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Mathematics Teacher Noticing: A Case of Students' Cognition of a Course Content

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Authors' contribution

This work was carried out in collaboration among all authors. Author DOK did the conceptual frame. Author CKA designed and typesetting. Authors LAO and SA did the data collection. Author CSB analyzed and interpretation. Author FN supervised and guidance. All authors read and approved the final manuscript.

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ABSTRACT

It is essential for Course Lecturers and Course Tutors to be aware of their students' cognition. It is noteworthy in the context of teaching and learning. Teacher recognition is critical to improving classroom teaching and learning and has been the core mandate of every educational institution worldwide. And it has become critical that various approaches and shifts be learned and incorporated into the educational system. This study used a purely qualitative approach and a Single Case Design. It also determined the cognition level of topics facilitated by a Course Lecturer or Course Tutor and topics learned in groups by students. It was carried out to ascertain the cognition of some university students enrolled in a semester course. The Teacher Noticing framework was used for this. A diagnostic test was used in the study to assess the cognitive level of the topics covered in the fifteen (15) undergraduate participants' courses. The "ACS Model" conceptual framework was contextualized or framed to notice students' understanding and cognition in three levels: "A" for accuracy, "C" for creativity, and "S" for stumbling. Within the time frame, eight related topics were covered. About 85% of the topics were taught with the help of the lecturer, and 15% were taught by the students in groups. The course lecturer also reiterated the few topics

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covered in groups. The findings indicated that university students (N=8) performed better than non-university students (N=8), with a percentage increase of 75.54% for topics covered by the course lecturer compared to 24.46% for topics covered by group projects. When comparing the topics covered with the instructor acting as the facilitator, topics 2 and 4 have higher means and lower standard deviations (mean = 2.8000, SD =.56061, and mean = 2.0667, SD =.88372, respectively). It is advised that the course lecturer and mathematics instructors use diagnostic tests and quizzes to monitor students' understanding of the subjects covered. In order to support teacher professional development and student assessment, it is advised that Teacher Noticing be incorporated into classroom discussions.

Keywords: Accuracy; ACS model; assessment; creativity; diagnostic quiz; learning to notice framework; mathematics classroom; mathematics teacher noticing; professional noticing; teacher noticing; students' cognition; stumbly.

1. BACKGROUND

The act of noticing has evolved into a paradigm or one of the dimensions of classroom evaluation, serving as a tool for both the teacher and the students. A deliberate observation of a situation or activity in the classroom is known as teacher noticing. In Noticing, teachers take on the role of the "Noticers" while students act as the "Observants". It is possible to observe for all topics or courses at all levels. This is evident when teachers' pay attention to their students' cognitive abilities during teaching and learning in the classroom [1]. The focus on students' mathematical thinking and its relevance to quality-oriented teaching [2] in the classroom has made studies on teacher noticing, which have primarily been conducted in the last two decades, very popular. Choy [3] asserts that teacher mathematical noticing is an important aspect of expertise in teaching mathematics and has been the subject of recent professional development initiatives.

"Expertise in noticing is paramount to detecting and making sense of instructionally important features in the mathematics classroom, as the act of focusing attention on and making sense of situation features in a visually complex world is a necessary skill for teachers," assert Jacobs and Spangler (2017, p. 771). To put it briefly, researchers in mathematics teacher education have focused on a new theoretical concept called "Teacher Noticing" in order to give teachers the tools they need to manage a challenging classroom environment in a way that improves students' learning. It can be viewed as linear, cyclical, and interrelated.

The "Learning to Notice Framework" is a crucial component of developing teacher expertise, according to van Es and Sherin [4]. Later, "Professional Noticing Framework" was developed by Jacobs, Lamb, and Philipp [5]. This was thought to be the best choice out of all of them. There is no distinct method for gathering data, according to recent studies like those by Amador, Bragelman, and Superfine [6], whose systematic review on the methodological approaches in supporting and analyzing notice of prospective teachers revealed. Some researchers observed students' knowledge in the classroom using recorded videos [7, 8] and written artifacts. A study on "teacher noticing and its growth toward expertise: a novice-expert comparison with pre-service and in-service secondary mathematics teachers" was done by Bastian et al. They discovered that there is a significant difference in classroom teacher noticing between pre-service teachers, inexperienced teachers, and experienced teachers of mathematics. As a result, the rating for novice noticing skill includes the words stagnant, mixed, inconsistent, and negative.

A study by Munson [10] on observing students' thinking only two years ago found that teacher noticing is essential for developing instructional responses. Concerns about students' retention of the material studied from their responses may serve as a good foundation for classroom teachers to present their lessons in ways that students will find meaningful. Among these studies [11], it is noteworthy that Castro, Pino-Fan, and Velasquez-Echavarria [12,13] all employed new or inexperienced teachers. This study focused on observing in-service, professional, or practicing teachers. For this study, the theoretical frameworks of Jacobs et al. [5] and van Es and Sherin [4] were conceptualized. It aims to examine the subjects that students can recall with accuracy, the subjects or materials they have mastered through creativity and critical thinking, and those that they cannot recall at all. That is falling short of the course. For this study, the "ACS Framework" was conceptualized. Cognition is a method of active learning. It primarily focuses on assisting a person in realizing the full potential of their brain. Assessment procedures such as diagnostic tests can stimulate cognition. Students are required to recall knowledge in the quizzes.

Diagnostic tests and teacher observation are both examples of classroom assessments [14]. What is Diagnostic Assessment? - Definition & Examples [14] states that a diagnostic assessment, also known as an assessment, is a type of initial test or examination that is conducted to enable a course teacher to ascertain the strengths, weaknesses, knowledge, and skills of students prior to teaching. Additionally, it is used to identify the challenges and areas of difficulty in a content course for effective curriculum planning. Diagnostic tests assist students in remembering what they have learned. Diagnostic tests are advantageous for both teachers and students. It acts as a blueprint for effective and meaningful classroom instruction. Assessing your students' knowledge and comprehension of a crucial skill or concept using diagnostic questions is a quick and effective way to spot any underlying misconceptions they may have. Because memory retrieval is a process that requires active recall, it is crucial to learning and extremely effective. You can access information from the past that was previously encoded and stored in your mind when you are remembering. In essence, the brain "replays" a neural activity pattern that was triggered in response to an event. The co-author of the Leaning to Notice framework, Miriam Gamoran Sherin, sparked interest that led to the creation of the study [15]. The study's main goal was to use the mathematics teacher's noticing mindset to identify notable aspects of students' cognition. Additionally, the "ACS Conceptualized Framework" was used to observe the differences in university students' understanding of course material between topics covered by lecturers and topics studied by groups of students. The degree to which students understand topics covered by their course lecturer and topics studied by them in small groups.

1.1 Methodology and Participants

The study's primary goal was very much in line with its largely qualitative methodology and use of a single case study design. Single Case Design (SCD), also known as single subject design, is an evaluation technique that can be used to rigorously test the success of an intervention or treatment on a specific case (i.e., a person, school, or community), as well as to offer proof of an intervention's overall efficacy. The intended audience consisted of Level 200 Diploma Mathematics Education students (N = 16) from a Ghanaian public university. Students pursuing a diploma in mathematics education (n = 15) made up the accessible population. The Single Case Design is effective with a sample size of sixteen. Since the researcher was a teacher who paid attention to this class and the course lecturer specifically, a purposive sampling was used to choose this class.

1.2 Instrumentation

The researcher decided to assess the level of cognition of the eight (8) topics covered by this course far away after two more months of lecturer on the semester's "Introduction to Matrices" course. The topics were grouped together based on their shared characteristics. These comparable ones were included in the study's same topics. Topics included "Definition of matrices, entries, and dimensions," "Types of matrices," "Scalar of a matrix," "Operations on Matrices," "Transpose of a matrix," "Determinant of a matrix," "Inverses of matrices," and "Adjoint application." Some of the topics were taught face-to-face by the course lecturer or tutor, while others were assigned to groups of students for group study and presentations in class. Topics 1 through 5 (62.5%), which were studied and presented in groups by the students in 37.5% of cases, were covered by the course lecturer. Consistency was checked among the course lecturer's semester-long course outline, his prepared lecture notes, assignments, group presentations, and students' written class notes. To ensure content validity, these were used. Due to the coherence of the course material and topics covered, this was subsequently accepted as reliable. Before a morning lecture, the researcher entered the lecture hall and distributed plain A4 sheets to the students. asked them to include the "Date" with their "Index Numbers." It was requested that none of the students write their names on the paper. "Discuss any five (5) content topics, or things you have learned in this course," the course instructor, lecturer, or tutor wrote on the board. The task was to be finished in a maximum of 10 to 12 minutes.

1.3 Theoretical Framework and the "ACS" Conceptual Framework

The ACS Conceptual Framework, an adaptation of the study's framework. The responses of the students were analyzed using a thematic analysis based on the ACS conceptual framework. Papers submitted by students had three-digit ID codes beginning with "000" on them (Appendix A).

In order to conceptualize this study, the theoretical frameworks of van Es and Sherin [4] and Jacobs et al [5] were carefully examined. The goal of this study was to determine which subject's students could recall accurately, which subjects they had mastered through creativity and critical thinking, and which subjects they could not recall at all. That is falling short of the course. For this study, the "ACS" Conceptual framework was conceptualized. The purpose of the ACS conceptual framework rubric is to assess students' level of cognition. Accuracy was denoted by the letter "A". Here, students could directly quote what they had learned in class and provide vivid examples to back up their arguments. This received a three-point rating. "Creativity" was represented by the "C." Here, students had the opportunity to mention a word that was used in one of the many topics covered or studied. Additionally, students should be able to create their own understanding from what was taught or studied in groups, writing in their own words rather than necessarily reproducing what was said [16]. This received a 2 out of 10 points rating. The "S" stood for "Stumbly" at the end. This is when a student becomes overwhelmed, is unable to write, and forgets what they were taught or learned in the group. For neither of the subjects, there was no writing. This received a score of 1 point. There is only a 3-Point Likert scale used in the ACS framework.

For each of the eight topics, the results were coded into SPSS and descriptively analyzed. A mean score of 1–1.49 according to the model (Fig. 1a and 1b) would be regarded as stumbly. A mean of 1.50 to 2.49 would be regarded as creative, while 2.50 to 3.00 would be regarded as accurate.

2. RESULTS AND DISCUSSION

The results of the descriptive are displayed in the following tables. The data gathered for the eight completed topics in the semester's course work are presented in Table 1 as a fair descriptive statistic. Out of the six students who attempted Table 2, Topic 1: "Definition of matrices, entries, and dimensions," four (66.67%) provided a precise definition of "matrices" and received a score of 3. Of the two (13.3%), one could explain, while the other merely mentioned "entries" and "dimensions" without providing any examples to demonstrate comprehension. This demonstrates that when definitions are properly explained in the classroom, students are able to follow through [17,18]. It is implied that teachers should provide appropriate examples to support the material to be taught to students after noticing this. It is shocking to see that 9 (60.0%) of the total number of students were unable to try at all. This suggests that in order to support students' learning, teachers must become more skilled at noticing [5].

A total of 14 students (93.7%) attempted to write about Topic 3: Types of Matrixes in Table 2. 13 students (86.67%) correctly explained and discussed what their lecturer on "Types of Matrices" had taught them. This supports the higher level in Table 1 (M = 2.8000, SD =.56061). The only student (6.7%) who chose not to attempt this received a score of 3.5 out of 5. demonstrating that they were not ignorant of the different kinds of matrices or the examples, but rather that they might be displaying exceptionality.

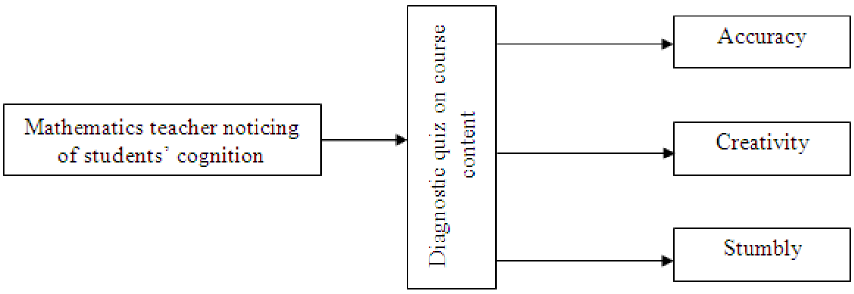

Fig. 1a. Kwakye (2022), ACS Conceptual Framework

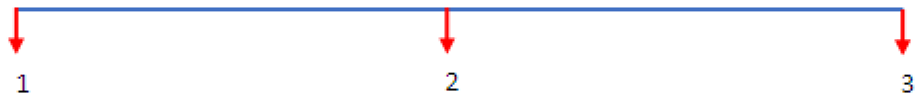

Fig. 1b. Kwakye (2022), Accuracy: 2.50 – 3.00, Creativity: 1.50 – 2.49, Stumbly: 1 – 1.49

Table 1.

Topics	N	Mean	Std. Deviation
Topic 1 - Definition of matrices, entries and dimensions	15	1.6667	.89974
Topic 2 - Types of matrices	15	2.8000	.56061
Topic 3 - Scalar of a matrix (enlargement and reduction)	15	1.4667	.83381
Topic 4 - Operations on Matrices	15	2.0667	.88372
Topic 5 - Transpose of a matrix	15	1.8667	.91548
Topic 6 - Determinant of a matrix	15	1.5333	.74322
Topic 7 - Inverses of matrices	15	1.2667	.59362
Topic 8 - Adjoint application	15	1.07	.258

Source: Field Survey

Table 2. Topic 1 - Definition of matrices, entries and dimensions

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Stumbly	9	60.0	60.0	60.0
	Creativity	2	13.3	13.3	73.3
	Accuracy	4	26.7	26.7	100.0
	Total	15	100.0	100.0	

Source: Field Survey

Table 3. Topic 2 - Types of matrices

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Stumbly	1	6.7	6.7	6.7
	Creativity	1	6.7	6.7	13.3
	Accuracy	13	86.7	86.7	100.0
	Total	15	100.0	100.0	

Source: Field Survey

Table 4. Topic 3 - Scalar of a matrix (enlargement and reduction)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Stumbly	11	73.3	73.3	73.3
	Creativity	1	6.7	6.7	80.0
	Accuracy	3	20.0	20.0	100.0
	Total	15	100.0	100.0	

Source: Field Survey

Table 5. Topic 4 - Operations on matrices

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Stumbly	5	33.3	33.3	33.3
	Creativity	4	26.7	26.7	60.0
	Accuracy	6	40.0	40.0	100.0
	Total	15	100.0	100.0	

Source: Field Survey

Table 6. Topic 5 - Transpose of a matrix

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Stumbly	7	46.7	46.7	46.7
	Creativity	3	20.0	20.0	66.7
	Accuracy	5	33.3	33.3	100.0
	Total	15	100.0	100.0	

Source: Field Survey

Table 7. Topic 6 - Determinant of a matrix

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Stumbly	9	60.0	60.0	60.0
	Creativity	4	26.7	26.7	86.7
	Accuracy	2	13.3	13.3	100.0
	Total	15	100.0	100.0	

Topic 7 - Inverses of matrices

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Stumbly	12	80.0	80.0	80.0
	Creativity	2	13.3	13.3	93.3
	Accuracy	1	6.7	6.7	100.0
	Total	15	100.0	100.0	

Topic 8 - Adjoint application

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Stumbly	14	93.3	93.3	93.3
	Creativity	1	6.7	6.7	100.0
	Total	15	100.0	100.0	

Source: Field Survey

Even though multiplying a matrix by a scalar—either enlargement or reduction—is very simple to remember, only four students (26.7%) attempted it in Topic 3: "Scalar of a Matrix" (Table 4). 90% of them perfectly cited examples to demonstrate their understanding of this quota. The following was mentioned as an illustration:

a. “Multiplication of 2×2 matrix with constant, $k = 3$. And gave a 2 by 2 matrix, $A = \begin{bmatrix} 1 & 3 \\ 2 & 4 \end{bmatrix}$,

   i. $kA = 3\begin{bmatrix} 1 & 3 \\ 2 & 4 \end{bmatrix} = \begin{bmatrix} 3 & 9 \\ 6 & 12 \end{bmatrix}$”

b. “Scalar matrices are matrices whose elements are multiply by a factor.
   Example: $2 \times 2.\ A = 2\begin{bmatrix} 2 & 4 \\ 2 & 1 \end{bmatrix} = \begin{bmatrix} 4 & 8 \\ 4 & 2 \end{bmatrix}$”

Additionally, Table 1's results indicate that students lacked creativity (M = 1.4667, SD =.83381). Many 11 (73.33%) students could not write about the "Multiplication of a matrix by Scalar," whether it was enlargement or reduction, according to Table 1. This shows that not all students can recall information quickly. It's also possible that some of the students were unfairly disadvantaged by the quiz's length or timing.

"Operations on Matrices" is Topic 4. Addition, subtraction, and multiplication were among the "operations on matrices." 10 people (66.67%) tried this (Table 5). Six (60%) of those who tried provided good examples to back up their explanation and demonstrate that they understood the subject. This resulted in a high mean (M = 2.0667, SD =.88372) in Table 1 and an accuracy score of 3 (Fig. Here, it can be inferred and seen that the lecturer gave examples that were clearly stated to explain a concept so that students could also give their own with understanding.

About 26.67% (4) of the students had the courage to write about Topic 5, "Transpose of a Matrix," which was the final topic covered along with the operations on matrices. Overall, more than half of the participants (N = 8 (53.33%), M =

1.8667, SD =.91548) demonstrated a respectable level of understanding by "mentioning" or "listing" or "transposing" in their written responses. Only 25% of them were able to provide solid examples in their writing to back up their arguments.

The topics of "Determinant of a matrix," "Inverse of matrices," and "Adjoint application" from Table 7 were assigned to students for group learning and presentation. Four students (26.67%), three (20.00%), and zero (0%), respectively, demonstrated knowledge in the diagnostic quiz used by the teacher to assess the students' comprehension and recall. It is disappointing that N = 14 (93.33%) of the total student body did not attempt that. Again, a mean (M = 1.07, SD =.258) recorded in Table 1 indicates that the "Adjoint application" is not understood at all. This demonstrates that students still have a lot of faith and hope in their professors. Despite having studied in groups and given presentations in class, they still want their lecturer to go over their points again [12].

3. RECOMMENDATIONS AND FUTURE RESEARCH

The purpose of the study was to determine whether the cognitive levels of topics covered by the course lecturer and those that the students themselves learned in small groups differed. Through the use of a diagnostic quiz, the concept of teacher observation was used to examine how students are responding to the classroom conversation. In the study, it was found that while many students performed accurately on topics covered by the course lecturer, they performed poorly on topics that students in groups were studying. It is advised that math instructors and course lecturers use diagnostic tests to gauge their students' understanding of the material being covered. Additionally, instructors and lecturers should go over any topics assigned to students for group study because doing so will improve their accuracy level during assessment. Last but not least, it is advised that Teacher Noticing be incorporated into classroom discussions for professional development. Future studies must be conducted over the course of an entire semester to track trends in students' cognitive development. This will reveal the actual skill level of the course's participants.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX A

ACS conceptual framework rubric

ID	Topic 1	Topic 2	Topic 3	Topic 4	Topic 5	Topic 6	Topic 6	Topic 6
004	Creativity	Accuracy	Stumbly	Stumbly	Stumbly	Stumbly	Stumbly	Stumbly
073	Stumbly	Accuracy	Accuracy	Creativity	Stumbly	Accuracy	Stumbly	Creativity
003	Stumbly	Accuracy	Creativity	Creativity	Creativity	Stumbly	Stumbly	Stumbly
006	Accuracy	Accuracy	Stumbly	Accuracy	Stumbly	Stumbly	Stumbly	Stumbly
063	Accuracy	Accuracy	Stumbly	Stumbly	Stumbly	Accuracy	Accuracy	Stumbly
078	Stumbly	Accuracy	Stumbly	Accuracy	Creativity	Creativity	Creativity	Stumbly
049	Stumbly	Accuracy	Stumbly	Accuracy	Creativity	Creativity	Creativity	Stumbly
001	Accuracy	Accuracy	Stumbly	Stumbly	Accuracy	Stumbly	Stumbly	Stumbly
066	Stumbly	Accuracy	Stumbly	Stumbly	Accuracy	Stumbly	Stumbly	Stumbly
074	Stumbly	Accuracy	Stumbly	Accuracy	Stumbly	Stumbly	Stumbly	Stumbly
073	Accuracy	Accuracy	Stumbly	Stumbly	Accuracy	Stumbly	Stumbly	Stumbly
007	Stumbly	Stumbly	Accuracy	Creativity	Accuracy	Stumbly	Stumbly	Stumbly
047	Stumbly	Accuracy	Accuracy	Accuracy	Stumbly	Creativity	Stumbly	Stumbly
068	Creativity	Creativity	Stumbly	Creativity	Accuracy	Creativity	Stumbly	Stumbly
002	Stumbly	Accuracy	Stumbly	Accuracy	Stumbly	Stumbly	Stumbly	Stumbly

Source: Field Survey, 2022

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