

Assessing the Impact of Inking Technology in a Large Digital Design Course

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ABSTRACT

Since the introduction of inking technology, computer science and engineering education has experienced a flurry of new instructional approaches. Many studies have assessed qualitative improvements over traditional classroom presentation techniques. In this paper, we present *quantitative results* on the improved student perception of teaching when using Classroom Presenter instead of PowerPoint for classroom presentation. We present an overview on how Classroom Presenter was used in a large undergraduate digital design course and discuss the assessment of results and their analysis. Our data shows with statistical significance that students perceive lectures with Classroom Presenter as more interesting and more adequately paced.

Categories and Subject Descriptors

K.3.2 [Computers and Education]: Computer and Information Science Education; B.6.0 [Logic Design]: General

General Terms

Human Factors

Keywords

Educational technology, Tablet PC, classroom presentation

1. INTRODUCTION

Classroom presentation is one of the most fundamental components of instruction. Choosing the right mode of instruction can have considerable impact on how students perceive lectures and thus how students succeed in a course. The introduction of Tablet PCs has added electronic ink to the set of established presentation techniques that range from chalk notes to PowerPoint presentations. In this paper, we compare the effectiveness of one specific inking software, Classroom Presenter, to that of PowerPoint.

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The context in which we perform this assessment is a large freshman course on digital design. This course is particularly suitable for our purpose, as it exhibits two important characteristics: (1) the subject of digital circuit design and analysis is very visual and thus suitable for instruction with electronic ink; (2) the large class size provides a broad basis for collecting assessment data.

The results of our assessment yield two important observations: When using Classroom Presenter, students perceive (with statistical significance) lectures (1) to be more exciting and (2) to be more adequately paced. We also observe that students perform better in terms of their final grade when Classroom Presenter is used in lectures.

The remainder of the paper is organized as follows. Section 2 discusses related work. Section 3 introduces the presentation techniques compared in this paper. The assessment methodology is described in Section 4. Results and their analysis are presented in Section 5. Section 6 summarizes and concludes this paper.

2. RELATED WORK

Inking technology for classroom presentation has been proposed in many forms since it has become technologically feasible several years ago [1]. Many studies of inking technology in general and Classroom Presenter specifically have focused on details of the system and its use in the classroom. For example, Anderson et al. [3] have studied the use patterns of ink by the instructor and Razmov et al. [7] have studied the impact of student interactions with inking technology. In our work, we attempt to answer the very general question of what presentation technique is the best choice for students. The main difference to other work is our assessment approach.

There are numerous studies on inking technology that are *qualitative* in nature. Golub [5] studies the pros and cons of inking technology in a discrete mathematics course. Edwards et al. [4] study the use of Tablet PCs in programming laboratories. A more quantitative study of the Classroom Presenter system has been published by Anderson et al. [2], where its impact was assessed by exposing students to Classroom Presenter and surveying if they perceived that it had a positive impact on understanding and attention. The analysis of impact is based on several courses from different instructor and thus it is unclear what is considered the baseline of comparison. Our paper addresses this issue by comparing Classroom Presenter specifically to one alternative, namely PowerPoint. Instead of exposing the same group of student to two systems and running the risk of getting a biased re-

sult due to the “novelty factor” of new technology, we use two large and independent populations of students (i.e., two different instances of the course) that are exposed to one system for the duration of the entire semester. This allows us to *quantify* the benefits of Classroom Presenter and perform a rigorous statistical analysis on the data.

3. CLASSROOM PRESENTATIONS IN DIGITAL DESIGN COURSE

The course that is studied in this paper is an introduction course to digital design that focuses on the fundamentals of digital electronic circuits. Topics covered in this course are binary data representation, Boolean algebra, combinatorial and sequential logic, standard design components, and design and analysis of digital circuits. As such, the course is a foundation for the electrical and computer engineering curriculum and a common support course and elective for the computer science curriculum.

The subject of digital design is particularly suitable for a study of inking technology in the classroom, as many topics are very “visual” in nature. A few examples are:

- Propagation of logic values (i.e., “zeros” and “ones”) in circuits.
- Circuit minimization using Karnaugh maps where regions of equal logic values need to be visually identified.
- Design of finite state machines for sequential circuits represented as Moore or Mealy automata.

It is therefore particularly important to consider how this visual aspect can be presented in an effective manner in a large lecture hall.

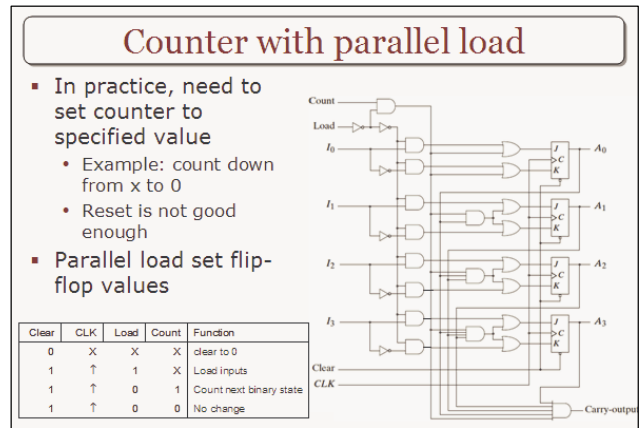
For this purpose, two different instructional technologies have been used in two different instances of this course: PowerPoint and Classroom Presenter. The course was taught by the author in the Fall 2004 with PowerPoint and in Fall 2005 with Classroom Presenter with an enrollment of 136 and 115 students respectively. In both cases the course was a freshman course with an identical sequence of lectures. It is important to note that the course consisted of lectures, discussions, and lab components, but this study focuses solely on the lecture portion of the course.

3.1 PowerPoint

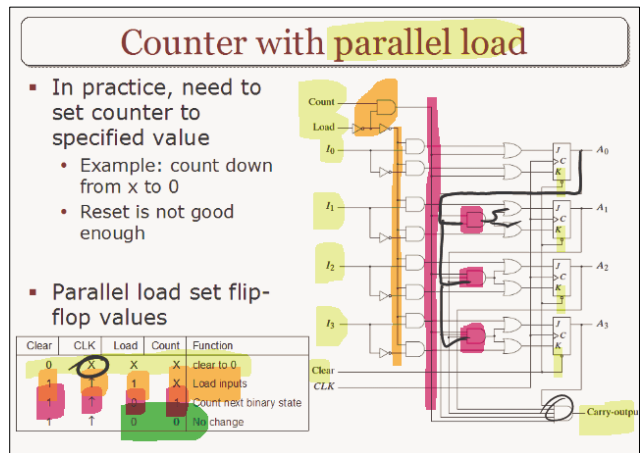
In this setup of classroom instruction, PowerPoint presentations were used to convey the content of the lecture. To develop ideas step-by-step, sections of slide were programmed to appear (without animation or sound effects) on screen at the click of a button on the remote control. An example of a slide from an actual lecture is shown in Figure 1(a).

Since PowerPoint does not allow any dynamic adaptation of the lecture to student input¹, slides were presented approximately in the order they were set up. To reinforce some example and in response to student questions, some examples were presented on a marker board that was visible to students in parallel to the presentation projection.

¹It is possible to add hyperlinks in PowerPoint to interactively jump between slides. This is however difficult to implement and use in practice and is therefore not considered here.



(a) Instruction with PowerPoint



(b) Instruction with Classroom Presenter

Figure 1: Examples of Presentation Slides used in Different Modes of Instruction.

3.2 Classroom Presenter

In this setup of classroom instruction, Classroom Presenter was used by the instructor on a Tablet PC configuration (without the optional feature of connecting any student computers via the wireless network). The setup was such that the instructor could move untethered through the classroom and transmit ink annotations from the Tablet via the wireless network to a second laptop that was connected to the projector. The basis of the Classroom Presenter slides were PowerPoint slides from the previous year where content had been removed to allow its step-by-step development during the lecture. An example of a Classroom Presenter slide is shown in Figure 1(b). In some cases, equations and longer text sections were written by hand by the instructor.

Based on student input, certain concepts were explained repeatedly and in-depth through color annotations on the slide (for an example see Figure 1(b)). The availability of a “film-strip view” of slides on the instructor TabletPC allowed for easy navigation in the slide deck. In some cases, new blank slides were added during the lecture to provide space for additional ink annotations.

3.3 Alternatives

Clearly, there are other modes of instruction in addition to the two studies in this paper. Commonly, simple chalkboard notes or projections of transparencies are used during a lecture. We have listed these techniques in Table 1 and indicated the qualitative tradeoffs between each approach.

Chalkboard notations are clearly the easiest to set up, but do require some effort during lecture (i.e., wiping the board). The biggest drawback of this approach is the lack of ability to present “canned” content (e.g., complex figures or images) since everything needs to be written onto the board by the instructor during the lecture. Also, the chalk approach does not provide a record of the lecture unless somebody specifically takes notes.

The use of transparencies can address some of the problems of chalk-based instruction. While transparency projections are generally easier to view in a large lecture hall, smudges on the foils, poor alignment, and the “keystone” effect of a poor projector reduce the visual attractiveness of this approach. Canned content can be provided by printing or copying figures onto transparencies. Also, a record (albeit somewhat difficult to use) of the lecture is taken down.

The use of PowerPoint and Classroom Presenter is clearly more attractive in terms of visibility (assuming suitable lighting conditions). A big drawback is the need for a more complex setup. Classroom Presenter is a bit more effort during the lecture as the instructor needs to write and annotate slides instead of simply pressing a button. However, in terms of interactivity, Classroom Presenter is comparable to chalkboard instruction and thus overcomes the problematic linearity of a PowerPoint slide show.

This comparison provides a qualitative comparison of these instructional techniques. The following section presents our approach to quantitative assessment.

4. ASSESSMENT METHODOLOGY

As explained in Section 3, PowerPoint and Classroom Presenter were used in two different instances of the same course. In both cases, the same content was taught in the same order over the same amount of time (36 50-minute lectures). This section describes how student perception of instruction was assessed.

To obtain feedback from students regarding their perception of the in-class instruction, an optional per-lecture feedback mechanism was set up using WebCT. The use of WebCT ensured that each student submitted at most one feedback form per lecture.

The questionnaire that was used is shown in Figure 2. The two main questions pertaining to the perceived pace and interest of the lecture are shown in the figure. Other questions in the feedback form were used for text comments and are not further considered in this paper.

The questions regarding pace and interest are specifically chosen to be non-scalar (i.e., not a value from ‘1’ to ‘5’ as it is often done in surveys). This avoids an accidental misinterpretation where one may claim that a ‘4’ means twice the pace or interest of a ‘2’.

5. RESULTS

This section presents the assessment data and its interpretation regarding the effectiveness of PowerPoint and Classroom Presenter in lectures.

Feedback Lecture 1

Number of questions: 6

Question 1

How was the pace of the lecture?

a. Way too slow.

b. A bit too slow.

c. Just right.

d. A bit too fast.

e. Way too fast.

Question 2

How did you perceive the contents of the lecture?

a. Very boring.

b. Not my area of interest.

c. Interesting.

d. Exciting.

Figure 2: Sample Questionnaire Used for Assessment. Additional questions (not shown) provide opportunities for free-form responses.

5.1 Student Responses

The responses by students are summarized in Table 2. The overall number of responses is high with 611 responses in 2004 and 774 responses in 2005. When comparing this number to the overall enrollment, each student filled out an average of 4.5 and 6.7 surveys respectively per course.

Since the assessment setup did not force any student to submit a survey, it is possible that some students submitted up to 36 surveys (one per lecture) and other student submitted none. To show the distribution of how many surveys each student submitted, Figure 3 plots the number of submitted surveys vs. the final grade of each student². The figure shows that there is little correlation between the number of submitted surveys and the final grade obtained (a Spearman’s rank correlation analysis yields a value of $\rho = 0.03$ and $p = 0.747$ for 2004 data and $\rho = 0.18$ and $p = 0.060$ for 2005 data). Thus, the survey responses do not put more weight on students who perform better or worse than the average in class.

5.2 Analysis

To compare the perception of students regarding the perceived pace of lectures and the perceived interest, Figures 4 and 5 show the percentage of responses in each category for

²Final grades are shown as a percentage between 0 and 100, which was computed from the appropriately weighted number of points obtained from each course component. Using this metric instead of the final letter grade provides data with higher resolution.

Table 1: Qualitative Comparison of Instruction Alternatives in Large Lecture Settings. Symbols indicate positive ('+'), negative ('-'), and neutral ('o').

Technique	visibility	ease of setup	ease of in-class use	interactivity	canned drawings	record
Chalkboard / marker board	-	+	-	+	-	-
Transparency projector	o	o	o	+	o	o
PowerPoint presentation	+	-	+	-	+	+
Classroom Presenter	+	-	o	+	+	+

Table 2: Student Responses

Instruction	Year	Enrollment	Responses	Content					Pace					
				very boring	not interesting	interesting	exciting	no response	way too slow	a bit too slow	just right	a bit too fast	way too fast	no response
PowerPoint	2004	136	611	19	109	440	18	25	1	14	393	158	20	25
Presenter	2005	115	774	9	80	505	120	60	3	41	478	157	36	59

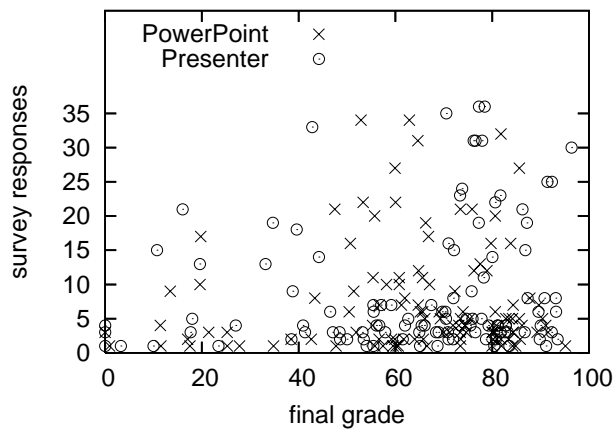


Figure 3: Comparison of Number of Responses and Final Grade.

both instructional technologies. Figure 4 shows that with Classroom Presenter, approximately 5% more students perceived lectures to be a bit too slow. Also, 5% fewer students perceived lectures to be a bit too fast compared to PowerPoint. From Figure 5, it is apparent that a considerable number of students perceived lectures to be more exciting (17% vs. 3%). Also, fewer students found lectures to be not interesting or boring.

This qualitative comparison gives a first glance at the differences in the effectiveness of Classroom Presenter over PowerPoint. To perform a more thorough analysis, we use a Mann-Whitney test to analyze the data. The Mann-Whitney test (also known as the Wilcoxon rank-sum test) is a non-parametric statistical significance test that assesses whether the difference in medians between two samples of observations is statistically significant [6]. Table 3 shows the results from this analysis. Both hypotheses, “perceived lecture pace is slower with Classroom Presenter” and “perceived lecture interest is higher with Classroom Presenter” are shown to be true with statistical significance. The ob-

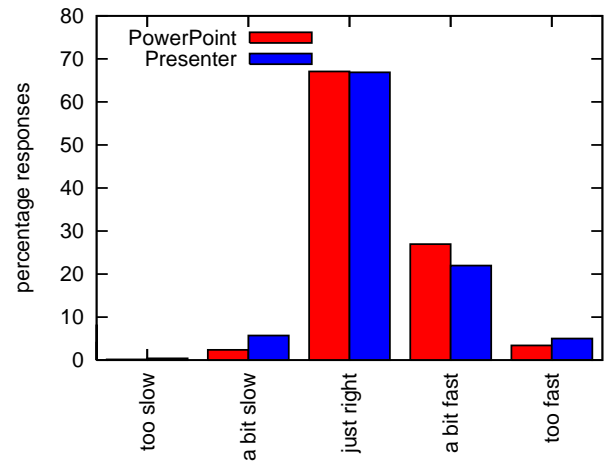


Figure 4: Comparison of Perceived Pace.

Table 3: Mann-Whitney Test on Assessment Data. Stars after p-values indicate level of statistical significance.

Hypothesis	p-value
Perceived lecture pace is slower with Classroom Presenter	0.02489 *
Perceived lecture interest is higher with Classroom Presenter	$1.252 \cdot 10^{-15}$ ***

servation regarding pace is true with statistical significance at the 95% confidence level (indicated by “*”) and the observation about interest is true with statistical significance at the 99.5% confidence level (indicated by “***”).

This clearly shows that in this particular course, presentations with Classroom Presenter were not only perceived

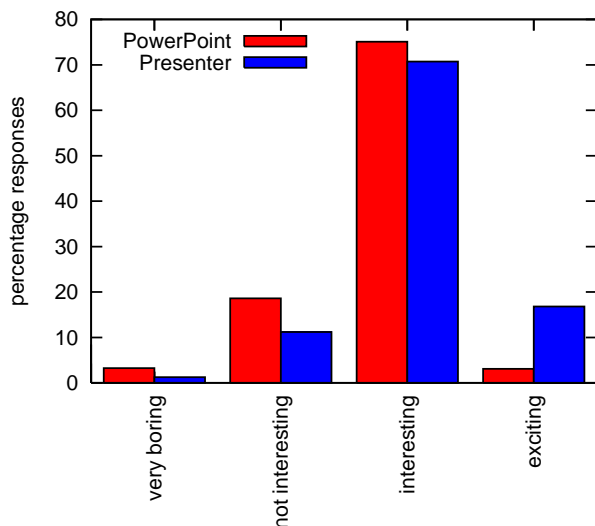


Figure 5: Comparison of Perceived Interest.

to be more exciting, but also more adequately paced. It is important to reiterate that in both instances of the course the exact same content was taught. Thus, the pace of lectures with Classroom Presenter are *perceived* to be slower than those with PowerPoint even though the same content is covered.

A final question is if the use of Classroom Presenter has an *actual* benefit on student achievement. To explore this issue, we compare the final grades of students in both instances of the course. The mean grade in 2004 using PowerPoint was 59.7 out of 100. In 2005 with Classroom Presenter, it improved slightly to 61.3 out of 100. A more detailed analysis of the grade distribution is shown in Figure 6. This figure shows that students in the upper half of the class (percentile of course rank 50% – 100%) improved by about 5 percentage points on their final grade. Only students ranked around the 25% percentile range performed less well with Classroom Presenter instruction than with PowerPoint instruction.

These results show that Classroom Presenter instruction is not only perceived better, but also leads to slightly better student achievements.

6. SUMMARY AND CONCLUSIONS

This paper presents a comparison of two different classroom presentation techniques, PowerPoint and Classroom Presenter. We show how we have applied both techniques to a large lecture course on digital logic. We have assessed the perceived pace of lectures and students' interest in two different instances of the same course that use different teaching approaches. The analysis of nearly 1400 survey responses shows that Classroom Presenter yields lectures that are perceived more interesting and more adequately paced than PowerPoint. The results are significant in a statistical sense. When comparing student achievement, we show an average improvement of 2% on the final grade with Classroom Presenter.

These results are encouraging for the use of inking technology in the classroom. We have shown that the benefits

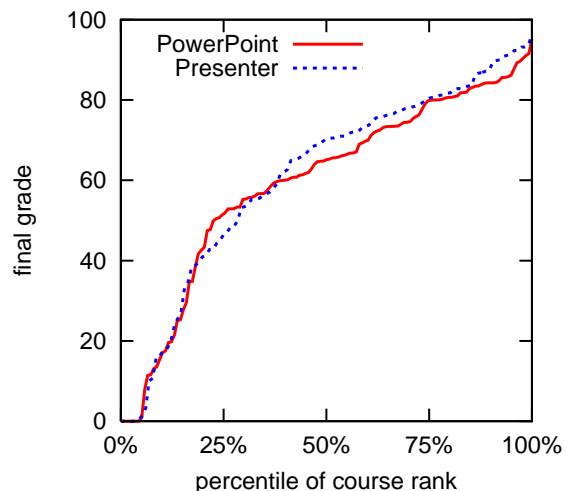


Figure 6: Comparison of Final Grades.

of such a teaching approach do not solely exist in the minds of the instructors but are observable and quantifiable.

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