MATH TALK MATTERS: INTERRELATIONSHIPS OF CLASSROOM TALK CATEGORIES IN HIGH SCHOOL MATH CLASSES OF BUKIDNON

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ABSTRACT: *Effective classroom talk facilitates teaching and learning, particularly in high school mathematics classrooms. As teachers use this technique anytime in class discussion, it is imperative to understand and explore the nature of relationships of the types of classroom talk that occur in secondary classes. This study determined and examined the frequency of usage and interrelationships of categories of classroom talk of mathematics teachers as perceived by students in the province of Bukidnon. The participants of this correlational study were 1,638 Grade 9 students taking up Mathematics 9 subject. Results showed that mathematics teachers use the performative type of talk most frequently. Furthermore, a procedural talk usually follows it, and lastly, conceptual talk is the least used type of talk in classroom discourse. Moreover, the different categories of talk exhibited a moderate positive relationship. This study recommends future research to explore the relationship between different categories of talk with other factors, such as students' performance and engagement in the classroom, by using advanced statistical tools. Additionally, it is recommended that a mixed-method approach be employed to explore classroom talk from different perspectives, such as classroom observation and interviews.*

Keywords: *classroom talk; questioning; mathematics classes; Bukidnon; correlational study*

I. INTRODUCTION

Effective classroom talk is crucial in facilitating learning, particularly in mathematics education, where it heavily relies on the teacher's ability to ask high-quality questions and conduct questioning activities skillfully [1]. Teachers who are proficient in high-quality questioning techniques foster deeper student engagement, encourage critical thinking skills, and aid in understanding the material [2].

Research shows that appropriately utilizing questioning techniques increases student motivation and engagement in the classroom. Moreover, skillfully used questioning techniques create productive learning experiences for both teachers and students, leading to more significant critical thinking and understanding of the subject matter [3, 4].

While lower-order questions may not fully promote critical thinking abilities in students [5], many teachers tend to use them frequently when teaching mathematics [6]. Nonetheless, it is essential to recognize that lower-order questions can act as building blocks for higher-order questions. By using lower-order questions as a foundation, educators can skillfully incorporate higher-order questioning techniques into their teaching practices to promote deeper learning and cognitive growth among their students. Further, earlier research studies have attempted to sort classroom talk and questions by various methods, including the dualistic approach that divides questions into two categories [7,8]; the categorical approach that organizes questions into multiple classifications [9,10,11,12]; and the hierarchical approach that arranges questions based on their complexity [13]. These studies have primarily aimed to identify and classify different types of questions, rather than exploring the relationships between them. As a result, there is a need to dig deeper and explore the interrelationships among categories of talk in mathematics classes, particularly in Bukidnon.

The present study aims to ascertain the interrelationship of the different types of talks and questions in mathematics classes in Bukidnon to understand better how classroom talk can be used effectively to facilitate student learning and understanding of mathematical concepts. Furthermore, this study also offers additional perspectives on whether lower-level questions stimulate other forms of classroom talk that could improve students' ability in mathematics classes [14], especially in the context of Bukidnon.

Exploring the interrelationship of classroom talk could provide valuable insights into the existing underlying structure of the classroom discussion that would lead to effective teaching practices and thoughtful utilization of different questions in the classroom, which can provide students with various possibilities to enhance their mathematical reasoning and encourage their involvement [15].

Classroom Talk

Classroom talk is a multifaceted phenomenon that involves various types of discussion between teachers and students. Table 1 presents different categories of classroom talk based on their unique features and functions, including the dualistic, categorical, and hierarchical approaches. By recognizing these various types of discourse, educators can develop learning activities that foster effective communication and interaction in the classroom. Moreover, it is worth noting that some of these categories of talk from different authors have similarities and connections that overlap with one another, despite having different names and category levels. These similarities and connections suggest that there may be underlying principles or structures that govern classroom talk, regardless of how it is categorized or labeled.

Table 1. Categories of Classroom Talk

Authors	Categories of Classroom Talk
Dualistic	
Woolfolk (1998) [5]	*1. Convergent* *2. Divergent*
Scott, Mortimer, and Aguilar (2006) [6]	*1. Authoritative* *2. Dialogic*
Categorical	
Cunningham (1987) [7]	*1. Factual recall* *2. Conceptual questions* ***3.** Evaluative questions*
Barnes (1990) [8]	*1. Factual* *2. Reasoning* *3. Open*
Alexander (2010) [9]	*1. Rote* *2. Recitation* *3. Instruction/Exposition* *4. Discussion* *5. Dialogue*
Mercer & Wegerif (1999) [10]	*1. Disputational Talk* *2. Cumulative Talk* *3. Exploratory Talk*
Hogan et al. (2012) [14]	*1. Performative Talk* *2. Procedural Talk* *3. Conceptual Talk*
Heirarchical	
Anderson and Krathwohl (2001) [11]	*1. Remembering* *2. Understanding* *3. Applying* *4. Analyzing* *5. Evaluating* *6. Creating*

The categories of classroom talk adopted from Hogan et al. [14] were chosen for this study to classify different talks in high school mathematics classes. The researcher considered several reasons for the selection of these categories: (i) they reflect different levels of thinking [14], (ii) they have been used in previous studies [16,17], (iii) they capture essential aspects of classroom talk [14], and (iv) align with standard classroom practices. Moreover, the following definitions were adopted: *Performative talk* is a classroom discourse that centers on the teacher's use of closed-ended questions to assess students' understanding of a particular topic or concept and on students' attempts to provide the correct response. *Procedural talk* refers to the statements used by teachers in the classroom to discuss and clarify the procedures, rules, and steps involved in completing a task or activity. *Conceptual talk* in the mathematics classroom was categorized into four different types: explanatory, clarifying, connecting, and epistemic talk. *Clarifying talk* focuses on helping students understand new concepts or clarify confusing ideas. *Connecting talk* helps students connect new information to prior knowledge or experiences. It can also help students see how different mathematical concepts are related. The explanatory talk is used to provide detailed explanations of concepts or processes. It may involve breaking down complex ideas into smaller parts and ideas. *Epistemic talk* encourages students to think critically about how they know what they know. It also involves synthesizing ideas to verify or validate student claims [14,16,17].

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II. METHODS

Research Design

This study employed a correlational research design. Correlational research is designed to explore and understand the relationship between two or more variables. It is used to identify potential cause-and-effect relationships or to make predictions about future outcomes based on the observed patterns of variation [18]. This design is appropriate to answer the research questions by describing and interpreting the level and interrelationships of categories of classroom talk in high school mathematics classes in the Province of Bukidnon.

Locale of the Study

This research was conducted in secondary schools in the province of Bukidnon. The province has a total land area of 10,498.59 square kilometers and comprises 20 municipalities and two component cities, Valencia and Malaybalay [19]. Also, it has three (3) Department of Education (DepEd) divisions: Division of Bukidnon, Division of Malaybalay City, and Division of Valencia City.

Research Participants

The study participants were the 1638 grade 9 students taking up Mathematics 9 subject in secondary schools in Bukidnon. The researcher used stratified random sampling to ensure fair distribution and representation from each division. Among the 1638 participants, the following is the breakdown of the number of participants by division: 567 from the Division of Bukidnon, 616 from the Division of Malaybalay City, and 455 from the Division of Valencia City.

Research Instrument

The study adopted the Mathematics Classroom Talk Instrument developed by [14], using a scale consisting of 5 points ranging from 1 (Never) to 5 (Always). It measures how frequently the given item/question is implemented and utilized by the mathematics teacher in a class to initiate an interaction between the teacher and students. The instrument was modified and underwent a validity and reliability analysis. Four (4) experts in mathematics education were consulted to validate the modified instrument, which resulted in the final instrument having 27 items in total divided into the categories of talk, namely: four (4) items for performative talk, four (4) items for procedural talk, and 19 items for the conceptual talk which has three subcategories [five (5) items for explanatory talk, four (4) items for clarifying talk, four (4) items for connecting talk, and six (6) items for epistemic talk]. Afterward, the researcher administered the instrument through reliability analysis for each category and the whole instrument. The internal consistency analysis reflected a Cronbach alpha value presented by category: Performative Talk (0.75), Procedural Talk (0.81), Explanatory Talk (0.84), Clarifying Talk (0.71), Connecting Talk (0.74) and Epistemic Talk (0.77). The instrument used in the study demonstrated a high level of reliability, with a Cronbach's alpha value of 0.92.

Data Gathering Procedure

A permission letter was sent to the Schools Division Superintendent of the three (3) divisions and to the principals of the target schools where the data were collected and administered. Moreover, a consent form to the participants was distributed to ensure voluntary participation, explaining the risks, benefits, purpose, confidentiality, and data privacy protection following the Data Privacy Act of 2012. Moreover, upon obtaining permission, the researcher facilitated the data collection process to assist the participants in completing the survey questionnaire. The participants were instructed to assess how often teachers present or utilize the question in their mathematics classes. The data was gathered face-to-face; hence, the researcher conducted the instrument by reading each statement aloud to the participants and translating/rephrasing it to the vernacular for better comprehension, giving enough time for the participants to answer and review their responses before collecting the instrument.

Data Analysis

The data underwent data screening and cleaning to achieve assumptions for correlational analysis. Responses with issues in normality, missing values, multivariate outliers, single response *(standard deviation=0)*, and obvious patterned answers were deleted. The data were analyzed using the following statistical tools: mean and standard deviation were utilized to assess the frequency of utilization of various categories of classroom talk in high school mathematics classes in Bukidnon. This measures which category of classroom talk is the most frequently used by the high school mathematics teacher in the province. Moreover, a Pearson-Moment Correlation Coefficient was used to ascertain the level of interrelationships among the categories of classroom talk. This is evaluated to determine if the different types of talk do or do not correlate with each other in their uses in mathematics classes.

III. RESULTS AND DISCUSSION

Mean Scores of Categories of Classroom Talk

Table 2 presents each category's mean and standard deviation arranged in descending order through their mean scores. The descriptive statistics revealed that among the three broad categories of classroom talk, the performative questions are the most prevalent in secondary mathematics classes in Bukidnon, reflected by the mean of 3.80 and standard deviation of 1.15. Procedural questions follow that, with a mean of 3.58 and a standard deviation of 1.13, which is also more recurrent than the conceptual types of talk, with a mean score of 3.19 and a standard deviation of 1.16. It indicates that performative and procedural talk are the statements used to start discussions in mathematics classrooms, and teachers tend to use them frequently over conceptual ones.

Besides, among the subcategories of conceptual talk, connecting talk has the highest mean of 3.32, with a standard deviation of 1.16, followed by clarifying talk and epistemic talk, with a mean of 3.23 and 3.21, respectively—lastly, explanatory talk with a mean of 2.99 and a standard deviation of 1.17.

Table 2. Mean scores of the usage of Categories of Talk in High School Mathematics Classes in Bukidnon

Categories	Mean	SD
Performative	3.80	1.15
Procedural	3.58	1.13
Conceptual	3.19	1.15
-Connecting	3.32	1.13
-Clarifying	3.23	1.16
-Epistemic	3.21	1.16
-Explanatory	2.99	1.17

The previous result aligns with Table 3, as the two questions under the category of performative talk, "What is the solution to this problem? (4.20)", and " Is this answer correct or incorrect? (3.85)", have the highest means among the set of questions in the instrument.

Table 3. Mean scores of each indicator of Categories of Classroom talk

	Questions	Type	Mean	SD
1.	What is the solution to this problem?	PE	4.20	1.04
2.	Is this answer correct or incorrect?	PE	3.85	1.11
3.	How would you prove that your answer is correct?	EP	3.81	1.13
4.	What is the next logical step to solve this problem?	PR	3.63	1.13
5.	Is this statement true or false?	PE	3.61	1.22
6.	How did you know that this solution is correct?	PR	3.57	1.15
7.	How did you come up with that answer?	PR	3.55	1.09
8.	What is the best way to solve this problem?	PR	3.55	1.14
9.	What ideas have you learned before that helped solve this problem?	CO	3.54	1.16
10.	Do you think the answer is logical?	PE	3.52	1.24
11.	What is this concept's relation to the other mathematics topics?	CO	3.44	1.20
12.	What makes this formula accurate?	EP	3.41	1.12
13.	How would you describe the problem in your own words?	CL	3.29	1.15
14.	Could you explain what you mean?	CL	3.27	1.13
15.	Could you give us details on what you are trying to imply?	CL	3.27	1.17
16.	What makes your idea correct/wrong?	EP	3.26	1.14
17.	How is this idea similar or different from the other?	CO	3.24	1.12
18.	How would you know whether that is true or not?	EX	3.19	1.13
19.	Is that true for all cases? Explain.	EP	3.11	1.23
20.	What do you mean?	CL	3.09	1.19
21.	How good an explanation is that?	EX	3.08	1.22
22.	How can you use this concept in the other topic/subject?	CO	3.07	1.18
23.	Can you give me reasons for why you think that way?	EX	3.02	1.20
24.	Can you elaborate further on what you mean?	EX	2.95	1.13
25.	Can you think of a counterexample?	EP	2.85	1.12
26.	What assumptions are necessary?	EP	2.84	1.21
27.	What makes this a reasonable guess?	EX	2.69	1.16
28.				

Legend: PE: Performative PR: Procedural EX: Explanatory
CL: Clarifying CO: Connecting EP: Epistemic

The result suggests that teachers often use questioning strategies to assess students' comprehension of the topic, method, and correct solution to a given problem or scenario. Moreover, when the teacher poses a problem (solving equations, identifying patterns, finding the value of a variable) to the students, they initiate the classroom talk by asking questions in the performative category, such as asking what the right value is or correct solution of the given problem and verifying the answer of the student whether it is right or wrong. The results were consistent with the findings of [14,16,17], which concluded that when it comes to teacher questioning in mathematics classes, performative talk is the most used form, surpassing other categories.

Further, the result supported the findings of Monteiro et al. [20], which established that teachers mainly initiated the conversations in the mathematics classroom, asking questions with specific answers already known by the students. These questions mainly required factual responses and resulted in feedback focused on the task or problems being solved.

Also, all indicators under the procedural talk belong to the first eight highest means in Table 3, "What is the next logical step to solve this problem? (3.63)", "How did you know that this solution is correct? (3.57)", "How did you come up with that answer? (3.55)" and What do you think is the best way to solve this problem? (3.55)". It implies that apart from a performative talk, procedural types of talk are also common and frequently used type of categories of talk in mathematics discussion. Usually, a teacher follows up the performative talk by asking the students about the process or how they solve the given problem, inquiring about what method is appropriate or being used to get the correct solution to the problem. The study's results corroborated with Chan's [16] findings, where performative questions were commonly succeeded by a coherent pattern of procedural questions that encouraged student discussions.

Asking questions that engage thinking and reasoning by the students is seldom used by mathematics teachers in discussions compared to performative and procedural types of talk. The items with lower means are the statements "Can you think of a counterexample? Explain. (3.11)", "What assumptions are necessary? (2.84)," and lastly, "What makes this a reasonable guess? (2.69)". The study of Mahmud et al. [21] supported the findings, concluding that teachers infrequently utilize open-ended questioning or questions to promote critical thinking and reflection. In addition, this corroborates with the study, which found that there needs to be higher-order questioning in many classrooms, which requires students to engage in critical thinking and problem-solving [22].

Relationship among the Categories of Classroom Talk

Table 4 presents the correlation matrix among the categories of classroom talk in high school mathematics classes in Bukidnon. There is a moderate positive correlation between the categories of classroom talk, with a correlation coefficient value ranging from 0.403 to 0.618. Additionally, all correlation values between variables are highly significant at the 0.01 level of confidence. This implies that as one category of talk increases or is used in the classroom; the other categories also tend to increase. This suggests that the high covariance between the categories of the talk follows a strong relationship among them, indicating that they work hand in hand in the classroom discussion.

Table 4. Correlation Matrix of the Broad Categories of Classroom Talk

	PE	PR	CL	EX	CO	EP
PE	1					
PR	0.518**	1				
CL	0.436**	0.453**	1			
EX	0.413**	0.481**	0.580**	1		
CO	0.403**	0.447**	0.513**	0.540**	1	
EP	0.485**	0.445**	0.592**	0.618**	0.580**	1

**significant at 0.01 level

Legend: PE: *Performative* PR: *Procedural* EX: *Explanatory* CL: *Clarifying* CO: *Connecting* EP: *Epistemic*

In other words, teachers do not exclusively rely on one type of question or mode of discourse when teaching mathematics. Instead, they use various types of questions to promote learning and implement their subject matter in the classroom.

The result of this study aligns with the findings, which state that the forms of talk are complementary and not orthogonal in achieving successful learning outcomes [14]. Studies have demonstrated that incorporating diverse forms of classroom discourse, such as open-ended and closed questions and discussions led by students, can positively impact the quality of teaching and learning in mathematics classes [23,24]. Likewise, as argued that providing answers tends to stimulate additional questions and is viewed as a stepping stone to further dialogue rather than the endpoint of the conversation; thus, in a learning environment, the interactions between teachers, students, and peers are woven into logical and connected lines of inquiry rather than being isolated and disconnected [25].

IV. CONCLUSION & RECOMMENDATIONS

Among the categories of classroom talk, performative talk is the most frequently used by mathematics teachers, followed by procedural as a building block towards conceptual talk. Henceforth, it leads that these different categories of talk are positively interrelated with each other implying that teachers use these types of questions in implementing their classroom discussion. These types of questions work hand-in-hand to provide opportunities for the students to create a discussion-based classroom to share ideas and insights about mathematics lessons.

Although the correlation or degree of association between categories of classroom talk is significant, it does not provide information on the exact causal paths and links between them. Hence, more advanced statistical analyses are required to investigate the predictive potential of these talk categories

concerning other factors. Future research endeavors are recommended to explore the mainstream of talk in mathematics classes through qualitative and quantitative findings to develop a stable relationship among these categories of talk associated with other factors, such as students' performance and engagement. A more comprehensive exploration of the implementation of classroom talk in high school mathematics lessons in the province is suggested through classroom observations and interviews.

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