



Students' Perceptions of Teaching Styles in Mathematics Learning Environments

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Abstract: The use of interactive assessment strategies along with interactive instructional strategies in order to enhance student learning makes good educational sense. In fact, the two are inextricably linked to one another. The definition formative assessment, for example, contains many “actions” that students and teachers can take independently and collaboratively during the instructional process. The actions of the students and teachers produce feedback that is used to make adjustments either in teaching, in learning or in both and thereby, create successful interactive learning environments.

INTRODUCTION

An effective mathematics learning environment is one in which students and teachers interact in ways that allow students to have an opportunity to maximize how much they learn. There are a variety of ways in which students and teachers interact in a learning environment. Some interactions result in student learning, however, others have very little effect on student learning. Classroom discussions, teacher and student initiated questions, cooperative group work, peer tutoring and a host of other feedback systems such as assignments, examinations and electronic response systems such as the personal response system (PRS) and the personal data assistant (PDA) are instructional strategies that provide a measure of two-way communication in which information about what is taught and what is learned is exchanged between two people. On the other hand, there are instructional strategies in which students sit passively in classrooms where there is one-way communication – from teacher to students. On many college and university campuses, for example, the professor operates as the proverbial “sage on the stage” and the didactic lecture is the modal way of teaching. And although the lecture is an efficient method for transmitting information from a teacher to a large group of students, telling information to someone does not mean that learning takes place. In order to determine whether learning is occurring – in fact, to ensure that learning is taking place, there must be teacher-student *assessment interactions* along with the instructional interactions.

Assessment interactions between students and teachers occur when teachers gather information about student learning and use that information to help students better understand concepts and principles and apply knowledge, not just learn facts. This type of assessment interaction referred to as formative assessment is defined as follows: *Formative assessment is a process used by teachers and students during instruction that provides feedback to adjust ongoing teaching and learning to improve students' achievement of intended instructional outcomes* (Council of Chief School State Officers, 2008). It is clear from this definition that formative assessment is a *process*. It is a process that may employ tests or various other types of assessments, but it may also employ interactive instructional strategies such as classroom discussions, assignments, homework, quizzes, projects, investigations, electronic response systems or oral questions to gauge and improve student learning (Angelo & Cross, 1993; Fennell, 2006).

Creating an interactive learning environment inside the mathematics classroom in which students are engaged in mathematics learning can be challenging. Students may experience discomfort about their own level of mathematics content knowledge and may shy away from participating openly in class discussions or responding to teachers' oral questions. Further, the complex negotiation of teacher talk, student talk, and classroom dynamics while remaining on-task requires certain skills and know-how. In some models of “best practices” in mathematics teaching and learning, these classroom dynamics are viewed as a social endeavor (Cobb & Bauersfield, 1995) in which the classroom functions as a learning community where thinking, critiquing, debating, disagreeing and agreeing are encouraged. When these dynamics work well, the result can be the creation of a learning environment in which critical thinking and quantitative reasoning develop, student learning thrives, and students take increasing responsibility for their own learning.

This paper discusses the various ways in which interactive mathematics classrooms can be created with the use of formative assessment strategies. In addition, it will report on students'

responses to a questionnaire in which students enrolled in several sections of a pre-calculus course were asked to share their opinions about current and preferred teaching styles.

The Interactive Learning Environments and the Role of Feedback

According to Motani and Garg (2002), a successful learning environment is one in which students and teachers interact easily, continuously and without any inhibitions. In this type of learning environment, student learning is not left to chance; rather, teachers know whether their students understand intended concepts. The key to this success is the implementation and use of an instantaneous feedback system. Instantaneous feedback enables teachers to intervene immediately when students misunderstand a concept or principle which is important in meeting the learning objective. A teacher may have to adjust a teaching strategy, provide different examples or offer alternative explanations. In making these adjustments, teachers show that they recognize and appreciate that previous attempts at teaching the concept or principle were not effective. Furthermore, making adjustments in teaching instantaneously with the aim of reaching all students, and especially less successful students, leads to improved learning for all students (Guskey, 2003).

Mathematics teachers can use several strategies to get and give feedback about how well students are learning material that is being taught. Motani and Garg (2002) observe that there are electronic and non-electronic mechanisms for getting feedback. Non-electronic mechanisms may include class discussions, cooperative group work, board-work, seat-work or answering questions that are posed orally. While these interactive strategies are effective, a major shortcoming is that at any particular time, only a subset of the students in the class are actively providing information to the teacher about their learning *and* are receiving feedback from the teacher. Class discussions are a good example of how an interactive strategy can work for some, but not all students. Silverthorn (2006), a professor of physiology, noted, "There was always a group of students, usually sitting at the front of the room, who would answer questions and talk to me as if we were chatting in my office, while the remainder of the class sat passively at the back [of the room] and listened and took notes" (p. 136). The students who sat at the front of the room benefited from the verbal interactive exchange with the professor. The students in the back of the room did not benefit from the exchange of information about their learning with the professor. Therefore, in order to engage more students in the interactive activities in the class, Silverthorn (2006) suggests that professors employ more student-talk, less teacher-talk and more class time for problem-solving activities.

Even when teachers employ interactive assessment strategies such as assignments or examinations to determine what and how much students have learned, care must be taken so that these strategies are effective in improving student learning. One reason that care must be taken is because the feedback to students from teachers is often delayed – that is, the feedback to students does not occur during the instruction. When students respond to questions on an assignment or examination, they may not get feedback for several days or weeks. Thus, by the time they receive feedback, they may have moved on to "learning" new content. If understanding of the new content is dependent on understanding of the old content, and if there were misunderstandings of the "old" content that were not addressed immediately when it was presented, then the cumulative effect of misunderstandings coupled with no corrective feedback could put students at risk of underperformance or even failure. A second reason is that students generally focus on doing what is necessary to get the highest grade possible on an assignment. Strategies used by students in this

context may result in very little learning. Should either of the above scenarios exist, the goal of improved student learning would be compromised.

Over the last 25 years, technological advances have provided opportunities for creating interactive mathematics learning environments using electronic mechanisms. Some examples of electronic mechanisms are personal response systems (PRS) and personal data assistants (PDA). These e-mechanisms allow interaction between fellow students and students and teachers and enable teachers to provide instantaneous or immediate feedback. For example, the PRS allows students to respond privately (and anonymously) to questions posed by the teacher during instruction. The student responses are collected, analyzed, summarized and displayed as a histogram. The teacher is able to use the results to make adjustments in teaching in real time and correct any misunderstanding of concepts or principles among students. “Low tech” strategies that accomplish similar interactive learning objectives as the “high tech” PRS and PDA are colored flash cards and quiz games. Notably though, PRS and PDA provide students who would otherwise be reluctant participants in an open interactive classroom with a safe and non-threatening way to participate in classroom activity and still provide the teacher with information about their learning that will ultimately help themselves and others maximize learning of intended instructional objectives.

The Interactive Lecture: An Oxymoron?

Research has shown consistently that traditional lecture methods in which professors talk and students listen dominate college and university classrooms. Nevertheless, for at least sixty years, and particularly during the current standards movement in education, there has been considerable effort in identifying more effective methods and procedures to enhance learning (Tyler, 1949; Hake, 1998; Robinson & Maceli, 2000; Webb, 2003; Morton, 2007).

In the 1940’s, Tyler (1949) noted that learning takes place through the active behavior of the student. According to Tyler, it is not what the teacher does, but through what the student does that learning takes place. That said, (Mazur, 2009) suggested that a modification of traditional lectures is one way to incorporate active learning in the classroom. For example, if a faculty member allows students to consolidate their notes by pausing three times for two minutes each during a 60-minute lecture, students will learn much more information (Silverthorn, 2006).

Several alternatives to the lecture format not only increase student achievement but also raise levels of student engagement in the learning activity. For example, the feedback lecture consists of two mini-lectures separated by a small-group study session built around a study guide. In the guided lecture, students listen to a 20- to 30-minute presentation without taking notes, followed by their writing for five minutes about what they remember, and then spending the remainder of the class period in small groups clarifying and elaborating the material. Morton (2007) calls the latter third of the guided lecture the “active review.” Students can also become involved during a lecture by completing short, *un-graded* exercises followed by class discussion.

Clearly, there are a variety of teaching methods and styles that can be used in mathematics classrooms. They range from mostly interactive to mostly lecture. Information gathered from students can provide incite into the degree to which teaching styles are interactive and the effect of those styles on their learning. The purpose of this study was three-fold: (1) to determine if there were differences in students’ perceptions of the amount of interaction that occurred between themselves and their teachers across sections of a pre-calculus course; (2) to report on the type of

teaching style students experienced in their last mathematics course, and the type of teaching style students would prefer in the next mathematics course if they were to enroll in one in the future; and (3) to examine the relationship between students' perceptions of the amount of interaction in the teaching style of their pre-calculus course and the extent to which that teaching style helped them understand concepts taught in the course.

METHODOLOGY

Participants

The sample consisted of 117 students who were enrolled in three different sections of a pre-calculus course during the spring semester. At the beginning of the semester, enrollment in the three sections was approximately the same. The different sections of pre-calculus were randomly assigned to experimental and control conditions. Two instructors were assigned to the experimental condition and one was assigned to the control condition. By the end of the semester, 101 students were enrolled in two experimental sections and 16 students were enrolled in the control section. There were 41 males and 74 females. Two students did not identify their gender.

Experimental vs. Control Sections of Pre-calculus

Instructors who were assigned to the experimental sections of pre-calculus employed a teaching style that incorporated frequent use of questioning that was designed to engage students, provide them with greater opportunities to learn, and improve their understanding of concepts. This teaching style also involved more examples in real world contexts. Longer "wait times" were embraced and most questions sought to determine if students had developed conceptual understanding of concepts rather than just knowledge of simple facts. In contrast, the instructor who was assigned to the control section employed a traditional lecture approach to teaching pre-calculus.

Teaching Style Questionnaire

At the end of the semester, students completed a seven-item questionnaire in which they were asked to respond to questions about their perceptions about the amount of interaction characterized by the teaching style of various mathematics courses – past, current and future. In particular, the questions were grouped according to the teaching style of the instructor for the current course, the teaching style of the instructor for the mathematics course taken previously, the students' preferences for teaching style in a future mathematics course, and their perceptions about the extent to which the teaching style employed in the mathematics course helped them to understand the concepts that were taught (See **Appendix**). At the time the questionnaire was administered, all instructors were teaching the same mathematical content--in fact, all were at the same point in the syllabus.

RESULTS

Null Hypothesis 1: "There are no differences in students' perceptions of the amount of interaction that occurred between themselves and their teachers across experimental and control sections of a pre-calculus course."

Descriptive statistics were used to calculate the percent of students who responded on a continuum from "strongly disagree" = 1 to "strongly agree" = 5 for Item 2 which states: "The teaching style in my (current) pre-calculus course is mostly interactive." The results indicate that among students enrolled in the control section of pre-calculus, 25% "strongly agreed" or "agreed" that the style of teaching was interactive; whereas, among students enrolled in the experimental sections, 74.3% "strongly agreed" or "agreed" that the style of teaching was interactive.

To test the null hypothesis of no differences in students' perceptions about the amount of interaction that occurred between themselves and their teachers across the control and experimental sections, a one-way analysis of variance was performed on the sum of the items that dealt with lecture (Item 1) and interactive styles (Item 2), with corresponding contrasts to test the differences in means between the combined experimental sections and the control sections. The results revealed that (1) there were significant differences in the teaching styles among the three pre-calculus instructors ($F = 9.36$, $df = 2, 114$, $p = .0002$), and (2) when the combined means of the experimental sections were compared with the control section, the difference was significant ($t = 4.28$, $df = 114$, $p < .0001$). The results indicate that the teaching style in the experimental sections was significantly more interactive than in the control section. Thus, the null hypothesis of no differences in teaching styles among the (current) pre-calculus instructors was rejected.

Null Hypothesis 2: "There are no significant differences in students' perceptions of the teaching styles employed by instructors in students' last (previous) mathematics course."

Sub-hypothesis 2.1: "There are no differences in the proportions of students across control and experimental groups who prefer 'at least some interaction' in the teaching style of their future (next) mathematics instructor."

To get a sense of the style of teaching the students had experienced just prior to their enrollment in the pre-calculus course, the students were asked to respond on a continuum from "strongly disagree" = 1 to "strongly agree" = 5 to Item 6 which states: "The teaching style of the instructor for the *last* mathematics course was mostly interactive." Descriptive statistics were used to calculate the percent of students who responded at each level on the continuum. Among students in the control section, 27.5% "strongly agreed" or "agreed", 18.8% were "unsure", and 43.8% "strongly disagreed" or "disagreed". Responses from students in the experimental sections indicated that 38.8% "strongly agreed" or "agreed", 12.9% were "unsure", and 58.5% "strongly disagreed" or "disagreed". A one-way analysis of variance was performed to test the hypothesis of no differences among the means of the three classes. The results indicate that there were no significant differences ($F = 1.54$, $df = 2, 113$, $p > .05$). Thus, regardless of whether the students were enrolled in the experimental or control sections, they perceived that the teaching style of the instructor in their previous mathematics course was "mostly lecture." Thus, the null hypothesis of no differences in the teaching styles of instructors of the students' last or previous mathematics course was supported.

To get a sense of their preferred teaching style, and address Sub-Hypothesis 2.1, students were asked Item 7 which states: "If you were to enroll in a mathematics course in the future, which

style of teaching would you prefer?" Students selected among: "mostly lecture," "some lecture, some interaction," and "mostly interactive." Of all students surveyed, 98.3% preferred a teaching style that has "some interaction" or is "mostly interactive." Interestingly, among the students in the control section, 100% responded that they would prefer some type of interaction in a future mathematics class. Among the students in the experimental sections 98% responded similarly; hence, there was no difference in the proportion or percent of students across control and experimental sections who prefer some type of interaction in their next mathematics instructor's teaching style.

Null Hypothesis 3: There is no relationship between students' perceptions of the amount of interaction in the teaching style of their current pre-calculus course and their perceptions of the extent to which that teaching style helps them understand the concepts taught in the course.

Students were asked to respond on a continuum from "strongly disagree" (1) to "strongly agree" (5) to Item 3 which states: "The teaching style of the instructor for this mathematics course helps me understand the concepts taught in the course." Students enrolled in the control section of pre-calculus, 31.3% "strongly agreed" or "agreed", 12.5% were "unsure", and 56.3% "strongly disagreed" or "disagreed." For students in the experimental sections, 81.1% "strongly agreed" or "agreed", 8.9% were "unsure", and 8.9% "strongly disagreed" or "disagreed."

The results also reveal that there is a significant correlation ($r = .37, p < .01$) between the students' perceptions of the extent of interaction in the teaching style employed in the *current* pre-calculus course and their perceptions of the extent to which the teaching style in the course facilitated understanding of concepts. This correlation coefficient indicates that the more interactive the teaching style in their pre-calculus course, the more that teaching style helped them understand the concepts taught in the course.

To test the hypothesis that there are no differences among the three pre-calculus sections in students' perceptions about the extent to which the teaching style of the mathematics course helps the student understand the concepts taught in the course, a one-way analysis of variance was performed with a corresponding contrast to test the difference in means between the combined experimental sections and the control sections. The results reveal that (1) there were significant differences in the students' perceptions of the effectiveness of the teaching style in facilitating understanding of concepts taught in the course ($F = 13.66, df = 2, 113, p < .0001$), and (2) when the combined means of the experimental sections were compared with the control section again the difference was significant ($t = 5.12, df = 113, p < .0001$). The results indicate that students in pre-calculus felt that a teaching style that is "mostly interactive" facilitates understanding of concepts to a greater degree than a style of teaching that is "mostly lecture."

Finally, when asked if the teaching style in the *last* mathematics course facilitated understanding of concepts, there was a significant correlation ($r = .58, p < .01$) between the students' perceptions of the extent of interaction in the teaching style employed in the *last* mathematics course taken by the students and their perceptions of the extent to which the teaching style facilitated understanding of concepts. The results also revealed that there were no differences in the mean responses of the three classes ($F = 1.43, df = 2, 114, p > .05$). Additionally, among the students in the control section 43.8% "strongly agreed" or "agreed", 12.5% were "unsure," and 43.8% "strongly disagreed" or "disagreed" that the teaching style in the last mathematics course helped them understand the concepts being taught. Among the students in the experimental sections 44.5% "strongly agreed" or "agreed," 10.9% were "unsure," and 44.6% "strongly disagreed" or

“disagreed.” When these results are considered along with the results of Null Hypothesis 2, we find that less than half of all students “strongly agreed” or “agreed” that a teaching style that is “mostly lecture” helps them understand concepts that are being taught in their mathematics course.

DISCUSSION

Interest in improving the quality of mathematics teaching and learning in American primary and secondary schools *and* in colleges and universities has grown tremendously in recent years. Part of the growth is due to a realization that the world is getting “flatter” (Friedman, 2006) and that a key to remaining competitive in the midst of globalization is to have a mathematically literate citizenry. The making of a mathematically literate citizenry will not happen by chance or overnight. Without an instructional focus on teaching for *understanding*, students are at risk of viewing mathematics as a collection of rules and procedures to be memorized, regurgitated and eventually forgotten. Teaching mathematics for understanding, on the other hand, engages students more fully in the learning process by making use of interactive assessment and teaching strategies (Silver, et al, 2009).

Learning and teaching are iterative processes that ideally continue until a desired goal has been reached. In the interactive learning environment, there are many strategies that can be used to produce feedback that can be used to reach the goal. Before the information is used, however, a “gap analysis” is performed to determine the “next steps”. Feedback fills the gap iteratively until the goal is met. The feedback might come instantaneously with the aid of e-mechanisms such as the PRS or PDA or it may be delayed when more traditional methods of assessment are used such as assignments or examinations. In either case, the interactive mechanism might engage a few students at a time for example through class discussions or cooperative groups or it may allow for maximum participation through the e-mechanism.

The use of interactive assessment strategies along with interactive instructional strategies in order to enhance student learning makes good educational sense. In fact, the two are inextricably linked to one another. The definition formative assessment, for example, contains many “actions” that students and teachers can take independently and collaboratively during the instructional process. The actions of the students and teachers produce feedback that is used to make adjustments either in teaching, in learning or in both and thereby, create successful interactive learning environments. For students, that information can come from teachers, other students or from the student himself. Interacting with teachers or other students to get feedback about a task helps a student to remain on target toward the desired goal. Interacting with oneself in the assessment/instructional process builds self-monitoring, self-reflection, self-assessment, and self-regulation skills. When students develop these “self-” skills, they become independent, life long learners.

Comfort level with certain types of interactive assessment mechanisms may be generational-based. If the learning environment is made up of millennials (ages 27 and younger), there is a good chance that they have grown up with technology. Millennials make up the general population of undergraduates and graduates on most college and university campuses. For this group, education through technology is the norm (Eshleman, 2008). On the other hand, if the learning environment consists primarily of traditionalists (over age 60) or boomers (ages 48 to 62), they expect their educational experiences to resemble the didactic lecture format and may view the ubiquitous



MATHEMATICS TEACHING-RESEARCH JOURNAL ONLINE
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PowerPoint presentations as “high-tech.” They may also feel threatened by interactive Web-based or Internet technologies. Still, they are good at leading cooperative groups. Finally, there are the GenXers (ages 28 to 47). They, like the millennials, are generally comfortable with technology and are good at thinking outside the box (Eshleman, 2008). A successful interactive learning environment will meet the needs of all of these diverse components of the general population.

As the twenty-first century unfolds, the United States is faced with an extraordinary challenge – that of providing a quality education for all of its diverse citizens. The diversity of its citizenry is what makes it unique; but failure to nurture, appreciate and educate that citizenry will mean the lost of valuable human capital – capital the United States cannot afford to lose. Education is the tool for developing that human capital. Furthermore, making sure that learners actually learn with understanding regardless of gender, socio-economic status, race/ethnicity, or even generational membership may be a challenge, but it is one that can be overcome successfully. By implementing effective interactive assessment and teaching strategies, educators can ensure that all citizens are able to make meaningful contributions to their local, national, and the global communities.

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MATHEMATICS TEACHING-RESEARCH JOURNAL ONLINE
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Appendix

**Student Questionnaire on Perceptions of Teaching Style
and Understanding of Mathematics Concepts**

Directions: For each statements in Items 1-6, indicate the extent to which you agree with the statement, where “strongly disagree” = 1; “disagree” = 2; “unsure” = 3; “agree” = 4; and “strongly agree” = 5. For Item 7, please indicate whether for a

ITEMS	Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree
1. The teaching style in my (current) pre-calculus course is mostly lecture.					
2. The teaching style in my (current) pre-calculus course is mostly interactive.					
3. The teaching style of the instructor for this mathematics course helps me understand the concepts taught in this course.					
4. The teaching style in my last mathematics course was mostly lecture.					
5. The teaching style in my last mathematics course was mostly interactive.					
6. The teaching style of the instructor in my last mathematics course helped me understand the concepts taught in that course.					
	Mostly Lecture	Some Lecture	Some Interaction	Mostly Interactive	
7. If you were to enroll in a mathematics class in the future, which teaching style would you prefer?					