error detection ($r = .294$, 2-tailed $p <.01$), error correction ($r = .232$, 2-tailed $p <.05$), and error prevention ($r = .251$, 2-tailed $p <.05$).

Another significant relationship is found between *causes of students' errors should be looked into* and error prevention ($r = .232$, 2-tailed $p <.05$), *individual correction of students' errors in their written tasks is significant* and error prevention ($r = .250$, 2-tailed $p < .05$), *investigation of error patterns in students' works is crucial in the teaching-learning process* and error detection ($r = .226$, 2-tailed $p <.05$), and *students could benefit from another's errors* and error detection($r = .324$, 2-tailed $p <.01$) and error prevention ($r = .215$, 2-tailed $p <.05$).

The findings show a positive relationship between respondents' beliefs and practices in handling errors in a Mathematics class. The results indicate that the greater the respondents' belief in the benefits of error handling, the more of a supportive learning environment they create. This demonstrates how teachers' beliefs influence their classroom actions, particularly when providing an error-tolerant classroom conducive to learning. When teachers recognize the opportunity offered by handling errors in class and view errors as educational moments, they are more likely to foster an error climate in which students are not afraid to make errors and learn from others' errors and their own.

Table 5. Correlation matrix of mathematics teachers' practices and beliefs in handling students' errors

Beliefs	Practices: Error Detection	Error Correction	Error Prevention	Overall Practices
1. Errors students make should be accepted and corrected	.287**	.270**	.258**	.209*
2. Causes of students' errors should be looked into	.163	.178	.232*	.148
3. Students' errors are considered essential components in the learning process	.230*	.072	.093	.105
4. Individual correction of students' errors in their written tasks is significant	.128	.162	.250*	.194
6. Occurrence of students' errors in class is natural	.193	.057	.129	.058
7. Students could benefit from another's errors	.324**	.173	.215*	.240*
8. Prevalence of errors in class could be a learning opportunity	.294**	.232*	.251*	.297**
9. Error-tolerant classroom is a learning environment that accepts students' errors	.116	.145	.083	.137
10. Investigation of error patterns in students' works is crucial in the teaching-learning process	.226*	.067	.102	.117
6. Occurrence of students' errors in class is natural	.193	.057	.129	.058
Overall Beliefs	.345**	.210*	.238*	.210*

Strength of Correlation: r < 0.3 (None or Very Weak); 0.3 < r < 0.5 (Weak); 0.5 < r < 0.7 (Moderate); r > 0.7 (Strong). *p ≤ 0.05, **p ≤ 0.01.

The OECD (2009) concurs with the previous findings, stating that teachers who believe in the constructivist approach are more likely to use practices that strive to create an enriched and challenging learning environment geared toward the students' construct of knowledge. This conclusion is further supported by Voss et al. (2013), who also claims that teachers' mathematics beliefs impact their instructional practices, affecting students' learning outcomes. However, some teachers believe that their students would be embarrassed if their mistakes were broadcast in class (Bray, 2011). This could be why some teachers try to avoid discussing errors in the classroom. This contradicts the idea that errors aid in student learning, and those errors are often an important stage in the conceptual development of learners (Anthony & Walshow, 2009). O'dell (2015) adds to this notion by stating that when students make errors, they get an opportunity to learn.

The findings of the study in Table 6 show that the overall attitudes is significantly correlated to the three error-handling practices, such as error detection (r = .246, 2-tailed p < .05), error correction (r = .195, 2-tailed p < .05), and error prevention (r = .195, 2-tailed p < .05).

The table further displays a significant association between a specific belief and error-handling, such as *constructive feed backing of errors motivates the students to perform better* and error detection (r = .311, 2-tailed p < .01), error correction (r = .300, 2-

tailed $p < .01$), and error prevention ($r = .270$, 2-tailed $p < .05$) and error detection ($r = .311$, 2-tailed $p < .01$), error correction ($r = .304$, 2-tailed $p < .01$), and error prevention ($r = .326$, 2-tailed $p < .05$).

Table 6. Correlation matrix of Mathematics teachers' practices and attitudes in handling students' errors

Attitudes	Practices			
	Error Detection	Error Correction	Error Prevention	Overall Practices
1. Constructive feedbacking of errors motivates the students to perform better	.311**	.300**	.270**	.300**
2. Appropriate strategies should be employed to address the types of errors	.311**	.304**	.326**	.280**
3. Appropriate remediation is necessary to respond to a particular type of error	.241*	.229*	.173	.184
4. Error analysis is the first step in learning about the common errors in the class.	.161	.372**	.343**	.325**
5. Use of students' errors in the educative process would improve the learning outcome	.257**	.198*	.123	.190
6. Acceptance of students' errors in the learning environment may reduce their anxiety in mathematics.	.267**	.185	.156	.184
7. Proper handling of errors could address students' misconceptions about procedures and concepts.	.173	-.023	-.017	.072
8. Discussion of errors in class would clarify the topics being tackled.	.018	-.109	.025	-.109
9. Students discussing their incorrect solutions in class demonstrate that mistakes should not be embarrassed about.	.102	.119	.138	.059
10. Correction of students' errors in class promotes students' self-confidence	-.208*	-.165	-.200	-.226*
Overall Attitudes	.246*	.195*	.195*	.154

Strength of Correlation: r < 0.3 (None or Very Weak); 0.3 < r < 0.5 (Weak); 0.5 < r < 0.7 (Moderate); r > 0.7 (Strong). *p ≤ 0.05, **p ≤ 0.01.

Another significant association is found in this study, such as: relationships between *appropriate remediation is necessary to respond to a particular type of error* and error detection ($r = .241$, 2-tailed $p < .05$), and error correction ($r = .229$, 2-tailed $p < .05$); *error analysis is the first step in learning about the errors that are common in the class* and error correction ($r = .372$, 2-tailed $p < .01$), and error prevention ($r = .325$, 2-tailed $p <.01$); *use of students' errors in the educative process would improve the learning outcome* and error detection ($r = .257$, 2-tailed $p < .01$), and error correction ($r = .198$, 2-tailed $p < .05$); *acceptance of students' errors in the learning environment may reduce their anxiety in mathematics* and error detection ($r = .267$, 2-tailed $p< .01$); *correction of students' errors in class promotes students' self-confidence* and error detection ($r = -.208$, 2-tailed $p <.05$).

The above findings show that respondents' attitudes positively correlate with three practices: error detection, error correction, and error prevention. The findings indicate that teachers' favorable attitudes toward error handling will undoubtedly result in more error-tolerant mathematics classrooms. The teachers' view of the importance of error management in the educative process can shape their students' learning experience. They exhibit favorable tendencies toward applying necessary strategies to address the various types of errors encountered in class. Also, they view error correction as an essential component of motivating students to improve their performance rather than an impediment to success.

This value of teachers' attitudes in their teaching practices is consistent with Richardson's (1996) assertion that teacher attitudes are essential factors affecting the teaching and learning process. Similarly, Wilmot and Otchey (2012) believe that fostering a positive attitude toward error handling must be emphasized because it affects students' academic progress.

Numerous studies demonstrate that students have positive attitudes toward their teachers' handling of classroom errors (e.g., Kavaliauskiene & Anusiene, 2012; Zhu, 2010). According to Zhu (2010), the students believe they can learn a lot from their mistakes and prefer that their teachers address every inaccuracy since it helps them learn in class. It contradicts the findings of Bargiel-Matusiewicz and Bargiel-Firlit (2009), who claim that some students equate making errors with guilt and hence employ a prevention technique to avoid ridicule when they make one. This is one of the reasons why some teachers are reluctant to error correction, fearing that explicit correction will erode their students' self-confidence (Shi, 2017).

Relationships between mathematics teachers' attributes and their practices, beliefs, and attitudes in handling students' errors

Based on the survey results, 33.98% of the respondents were male, and 66.02% were female. Their average age is 38, the oldest is 68, and the youngest is 22. On average, their years of teaching mathematics correspond to 10 years, with the highest year of 34 and the lowest year of 1. Most of the respondents have units in Master of Arts in Education (48.51%), and it is followed by a bachelor's degree (38.37%), a graduate of Master of Arts in Education (12.87%), and a unit with Doctorate (1%). About 81.37% of respondents are math majors, and only 18.63% are non-math majors. Specific courses for non-math majors are BS Commercial Science Major in Accountancy (1), BS Accountancy (1), BS Engineering (8), BS Environmental Science (1), BS Industrial Education (1), BS Mathematics (3), BS in Agricultural Education (1), BSC Management (1), BS Physics (1), and BS in Information Technology (1). In terms of training and seminar attended for the last three years, 37 respondents attended a seminar on classroom management, 39 attended seminar on critical content in Mathematics, and 26 attended a seminar on teaching strategies.. The seminar and training hours average 42.8 hours, with 8 hours the lowest and 288 hours the highest.

The study used the Canonical Correlation Analysis (CCA) to investigate the relationships between teachers' practices, beliefs, and attitudes in handling students' errors and their attributes such as age, gender, number of years in teaching mathematics, educational attainment, specialization, and training attended.

The CCA is performed between the two variable sets. The first set of variables are respondents' attributes, such as age, sex, field of specialization, no. of years in teaching mathematics, highest educational attainment, and seminars attended. The second set of variables consists of respondents' practices, beliefs, and attitudes towards handling students' errors. According to Sherry and Henson (2005), the total number of canonical functions equals the total number of variables in the smaller variable set. So, six canonical functions were generated because the first set had only six dimensions. The CCA is presented in Table 7.

The significant contributions of each variable to a given canonical correlation were gauged using the standardized canonical coefficients. Using the cut-off correlation variable loading of .30, the researcher was able to identify the significant contributing variables in the canonical function.

Table 7. Canonical correlation analysis

Variables	
Attributes (Set 1)	
Age	.701
No. of Years in Teaching Mathematics	.338
Beliefs, Attitudes, and Practices (Set 2)	
Belief 3: Students' errors are considered essential components in the learning process	.495
Belief 4: Individual correction of students' errors in their written tasks is significant	-.650
Belief 5: Students' errors are teachable moments	-.535
Belief 9: Error-tolerant classroom is a learning environment that accepts students' errors	.410
Belief 10: Investigation of error patterns in students' works is crucial in the teaching-learning process	.425
Attitude 1: Constructive feedbacking of errors motivates the students to perform better	-.356
Attitude 3: Appropriate remediation is necessary to respond to a particular type of error	.411
Error Detection 4: I record the incorrect responses of my students to analyze error patterns	.431
Error Correction 5: I encourage my students to discover their errors	-.543
Error Correction 6: I make use of constructive conversations in class when my students display procedural and conceptual errors	.442
Error Prevention 10: I connect the topic to real-world situations to make sure that my students have a complete grasp of the lesson	-.305
Error Prevention 13: I incorporate an error checklist into the regular classroom routines and procedures to let the students identify frequent errors in their works	-.600

Wilk's λ=.00162
F (324, 206) = 1.23
p = .05
CV – 1 = .74838 (99.8%)
R_c = .890
R_c^2 = .793 (79.3%)

Only fourteen variables with significant loading values explained 99.8% of the variance shared by the variable sets (CV – 1 = .998). The results of Table 12 show the correlated variables for each set of dependent and independent variables. Being older (.701) and having more years of teaching mathematics (.338) were both related to a rise in the beliefs that *students' mistakes are considered important components in the learning process* (.495),that *error-tolerant classroom is a learning environment that accepts students' errors* (.410), and that *investigation of error patterns in students' works is crucial in the teaching-learning process* (.425); decrease beliefs that *individual correction of students' errors in their written tasks is significant* (-.650) and that students' errors are teachable moments (-.535); escalate the attitudes that *appropriate remediation is necessary to respond to a particular type of error* (.411); reduce positive attitudes that *constructive feed backing of errors motivates the students to perform better* (-.356); accelerate error-tolerant practices in class such as *record the incorrect responses of the students to analyze error patterns* (.431) and *make use of constructive conversations in class when the students display procedural and conceptual*(.442); reduce the frequency of error-handling practices execution, such as *encourage the students to discover their errors* (-.543), *connect the topic to real-world situations to make sure that the students have a complete grasp of the lesson* (-.305), and *incorporate an error checklist into the regular classroom routines and procedures to let the students identify frequent errors in their* (-.600).

Based on the findings, most respondents are young and are just getting started in the service. The majority of them have a bachelor's degree, and most are women. Almost all of the respondents are math majors, and the others have completed their courses specifically related to mathematics. The findings also showed that all seminars concentrated on general topics, and no seminar focused on error handling. The CCA model further revealed that respondents' attributes are significant factors contributing to their practices, beliefs, and attitudes in error handling. This indicates that teachers' attributes play a vital role in the educational process (Rice, 2003; Rahman et al., 2011).

However, the findings show that the variables sex, level of education, the field of specialization, and seminars attended have the least effect on canonical correlation coefficients. Master's degrees have no discernible impact on secondary school teachers' ability to be effective (Anthony et al., 2019), and even if the quality of teachers was high in terms of academic and professional qualifications, it did not reflect much on the students' performance (Bonney et al., 2015). Specialization is not a significant factor since non-math major respondents have taken math-related courses. Additionally, the seminar and training are not major contributory factors in the association, as much of the training offered is general, and there is no seminar conducted that focuses mainly on error-handling. According to OECD (2009), although the time spent in training is essential, the type of training matters more. It is considered that particular forms of professional development, such as mentorship and networking for professional development, enable teachers to learn modern and multifaceted teaching practices (OECD, 2009; Morallo & Abay, 2019).

In addition, it is noted that some practices, beliefs, and attitudes have been found to reduce error handling as respondents get older and gain teaching experience in Mathematics. This remarkable result demonstrates how teachers appear to depart from the significant contribution of error-tolerant mathematics classrooms as they get older and gain more teaching experience.

CONCLUSION

With the study's findings, it can be concluded that the respondents' error handling practices usually come in three stages: error detection, error correction, and error prevention, which proves that they are competent in handling students' errors based on the Professional Error Competence Model. The findings suggest that these practices are influenced by their beliefs and attitudes toward error handling. Additionally, respondents express favorable attitudes and beliefs about the inherent benefits of classroom errors. However, the findings show that respondents are still ambivalent about correcting students' errors out of fear of embarrassment, which they believe would decrease self-confidence. This is an indication that some view errors as impediments to learning. Therefore, it is necessary to foster positive attitudes among teachers and demonstrate that errors can serve as opportunities for learning rather than as impediments to the learning process.

In light of its findings, the study recommends that teacher training programs and benchmarking activities may be done to emphasize the importance of appropriately handling students' errors and help teachers create error-tolerant mathematics classrooms that provide significant learning opportunities. Content detailing high school students' most common math errors may be incorporated into teacher preparation courses and graduate programs. By exposing future teachers to common classroom errors, they can develop effective preventive strategies. The manner teachers deal with errors in an online learning environment may be investigated and explored. Additionally, future researchers may determine whether students and teachers share similar perspectives about handling math errors. They may also examine the mediation effects between students' performance and teachers' practices, beliefs, and attitudes regarding handling errors.

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