

Moderating Effect of Self-Confidence Between General Communication and Mathematics Communication Skills

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ABSTRACT

This study investigated the interplay between general communication skills (GCS), mathematics communication skills (MCS), and self-confidence in mathematics (SCM) among Bachelor of Secondary Education major in Mathematics (BSEd-Math) students in the Philippines. Utilizing a quantitative, descriptive-correlational design, data were obtained from 104 BSEd-Math students at the University of Mindanao through convenience sampling. Spearman's Rank Correlation Coefficient and regression analysis were employed to examine the relationships among the variables and to assess the potential moderating role of SCM. Findings indicate a non-significant correlation between GCS and MCS, suggesting the need for targeted pedagogical interventions to enhance mathematical communication skills among prospective mathematics educators. Moreover, SCM did not significantly moderate the relationship between GCS and MCS. These results emphasize the critical role of fostering both communication proficiency and mathematics confidence as integral components of teacher preparation. The study's implications extend to instructional practice, highlighting the importance of interventions designed to strengthen problem-solving abilities and improve the clarity and precision with which mathematical concepts are conveyed in educational contexts.

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1. INTRODUCTION

Communication in mathematics classrooms has remained underdeveloped, partly attributed to insufficient research that directly addresses the issue. For over 20 years, with the aid of less than 10 articles per year have been published, totaling to only 25 studies from that time frame [1]. In relation to the issue of communication in mathematics itself, an analysis of a comparative study revealed a significant gap in mathematical thinking and communication ability between Filipino and Japanese students. Only 42% of Filipino students could explain their mathematical problem-solving reasoning, in contrast to 83% of Japanese students who used visual representations when solving open-ended questions, highlighting potential differences in teaching methods between Japan and the Philippines [2].

Communication in mathematics is important because it enables students to actively engage in class discussions, share mathematical information, and effectively express their ideas and understanding, ultimately facilitating their learning and comprehension of mathematical concepts. Students need such ability during class discussions as they are required to share, distribute, and exchange information related to the subject [3]. With a proper level of communication ability, students can evaluate and elucidate their mathematical understanding and fluently share their concepts and ideas, whether it be by expression, drawing, or writing [4].

Proficiency-based instructions, when complemented by effective interpersonal communication, can significantly enhance students' capacity to acquire knowledge, improve their skills, and positively shape their attitudes and behaviors [5]. Having proper English communication means that the quality of understanding mathematical vocabulary, spoken or written, increases [6]. The Communication Accommodation Theory posits that individuals adapt their communication behavior, either converging to match their peers' communication styles or diverging to emphasize social differences. In the context of mathematics education, students are likely to improve their mathematical communication skills when teachers simplify complex terms to accommodate their conceptual understanding. Similarly, when students engage in discussions with peers of similar mathematical communication skills, they collaborate to better grasp specific mathematical terms and concepts [7]. The Dunning-Kruger (DK) effect explores how individuals tend to overestimate their social and intellectual abilities, and the tendency wherein self-realization takes place after reflecting on their cognitive incompetence. In the context of the field of mathematics, students are likely to overrate themselves when being asked about their capability in solving and calculating, especially when having low scores or performance, when an assessment takes place [8].

General communication skills are the capabilities that are utilized in terms of sending and receiving various types of information [9]. The acquisition of communication skills holds a significant role in interacting with fellow members of society, whether it would be on a verbal or a non-verbal level [10]. Oral communication is speaking with expressed words, and a verbal type of correspondence where you impart and present your thoughts. [11]. Written communication encompasses the formal transmission of messages, orders, or instructions using written formats like letters, reports, and memos, which not only creates a permanent and legally admissible record but also necessitates clarity, completeness, conciseness, correctness, and courtesy for its effectiveness [12]. Non-verbal communication is the point at which an individual conveys their thoughts, feelings, and state of mind through visual as opposed to verbal signals like looks, eye-to-eye contact, nonverbal cues, manner of speaking, contact, stance, and individual space [13]. Visual communication is the act of utilizing visual components to convey an idea, rouse change, or inspire an inclination, and exists in two sections: communication design and graphic design [14].

The indicators related to mathematics communication encompass various facets. The National Council of Teachers in Mathematics highlights the importance of students managing their mathematical knowledge, coherent expression of mathematical concepts, critical analysis of peers' ideas, and precise use of mathematical language [15]. Written text in mathematics is the ability to conceptualize ideas in a mathematical language, which is a complex process that integrates coherent analysis and cognitive thinking [16]. Drawing in mathematics is the action of integrating tools and applications to create a mathematical model to better understand mathematical terminology. [17]. The use of drawing in the problem-solving scenario impacts the students' extrapolation abilities and overall performance [18]. A mathematical expression is the compilation of symbols, syntax, and semantics in the mathematical language while observing proper usage [19]. Efficiency in mathematics is the ability to interpret mathematical ideas into fruition and is able to reflect a self-assessment on oneself when given math-related tasks [20]. Self-confidence is the ideology that a person can achieve a productive decision on a given situation in the best way feasible with a strong fortitude [21]. Conversely, self-confidence in mathematics may not be one of the factors that can moderate in relation to mathematics performance or comprehension was conducted towards accounting students. Previous findings indicate that the variable in question does not significantly influence satisfactory learning outcomes. This implies that although other factors related to measurable mathematical skills may correlate with learning outcomes or attitudes, self-confidence does not serve as a moderating variable in these relationships [22].

Considering the challenges posed by students' limited understanding and low performance in mathematical communication, this study aims to investigate the relationship between the students' communication skills and their mathematics communication skills while assessing how confidence in mathematics affects the relationship between the two. The researchers present the questions about what the level of the students' general communication skills was in terms of oral communication, written communication, non-verbal communication, and visual communication; what the level of the students' communication skills in mathematics was in terms of written text, drawing, mathematical expression, and efficiency; and what the level of the students' confidence in mathematics is. The researchers hypothesized that the level of students' confidence in mathematics did not influence the communication in mathematics caused by general communication skills.

Moreover, this study seeks to deepen the understanding of students' mathematical communication skills by examining the role of their general communication abilities. Its contribution to knowledge emphasizes the importance of mathematical confidence, which significantly influences students' ability to communicate mathematical ideas and enhances their problem-solving capacities. By providing insights into the interplay between communication and mathematics, the study supports the review and refinement of teaching practices, with implications for improving student learning outcomes and strengthening the overall education system. In addition, it underscores the value of fostering well-rounded individuals equipped with communication skills that extend beyond academic settings. The research also contributes to the pursuit of equitable education by addressing potential barriers and promoting inclusivity. Ultimately, the findings are expected to inform educational policy and curriculum design, advancing the goal of creating mathematically literate and productive students.

2. METHOD

2.1 Research Respondents

The respondents of the study were Bachelor of Secondary Education major in Mathematics (BSEd-Math) students from the University of Mindanao. A total of 104 out of 142 BSEd-Math students were able to participate in the study. Participation was voluntary, with students free to withdraw at any time. Convenience sampling was employed, as the selection of respondents depended on accessibility, availability, and reach [23]. This approach was deemed appropriate since students had varying schedules, making on-the-spot participation the most feasible method for data collection, while also recognizing that such sampling applies to a specific group rather than a generalized population [24].

2.2 Research Instruments

The instruments used in this study consisted of two adopted survey questionnaires and a five-item problem-solving questionnaire. Both survey questionnaires demonstrated good internal consistency, with reliability analysis yielding a Cronbach's alpha of 0.83. The problem-solving questionnaire underwent expert validation, receiving an overall mean rating of 4.0 out of 5, and was pilot tested with non-BSEd Mathematics students to ensure clarity and applicability.

The first adopted instrument measured students' general communication skills through a 27-item questionnaire and was quantified on a 5-point Likert scale format, ranging from Strongly Agree to Strongly Disagree [25]. The items in the instrument were categorized into four domains: oral communication with 10 items, written communication with 7 items, non-verbal communication with 5 items, and visual communication with 5 items. The scores were interpreted according to three levels, namely low (0.00 to 1.67), average (1.68 to 3.34), and good (3.35 to 5.00) communication skills [26].

The second instrument measured students' communication skills in mathematics through an adapted test questionnaire designed in a problem-solving format [27]. Students were tasked to answer open-ended mathematics problems. The test consisted of five items evaluated across four indicators,

namely written text (0.00–4.00), drawing or symbolic representation (0.00–2.00), mathematical expression (0.00–2.00), and efficiency of the conclusion (0.00–2.00). Each indicator was assessed based on a rubric, ranging from no response to a complete and correct representation of the solution.

The third instrument measured students' confidence in mathematics using a 21-item questionnaire on a 5-point Likert scale, ranging from Strongly Agree to Strongly Disagree [28]. Responses were interpreted across three levels, namely low confidence if the mean score is below 1.67, moderate confidence if the mean score ranges from 1.68 to 3.34, and high confidence if the mean score ranges from 3.35 to 5.00.

2.3 Research Design and Procedures

This study utilized a quantitative descriptive correlational design with moderation analysis. The correlational component examined the relationship between students' communication skills and mathematics communication, while mathematics confidence was tested as a moderating variable [29]. In this framework, the moderating variable serves as a determinant of the strength of association between the independent and dependent variables, with regression analysis used to test the moderating effects [30].

Prior to data collection, approval was secured from the college dean. The researchers then visited classrooms within the college building during vacant periods and invited BSEd-Mathematics students to participate. Interested students received a questionnaire accompanied by an informed consent letter. Respondents were asked to provide basic demographic details to confirm eligibility. Participation was voluntary, and respondents were free to seek clarification on any questionnaire item. Completed forms were collected immediately, and respondents were thanked for their cooperation. Confidentiality of personal information was assured, with all data used solely for research purposes.

The statistical tools employed in the analysis included mean, standard deviation, Spearman's rank correlation coefficient, and regression analysis. These were used to describe the data, examine the strength of associations, and test the moderating effect of confidence in mathematics.

3. RESULTS AND DISCUSSION

Level of General Communication Skills

Table 1 presents the level of general communication skills of BSEd-Math students per indicator. Additionally, the section also further investigated the attributes of the collected data, such as the indicator with the highest value, and described each indicator based on its quantifiers.

Table 1. Level of General Communication Skills of BSEd – Math Students

Indicator	Mean	Standard Deviation
<i>Oral Communication (OC)</i>	3.69	0.54
<i>Written Communication (WC)</i>	3.59	0.66
<i>Non-Verbal Communication (NVC)</i>	3.93	0.76
<i>Verbal Communication (VC)</i>	4.00	0.71
General Communication Skills (GCS)	3.80	0.56

Drawing from the data presented in Table 1, the total mean of students' General Communication Skills was 3.8, with a standard deviation of 0.56, indicating that students have good communication skills in all categories, with Verbal Communication getting the highest mean. Additionally, low scores were rarely selected by students for their General Communication Skills, given by the low standard deviation, which implied that few students observed themselves having

low communication skills. The following level of mean score suggested that students' essential attribute in any setting is a good general communication level [31]. These results align with Pratiwi et al [32], who conducted a descriptive study applying the commognitive framework, found that students with stronger communication skills were more effective at expressing algebraic ideas, indicating a direct link between communication proficiency and conceptual mathematical reasoning.

In observation for each individual indicator, the data implied that in terms of Oral Communication, Written Communication, and Non-verbal Communication, students have observed the statements per indicator in the questionnaire between 5 and 9 times. With the exception of Verbal Communication, where students observed the statements between 7 to 9 out of 10 situations, which was higher than the other indicators. The following observation for Verbal Communication being the highest average of 4.00 implied that Verbal Communication played a very significant role in many assessments in classrooms and social environments, as it is an essential key tool for education students [33]. In addition, the lowest mean score was Written Communication at 3.59, which implied that poor understanding of English writing, such as guidelines and grammatical rules, could be a hindrance to the students, albeit slightly significant compared to the other indicators [34].

Level of Mathematics Communication Skills

Table 2 presents the level of mathematics communication skills of BSEd-Math students, which is categorized into four, namely Mathematical Expression, Written Text, Drawing, and Efficiency. The total mean for the overall score of the students was interpreted to determine the level of Mathematics Communication Skills in general.

Table 2. Level of Mathematics Communication Skills of BSEd – Math Students

Indicators	Mean	Standard Deviation
<i>Mathematical Expression (ME)</i>	0.56	0.48
<i>Written Text (WT)</i>	0.61	0.48
<i>Drawing (D)</i>	0.68	0.71
<i>Efficiency (E)</i>	0.55	0.47
Mathematics Communication Skills (MCS)	0.60	0.51

Drawing from Table 2, a total mean score of 0.60 showed that students' scores did not satisfy the passing grade of the 5-item quiz. Additionally, the students performed very poorly across each indicator of Mathematics Communication Skills, although some managed to achieve satisfactory scores on the 5-item quiz. The following data suggest that most students did not attain high scores per rubric, indicating poor performance in Mathematics Communication Skills. Contributing factors included poor computational abilities, infrequent use of didactic approaches, and low utilization of inferences [35].

The mean data for each indicator in Table 2 reflects the students' struggles with solving problems based on the provided rubrics. For Mathematical Expression, a mean of 0.56, and for Written Text, a mean of 0.61, imply difficulties in problem comprehension and in the transformation and transcription of solutions on paper. For Drawing, a mean of 0.68 indicates that students did not support their solutions with comprehensive visualizations that could better represent their unknowns. For Efficiency, a mean of 0.55 suggests that students did not properly conclude their solutions or provide a single coherent context for their conclusions. The findings coincide with the study of Wahab et al. [36], whose study revealed that students encounter distinct challenges across all stages of problem-solving, ranging from motivational and literacy issues to misconceptions, procedural errors, and inadequate evaluation of the mathematical problems.

Level of Self-Confidence in Mathematics

Table 3 details the level of self-confidence in Mathematics of BSEd-Math students. The variable determined whether their confidence was at a low, mid, or high level by obtaining the mean of all the statements in the questionnaire. The standard deviation determined how variable the students' responses were.

Table 3. Level of Self-Confidence in Mathematics of BSEd – Math Students

	Mean	Standard Deviation
<i>Self-Confidence in Mathematics (SCM)</i>	3.79	0.50

Drawing from Table 3, the overall level of self-confidence in Mathematics, with a mean score of 3.79 and a standard deviation of 0.50, indicated a high level of confidence. The mean score suggested that students generally had high confidence when confronted with mathematical situations, both in practical and theoretical contexts. The low standard deviation showed that students' responses were relatively consistent, indicating general agreement or similar thoughts regarding the statements. Additionally, students demonstrated efficient critical thinking and problem-solving skills in challenging situations [37].

The total mean and standard deviation of the students' self-confidence in Mathematics were shown. The maximum score for all of the items was 5.00, which means all students marked a 5 on at least one of the 21 statements in the part of the questionnaire. The highest level of confidence of all of the statements, being 4.70, was item 1, which stated that "I want to develop my mathematical skills," indicating that students felt constant eagerness to move forward or refine their current mathematical skills, which is observed as a positive attitude towards Mathematics [38]. While the lowest level with a mean of 3.25 was item 14, which stated that "I can feel a sense of insecurity when attempting mathematics," which implied that students did not have anxiety in mathematical problems, as education students. These findings reinforce the conclusions of Odiri [39], whose study revealed that students' confidence in their capability in mathematics influences their ability to do mathematics.

Relationship between GCS and MCS

Table 4 presents the correlation between GCS and MCS across various indicators. Each cell in the table displays the correlation coefficient at the top and the significance value at the bottom. The format allowed for an understanding of how each indicator of GCS relates to the corresponding indicator of MCS.

The data were not normally distributed, so Spearman's Rank Correlation Coefficient was used to analyze the monotonic relationship between GCS and MCS, rather than the linear relationship that Pearson's Correlation Coefficient would observe [40].

Table 4. Relationship between General Communication Skills and Mathematics Communication Skills

		ME	WT	D	E	MCS
OC	<i>Correlation coefficient</i>	-0.01	-0.003	-0.03	0.13	-0.003
	<i>Sig. (2-tailed)</i>	0.89	0.98	0.76	0.89	0.97
WC	<i>Correlation coefficient</i>	0.10	0.13	0.04	0.15	0.11
	<i>Sig. (2-tailed)</i>	0.35	0.18	0.68	0.12	0.29
NVC	<i>Correlation coefficient</i>	0.10	0.13	0.09	0.18	0.14
	<i>Sig. (2-tailed)</i>	0.30	0.18	0.37	0.06	0.16
VC	<i>Correlation coefficient</i>	0.07	0.07	0.06	0.03	0.08

GCS	<i>Sig. (2-tailed)</i>	0.48	0.49	0.57	0.77	0.44
	<i>Correlation coefficient</i>	0.07	0.09	0.03	0.12	0.09
	<i>Sig. (2-tailed)</i>	0.49	0.38	0.76	0.22	0.37

In the intersection of the exact correlation value between GCS and MCS, there was a correlation coefficient of 0.09 with a p-value of 0.37. According to the Spearman's Rank Correlation Coefficient interpretation table, a coefficient of 0.09 is classified as an insignificant relationship between the two variables [41]. The data implied that there is no significant relationship between GCS and MCS, making it unsuitable for further moderation analysis, which is consistent with prior findings indicating that general communication abilities do not consistently support mathematical communication across all domains [42]

In addition, GCS did not show any pairs of indicators with a significant relationship with MCS, as all p-values were greater than 0.05. It indicated that none of the indicators had a significant impact or major difference in relation to GCS when compared to the different types of Mathematics Communication indicators [43]. While existing literature often demonstrates that general communication skills, such as verbal and non-verbal reasoning, are positively related to mathematical communication and achievement, the evidence does not uniformly support such relationships across all contexts or populations.

Moderating Effect of Confidence in the Relationship between GCS and MCS

Table 5 presents the regression analysis of self-confidence in Mathematics (SCM) as a moderating variable between the relationship of general communication skills (GCS) and Mathematics communication skills (MCS). The significance measured whether SCM predicts the relation between the two variables. R Square and Adjusted R Square determined the variance of GCS, and Significance F change referred to the value of whether CM improved the prediction.

Table 5. Confidence in Mathematics as a Moderating Variable

Model	R	R Square	Adjusted R Square	Significance (p-value)	Change Statistics	
					R Square Change	Sig. F Change
1	0.235	0.055	0.037	0.056	0.06	0.06

The significance or the p-value of the regression table was 0.056, reflecting the average distance between the observed values and the predicted values by the regression model. The change statistics reveal that the R-squared change was 0.06, indicating the increase in explained variance due to the addition of SCM and GCS. In addition, the adjusted R-squared being 0.037, which is lower than the previous R-square, implied that with either of the two values of the regression line, the predictor, in this case, GCS, did not predict or determine the relationship of MCS.

The summary provided a comprehensive overview of the regression model's performance and the extent to which the included predictors contributed to explaining the variance in MCS among the participants, and that students had an overconfidence in their capabilities in problem-solving questions [44]. Overall, the coefficients analysis highlighted that while GCS alone did not significantly predict MCS, it further proved that SCM did not play a significant moderating role in the relationship between GCS and MCS.

4. CONCLUSION

The primary objective of this study was to examine the relationship between general communication skills (GCS) and Mathematics communication skills (MCS) among BSEd–Math students, and to determine whether self-confidence in Mathematics (SCM) moderated this

relationship. Findings revealed that students exhibited consistently high levels of GCS across all indicators, reflecting strong communication competencies in general. However, they encountered notable difficulties in MCS across all dimensions. Despite these challenges, students reported high levels of SCM, suggesting a generally positive disposition toward engaging with mathematical tasks.

Correlation analysis showed only a very weak positive relationship between GCS and MCS, indicating that GCS had little influence on students' mathematics communication. As a result, SCM could not be established as a significant moderator. Regression analysis confirmed that GCS was not a significant predictor of MCS and that SCM did not exert a moderating effect on their relationship. Overall, the findings suggest that while students are confident in mathematics and skilled in general communication, these factors do not directly translate into enhanced mathematics communication skills. This underscored the importance of not only developing strong communication skills but also fostering confidence in mathematical abilities despite the low scores in the learning assessment among BSEd - Math students.

Recommendations include implementing targeted interventions to improve problem-solving strategies, promoting effective written and verbal communication of mathematical concepts, and enhancing students' efficiency in tackling mathematical challenges. Additionally, future researchers could also use a different form of sampling method, as external factors such as time constraints, scheduling, and population contributed to the difference in information gathered among the BSEd – Math students. The researchers also recommend an integration and an intervention program of MCS in the related organization, as it would further develop the students' overall mastery of the mathematics subject. Additionally, the researchers recommend an analysis of the relationship between GCS and MCS alone and conduct a study where SCM is an independent variable to either one of the indicators of both GCS and MCS. Future research may delve deeper into the mechanisms through which SCM influences the relationship between GCS and MCS, potentially informing pedagogical strategies for mathematics education.

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