

# Teachers' Use of Classroom Connectivity Technology: Log File Analysis

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**Abstract:** This paper introduces a software usage tracing mechanism and analysis of user log files for a large scale educational research project. The research data is collected online from 50 teachers. The data is parsed and stored in a MySQL database using scripting technologies. In this presentation, a logging process appropriate for educational software usage and the analysis of user traces in educational settings are described by frequency analysis techniques. This novel format of obtaining electronic user traces provides more valuable information about teachers' educational technology use compared to standard logging structures. Data analysis shows that teachers' implementation level and student participation in classroom activities differ with the time of the year, course content, choice and amount of different components and arrangement of instructional strategies in the classroom. Overall student participation in classroom activities is high. It is concluded that the technology use enables teachers to improve their understanding of student learning.

## Introduction

The Classroom Connectivity for Promoting Mathematics and Science Achievement (CCMS) project is an interdisciplinary effort to study the effects of using electronic classroom communication systems on the changes in teachers' practices and technology use strategies in algebra and physical science classrooms (funded June 1, 2005 by the Institute of Education Services, USDOE, Project # R305K050045). Findings of this research will enlighten educators about how the teachers employ formative assessment techniques, whether the quality of their questioning can be improved with professional training and the effect on student self regulated learning skills. The project also aims to elucidate the development and improvement in classroom discourse by the use of classroom communication technology. The whole project includes 104 middle and high school teachers from a national sample (37 states), half in experimental groups and the other half in control groups. The teachers include algebra 1 (95) and physical science teachers (8) in treatment group.

The classroom communication system used in this research effort is a wireless hardware and software combination that works with a class set of graphing calculators for each student, wireless hubs for every four students, an access point that communicates with the hubs and a personal computer with the TI-Navigator™ software loaded. When connected to the system, graphing calculators turn into wireless handheld devices and can send and receive textual and numeric information to and from the computer.

The proposed intervention in this project consists of provision of connected classroom technology, professional development program consisting of a weeklong summer institute, one day workshops and online web based training. The research effort in this project is to find out how the use of connected classroom technology affects student achievement self regulated learning behaviors and their views about mathematics and science. Teachers are also being investigated for the change in their formative assessment and discourse practices patterns with the use of connected classroom technology. The project examines the use of classroom connectivity technology to understand the relationship between pedagogy and technology in connected classrooms.

Similar to many research efforts in the instructional technology field, one of the basic issues in data collection process of CCMS project is to obtain valid and reliable information about the actual use of the technologies in the classroom. It is important to know if and how teachers use the technology as well as to study both powerful aspects and weaknesses. Educational institutions often invest in technology based

on the outcome and the implementation level. Researchers want to know how and to what extent the teachers implement technology not only to better facilitate educational resources, but also to find out what factors affect implementation of the technology. Carefully designed and accurate quantitative research studies depend on concrete measures of actual occurrences in educational settings. Research supports the idea of using computerized tools to help teachers better assess what students know (Paschal, 2002). Teachers can obtain fast and accurate information about student learning with the use of classroom response technologies like clickers (Preszler, Dawe, Shuster, & Shuster, 2007). Furthermore, we need to know how teachers use the instructional software to employ the best practices of various profiles and types of technology users since different characteristics suggest different needs.

There are three main data collection tools used in research to obtain implementation information and these have their own advantages and disadvantages:

a. User report: Many studies ask users (teachers and students) about the actual use of technology in the classroom. Many attempt to use surveys and interviews as data sources. The advantage of this method is to collect data about user opinions about the use of the technology. However, it fails to accurately reflect the use of the technology in a longer period of time since the data is limited to user's memory. (Wozney, Venkatesh, & Abrami, 2006; Owston, 2000; Rakes, Fields, & Cox, 2006).

b. Classroom observations: Accurate information about actual implementation can be collected by observing whether it is being used. It also allows for a sense of the environment within which the technology is used, but number and duration of observations are very limited in most cases. Limited number of cases does not provide opportunity to conduct powerful correlational analyses. Classroom observations make possible the examination of a limited number of classrooms in depth, but not a large sample for a long period of time due to the nature of the research method employed. It is also very likely to overlook examples that are not evidenced during the classroom observations (Mills & Ragan, 2000)

c. Software tracing: Computer applications can leave electronic traces of technology use which may be saved automatically. Analysis of these "log" files can provide information about actual use of technology (Saye & Brush, 2001; Nurmela, 1999; Reips & Stieger, 2004).

## **Log File Analysis**

Log files are usually text files holding information about user actions. Most computer programs including operating systems are arranged to record events in one or more files. Logging in electronic use is intended for troubleshooting purposes. For software, they provide information to point out programming errors or bugs. In network environments, they are used to understand the traffic to or from a system being monitored or protected. Operating systems tend to log many types of computer events to troubleshoot and optimize the system performance. These files have slightly different structures, but they generally contain information about a) the date and time of the event, b) type of event, and c) source of event.

The most common log file format is the one used by web servers as described by the W3 consortium (Luotonen, 1995). This type of logging function provides usage information about when and where web clients are connecting to the server, and which resources are being visited in almost every web based e-learning application. Many research studies report attempts to use log files to investigate e-learning experiences. Logging function of a web server is a standard W3C format and it provides some useful information for educational research but it does not help us develop detailed understanding of instructional use (Boving & Simonsen, 2004; Nyvang & Bygholm, 2005; Owston, 2000). As a result, researchers have not seriously considered log file data as a useful source of information regarding learning behavior (Zupancic & Horz, 2002) TI Navigator™ software, on the other hand, has a different logging mechanism targeted specifically for educational research. This feature, described later in this paper, is designed to understand teacher and student behaviors in a classroom where the technology is utilized.

The TI-Navigator™ software runs on the computer and does more than controlling the information stream by allowing the teacher to design and conduct learning activities which can adequately support inquiry based lessons. Furthermore, one of the strong features of this technology is that it can provide fast, accurate, and relevant information about student learning. The teacher can collect answers to a question from all of the students in a matter of seconds. Then as a class, they can share and discuss the results (Davis, 2003). There are four important components integrated in the system: Activity center, quick

poll, screen capture and class analysis.

## **Activity center**

This group of components is used to exchange information among students and teacher. These are combined in the software and they can be used on the fly, or for preplanned activities. Four types of activities can be carried out: Equation activity, list activity, point activity and form activity.

**Equation activity:** Teacher can send equations and graphs to student calculators to introduce or use mathematical concepts as well as real world problems and in other subject areas such as physics and chemistry. Students can also send equations and/or graphs to teacher's computer and teacher can aggregate what individual students just sent, and can share it with the whole class to initiate class discussion. This activity is most advantageous when the students struggle with visualizing an equation or some mathematical process since it is possible for teacher to convert the equation to its graph form with a single click of a button.

**Points activity:** The handheld devices have a graphic screen which can show low resolution images and graphs. Teacher can send a background image to student calculators and students can mark a point on the image. When teacher collects the data set from student calculators, all class points will show on a projected screen with each student's marking in front of the background image. Additionally, students can interactively connect to teacher's computer and move their cursors on the projected screen in real time. This functionality is particularly useful to introduce special points on a graph, or certain aspects of scales (i.e. pH) or maps.

**List activity:** Dealing with the real world problems in a discovery based lesson often requires students to gather data. Using list activity, the teacher can aggregate the data coming from the group or individual students and display the list and/or graph on a projected screen. The teacher can send data sets back to calculators so that the students can work on real world data and discuss related mathematical or science concepts.

**Form activity:** It is very similar to using lists, but it requires less procedural skills to enter data sets onto the calculators. Teacher prepares the form and sends it to student calculators. Students collect data and enter it using the form on the calculator.

## **Quick poll**

This functionality is to gather information from students. Quick poll is the most commonly used function in the classroom and it is very similar to clicker application. Teacher can send probes, or questions in many different types, including customized multiple choice, true/false, agree/disagree, and open ended questions. Teacher can send the question probe to students calculators and collect the answers. The results can be displayed on the screen, or can be saved for later evaluation. This application enables teachers to collect student input rapidly and is mostly used for formative assessment purposes.

## **Screen Capture**

This small but useful application displays current calculator screens. With a click of a button, the teacher can see what each student is working on at any given moment. This function allows the teacher to have a more accurate judgment on student's task orientation. The screen pictures of student calculators can be projected for the whole class to see and this also increases student engagement and student on-task behavior. Teachers can provide individualized differentiated instruction since they are better informed about student task behavior with the use of screen capture.

## **Class Analysis & Learning Check**

Two applications are used to assess student understanding. Learning check is a test creating application. Class analysis is used to collect and assess student answers through the classroom communication system against correct answer choices. Teacher prepares the test using various types of

questions and sends the test to student calculators. Students can work on the test in the classroom, or they can take the calculators and do the test as homework. The answers can be collected as soon as students log back in to the system. The results can be presented on the screen in various forms. All applications revealing student input allows teachers to choose displaying student identification.

### **Software logging feature**

The logging feature of the Navigator™ is considerably different than the standard logging formats. Once enabled, the software creates four comma separated text files. These include normalized and hierarchically structured data of the occurrences during the time the software is being used. Below are brief descriptions of these files:

Class Sessions File: Software traces regarding to the class session created on the computer with registered student usernames included in this file. The information attributes are following;

a. Session identifier: When teacher starts the class session from the software, this unique ID is created.

b. Start and end timestamps of the class session. Although this may not be the actual time when the "real" class begins, classroom observations and teacher interviews suggest that teachers start the class even if they do not plan to use the technology in their classroom.

c. Class name as created by the teacher

d. Number of students logged in for that session.

Activities File: Marked by the class session identifier from class sessions file, each record in this file represents an occurrence of usage of one of the components. The information included in this file is under these headers:

a. Class session identifier: To connect each record with the class session, this field includes the same information from the matching record in class sessions file.

b. Activity type: This field contains information about the component of the software being utilized (Points activity, quick poll, screen capture, etc.)

c. Activity detail: Different activities have different attributes in this field: Activity center: Whether this is a point, line or equation activity ; quick poll: type of question used (i.e. open response, multiple choice) and the question probe that teacher sent to the student calculators; learn check: Name of the file that has been transferred and direction of the transfer (from teacher to students or vice versa) ; screen capture: Whether teacher started or refreshed the student calculators' screen.

d. Start and end time stamps. Each component has a start and stop button, with the exception of screen capture which has refresh button.

e. Number of students enrolled in the activity.

Attendance File includes student usernames and a class session identifier. Activity Types File is a simple list of possible components with id numbers which are used to relate activity records, these last two files are not collected and not included in the analysis.

Although there are countless of different types of information that can be extracted from log file analysis, this presentation focuses on the solutions of practical issues related to employing a concrete information source that provides data for the broader research questions asked in CCMS project. The types of information gathered are as following;

- Technology use: Average duration and weekly frequency of use of the software.
- Pedagogical use: Types and frequency of instructional activity use (activity center), average number of assessment activity use (Quick poll, class analysis), average number of student monitoring activity use (screen capture), average duration for teacher to stop the activity and the rate of the students who did not enrolled in activities.

It is reported in the literature that the use of this technology improves teachers' use of formative assessment techniques and allows students to participate in class activities in larger rates (Paschal, 2002; Preszler et al., 2007). When a question is posed students tend to respond more frequently and freely. There are some factors affecting this behavior such as anonymity and ownership. Students see that their answers are anonymous. They recognize their own answers and realize that there are in fact others like them putting the wrong answer. Also, the assessment results are shared on a projected screen and teacher build a discussion on it. This makes students feel that their answers are part of the process of construction of knowledge and this creates a community in the classroom. (Abrahamson, 1998; Roschelle, Penuel, &

Abrahamson, 2004; Davis, 2002; Black & Wiliam, 1998)

## Method

104 middle and high school mathematics and physical science teachers from 37 states have enrolled in one-week summer institutes in three groups. Having the same structure, three institutes in three years provide teachers with the opportunity of learning how to use the software, how to use it in educational settings, what type of classroom activities it supports and what learning opportunities it can reveal. They also engaged in long structured discussions about two important and beneficial pedagogical applications of the software: formative assessment and self regulated learning. They have also designed their own sample lessons and presented to the whole group.

Shortly after each institute, teachers obtained their Navigator hardware and started using in their classroom. They were instructed to enable the logging feature. Then a web-based application was created to receive the log files, parse them into usable information chunks and transfer them into a database. Teachers started to upload their log files earlier in the school year, and once they did, records in these comma separated text files converted to row/column format and were stored in a database by a php script running on the server side. The data is collected from 50 out of 104 treatment group teachers.

The other data sources used are telephone interviews with each teacher and classroom observations of selected group of teachers. Teachers' technology use information and class demographics are collected through surveys. The information collected from these sources is used to compare the usage information.

## Findings

Average class session duration is defined as the average number of minutes of the time period between the "begin class" and "end class" buttons are pressed when more than one student logged in to the class. The average class duration is found 53:58 min (s.d. 25:07). The difference among teachers is considerably large. The results change from 36 min to an hour and 26 min. There are two groups of class sessions: single-period (~ 40 min) and block (~90 min). The results are correlated with the information reported by teachers (Correlation coefficient: .413,  $p < .005$ ), although there is a significant difference between two data set suggesting that the teachers overestimated class period ( $t = 3.086$ ,  $p < .003$ ).

Average class size is the average number of students logged in to class sessions. Calculated overall average is 16.97 (s.d. 7.24). This information confirms the teacher reported data. Even though there is a significant correlation between teacher reported and log file revealed results ( $r = .538$ ,  $p < .000$ ), there is also significant difference between two data set ( $t = 7.885$ ,  $p < .000$ ). This probably reflects the fact that not all students attend class everyday, and there are usually a few students missing in the class session.

Average usage per week is one of the important measures of implementation fidelity construct. Analysis revealed that teachers use the technology an average of 2.85 times per week (s.d. 2.19) This result set shows (Table 1) that most teachers use technology 1-2 times per week.

Average use per week	N	Percentage (%)
less than once	10	20
1-2 times	15	30
2-3 times	3	6
3-4 times	9	18
4-5 times	3	6
More than 5 times	10	20

**Table 1:** Average weekly use of the technology.

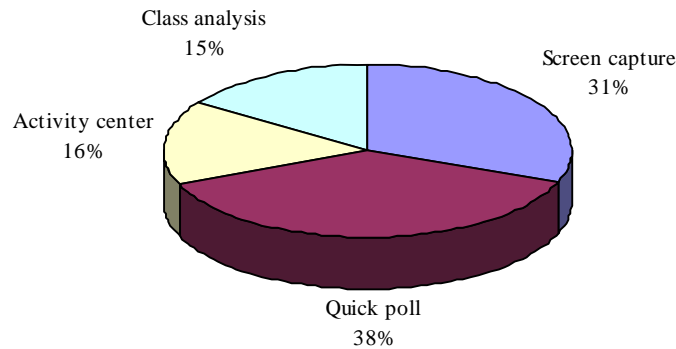
The number and frequency of component use is also calculated. Teachers used 4.50 activities per class session. Table 2 shows the component use average per class session.

Component	Average
Screen capture	1.49
Quick poll	1.81
Activity center	0.77
Class analysis	0.42

**Table 2:** Average number of component use per class session.

The findings show that screen capture and quick poll can be used more than once per class. This is probably because these are relatively brief activities. Activity center, however, may very well last for the entire class session. Class analysis is a type of component that teachers use toward the end of a unit or a broader subject.

The graph in Figure 1 shows the number of components used for the academic year. As can be seen from the graph, screen capture and quick poll are the most used components. This suggests that the components usually used for assessment purposes are the ones that are prevalently utilized (Quick poll and screen capture). Screen capture is a class monitoring tool for most of the time since teacher can see and show current individual student calculator screens.



**Figure 1:** Overall distribution of components.

The analysis of log files revealed that teachers employ different components in various periods of school year. This suggests the content dependency of the technology. Classroom activities differ over a course within the year, and the findings demonstrate that quick poll component is excessively used toward the end of the academic year.

It is also found that the average student participation in the classroom activities is considerably high. Table 3 shows that an average 91 percent of the students participated in class activities. Student attendance differs with components and there is no student participation data for screen capture.

Component	Percent
Overall	91%
Quick poll	85%
Activity center	93%
Class analysis	97%

**Table 3:** Student participation in class activities with different components used.

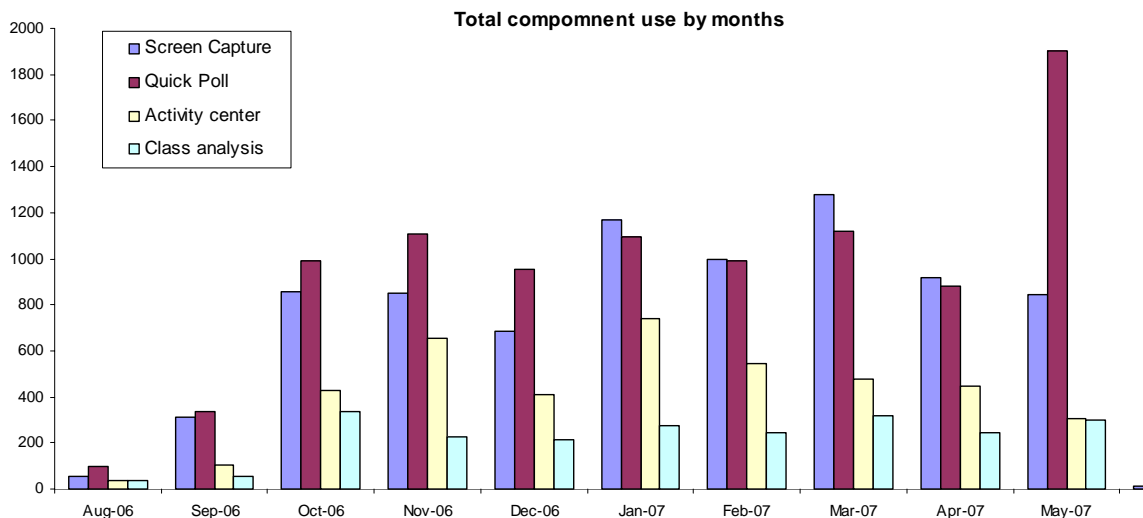


Figure 2: Monthly usage distribution of components.

## Conclusion

The results show that the analysis of log files can provide concrete and tangible information about the technology used in the classroom. Class session duration information provides insight about the maximum possible time that the technology is being used in the classroom. There seem to be two major class type among the teacher participated in this study: single period and block. The actual classroom observations suggest that teachers use the technology during the actual instruction period, but not the whole class period set by the school calendar. Interestingly enough, both average class duration and the average number of total students per class session turned out to be overestimated. This finding agrees with the prior research reported in the literature (Ballantine, Larres, & Oyelere, 2007)

Different components in this software serve different purposes. We can tell from the Table 2 that an important way teachers used this technology was to receive feedback. This can be considered as part of the formative assessment process during the class since teachers can see actual student activities on the calculator screens and can decide if they are on task or not. Additionally, it is observed in the classroom that screen capture can be used as student input tool for the classroom activity as well as a tool for student feedback as in quick poll. In any case, these two components are the major tools in this system that supports on-the-fly assessment practices. The results suggest that the classroom connectivity technology helps teacher formatively assess student learning as the lesson unfolds.

Student participation is also an important aspect of overall implementation of classroom communication technology. The studies suggest that the instructional technology increases the student participation in learning activities in class. If we look at Table 2 and Table 3 together, we see that high participation rate in quick poll shows 85 percent of the students participation as feedback for 1.81 times per class session. This shows one of the powerful aspects of the technology as well as the logging mechanism.

This novel logging process provides an information source to verify some aspects of implementation fidelity of desirable pedagogy in the classroom. Reported research on the area of analyzing usage information in software applications in the classroom lacks the level of detailed information reported here. Previously, log files were considered to be a secondary information source. Standard logging formats are designed to find bugs, track malicious use, and improve the software functionality, while TI\_Navigator™ logging mechanism is created to trace only user actions with actual meanings which can be very useful in educational research. It is more feasible because it provides usage information about every classroom session; information is concrete and practical for educational settings.

There is still some information missing in this analysis. The log files fail to inform researchers about actual thinking processes of teachers and students. We can know when the class starts or how long the technology is used. We can even know how the technology is used and how the teacher designed the lesson, but the deeper information on learning in the field remains uncertain.

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