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Roles of Classroom Management and Mastery-Oriented Instructions on Relationship Between Pedagogical Content Knowledge and Mathematics Achievement

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ABSTRACT

Despite multiple studies in the past, seeking to assess the determinants of students' achievement in mathematics, less attention has been paid to the simultaneous role of classroom management (CM), mastery-oriented instructions, and teacher pedagogical content knowledge (PCK). This study, therefore, looked at the mediation effects of mastery-oriented instructions and CM in the relationship between teacher PCK and students' mathematics achievement. The study was a survey and quantitative. A simple random sampling approach was used to select 401 senior high school students from five schools in the Kumasi Metropolis. A structural equation model was used in analyzing the effect of the relationship between the variables. It was concluded that teacher PCK had a significant relationship with students' mathematics achievement. It also had a significant effect on mastery-oriented instructions and CM. It was revealed that both teacher PCK and CM did not mediate the relationship between teachers' PCK and students' mathematics achievement.

Keywords: classroom management, mastery-oriented instructions, pedagogical content knowledge, mathematics achievement

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INTRODUCTION

Any nation or government that wants to develop starts by providing the right form of education to its citizen. The importance of mathematics in developing a nation cannot be overemphasized. This is the reason why teaching and learning mathematics at all levels of education in any country is very important. Students' success in education cannot be achieved without mathematics achievement. Students' achievement in mathematics is dependent on several factors. Some of these factors are but limited to classroom management (CM), mastery-oriented instructions, and teacher pedagogical content knowledge (PCK).

One construct that has attracted a lot of attention from stakeholders in the education industry in recent years is Teachers' PCK (Odumosu & Fisayi, 2018). The mathematics teachers' PCK is a very important attribute. Students gain an understanding of mathematical concepts by doing. And the teacher's role in guiding the student in this regard would be effective if he has the content and the pedagogical knowledge of the subject. According to Odumosu and Fisayi (2018), students instructed by effective teachers over a continuous year could lead to an increase in their mathematics achievement. Akin et al. (2016) intimated that enough studies have not been done on teachers' PCK in developing countries. To be able to achieve the primary purpose of bringing a fundamental change in learners at all levels, the mathematics teacher is expected to have a high understanding and knowledge of the concept he teaches (Odumosu & Fisayi, 2018).

CM is also an important attribute of a good teacher. A good mathematics teacher possesses the ability and technique of providing a siren and conducive environment for teaching and learning. Effective CM is one-way students' mathematical understanding can be achieved. According to Sekreter (2018), an environment with established behaviors like teachers, students and their relationships, the equipment, materials, and daily activities whose interaction affects the instructional process is referred to as a classroom. Akin et al. (2016) stated that a classroom is an environment that provides emotional and physical security and a cover for learners. However, classroom comes with its situation, functionality, and dynamics that are critical issues to be managed (Zhou & Li, 2015). According to Saifi et al. (2018), the motivation of students in the class, immediate feedback to the students, and constructive criticism improve the students' achievements. Therefore, it is imperative for mathematics educators and researchers to extent of the correlation between CM and students' mathematics achievement.

Research shows that a mastery orientation supports attributes in education like greater engagement, requesting appropriate help, and seeking conceptual understanding (Elliott & Dweck, 2007). Students with believe that effort gives success are not worried about failure (Grant & Dweck, 2003). In the process of learning, the student must be willing to learn, this will motivate the student to accept the more difficult task in the learning of mathematics. Students must be encouraged both internally and externally, with little effort, their performance, skills, understanding, and control of learning mathematics increases. Teachers' role in students' mastery-oriented learning is very critical in mathematics instructions. They are to manifest these approaches in their instructions in the classroom.

Mastery-oriented instruction, CM, and teachers' PCK and their effect on student mathematics achievement have severally been studied across the world (Akin et al., 2016; Elliott & Dweck, 2007; Odumosu & Fisayi, 2018). There have been some studies on the relationship between CM and student mathematics achievement. Researchers have looked into this relationship in different settings using different methods. Strong et al. (2011) used estimated value-added model scores to investigate teachers' PCK on students' ability in reading and mathematics. Another relationship that researchers have looked into most of the time is the relationship between teachers' PCK and students' mathematics achievement. However, what appears not to have been studied much in Ghana is looking at the relationship between teachers' PCK and CM and their overall impact on students' mathematics achievement.

The impact that teacher PCK has on CM and their combined effect on students' mathematics achievement is a critical issue that teachers and educational actors have not paid much attention to. Mastery-oriented instructions are one of the issues, which has not received much attention. Examining the effect of teacher pedagogical contented knowledge on mastery-oriented instructions and its effects on student mathematics achievement will be a great contribution to mathematics education. This study looks at these relationships using structural equation modelling. We looked at path analysis examining the relationship between these key variables in the mathematics classroom. This help in identifying the direct and indirect relationship between CM and mastery-oriented instructions have on student mathematics achievement through teacher PCK.

The study assessed the mediation role of CM and mastery-oriented instruction in the relationship between teacher PCK and students' mathematics achievement using structural equation modelling. The following were research questions for the study:

1. What is the relationship between teacher PCK and students' mathematics achievement?
2. What is the relationship between CM and students' mathematics achievement?
3. What is the relationship between mastery-oriented instructions and students' mathematics achievement?
4. What is the mediation role of mastery-oriented instructions in the relationship between teacher PCK and students' mathematics achievement?
5. What is the mediation role of CM on the relationship between teacher PCK and students' mathematics achievement?

HYPOTHESIS DEVELOPMENT

Teacher Pedagogical Content Knowledge

Teachers' PCK has a significant role in the classroom (Jacob et al., 2020). Different scholars have viewed PCK's component from a different perspective. Jacob et al. (2020) posited that teachers' competence in delivering relational understanding, conceptual approach, and conceptual approach constitutes PCK. According to Gudmundsdottir and Shulman (1987), PCK is teachers' knowledge of the topics in the subject, concepts in the topics, and areas based on the level of learners' the subject matter that can be taught. They further stressed that the knowledge and understanding of the order in which the topics in the subject, concepts in the topic, areas within a subject should be taught, and the merits and demerits of the various approaches used in teaching the concepts can also constitute PCK of teachers.

A good number of studies have been conducted on the relationship between teachers' PCK and students' achievement. Some of these studies investigated whether students of teachers' PCK vary directly from their students' mathematics score. Hill et al. (2005) revealed that mathematical knowledge for teaching first and third graders in the USA correlated with their achievement gain over one year. Kane et al. (2008) found that PCK predicted students' achievement in mathematics in German secondary school. They also established that PCK predicted students' mathematics achievement higher than content knowledge. This was established from their structural equation model which used activation, curricular, and cognitive task as mediating variables. It was also found in Cueto et al. (2017) that a relationship between teachers' PCK and students' mathematics achievement in Cambodian primary school. Also, Carnoy and Arends (2012) identified a positive relationship between mathematics teachers' knowledge and students' achievement in Botswana.

Classroom Management

CM is defined as teachers' and students' ability to agree and carry on with a common rule for social and academic interaction (Doyle,1986; Freiberg,1983). Rogers and Freiberg (1994) posited that CM is ethics of effort which work within a social framework and is built over time to help students to develop discipline. CM paves way for learning to happen in a robust system of instruction and interaction with students (Cohen & Lotan, 2014). The inability to manage the classroom effectively can reduce the students learning opportunities (Wang et al., 1993) which can affect students' mathematics achievement. Literature shows that CM has an impact on students' achievement. According to Rogers and Freiberg (1994), the management of the classroom can have a great impact on learning. And for this reason, many studies have considered it an element of effective instructional practice (Kraft, 2010; Martin & Sass, 2010; Marzano et al., 2003; Wolfgang & Glickman, 1980). It is instructive for teachers to manage the behaviour of their students so that it will not affect the learning environment thereby increasing students' mathematics achievement.

Mastery-Oriented Instruction

Mastery learning is based on groups and guided by the teacher to mastery instruction wherein students learn, and most of the time with their mates in a cooperative form (Block & Burns, 1976). Teachers' instructions involving these process and procedures as defined by Block and Burns (1976) makes their instructions a mastery-oriented one. According to Zaw and Lwin (2020), the teaching of mathematics well

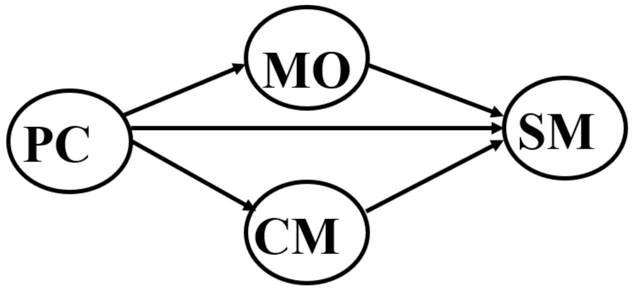

Figure 1. Conceptual model showing relationship between variables

involves creating, enriching, maintaining, and adapting instructions to make progress towards the mathematical goals, and maintaining interest and engaging students in establishing mathematical understanding. All these can be realized when teachers adopt mastery-oriented instructions. Mastery-oriented can help all students to achieve high in mathematics. This claim is supported by Guskey (2005), who suggested that even though students vary in learning rates if they are allowed the necessary time and learning conditions, many of them can attain higher learning achievement levels. **Figure 1** presents the conceptual framework of the study.

Hypothesis

The following hypothesis was generated:

1. **H_1:** Teachers' PCK predicts students' mathematics achievement.
2. **H_2:** CM predicts students' mathematics achievement.
3. **H_3:** Mastery-oriented instructions predict students' mathematics achievement.
4. **H_4:** Mastery-oriented instructions mediate the relationship between teachers' PCK and students' mathematics achievement.
5. **H_5:** CM mediates the relationship between teacher PCK and students' mathematics achievement.

METHOD

This study is a quantitative research design that uses a structural equation model. The researchers selected five senior high schools using a simple random sampling technique. The same technique was used in selecting 401 participants (students) as the sample for the study. These comprised form one, form two and form three students in the selected schools. A 5-point Likert-scale questionnaire from never (1) to always (5) for CM, mastery-oriented instruction, and teacher PCK. For students' mathematics achievement, the researchers used the same scale from strongly disagree (1) to strongly agree (5).

The administration of the questionnaires was done while the participants were in school after official approval from the school authorities. After a mahalanobis test on the data from the respondents using SPSS version 23, the outliers were excluded from the data. Analysis was done on 394 participants. An exploratory factor analysis (EFA) was done and afterward, confirmatory factor analysis (CFA) was using AMOS version 23. Based on the factor loadings of the observed variables from the EFA, the observed variables that loaded were on the components was selected and all other analysis was done with these indicators for each of the four constructs.

Table 1. Demographics of students

Demographics	Frequency (n)	Percentages (%)
Gender	**394**	**100.0**
Male	199	50.5
Female	195	49.5
Age	**394**	**100.0**
11-15 years	91	23.1
16-20 years	289	73.4
Above 20 years	14	3.6
Form	**394**	**100.0**
Form one	149	37.8
Form two	121	30.7
Form three	124	31.5

RESULTS

The study assessed the mediation role of CM and mastery-oriented instruction on the relationship between teacher PCK on students' mathematics achievement. This section presents the analysis of data from the SPSS and AMOS.

Demographics and Descriptive Analysis

The frequency and percentage of participants in the study. Out of the total of 394 students, 199 constituting 50.5% were males, and 195, constituting 49.5% were female. Also, 91 of the respondents were between the ages of 11 to 15 years, 289 were between 16 to 20 years and the remaining 14 of them were above 20 years. Out of the total participant, 149 were in form one, 121 of them were also in form two and the remaining 124 were in form three (**Table 1**).

Exploratory Factor Analysis

This section presents the reliability and validity of the model using the EFA and CFA analysis. In EFA, the Kaiser-Meyer-Olkin (KMO) test measures the adequacy of the sample. The standard KMO test is between 0 and 1. KMO of zero shows factor analysis is inappropriate since the sum of correlations for parts of the sample is large in comparison with the sum of all correlations. For this study, the KMO was 0.823 which is greater than 0.5 (acceptable value). Bartlett's test was significant at a 0.05 level. The table shows the loaded items in a rotated component matrix. It helped to fit each observed variable to one construct, the loading which was less than 0.5 were suppressed. Items for CM loaded on component 3, and for teacher PCK, it loaded on component 4. Mastery-oriented instructions items were loaded on component 1 and lastly, students' mathematics achievement items were loaded on component 2. The total variance explained was 66.744%.

Confirmatory Factor Analysis

CFA is presented in this section (**Table 2**). The model fit indices were used for the evaluation of the goodness of the conceptual model fitness with the data collected from the respondents. The following are the model fit indices; CMIN/DF was 1.948, which satisfies the maximum threshold of 3. CFI and TLI were 0.966 and 0.956 respectively, which met the threshold being greater than 0.9. RMR and RMSEA were 0.073 and 0.049 respectively. Which satisfies the threshold (≤0.08). PClose should be ≥0.05, and for this model, it was 0.535. In summary, all these indices show the fitness of the model the study was satisfactory.

For each of the constructs, Cronbach's alpha coefficient for internal consistency was conducted. The coefficient for CM, teachers' PCK,

Table 2. Confirmatory factor analysis

Model fit indices: CMIN=161.707; df=83; CMIN/df=1.948; CFI=.966; TLI=.956; RMR=.073; RMSEA=.049; & PClose=.535	Standard factor loading
Classroom management (CM): CA=0.799; CR=0.801; & AVE=0.503	
I get the chance to ask questions in mathematics class (CM1)	.669
I pay attention in the mathematics class (CM2)	.643
I am allowed the same opportunity as other students to answer questions (CM3)	.737
My teacher gives me the same encouragement as other students do (CM4)	.780
Teacher pedagogical content knowledge (PCK): CA=0.811; CR=0.816; & AVE=0.597	
My mathematics teacher maintains a positive learning environment during activities in class (PCK1)	.831
My mathematics teacher appears confident when teaching (PCK2)	.705
My mathematics teacher seems to have a firm understanding of when teaching (PCK3)	.777
Mastery-oriented instructions: CA=0.827; CR=0.815; & AVE=0.532	
I am provided enough time to record class notes during instruction (MOI1)	.593
My teachers show tricks to remember information presented in class and textbooks (MOI2)	.587
My teacher gives details of the rubrics when projects are assigned (MOI3)	.840
My mathematics teacher uses mathematics games in lessons (MOI4)	.851
Student in mathematics achievement (SMA): CA=0.817; CR=0.822; & AVE=0.536	
I have a purpose in my life for learning mathematics (SMA1)	.684
Mathematics doesn't scare me at all (SMA2)	.677
I continue to think about a question when it is left unanswered in mathematics class afterward (SMA3)	.795
Being first in a mathematics competition makes me pleased (SMA4)	.766

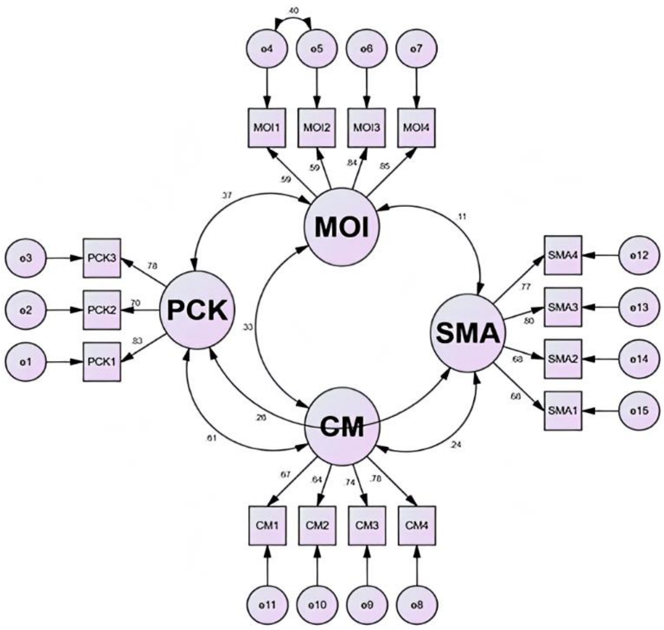

Figure 2. Confirmatory factor analysis

mastery-oriented instructions, and students' mathematics achievement were 0.799, 0.811, 0.827, and 0.817, respectively. The reliability analysis for all the four constructs met the threshold of being greater than 0.7 as suggested by Nunnally (1978).

The average variance extracted (AVE) and construct reliability (CR) were conducted for each of the constructs. The minimum threshold for AVE and CR is 0.5 and 0.7, respectively. CM had an AVE of 0.5030 and CR of 0.801, teacher PCK had an AVE of 0.597, and CR of 0.816. Mastery-oriented instructions had an AVE of 0.532 and CR of 0.815, The AVE and CR for students' mathematics achievement were 0.536 and 0.822 respectively. According to Valentini and Damasio (2016), AVE and construct reliability are used to determine the quality of a measure. The quality of the measures for the construct in this study has been achieved.

Standardized factor loading is the total effects each of the indicators has on the constructs. CM4 has the highest effect on CM, followed by CM3, CM1, and CM2. On teachers' PCK, PCK 1 has the highest effect, followed by PCK3 and PCK2. MOI4 has the highest effect on mastery-oriented instruction, followed by MOI3, MOI1, and MOI2. SMA3 has the highest total effect on students' mathematics achievement, followed by SMA4, SMA1, and SMA2.

The diagrammatic representation of the confirmatory factor analysis from the AMOS is shown (**Figure 2**).

Discriminant Validity

The descriptive statistics (means) on participant response to items on the variables; CM, teacher PCK, mastery-oriented instructions, and students' mathematics achievement (**Table 3**). The mean for CM was 4.31, and for teachers' PCK, the mean was 4.01. On mastery-oriented instructions, the mean was 3.61 and a mean of 4.28 for students' mathematics achievement. To establish discriminant validity, the correlation between each of the constructs was conducted (**Table 3**). The correlation between CM and teacher PCK, mastery-oriented instruction, and students' mathematics achievement were 0.605, 0.326, and 0.241, respectively. All were significant at a 0.01 level. Between PCK and MOI, and SMA, the correlation coefficients were 0.367 and 0.256, which were significant at the 0.01 level. The correlation between MOI and SMA was 0.107, which was not significant at the 0.05 level. Since the square root of AVE for each of the variables is greater than the correlations between the construct, discriminant validity for the construct in the model is established.

PATH ESTIMATES

Direct Effect

To answer the research questions, the model was reconstructed to depict the conceptual framework. The model indices were evaluated to test the fitness of the new model. CMIN/DF was 1.975; CFI and TLI were .964 and .955 respectively. RMR and RMSEA were .081 and .050 respectively. PClose was .495. this shows that the model passes the fitness test.

Table 3. Discriminant validity

Variables	Mean	CM	PCK	MOI	SMA
CM	4.31	<u>**0.709**</u>			
PCK	4.01	.605**	<u>**0.773**</u>		
MOI	3.61	.326**	.367**	<u>**0.729**</u>	
SMA	4.28	.241**	.256**	.107	<u>**0.732**</u>

Note. **~P-value significant at 1% (0.01) & √ AVE are **bold** and <u>underlined</u>

Table 4. Direct effects

Path	Standard estimate	CR
PCK→MOI	.459	6.302**
PCK→CM	.592	9.215**
PCK→SMA	.167	1.961*
MOI→SMA	.001	.021
CM→SMA	.132	1.583

Note. **~P-value significant at 1% (0.01); *~P-value significant at 5% (0.05); & Model fit indices: CMIN=165.905; df=84; CMIN/df=1.975; CFI=.964; TLI=.955; RMR=.081; RMSEA=.050; PClose=.495

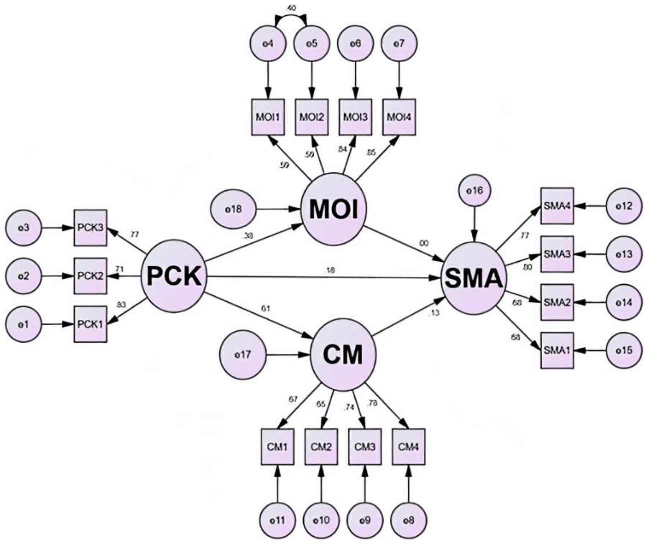

Figure 3. Structural paths

There was a significant effect of teacher PCK on students' mathematics. There was also a significant effect of teacher PCK on mastery-oriented instructions. And the effect of teacher PCK on CM was significant. There was no significant effect of mastery-oriented instructions and CM on students' mathematic achievement. All these effects were summarized (**Table 4**).

The model used for testing the direct relationships between the constructs in AMOS is shown in **Figure 3**.

Mediating Effect

The study was to assess the mediation role of CM and mastery-oriented instructions on the relationship between teachers' PCK and students' achievement in mathematics. The indirect effects of teacher PCK on students' achievement in mathematics were conducted using Sobel's test (**Table 5**). The analysis shows that the effect of teachers' PCK on students' achievement in mathematics was both insignificant. This conclusion was obtained by comparing the z-score from Sobel's test with the critical value from a 95% confidence interval. For z>1.96, then the mediation is significant, otherwise, the mediation effects are insignificant. The z-scores of 0.0234 and 1.5674 are less than 1.96.

DISCUSSION

The researchers conceptualized the relationship between teachers' PCK and students' mathematics achievement, the relationship between mastery-oriented instruction and students' mathematics achievement, the relationship between CM and students' mathematics achievement, and the relationship between teachers' PCK and CM and mastery-oriented instructions. Analysis of the conceptual model (structural equation model) indicated that teachers' PCK had a significant relationship with students' mathematics achievement. It is common knowledge that when teachers are having a good knowledge and understanding of the subject matter they teach; their students are likely to get a fair understanding of what they teach them. However, their understating of the right method and procedure in teaching these concepts of the subject matter enriches their teaching and is reflected in their students' performance in the subject matter. The finding agrees with studies by Carnoy and Arends (2012), Cueto et al. (2017), Hill et al. (2008), and Kane et al. (2008) who found that teachers' understanding of mathematics and the method of teaching it positively affected their students' performance. This study also revealed that CM has no significant effect on students' mathematics achievement. Even though it can be anticipated that when the classroom is managed well, it will give a sound environment conducive to learning the subject matter, which leads to an increase in students' performance. It was found that the student's performance cannot be influenced by CM only. This is in contrast with Rogers and Freiberg (1994), who posited that CM could affect learning. In the same way, the effect of mastery-oriented instructions on students' mathematics achievement was not significant. The regression of teacher PCK, mastery-oriented, and CM instruction on students' mathematics achievement may be a result of using a different scale of measurement for these constructs. The effects mean that teachers' PCK influences teachers' CM, and it also has effects on the way they teach mathematics. Thus, teaching involves creating, enriching, maintaining, and adapting instructions to make progress in mathematics goals as intimated by Zaw and Lwin (2020).

The mediation effects of mastery-oriented instruction and CM were revealed not to be significant. This was not surprising because the effect of mastery-oriented instruction and CM on students' mathematics achievement was not significant.

CONCLUSION

This study contributes to studies on teacher PCK, mastery-oriented instruction, and CM and the effects they have on students' mathematics achievement. The study shows that teachers' CM and mastery-oriented instructions do not mediate the relationship between teachers' PCK and students' mathematics achievement. Teachers need to note that teachers' PCK does not affect students' mathematics achievement only; it also affects CM and mastery-oriented instructions.

Recommendations

Additional study is needed to assess the mediation of CM and mastery-oriented instructions on teacher PCK and students' mathematics, by using a larger sample than was used in this study. Researchers can also use a standard achievement test instead of a Likert-scale questionnaire to measure achievement. Mastery-oriented can be replaced with mastery learning to see if it will mediate PCK and SMA.

Table 5. Indirect effects

Paths	a		b		a*b	SE_{ab}	$Z = \frac{a*b}{SEab}$	p-value
	Estimated	Standard error	Estimated	Standard error				
PCK→MOI→SMA	0.459	0.073	.001	0.051	0.0005	0.0234	0.0196	0.492
PCK→CM→SMA	0.592	0.064	0.132	0.083	0.0781	0.0499	1.5674	0.0582

Note. $SE_{ab} = \sqrt{(SE_a)^2 \times b^2 + (SE_b)^2 \times a^2}$

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