WAIT A MINUTE…IS THAT ENOUGH TO MAKE A DIFFERENCE?

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The "one-minute paper" (Stead, 2005) is a technique for facilitating communication between students and the teacher and promoting reflection. In this paper we focus on the types of questions students ask and how they may be related to success. We present preliminary results from an introductory university-level calculus course, indicating that the nature of questions asked by more successful and less successful students are different, suggesting that the types of reflections that students engage in may have a significant impact on the efficacy of such an intervention.

Key Words: Calculus, Classroom research, Formative assessment, Self-regulation

Introduction

Formative assessment is a process of *evoking* information about learning and *using* it to modify teaching and learning activities (Black, Harrison, & Lee, 2003). Practicing formative assessment in large lecture courses presents a challenge, both due to the large number of students and the teacher-centered practice that such a classroom tends to promote. Accordingly, the "one-minute paper" is a technique that has been used to improve communication between students and the teacher (Stead, 2005). Students spend "one minute," near the end of class, to write a reflection on what they learned and what questions they have about the content from that day. In this paper we explore the types of questions that students ask and how they may be related to success.

Effective learners are self-regulating and engage in many important learning activities, such as: setting powerful goals, monitoring their performance toward those goals, and adapting their future activities based on the results of their performance (Zimmerman, 2002). In order to promote self-regulation in truly productive ways, simply asking students to reflect is insufficient; students must be taught to ask the *right* types of questions to monitor their progress, for instance. Because problem solving and understanding in mathematics are domain-specific (cf. Schoenfeld, 1985), it is evident that students must be taught mathematics-specific reflection skills. In order to evoke a shift in how students engage in mathematics and monitor their engagement, it is important to change for students what it means to know and do mathematics (Boaler & Greeno, 2000). If students perceive mathematics as a game of recalling facts and procedures (cf. Schoenfeld, 1988), they will not develop the appropriate reflective thinking skills necessary for success in mathematics.

Method

This paper reports on a portion of a larger ongoing study focused on promoting explanation and reflection in a first-semester university-level calculus course (Reinholz, 2013). The intervention promotes metacognition by integrating three "key" questions as a regular part of classroom discourse: (a) Why would you...?; (b) Why can you...?; and (c) What does it mean that...?. These particular questions are exemplars of *categories* of questions, representing three different viewpoints from which students can self-assess their understanding of a given problem or concept. These questions are meant to push students away from thinking about math as

memorizing facts and procedures. Additionally, students ended each day by answering 3 reflection questions:

1. On a scale from 0 to 100%, how well did you understand today's lecture?
2. What questions do you have? (What was unclear? How does today's lesson relate to other math concepts?; **write at least 2 questions.**)
3. Tell me something else you think I should know.

Daily reflections gave students an opportunity to incorporate the key questions used by their instructor into their regular reflective practice. Additionally, these questions played an important role in shaping future classroom practice (cf. Black & Wiliam, 2009).

Results and Analysis

As an ongoing study, this paper reports on results from the beginning of the semester, including performance on the first midterm exam, which has been shown to predict success in the course with 80% accuracy (using logistic regression; Reinholz, 2009). To investigate the relationship between the types of reflection questions asked by students and student performance, two groups of 5 students each were randomly constructed based on exam performance. "Successful" students scored 90% or above on the exam (the A cutoff), while "unsuccessful" students scored below a 60% (the C cutoff). The daily reflection questions asked throughout the semester (approximately 16 per student) were analyzed using a grounded theory approach (cf. Glaser & Strauss, 1967). In addition, the impact on instruction will be discussed.

Through the analysis of student responses, 7 major categories of questions emerged. The results are presented in Table 1.

Question Type	**"Successful" Students (39 reflections/78 questions analyzed)**	**"Unsuccessful" Students (38 reflections/76 questions analyzed)**
Future Topics	13 (16.7%)	2 (2.6%)
Connecting Concepts	4 (5%)	9 (11.8%)
Specific Concepts	29 (37.2%)	22 (28.9%)
Real-life Connections	4 (5%)	3 (3.9%)
Scoring/Logistics	20 (25.6%)	4 (5.3%)
"How-To" / Procedures	5 (6.4%)	21 (27.6%)
Other/Non-Mathematical	3 (3.85%)	15 (19.7%)

Table 1: Types of reflection questions asked by students

For the purposes of this brief report we focus on a few significant aspects of the coding and results. Successful students asked many more questions focusing on future topics and the logistics of exams, such as how to present a complete solution (see Table 2 for sample responses). It seems that successful students saw the course more holistically, rather than focusing only on a single lesson, considering what topics would be on the exam and what they would need to do to demonstrate mastery of the material.

Question Type	Sample Student Response
Future Topics	When will we learn to find f' without using limits?
Connecting Concepts	How does the definition of tangent relate to secant?
Specific Concepts	When does the derivative not exist?
Real-life Connections	What is a real application of limit?
Scoring/Logistics	Do we need to keep our answers in exact form?
"How-To" / Procedures	How do I "long divide" equations involving x?
Other/Non-Mathematical	Still unsure about limits

Table 2: Sample student responses for various question types

In contrast, unsuccessful students were much more focused on "how-to" solve problems and use procedures, and asked many more irrelevant or non-specific questions. In particular, questions in the "other" category often expressed confusion but did not construct a concrete question that could be answered to resolve the confusion.

There was some evidence that students asked the 3 key questions modeled by the instructor in class. These responses belonged to the categories of connecting concepts and specific concepts. However, there was no significant difference between the usages of these two questions across groups. The most likely explanation is that the usage of these questions increased for both groups as a result of classroom practice, but the increases in usage were similar between groups.

Impacts on Instruction

In addition to promoting reflective thinking, the one-minute paper also had a direct impact on instruction. The first question: On a scale from 0 to 100%, how well did you understand today's lecture?, gave the instructor immediate quantifiable feedback about how the students felt about the day's lesson. Regardless of the absolute accuracy of student judgments, when a number of students marked low percentages, it indicated that some of the content might need to be re-addressed.

Re-addressing content, however, was not always an easy task. Fortunately, the second question from the one-minute paper helped address this: What questions do you have? (What was unclear? How does today's lesson relate to other math concepts?; **write at least 2 questions.**). Student responses to this question provided further detail on what ideas and concepts the students were struggling with. This enabled the instructor to adapt future lessons according to student needs.

Discussion and Conclusions

The one-minute paper is a tool for promoting communication between an instructor and her students, as well as for promoting reflective thinking in students. Crucially, however, is not just that students ask questions, but that they ask the *right* types of questions. Preliminary analyses indicate that successful students were better able to see the course as a whole. In contrast, less-successful students focused more on "how-to" and expressed general confusion, both of which are harder to use to monitor performance and understanding. In addition, the one-

minute paper had an impact on instruction, allowing the instructor to address the needs of the students on a daily basis.

Open Questions

1. How might we design an intervention to be more effective at influencing the types of questions students ask?
2. How might we use such an intervention to study the types of questions students ask causally rather than correlationally?
3. In what other ways might we classify the types of questions students ask?

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