E-TEXTS AS LOW-COST AND EFFICIENT ALTERNATIVE IN COMPUTER GRAPHICS EDUCATION: ONE INSTRUCTOR’S JOURNEY

Magesh Chandramouli1, Patricia Reid2, Craig Zywicki 3

Abstract — University faculty are experiencing increasing demands to reduce costs and demonstrate students’ learning. This paper reviews one author/instructor’s development of an eText to reduce student costs and provide a better learning experience. First, a comparison of textbook and eText costs demonstrate how students and the university decreased expenses. Second, we present the justification for an eText and steps to integrate an eText into the course curriculum. Third, we present student feedback, which demonstrates students’ satisfaction with the eText. Finally, we provide recommendations for pedagogical improvements to courses based on writing an eText rather than ‘teaching to the book.’

Index Terms — Computer-assisted instruction; eText; Instructional Technologies; Outreach;

INTRODUCTION & LITERATURE REVIEW

This study addresses two major issues namely: the development of customized, electronically accessible course material in STEM curriculum and the reduction of students’ textbook expenses. The eText initiative is part of the university’s effort focusing on lowering the cost of higher education for students. The Provost recently wrote “…faculty adapt academic content to ensure its relevance for 21st-century students and conduct breakthrough research to answer the needs of our nation and world” and provided more detailed guidelines specifically about textbook selection, focusing on cost and value. The Chronicle of Higher Education published over 300 articles and EDUCAUSE published over 120 library items about textbooks. Themes in these are lowering costs and digitalizing textbooks (frequently referred to as eTexts). In addition, in 2013 the U.S. Senate introduced a bill to encourage faculty adoption of free online textbooks [1] and over 200 bills were considered at state levels between 2005 and 2012 alone [2]. A 2014 survey from U.S. Public Interest Research Group (PIRG) Education Fund and the Student PIRGs states “Over the past decade, textbook prices have increased by 82% - that’s an increase of three times the rate of inflation” [3]. One result is “65% of students said that they had decided against buying a textbook because it was too expensive” and “Nearly half of all students surveyed said that the cost of textbooks impacted how many/which classes they took each semester” [3]. “The survey also found that 94% of students who had foregone purchasing a textbook were concerned that doing so would hurt their grade in a course” [3]. “Many higher education institutions are considering whether to move from traditional textbooks to e-textbooks” [4]. Many universities are developing eText or textbook affordability projects. For example, the Open Textbook Network managed by Dr. D. Ernst at the University of Minnesota has 11 participating universities [5]. The two-year EDUCAUSE/Internet2 Pilot involved 23 colleges and universities. Publications on the results of this project include a full report (available here: www.educause.edu/ecar) and articles and presentations from several participating universities.

The EDUCAUSE/Internet 2 Pilot concluded “Faculty and students were both clear and consistent in their criteria for adopting digital course materials. In order of decreasing importance, they are cost, availability, portability, functionality, and innovation” [6]. While Grajek [6] found that most students did not change study habits when using eTexts, students still prefer print over digitized texts [6, 7, 8]. Giacomin et. al. [9] report that during the University of Washington pilot students were provided a free eText, but over 25% still purchased a print copy. This preference is slowly changing and students are becoming more comfortable with eTexts [8, 10]. Giacomin et. al. [9] found that student issues with eTexts range from ability to access the eText offline, a dislike of the eText reading experience, and the length of time eTexts were available (most eTexts are rented, not purchased). Grajek [6] reports the following additional common complaints:

- Lack of offline access to the e-textbooks
- Difficulty using e-textbook on a variety of tablets and limitations to smartphone access, such as inability to zoom content
- Unavailability of the e-textbook on e-readers
- Slow page loading and poor functionality compared with contemporary standards set by e-readers
- Difficulty reading text on screens and preferences for print

Proponents of eTexts point to additional advantages of the medium, such as providing instructors with the ability to incorporate online discussions about eText contents, providing students with collaboration and sharing

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opportunities. However, “to reach their potential, it is essential for e-textbooks to take better advantage of the affordances of the digital format and break the limitations imposed by the printed page” [9]. Giacomin recommends extending the eText beyond a digitized textbook by incorporating videos, collaborative discussions and wiki-type options, multimedia, etc. [9].

Final reports go beyond the eText itself to include university and instructor recommendations. Fowler et. al [4] recommend faculty professional development “from learning how to use the e-text platform to changing pedagogical practices that allow students and faculty to engage around the content.” This is based on survey results indicating that student eText experience is influenced by the instructor’s use.

AFFORDABILITY INITIATIVE

The authors were part of a large Midwestern university system (including regional campuses), which is in the second year of the Affordable Textbooks program encouraging and supporting faculty in developing textbooks in an online format. Recommendation #1 above is to build a collaborative partnership. This program is financed from the information technology group and is staffed by a collaborative team from the office of Information Technology and University Libraries. The program’s mission is to “Provide affordable and innovative online alternatives to the traditional textbook. Participating faculty members are given a stipend, copyediting services, graphical development, support for Open Educational Resources adoption, and investigation of homework system replacement.” To attract instructors and to support them during development, a small financial incentive was provided to each instructor (recommendation #2 above). In exchange, the instructors meet with support team members to discuss optimal use the technology to improve eText (recommendation #3). Instructors are currently using Skypepack© to deliver the eTexts, to enable device-agnostic access. Skypepack© is currently working on both real-time access (although students can access eTexts both on- and off-line) and Blackboard integration (experts’ recommendations #4 and #5). As a part of the program, each instructor/author can determine the price of the eText, with a base price of $10 which funds Skypepack© use. The majority of instructor/authors are not adding an additional charge and are, therefore, not collecting any royalties. This meets experts’ recommendation #6. Currently, ten eTexts are available. A comparison of costs shows both immediate and long-term student savings (see Table 1). A primary purpose for the project is to provide an affordable alternative to traditional textbooks. For each potential eText, the administrative project team identifies the potential break-even point; the time that the cost of developing and producing the eText is less than the cost students would pay for the textbook. The formula for this was developed by reviewing research reports from other universities. Table 2 shows the typical distribution of student textbook purchases and associated prices. By identifying the number of students traditionally enrolled in the course we determined the cost per semester.

<p>| TABLE I |</p>
<table>
<thead>
<tr>
<th>COMPARISON OF STUDENTS COSTS: TRADITIONAL TEXTBOOK VS. ETTEXT</th>
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<tr>
<td>Traditional Textbook</td>
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<tr>
<td>Per Semester Costs, excluding faculty incentive</td>
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<tr>
<td>3-year estimated costs, including faculty incentive</td>
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</table>

Based on the book distribution and cost of the textbook for each source, the 29 students in CGT241 spent a combined $874 upfront for the traditional textbook, but their cost after resale was $730. Using the $10 eText, the students’ total combined cost could have been $250. For appropriate comparison of print to eText, the University also considers the incentive as part of the cost. Although not directly charged to an individual student, this incentive is indirectly paid through tuition. Therefore, once the instructor/author determines how much the eText will cost, the overall breakeven point can be determined. This becomes complex if the institute also wants to consider new editions of the textbook, additional costs such as Webassign or MyLabs fees that may be included (or eliminated by use of the eText) and/or staffing costs for the support provided the instructor, etc. However, in this case, our university determined that the breakeven point for the instructor’s eText was approximately 3 years.

<p>| TABLE 2 |</p>
<table>
<thead>
<tr>
<th>DISTRIBUTION AND COST OF STUDENT TEXTBOOK PURCHASES</th>
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<tbody>
<tr>
<td>Place of Text</td>
</tr>
<tr>
<td>Print New Bookstore</td>
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<tr>
<td>Print New Online</td>
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<tr>
<td>Print Used Bookstore</td>
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<tr>
<td>Print Used Online</td>
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<tr>
<td>Rental</td>
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<tr>
<td>Library/borrow</td>
</tr>
<tr>
<td>No text</td>
</tr>
<tr>
<td>Total</td>
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</table>

SUPPORTING STUDENT LEARNING

According to Wiggins & McTighe [11], standard course planning begins with the instructor selecting a textbook and basing the syllabus, lectures, and exams on the textbook. Our provost states “Choosing a textbook for your class has
become a much more complex undertaking with many more alternatives for course materials” [12]. He goes on to point out three factors in selecting a resource: First, choose the course materials that best fit your class and promote learning.

Second, be aware that a common complaint among students is that the coursework doesn’t use the required text. If you require a textbook, be clear about its expected usage, especially in lower-level courses. Finally, you need to make your choices early [12]. The Affordable Textbooks program encourages instructors to focus their course on learning outcomes. When faculty develop their own resources, they can begin by reviewing the program documents for the course purpose and, from there, identifying the course outcomes. The eText can then be developed to specifically meet the course outcomes. Another advantage of online resources is the ability to include images, video, links, quizzes, discussion boards, and even animations within the resource, providing a richer learning environment. Discussion boards provide students an opportunity to tie their thoughts directly to a section of the eText. Links can provide further information. Quizzes provide immediate feedback, supporting deeper student understanding. This supports the experts’ recommendation #7. In view of the fact that both technology and courses change, the Textbook Affordability Program includes recurring money to support instructors as they change and adapt their eTexts. As both the technology and course content continually change, the Textbook Affordability Program includes recurring money to support instructors as they change and adapt their eTexts. This ongoing funding meets the recommendation from experts to continue evolving the eTexts to meet changing needs and greater capabilities [6]. Examples of other instructors’ eTexts show inclusion of Khan Academy videos, CSPAN videos, and quizzes. One instructor created a wiki-type of eText where his students receive credit for both recommending new webpages and for rating webpage for inclusion into the textbook. This supported students’ digital literacy by requiring them to critique online information for accuracy and value.

TABLE 3
CONTENT ORGANIZATION IN CHAPTERS

<table>
<thead>
<tr>
<th>Chapter #</th>
<th>Title</th>
<th>Summary of Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 1</td>
<td>Introduction</td>
<td>Brief historical perspective</td>
</tr>
<tr>
<td>Chapter 2</td>
<td>Production Pipeline &amp; Preproduction</td>
<td>3 Stages of production, storyboards, animatic, pre-visualization</td>
</tr>
<tr>
<td>Chapter 3</td>
<td>Modeling: Theoretical Foundations</td>
<td>Geometry, trigonometry, transformation, projections</td>
</tr>
<tr>
<td>Chapter 4</td>
<td>Nuts and Bolts of Modeling</td>
<td>Coordinate systems, points, lines, and polygons</td>
</tr>
<tr>
<td>Chapter 5</td>
<td>Modeling II: Advanced Modeling</td>
<td>Polygonal and Spline modeling, NURBS Modeling, CSG</td>
</tr>
<tr>
<td>Chapter 6</td>
<td>Animation</td>
<td>Key frame animation, Kinematics- Forward and Inverse Kinematics, Rigging, Posing</td>
</tr>
<tr>
<td>Chapter 7</td>
<td>Digital Lighting</td>
<td>CG lights, 3 Point Lighting, Illumination and Shadows</td>
</tr>
<tr>
<td>Chapter 8</td>
<td>Form, Composition, and Rendering</td>
<td>Perspectives: Linear, Overlapping, Elevation, Dwindling Size, Horizontal/vertical/diagonal lines, Elements of form and composition, Digital Rendering</td>
</tr>
</tbody>
</table>

EText Design: Content and Structure

Modeling and animation is a foundational topic not only for students in CG (computer graphics), but also for many other people interested in animation, 3D games, movies, etc. Despite the plethora of publications available on 3D modeling and animation, a textbook that not only introduces, but also provides a comprehensive coverage of all the inevitable aspects of modeling and animation is not easy to find. The following are some of the drawbacks among existing textbooks:

- Using difficult language/structure that is not easily understandable by undergraduate students
- Not delving deeply into the basics, which makes understanding the advanced topics difficult
- Not covering the mathematical /geometric /trigonometric foundations of modeling
- Covering too much unnecessary material not required in the introductory stage
- Improper and inadequate use of images

FIGURE. 1
PHOTOREALISTIC & NON-PHOTOREALISTIC IMAGES
The content and structure of the eText was decided after careful deliberation and consideration of the points discussed in the earlier section. Summarily, the salient features that describe the eText are as follows:

- Simple & straightforward approach aiding flow
- Ample illustrations (Figure 1 shows a collage of images created from custom-made models)
- Demystification of underlying mathematical concepts
- An easy to understand, example based approach for explaining complex concepts and phenomena
- Ample review material (quizzes and end of chapter review questions) to reinforce the learning.

Illustrations are always a very useful tool to present complex information in an easily understandable form [13] [14] [15]. This is especially true, in the case of modeling and animation, which are inherently CG disciplines. The vast majority of the images in this eText were custom made to serve specific purpose of meeting the course learning objectives. These were rendered (creating images from 3D models) from elaborate 3D models made especially for the instructional purpose.

**STUDENT FEEDBACK**

Twenty-nine students enrolled in the introductory animation course (spring 2015) received a link to an online seven-item survey near the end of the course. The purposes of this survey were to discover how the eText supported students’ learning, and determine possible improvements to the eText. To avoid bias, students responded anonymously and results were reported to the instructor after final grading. Nineteen students (65.5% response rate) completed the survey. When asked to specify whether the eText supported their learning, only two students indicated the eText did not support their learning. Comments reinforced positive aspects of the eText and also provided suggestions for prospective changes for future versions. Open-ended survey items soliciting feedback about why the eText did or did not support learning resulted in three key themes.

**Theme 1: Desires for digital and print references.** Students’ comments compared the eText to both print textbooks and their uses of other digital references, demonstrating their preference for required readings as a reference and willingness to seek additional references. For example: “I was able to reference [the eText] to help me with questions I had studying theory. It also helped me with providing information that I could use for my student presentation.”

**Theme 2: Content relevance and depth.** In general, students appreciated how the eText content aligned with the in-class content. Sample comments included, “I was able to augment lectures and use it as visual support for certain concepts,” and, “I find this book very useful because sometimes I’m not 100% of something that we may have discussed in class, so I go back in the book and review that section.” However, aligning eText content only with the in-class content left some students wanting more. For example: “I feel like if I was looking for more detailed information, I would have to look elsewhere. The textbook provided very good, basic background which makes sense since it is an introduction to animation not a more in depth course.”

**Theme 3: Accessibility.** Familiarity with print textbooks possibly explains why multiple students requested the eText also be downloadable. For example: “Due to it being online, I did not have constant access to it like I would a normal book. This was a slight disadvantage [sic] to me.”

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The mathematical and geometric theory behind graphics, modeling, and animation can span several volumes. It is not the intention of this introductory book into extreme basics of all the theoretical aspects. However, a basic knowledge of the following is extremely essential for any student of computer graphics: Points, lines, and polygons (Figure.1); Splines, NURBS, and Meshes; Transformations; Projection; Euclidean and Projective geometry. Different modeling platforms and animation software use different kinds of coordinate systems including world coordinate systems, object coordinates systems corresponding to world and object space. Coordinate systems can also be right handed or left-handed (Figure.2). Transformations can be local or global. In order to create a model with a hierarchy, and perform animation, a basic understanding of the above is inevitable. Before any modeling or animation can be done, first and foremost, the preproduction exercise needs to accomplish through a storyboard. Carefully planned, modeled, and rendered visual
representations (Figure 2) can serve to take complex and abstract concepts and present them in an easily understandable manner. Figure 2 illustrates the concepts of Boolean logic and Constructive Solid Geometry (CSG).

Despite the intention to be device-agnostic, Skyepack© portability issues have been noted by some students as observed from their feedback.

CONCLUSION

Overall, the curricular changes to the course as of spring 2015 established the foundations for improved student learning. The eText made required readings and references more affordable to students, without diminishing learning. From the overall eText initiative, we concluded that individual students saved money from a university eText development initiative. In addition, the act of writing an eText encouraged the instructors to modify their course to meet their learning outcomes and better support student learning. Instructors also have the opportunity to add media features not available in a textbook. The eText platforms provide the ability to update and add to the eTexts. New technologies are providing additional options for eText usability. These benefits are increasing student acceptance of eTexts. The recommendations from Fowler et al. [4], Giacomin et al. [6], and Grajek [9] provide a sound base for a university eText initiative.

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REFERENCES

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