

The eChalk system: Potential of teaching with intelligent digital Chalkboards

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eChalk is a software system that transforms an electronic whiteboard into a teaching tool simulating a traditional chalkboard. In addition to writing and drawings, the electronic chalkboard handles a wide range of multimedia enhancements. These may be used to enliven the lessons by visualization, allowing the system to surpass the didactic potentials of the traditional chalkboard. In order to use the eChalk Software in the classroom, a pen based input device and a wide display is needed. The system records all actions and provides both a live transmission and a replay of the lecture from the web as a by-product of regular classroom teaching. Remote students follow the lecture by watching the dynamic board content and listening to the recorded voice of the instructor. From our point of view, advantageous application in particular for teaching in different cultures is characterized. This is especially true for cultures with non-Latin scripts and regions which lack the infrastructure for high-speed Internet connections.

Keywords electronic boards; board metaphor; distance teaching; lecture recording

1. Introduction

Nowadays, it is common in university teaching to rely on the use of slideware (such as Microsoft PowerPoint) for additional motivation of students by providing a modern touch to their lectures. New teaching materials can be produced with relative ease, providing a professional, polished look, while publication is simultaneously simplified, both electronically and as hardcopies. Once created, the materials can be quickly and easily reused.

However, the employment of slideware products in teaching has also been heavily criticized [5]. These products have been developed for commercial presentation purposes. It has been argued that they are well-suited to the task of “selling” a product or idea but tend to be inadequate for presenting complex arguments [12, 13].

Also, the human brain can be easily overloaded by the sensory input that e-learning and multimedia technology is capable of delivering [4]. Even though such tools can be used to give an easy-to-follow lecture when correctly employed, they do foster a tendency to overwhelm learners with an overly rapid presentation of information. Lecturers, naturally, possess a deeper understanding of the subject and often tend to proceed through the lecture at a pace too fast for their students to follow. Traditional teaching using a chalkboard imposes a natural limitation on the pace that is overcome through the use of slideware. Also, classes given with slideware tend to be far less flexible and spontaneous than more traditionally presented ones. To use the words of a university lecturer, “*PowerPoint sucks the life out of a class*” [2].

Some approaches try to address this situation by adding annotations to slides. Office XP now features annotation tools in PowerPoint. Classroom Presenter streams a combination of PowerPoint slides and freehand “inking” [3]. The “eClass” (later “Classroom 2000”) software is an early example of recording snapshots of annotated slides and electronic whiteboard drawings for distance teaching purposes [1].

Looking instead for established teaching techniques, one finds that the old-fashioned chalkboard has been an unsurpassed teaching tool for ages. The board ensures that information stays available, providing context for further discussion. The learners can see how ideas are developed rather than being over-

whelmed with final results and are supported in following the conceptual process. The teacher is slowed down to the speed of his or her handwriting, giving the students time to follow his or her train of thought. Compared to the use of prepared slides, the “chalk and talk” approach allows for a much more flexible teaching style. Working on a chalkboard supports creative thinking, illustration, and sharing. Board drawings can be used to draw attention to details using circles, arrows, underlines, checks, groupings, etc. The inherent impreciseness and vagueness of freehand drawings holds extra information. Given these outstanding qualities for teaching, it comes as no surprise that the chalkboard is still so popular for teaching in many disciplines, especially for subjects where complex reasoning has to be taught, such as mathematics, engineering, and the natural sciences.

2. Our approach

These considerations inspired the development of a system called eChalk [6, 7]. During classroom teaching, the lecturer works directly on a pen-active wall display or uses a digitizer tablet. A good chalkboard lecture should automatically result in a good e-learning lesson. The goal is to preserve the pedagogical advantages and the easy handling of the traditional chalkboard, while extending its reach to distance learning. While the eChalk interface is based on the metaphor of the simple chalkboard, it is enriched by a wide range of multimedia enhancements. These may be used to enliven the lessons, allowing eChalk to surpass the didactic potentials of the traditional chalkboard.

All actions on the board are tracked. The development of the board content can be viewed by a remote learner, both as a live transmission or as an asynchronous replay. The voice of the lecturer can also be recorded. The distance learner is provided with a dynamic script of the class where none of the teacher’s side notes are lost. These two data streams already capture most of the substance of the lecture. Optionally, a video stream of the instructor can be added to provide a more personal touch to the remote lesson and enables one to observe the lecturer’s mimics and gestures.

The system is not designed to replace teaching in the classroom. The recordings should “capture the live experience” of the lecture’s natural flow, as well as having the teaching style influenced by interactions with a learning audience. The approach merges classroom teaching, distance teaching, and the production of courseware into a single task.

The development of eChalk has been guided by experience from ongoing deployment of the system in regular university teaching for several terms now. Field studies have been conducted in the course of university lectures to evaluate the use of eChalk, its impact on teaching, and its acceptance under real-life conditions [6, 8]. These studies were arranged by media psychologists from the Freie Universität Berlin and Berlin University of Technology (Schulte, Issing and Hendricks). Data gathered from 15 eChalk courses included 893 short and 898 full questionnaires. The results indicated a high acceptance rate of the system by the students. For a detailed summary of the results see [6].



Fig. 1 Mathematics lecture at Berlin University of Technology using a digital whiteboard and an extra projector.

3. The eChalk system

3.1. In the lecture hall

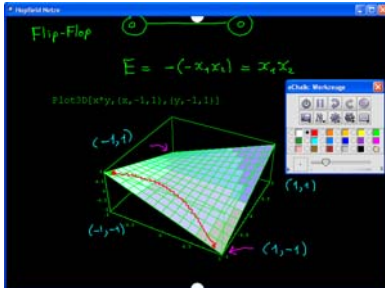


Fig. 2 Lecture containing a plot from a computer algebra system.

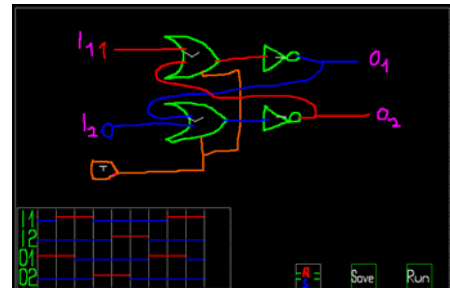


Fig. 3 Simulating a clocked RS Flip-Flop.

In order to use the eChalk software in the classroom, one needs a pen based input device and a wide display. Usually, one of the three alternative device configurations is used, a digitizer tablet or tablet PC with an LCD projector, a digitizing whiteboard (see Fig. 1) or a retro projector with pen tracking.

Having started eChalk, the system's user interface metaphor changes from a computer desktop to a chalkboard. The mouse is replaced by a pen-like input device and the need of using the keyboard is avoided wherever possible. The software transforms the screen into a black surface where one can draw or write using different colors and pen widths. The board can be scrolled up and down vertically, providing the lecturer with a virtually unbounded surface to write on. Instead of using a desktop-style scrollbar, two white *drag handles* are provided at the top and at the bottom of the screen, see Fig. 2. The user grabs the board at a drag handle using the pen and drags the board up or down.

The lecturer may embed images from the web or the local storage devices and annotate them. As a much more sophisticated feature, computer algebra systems (such as Mathematica or Maple) working in the background can be queried for their numeric or symbolic results or even for function plots, all seamlessly integrated into the board drawings, see Fig. 2. A mathematical formula recognition allows these requests to be input conveniently in handwriting, including such complex objects as differential operators, integral symbols, vectors, and matrices [7, 11].

The lecturer can also send queries to dynamic web services (CGI scripts) returning text or pictures. Interactive Java Applets can be run on the board to provide visualizations for abstract topics and concepts. Alternatively, custom eChalk modules called Chalklets can be used. These are controlled by means of strokes of the pen on the board and return drawing strokes themselves, preserving the board-like look and feel. For example, a logic circuit simulator [9] recognizes sketches of digital circuits and runs a simulation, color-coding the wires to indicate high or low voltages, as shown in Fig 3.

The system does not require the user to explicitly trigger a save. Everything is automatically and continuously stored for viewing through standard web browsers.

3.2. Remote usage

When remote students open the automatically generated web page of a given course with a browser, replay starts in the form of self synchronizing Java Applets. One Applet is started for every data stream present: board, audio, and video. An additional Applet, the control panel, is provided for navigation in archived lectures, see Fig. 4. All these Applets run in a standard Java-enabled browser, without requiring the download of a special plug-in. Audio and video is streamed using lossy compression and buffering to guarantee interruption-free transmission. A printable, static copy of the final board image is also included as an Adobe PDF file.

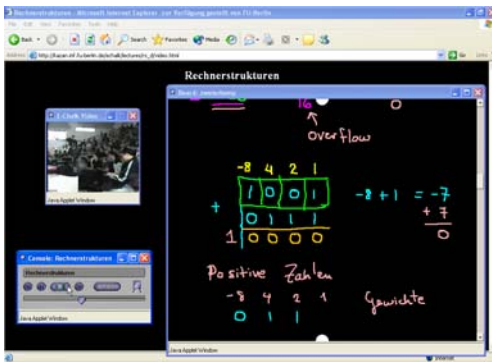


Fig. 4 Replay of a recorded eChalk lecture as seen in a browser.

4. Use in different cultures

The eChalk system relies on the audio signal captured from the lecturer combined with his or her free-hand writing and drawings as board input. This does not only enable the lecturer to input complex mathematics formulas much more conveniently than using a standard formula editor, a usually rather cumbersome task. It also makes the input completely independent of the writing system and language used, whether it relies on the western alphabet or Arabic script or other sign systems, instead of forcing the learners to work with a writing system other than their native one.

Most parts of the user interface rely on icons and graphical elements, see Fig. 2. Only the recording setup uses printed information to a greater extent. However, the overall user interface of eChalk has been localized to several languages including Arabic, see Fig. 5. A translation to simplified Chinese is currently under way.

From the very beginning, eChalk transmissions were designed to impose only low technical requirements on the users. This provides an extra advantage in areas where the Internet infrastructure available does not allow requiring students to have a broadband connection. Due to the board stream using a vector representation, the bandwidth requirements are very low. The bandwidth of the board stream peaks in the range of 3 to 5 kbps when using standard pen or mouse devices, i.e. with sampling rates between 50 and 125 Hz. In fact, average bandwidth needed in real lectures turned out to be less than 1 kbps [8].

Therefore in practice, the board's bandwidth requirement is negligible compared to the bandwidth used by audio (and optional video), particularly since audio stream codecs between 24 and 256 kbps can be chosen. Again, these numbers are maximum values rarely reached and only for a few seconds. Choosing the 64 kbps codec allows remote access to a board and audio stream of sufficient quality with only a modem connection.



Fig. 5 Setup dialog for an eChalk recording localized to Arabic.

5. Summary

Experiences in using the system in actual teaching and systematic evaluations confirmed the potential of eChalk as a beneficial and usable system for teaching. The lecturer can easily integrate material from

previous terms. Traditional chalkboard-related skills translate directly into skills for good eChalk lectures.

The system enables the user to produce electronic course materials simply as a by-product of classroom teaching. Students are supported in their revision of classes with a live and dynamic “transcript”. Only a browser is needed for this and no special software has to be installed. All substantial content of the lecture including audio and dynamic board image can be received with low bandwidth requirements.

The system presented here not only tries to preserve the didactic potentials and easy handling of the traditional chalkboard. Its reach is extended to extensive use of new media and remote access, enhancing the quality of teaching in mathematics and engineering education, and fostering understanding through interaction and visualization.

Field studies conducted so far covered university teaching only in a Western setting. While the system provides the technical requirements to teach in other cultures, impacts of different learning habits still have to be researched. For example, the importance of the different content channels board, audio, and especially video might be very different in other cultures. The importance of aesthetic writing in Far Eastern cultures, the cultural outlook on lecturers as persons of authority, or forms of etiquette are only some of the potentially influencing factors.

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