Abstract - This paper describes a pilot effort to reform the design graphics component of a first-year design course. In place of materials that are an ad hoc legacy of when graphics dominated the first year engineering curriculum in the 1980s, we have deployed the use of e-chapters for teaching, studying, and assignments. This intervention might be viewed from several theoretical perspectives, but we are viewing it as a user-centered design problem: what is the most effective way of delivering this curriculum in usability, time, and money. Finally, we reflect on extending this approach to “just in time” uses of e-resources like e-chapters in both the teaching and the practice of design.

I. Introduction

This paper describes a pilot effort to reform the design graphics component of a first-year design course. In place of materials that are an ad hoc legacy of when graphics dominated the first year engineering curriculum in the 1980s, we have deployed the use of e-chapters (Lieu & Sorby, 2009) for teaching, studying, and assignments.

The key parameters are convenience for students and teachers, the delivery infrastructure, pedagogical quality, and the learning outcomes. We also examine cultural issues such as student and faculty attitudes towards the use of e-chapters. Several practical issues and their resolution are described, and an initial assessment provided, of student achievements and attitudinal reactions. The Fall 2008 Semester pilot was just that and we learned some useful lessons. Nevertheless, it succeeded in demonstrating the viability of the approach and it will be tried on a broader scale in the spring 2009 semester. We think that gains are possible for all the parameters from convenience to pedagogical quality.

II. The Setting

The pilot was run in two+ sections of the first year design course at a large engineering school in the
United States. Approximately 15 sections of this course are run each semester, typically with 32 students in each. The one honors section, which was included in this study, has 23 students including 5 Theater students (the design teams are working on special effects for theater productions). The course is three credits and has three, two-hour meetings a week. Students have a lot of active learning and are expected to do proportionally less out of class than they would in a typical three hours a week class. These activities include graphics, CAD, product dissection, and a lot of design project work.

This course is the only engineering course for first-year engineering students. In their first year, students only have intended majors. They are accepted into majors after their third semester. About 60% of these first-year students will graduate in one of the 10 engineering majors within the College of Engineering.

In the early 1980s, the first-year engineering course was focused on traditional engineering graphics, which was about 60% of the curriculum. The rest was devoted to experimentation and report writing, both of which have either vanished or been radically transformed (product dissection and website documentation, respectively). Instruction in CAD began in 1983 (Devon, et al, 2007) and with it began the erosion of manual graphics and the study of graphical methods. By the early 1990s, we were using the first desktop solid modeler (Silver Screen) and measuring marked improvements in spatial visualization skills as a result (Devon, et al, 1994).

The CAD curriculum continued to expand and we moved through a series of CAD software ending with Solid Works (Dassault Systèmes), which has been used since about 2003. There is some movement towards adding a second CAD, SketchUp (Google), and using a threshold pedagogy (enough for self-sustainability) to facilitate doing both.

At present, the course has about 15% of class time devoted to learning and being tested in CAD and more for some students who use it in project work. Traditional graphics are used for 8-10% of class time. There is much use of old transparencies (and the overhead projector) and old worksheets. One instructor uses scanned materials and his Tablet PC for delivery. One other has also developed a solid modeling curriculum to support the CAD instruction.

The main reasons for keeping the graphics curriculum in this design course are (1) the need to understand graphical representation, (2) the legacy of manual graphics in professional use, and (3) the value of it in sketching (Devon et al, 2005). Current practice involves much copying and use of overhead projectors, whose bulbs fail too often. Both represent time and resources that could be better spent in other tasks.

III. The Theory

Learning theories try to explain what strategies and factors are most significant in effecting learning. However, there are factors that contribute to the efficiency of learning in addition to the effectiveness. Some of these factors include tools that facilitate learning in a shorter amount of time, tools that encourage learner engagement, and tools that provide cost effectiveness. These contribute overall to learner satisfaction with the learning environment, which, in turn, encourages learning in itself. Frustrated students learn less, and frustrated teachers teach less.

Strategies that support visual learning are well-researched. Engineers are very visual in their thinking and visuals, along with mathematics, are an integral part of learning engineering concepts (Imelman, 2001). In an engineering design course, the visuals and graphics are the focal point for conceptual learning and they must be used in a way that is effective and/or efficient in teaching those concepts. Graphics that are
difficult to interpret or that are perceived as less aesthetic may interfere with learning (Piskurich, 1993). Careful choice and presentation of graphics is essential for both effectiveness and efficiency in learning. Effective, efficient learning encourages students to continue learning.

If a tool can be made available to students that will be easy to interpret, consistent inside and outside the class, readily accessible, current, and adaptable, will students learn better?

Whereas most learning theory refers to the effectiveness of learning, the pedagogy of convenience names a theory that is about usability, about the design of technologies (instructional in this case) that meet the needs of the users. While user needs certainly include the effectiveness of learning, they also include non-learning factors such as the convenience in use and the cost. It may also include the aesthetics of the product (industrial design = usability and aesthetics) and the degree of pleasure, or aversion, felt by the users towards the product (affective design).

The pedagogy of convenience, then, means taking a service design approach to instructional systems with embedded product designs. It is more meaningful for the adoption and diffusion of the technology than it is for learning theory. It overlaps with learning theory in some areas such as the role of motivation and affect on learning and the effectiveness of any instructional system on learning will remain important.

IV. The Intervention

The intervention is unfunded research in a very productive workplace with existing workloads both heavy and complex. This is both a driver for the intervention, to make life easier and work more efficient and hence better quality, and a constraint on effective implementation and assessment.

One instructor has required the use/purchase of five e-chapters for the pictorials, multiview, sections, dimensioning, and working drawings. He brings the e-chapters up on screen in the classroom (all classrooms have computer driven displays) to teach the subject matter. The students use inexpensive (~$5) sketchbooks to practice what they see on screen and then to do a problem at the end of the chapter, which is also brought up on screen. The chapters they acquire from iChapters.com making an on-line purchase.

Back in their dorms, when they complete the assignment or review for the single graphics test, they will see the identical material. Their sketchbooks contain their practice work, assignments, and notes. As long as their e-materials are well done, this is a very contained, coherent and effective system. The other instructor teaches the same way but he did not require a sketchbook and still had to use some reproduced worksheets for practice.

A third instructor, who is new and teaching the class for the first time, was told about the text and e-chapters, but not asked to use them in his first experience teaching the course. On his own, he purchased one e-chapter and taught using it. He was immediately persuaded by the convenience of not using the overhead projector and having high quality material on screen. We only learned about this after the fact. He is now teaching the rest of the material using e-chapters. Like the second instructor, he is still using old worksheets but expects to move to a sketchbook next semester.

V. The Data

The assessment is being conducted by university assessment specialists. The first survey data collection began at the end of October. The survey was posted online and it was administered in class in a computer laboratory. The survey was kept short to ensure
students could complete it quickly and included the areas listed below.

- Learning from course materials
- Use of text and graphics in class
- Value of using e-chapters in a course
- Comparison of e-chapters to printed text
- Annotation and note taking practices
- Perceived value for cost of e-chapters

A few weeks before administering the survey, a short class discussion concerning the use of the e-chapters was held in the honors class. Most students at that time had no comment on e-chapter use. About 25% of the class, when pressed, stated they prefer a hand-held text, but only one raised it as an issue and none have gone to the expense of printing any chapters out. One student liked buying only the chapters that would be needed. He also liked not having to carry a heavy textbook around.

No students are printing anything out because they have strict limits on free printing and have better needs for their quotas. This provides a window on their priorities. The students seem to appreciate that the content is identical in class and at home on their computers. A few bring their laptops and follow along. The Theatre students using Macs have a 2D CAD program, VectorWorks (Nemetschek), that they use to draw almost as quickly as the other students sketch in their sketchbooks.

After a pilot administration of the survey was completed, the responses of 59 students were analyzed. Fifty-eight percent (58%) of the students indicated that they had purchased the e-chapters for the course. The students who had purchased the e-chapters were questioned about their perceptions and attitudes toward the use of an electronic textbook (Figure 1.).

<table>
<thead>
<tr>
<th>e-Chapters help me:</th>
<th>SA %</th>
<th>A %</th>
<th>N %</th>
<th>D %</th>
<th>SD %</th>
</tr>
</thead>
<tbody>
<tr>
<td>To learn more efficiently and in less time.</td>
<td>5</td>
<td>31</td>
<td>33</td>
<td>19</td>
<td>12</td>
</tr>
<tr>
<td>To understand the course material.</td>
<td>14</td>
<td>31</td>
<td>28</td>
<td>21</td>
<td>5</td>
</tr>
<tr>
<td>To remember the course material.</td>
<td>9</td>
<td>23</td>
<td>40</td>
<td>19</td>
<td>7</td>
</tr>
<tr>
<td>To prepare for the exams.</td>
<td>14</td>
<td>29</td>
<td>21</td>
<td>21</td>
<td>14</td>
</tr>
<tr>
<td>To get a better grade in this course.</td>
<td>12</td>
<td>36</td>
<td>21</td>
<td>14</td>
<td>17</td>
</tr>
</tbody>
</table>

SA Strongly Agree, A Agree, N Neutral
D Disagree, SD Strongly Disagree

Figure 1. Learning from course materials for Instructors One and Two (N=42, RR=84%)

Between 60 and 70% of the student responders felt the e-chapter graphics were attractive and easy to interpret, and none disagreed with the statement that “the (e-chapter) graphics the instructor uses in class are well designed.” [These data were replicated very closely by a second survey done in the class of the third instructor who only used e-chapters for instruction (N=22, RR=76%).] More than 50% agreed or strongly agreed that it was helpful to see exactly the same graphics in and outside the classroom. They felt they liked being able to buy only the chapters they needed. Additionally, 33% reported that they would purchase e-chapters again if they were available and almost 25% reported that they were more likely to sign up for a course that used an e-textbook. Questions the helpfulness of e-chapters were also very positive, except as a boost to expected grades (Figure 2).

In spite of this, student comments in the survey reflected those in the earlier discussion bringing up
issues concerning downloading the large files and their inability to do highlighting and markup on the e-chapter pages. In that sense they preferred printed materials.

<table>
<thead>
<tr>
<th>e-Chapters help me:</th>
<th>SA %</th>
<th>A %</th>
<th>N %</th>
<th>D %</th>
<th>SD %</th>
</tr>
</thead>
<tbody>
<tr>
<td>To learn more efficiently and in less time.</td>
<td>8</td>
<td>25</td>
<td>21</td>
<td>25</td>
<td>21</td>
</tr>
<tr>
<td>To understand the course material.</td>
<td>17</td>
<td>37</td>
<td>12</td>
<td>25</td>
<td>8</td>
</tr>
<tr>
<td>To remember the course material.</td>
<td>17</td>
<td>62</td>
<td>12</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>To prepare for the exams.</td>
<td>17</td>
<td>42</td>
<td>25</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>To get a better grade in this course.</td>
<td>0</td>
<td>0</td>
<td>42</td>
<td>42</td>
<td>17</td>
</tr>
<tr>
<td>I would like to have a search function</td>
<td>42</td>
<td>37</td>
<td>21</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

SA Strongly Agree, A Agree, N Neutral D Disagree, SD Strongly Disagree

Figure 2. eChapter Helpfulness for Instructors One and Two (N=42, RR=84%)

The graphics tests have produced good results but this will need a controlled experiment. To better determine the effect of the e-chapters on student learning, student performance will be assessed using a common graphics test in several of the trial sections and some sections that did not use e-chapters before, but who did have the same instructor.

In the follow-up study, the instructors’ reactions will be assessed. To date, we know that the instructor for the class that is using sketchbooks finds e-chapters very convenient. He no longer does any copying, generating and shuffling piles of transparencies, or struggles with an overhead project that may be missing or have dead bulbs. There is no class preparation at all.

He is very familiar with the material and can log on to the computer, boot the e-chapter, and begin teaching. He skips what he does not need. He scrolls back and forth when questions come out of sequence. Sometimes the display on the big screen is not as good as that on the computer. Reducing the classroom lighting and zooming in on details helps a lot.

The class runs efficiently with all the attention of the instructor on the material and none on the delivery technology. Both he and the third instructor find they finish the instruction sooner as a result. The second instructor is still using some old worksheets to compensate for not having a sketchbook. He also finds there are some missing topics in the text that he then covers in a traditional way. This has only happened once for the first instructor on a minor topic. The third instructor is teaching the class for the first time and found the e-chapters a much quicker way to prepare and teach than using old ad hoc methods. Assignments are given from the end of the chapter for further practice. There is no question that e-chapters are particularly suitable for a curriculum where graphics dominates over text.

A few logistical issues have arisen. The viewer works on only two computers on a single account. This was largely solved by making one of those a Tablet PC which was used in class via an A/B switch for the display. However, the Tablet PC allows markup of PDF files, but not when it is used with the iViewer. Similarly, highlighting on a conventional computer could not be used. However, the need to markup in class is not that great and usually means adding ugly lines to beautiful diagrams. Still it would be nice if the students could highlight the e-text. A discussion of the logistics with 18 students in the honors class revealed two students who saved money by not buying and used their roommates’ computer with e-chapters. Of the other 16, 12 had no problems. One upgraded to Acrobat 9

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and then had to get an upgraded iviewer to re-access the echapters. One downloaded the iviewer each time he used echapters. One downloaded it on his mother’s computer at home and could not get it to work on his own. One had inexplicable, intermittent problems. These issues need early and repeated monitoring.

VI. Conclusions and Plans for Further Implementation and Further Research

A summary of both the practice and the assessment results will be given to all the faculty who teach the introductory engineering design course. Then some faculty will volunteer for a larger trial in the spring semester. It is expected that many more sections of the course will use the e-chapters. The lead author will not go back. The use of e-chapters is simply too convenient to ignore, and the quality of instruction seems to be much improved. There is no time wasted shuffling transparencies and drawing on the whiteboard. The new resource website promises to make instruction even better (Cengage, 2008). This website has been made accessible to the students who have been looking at the animations done student authors. Cultural resistance by some students is important and we need to study that more closely. Hopefully we can reduce the resistance by showing new benefits. But greater usability for the instructor supports adoption where almost all students either like it or do not have strong feelings about it. However, buying a permanent resource is important and the current plan is to provide a CD for later use.

There are larger implications. Students may wish to use other chapters, such as that on tolerances, because their design project needs that expertise. For about five dollars, the team can buy the needed chapters. This is convenient for students and just as true for future courses that the students may take. If a faculty member decides to use a different set of chapters the next time s/he teaches, there is minimal work in involved in making the switch. New e-chapters can be provided by the publisher as the need arises, even without revising the hardcopy textbook.

There is an even bigger picture to consider. All our design curricula could be taught in this way, if we can find the e-chapters and other e-resources that we need. A customized set of chapters from various textbooks could be identified and purchased. The students can accumulate a library of curricula resource materials for learning and doing design that they can take with them into the professional world.

VII. References


