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Title: Modeling Teachers' Questions in High School Mathematics Classes

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Focus & Introduction

Questioning in the classroom

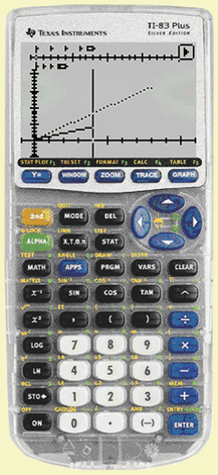
We examine teachers' practice of asking questions in a mathematics classroom and how it relates to student response, engagement, and how questioning can set the norm for classroom flow. The data we discuss is based on video records of classroom teaching at two high schools and a university in southern Massachusetts, USA. The video data was collected as part of a larger National Science Foundation study, that examines teachers' use of technology in classrooms, and was not chosen for the specific purpose of examining teachers' questioning. The video data consists of wirelessly connected classrooms using SimCalc Connected MathWorlds as well as non-connected classrooms.

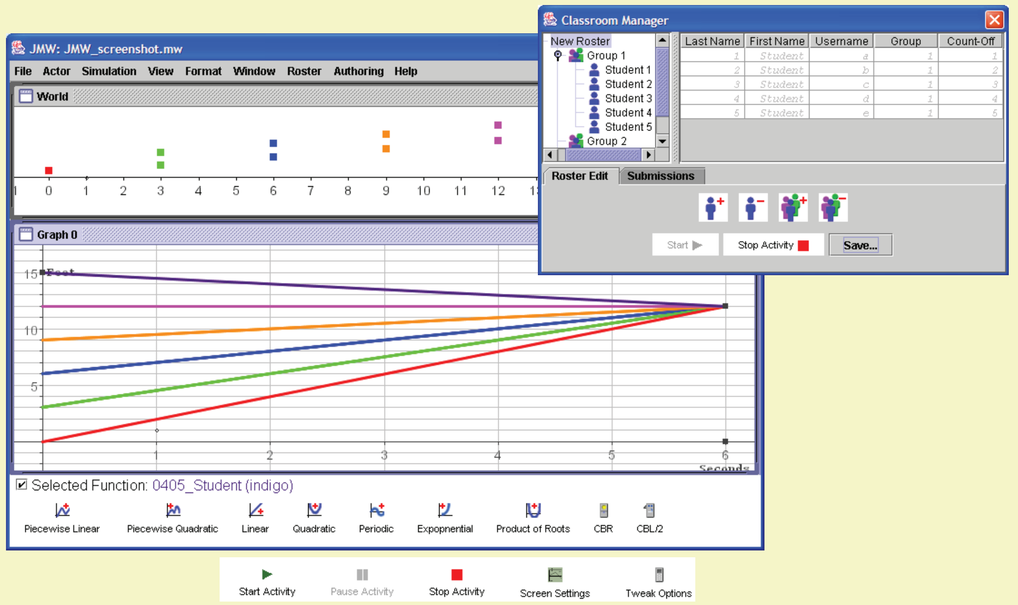
What is a wirelessly connected classroom using SimCalc Connected MathWorlds?

- A connected classroom combines two basic technology affordances: Representation and Communication

- Parallel software: Students create mathematical objects on our software running on the TI 83+/84+ graphing calculator that are aggregated into our host software running on the PC via TI's Navigator wireless network

- Such an action by the teacher, though, was not done in an arbitrary fashion (i.e. collect all work) but in a mathematically meaningful way





Questioning in The Classroom

It is not uncommon for teachers to ask a lot of questions in a mathematics classroom. We have looked at classroom videos of several teachers and when we plot the number of questions asked versus time, the plot is uniformly linear (r^2= 0.98). Based on our data, the constant rate of questioning often extends over an entire class period. When a teacher is asking, on average, 1 question per 10 seconds.

Time of questions (A representative graph)

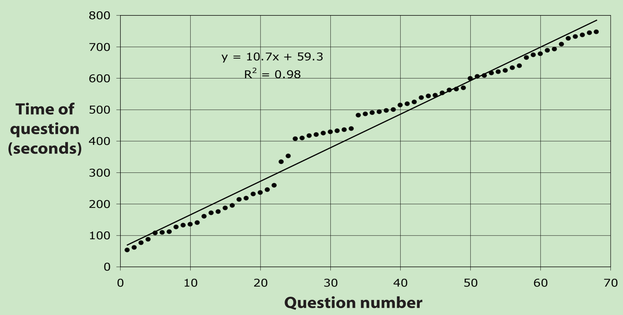


Figure 1. Time a question is asked versus question number. Representative graph; r^2=0.98

Distribution of Wait-Times

Mary Budd Rowe (1972) introduced the idea of "wait-time": the time from a teacher's question until the teacher speaks again. Her research showed that increasing wait-times to 3 or more seconds has a strong positive effect on student answers; student responses were longer and more accurate, the number of "I don't know" answers, and no answers decreased, more students volunteered appropriate answers, and test scores increased. We look at the descriptive statistics of wait times, and their distribution, for one of the video clips we obtained for Teacher A: these statistics are typical.

Teacher	Period, (minutes: seconds)	Mean time between questions (seconds)	r^2 for linear fit	Mean wait-time (seconds)	Stdev of wait-times (seconds)	% wait-times ≥ 3 seconds
A	9:39	9.1	0.97	3.1	2.1	45%

Table 1. Distribution of wait times for a teacher during a period of high questioning

We see from the table above, Table 1, that a uniformly high rate of questioning, with a brief average time between questions, is not inconsistent with a mean wait-time that is close to the recommended 3 second period, nor with a relatively high percentage of wait-times that are 3 or more seconds.

What is the nature of teachers' questions that have a significantly higher, or lower, than average wait-time?

Questions with a wait-time z-score greater than or equal to 1 were as follows:

Question	Wait-time (secs)	z-score
"Why is that line steeper ?"	7.9	2.28
"Which line is steeper now?"	7.2	1.96
"…someone explain that … where, where can you find one and a half, zero?	7.1	1.91
"We need to write the equation of the line passing through this point … and with … this slope. How do we start this, Corie?	6.8	1.77
"m is five halves … x is six … plus b. What are we finding here, John?"	6.0	1.36
"Where do the two lines intersect ?"	5.5	1.13
"Can you look [*student name*] and tell me which line will be steeper,.. which line will … steeper … Jarrad ?"	5.4	1.08
"Tara, what is that point?"	5.3	1.06
"Any other questions?"	5.2	1.00

Table 2. Questions with a wait-time z-score greater than or equal to 1

Questions with a wait-time z-score less than or equal to 1 were as follows:

Question	Wait-time (secs)	z-score
"We all put the same two equations, correct ?"	0.9	-1.01
"One and a half … yes?"	0.9	-1.05
"What is it?" [*following student response*]	0.8	-1.06
"… and what that does it changes all the signs. Correct ?"	0.8	-1.06
" a can't be negative, right?"	0.8	-1.08
"We only sent two equations, right?"	0.8	-1.09
"Which line will be steeper ?"	0.7	-1.11
"When we have the x-intercept the value of y is zero, correct ?"	0.7	-1.12
"What can you tell me about … slopes in general?"	0.4	-1.27

Table 3. Questions with a wait-time z-score less than or equal to 1

Our data collected relates directly to this work done by Rowe; the teachers we've looked at have a mean wait time of 3.1 seconds. The interesting part is that the data is a highly skewed distribution with a high percentage of wait-times that are 3 or more seconds. We have also found that the nature of the questions affects the wait time given by the teacher. In Table 2, the questions with longer wait times related to the teacher's aims for the class whereas the questions in Table 3 which had shorter wait times did not directly pertain to the objective of the class according to the teacher.

Future Direction

In the future, we plan on focusing on the following ideas:

- It has been shown that in a wirelessly connected classroom, shared student work can lead to complex student peer to peer discussions, engagement in mathematical activities, and student question generation. How does this affect the wait time after a teacher's question?

- How does teacher questioning change in a wirelessly connected classroom, particularly with respect to the number of questions asked, the type of questions asked, and the student responses to teachers' questions?

- Will the questions teachers ask which are directly related to their aims for the class go up?

- Will the rate of questions asked versus time during the course of a SimCalc Connected classroom be as constant and as uniformly linear as classes that are not conneted?

- Will the amount of questions which students ask in the classrooom change?

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