A CONTINUAL IMPROVEMENT PARADIGM FOR MODERN ONLINE TEXTBOOKS

Frank Vahid[1,3], Daniel de Haas[3], Sarah Strawn[3], Alex Edgcomb[1,3], Susan Lysecky[3], Roman Lysecky[2,3]

[1]Dept. of Computer Science and Engineering, Univ. of California, Riverside
[2]Dept. of Electrical and Computer Engineering, Univ. of Arizona
[3]zyBooks, Los Gatos, California

Abstract

Traditional college textbook publishing, for printed books as well as e-books, follows an "editions" paradigm, wherein a new edition of a textbook is developed and released every few years. The web has enabled a new paradigm wherein online learning material is continually improved, multiple times a year, and even live during a semester. We describe the technology and processes used at zyBooks to support a continual improvement textbook publishing paradigm, and summarize experiences over the past year with tens of thousands of students and hundreds of instructors using our materials. In short, via numerous user-feedback mechanisms, errors that survived the standard publishing quality control process are detected and corrected nearly immediately, such that rarely does more than one person ever see a particular error. Furthermore, such feedback often leads to live improvements to the material involving adding or rewriting some content to clarify material to be readily understood by as many students as possible, and also helps set priorities for larger revisions to the material done perhaps yearly.

Keywords: Textbooks, online learning, web-based learning, publishing paradigm, continual improvement, quality, instructor and student feedback.

1 INTRODUCTION

College textbook publishing has traditionally followed an "editions" paradigm. A book is initially published as a "1st edition". Any detected errors may be published as an "Errata" sheet distributed with the book or posted on the web, but rarely utilized. Years later, the book may be updated, and a "2nd edition" is published. The new edition may incorporate corrections, include new material, and/or rewritten or reorganized existing material. The process then continues.

The web era has led to increased used-book trade, rental books, illegal PDFs, and importing of low-cost international editions. As a result, typical "sell through" rates, namely the fraction of students in a class who purchase a new copy of a required textbook, is often reported (internally by publishers) as only being 1/6 or even 1/8, starting at about 9/10 in the first year, but dropping to only 1/10 by the third year [Gr07]. To maintain revenues in the web era, publishers appear to be creating new editions at a more rapid rate than before, sometimes every 2-3 years; the average rate in 2007 was 3.9 years [CSA08], and the rate has become even more frequent since then. Publishers have also increased prices to achieve sufficient revenue from the short window of new edition sales before sell through drops again; textbook prices have risen by 8x since 1980, versus just 2.5x for consumer goods [HP13].

Because most web-based textbooks, known as electronic books or e-books, are electronic versions of hardcopy books, publishers have mostly continued to follow the editions model for e-books.

In contrast to traditional college textbooks, some modern textbooks are created natively for the web. Even then, some web-native textbooks continue to follow an editions paradigm, which may in part be due to the entrenchment of the concept in publishing and academia. Another reason may be due to those e-books being formatted similarly to hardcopies, with page-by-page layouts that are hard to change, rather than taking advantage of the web's flexible layout.

However, freed from the economics of hardcopy books, web-native textbooks can potentially break from an editions paradigm. The net result can be material that is better for the student learner and for the teacher, due to clarity, correctness, better content, new interactive content, better match to course content, etc. This paper describes the paradigm we have followed at zyBooks, which is a "continual improvement" paradigm. Incremental updates occur frequently (weekly, even daily), consisting mostly of clarifications or corrections. And more substantial updates (what previously might have been called an edition) may occur almost yearly (without new-edition high prices, due to not experiencing the low sell through problem of hardcopies).

2 A CONTINUAL IMPROVEMENT PUBLISHING PARADIGM

A continual improvement process is an ongoing effort to improve a product (or service) [WKCIP15]. We view continual improvement as requiring two items: (1) *Input* that indicates what can be improved, and (2) *Output* that involves processes for making improvements.

Our mission is focused on bettering student learning and the teacher experience. As such, we view a textbook as an item requiring continuous improvement.

Our web-native textbooks not only contain text and figures, but also contain extensive more-complex features: animations (typically about 100), interactive learning questions (typically about 1000), and tens of built-in simulators or tools. Hundreds of auto-generated and/or auto-graded homework exercises are also integrated throughout. Due to the higher complexity of such material versus traditional text and figures, correcting errors or making clarifications is of *even greater importance* than in traditional textbooks.

Furthermore, the web is a diverse and changing environment. Various browsers are common, like Chrome, Firefox, Internet Explorer, and Safari. Browsers often have variations in how they render HTML5, and different browsers also have different bugs. Furthermore, the same browser (e.g., Chrome) may behave differently on different operating systems, such as on Windows 8, Windows 10, or Mac OS. Foreign language packs, browser extensions, and virus software can also impact how modern web-based material displays. In addition, browsers are continually updated themselves, and sometimes an update may introduce a bug or a change in how items render, requiring quick detection and update of our material in response. Cloud services also update regularly, which can introduce issues too. In short, online material that consists of simpler material, like PDFs, or basic HTML with a few question activities or videos, are simpler to maintain, but of course provide a weaker learning experience.

Instead, modern web-native material that utilizes the power of the web (HTML5, CSS, and Javascript) provides better learning (proven by various studies like [Ed14][Ed15]) but *especially* requires continual input from users and rapid updates in response.

3 INPUT TO CONTINUAL IMPROVEMENT

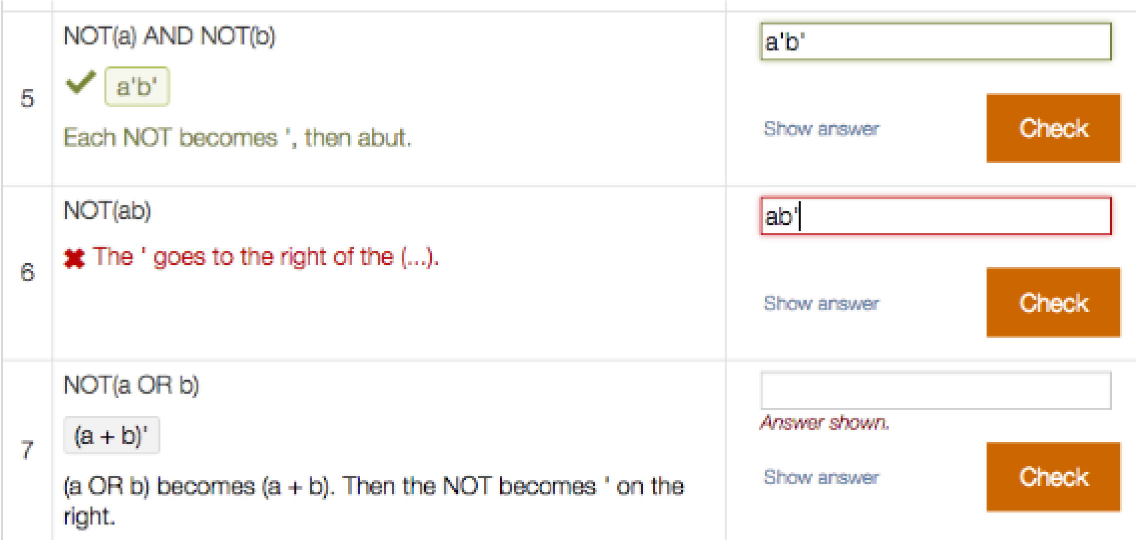
3.1 Monitoring

We have developed a platform for delivering web-native learning content, currently in use by tens of thousands of students and hundreds of teachers across about 300 universities and tens of high schools.

Monitoring usage is one way of providing input to the continual improvement process. Many kinds of monitoring can be considered. Some online sites will monitor the time spent viewing a page, or the number of views of a page or item like a video. Learning sites in particular may monitor the number of attempts of a learning question or exercise. All these provide some useful information. However, we have found two items to be particularly useful.

(1) <u>First-time</u> <u>incorrect</u> <u>data</u>. Our content contains several kinds of learning questions: Short answer, multiple choice, true/false, matching, and more. Those questions are not assessments or quizzes, but rather a more engaging and effective form of explanatory text. One might think of the learning questions as a dialog with a student, versus just explanatory text that is more like a lecture to the student. If a user provides a wrong answer, a short answer question provides a hint, while a multiple choice or true/false question explains why that answer is wrong. The user can attempt answering as many times as desired,

Figure 1: zyBooks' learning questions: Short answer samples.



without penalty. For multiple choice, true/false, or matching, the user can attempt each of the limited number of answers until finding the right answer. For a short answer question, if the user gives up, the user can press a button to show the answer. Our system records all answers, whether right or wrong, for every user. Sample short answer questions are shown in **Figure 1**; the user got question 5 right, got question 6 wrong and has been provided a hint (and can attempt as many times as desired), and showed the answer for question 7.

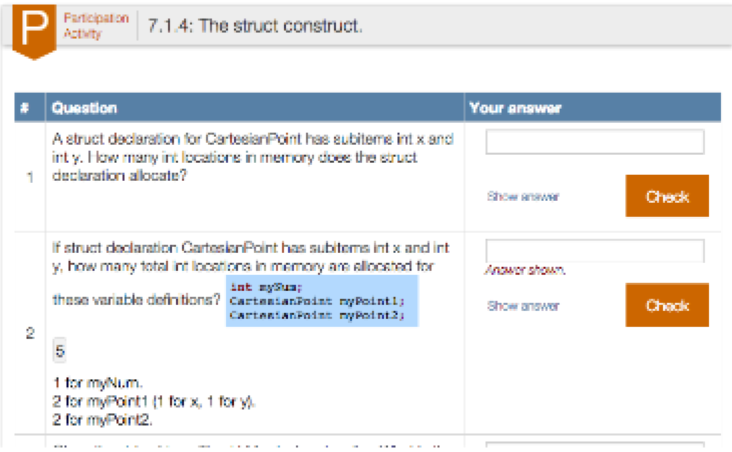
We run reports at various intervals (e.g., every several months) showing which questions users most-frequently incorrectly answer on the user's first attempt, illustrated in **Figure 2**. The authoring team of a book then examines each question and the provided answers. Sometimes, questions are designed to "trick" the user into a wrong answer, in order to expose and break-down common misunderstandings, which can be highly beneficial to learning (e.g., [Mo04][Mu08]). After filtering out such questions, the remaining questions and their wrong answers are manually examined. The authors may decide that the content before the question needs improvement -- perhaps a clarification (like a rewrite of text or a new sentence), or a new example or animation. Or, the authors may decide that a new additional question should be inserted before the existing question, to help the user learn prerequisite knowledge in a more incremental manner. Sometimes, the authors decide the question itself needs improvement, perhaps through a clearer description, different values, etc.

(2) *User earnestness*. Because our system records every user-submitted answer, we can run reports that suggest whether students are guessing on a particular question. For example, if a multiple choice question with four choices has a first-time correct percentage of just 25%, the users are likely guessing. Similarly, we can also run a report indicating which short answer questions students most frequently "forfeit" on (by showing the answer without even trying to enter their own answer first). In any case, the authors examine the question and the preceding content. Either situation is deemed to be a "low earnestness" situation: Students aren't really trying. As with first-time incorrect data, the authors manually examine these questions, and again will sometimes decide the preceding content needs improvement, or that a new preceding question is needed, or that the question itself needs revision.

Furthermore, if entire sections or chapters of content have low earnestness, authors may investigate whether a new section is needed, or if a section needs to be split in two. Sometimes, a section will have high earnestness in most schools, but low in one particular school. Investigation has sometimes unveiled a particular re-ordering of our content such that students aren't sufficiently prepared to understand a particular section in its new location in the book. Authors may examine whether the section can be

Figure 2: First-time incorrect data example.

Question	First-time incorrect %
PA 7.1.4 #2	70%
PA 7.3.9 #1	62%
PA 7.1.6 #1	38%
...	



PA 7.1.4 #2	
Incorrect answers	Frequency
4	42%
2	30%
0	18%
1	10%

written more modularly to support such a configuration. Similarly, authors may examine a class syllabus and notice that an instructor's pace is much faster than other schools. In some cases, we have observed 2x, 3x, and even 5x the normal pace, leading to low earnestness. These situations will soon be used to guide the authors in providing advice to instructors regarding configuration and pace, which is a higher-level form of continual improvement.

3.2 Soliciting user feedback within the book

In addition to monitoring, we also obtain input to the continual improvement process via feedback. We aggressively solicit feedback from users to feed into the continual improvement process. Every activity in our material includes a "Feedback" button, as shown in **Figure 3**.

The feedback form allows a user to type feedback, as well as rate the activity. Again, at various intervals, authors examine the feedback and decide whether to make improvements in response. Feedback from instructors is also flagged, so that authors can pay special attention to such feedback. Instructor feedback often contains very insightful tips from their own teaching experiences with tens or hundreds of students (i.e., from the "front lines").

Furthermore, each feedback form has a box "My comments describe a bug". Users can check that box to indicate what they believe to be an error in our material. *A feedback item marked as a bug becomes a support ticket in our support system.* This was a conscious decision on our part, per our philosophy that:

> *No more than one user should ever see an error in online material.*[1]

[1] An anecdote: One of this paper's authors had a daughter who was a college student using an online Statistics textbook and homework system from a major publisher, required for a college class. One of the homework problems had a serious error. The student saw no way of informing the publisher, so she informed the class instructor, who said he didn't know what to do. When a second daughter took the same class, the exact same serious error still existed, *two years later.* Unfortunately, such a situation is commonplace.

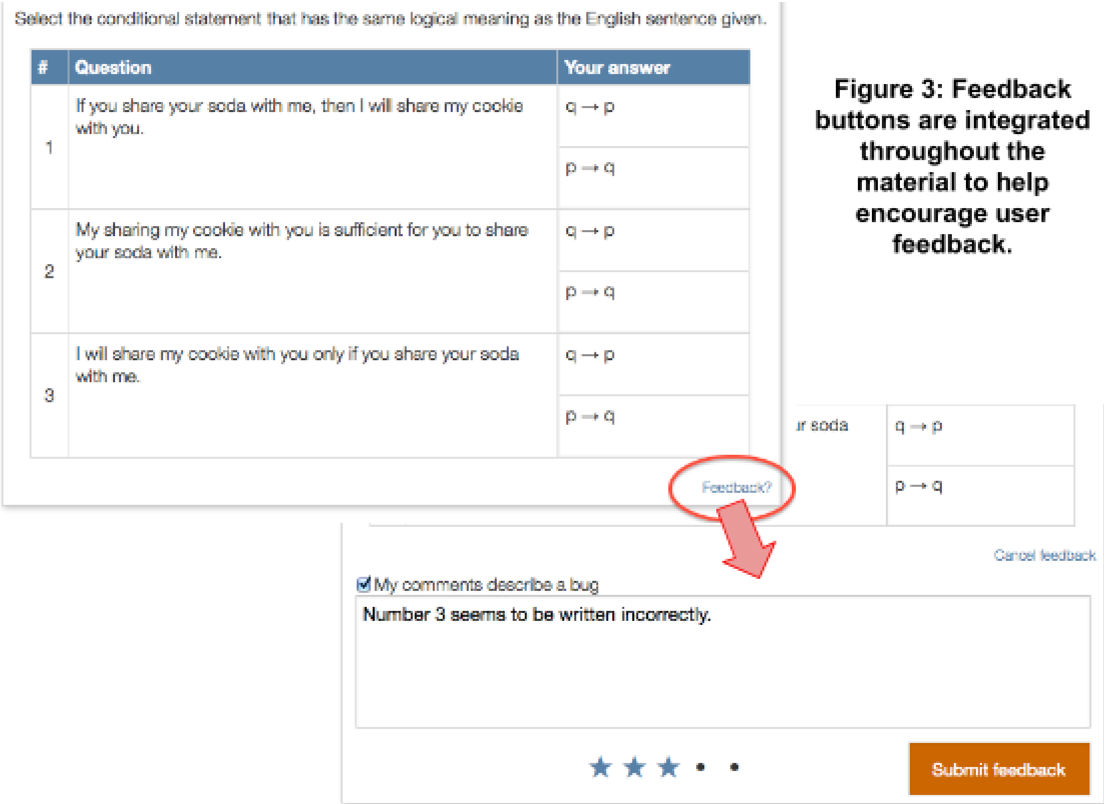


Figure 3: Feedback buttons are integrated throughout the material to help encourage user feedback.

By making bug feedback a support ticket, the issue enters into a process where fast resolution is mandated. Our support team strives to keep the support queue (the number of unsolved support tickets) to nearly zero. The queue rarely exceeds 10 items on a given day. Thus, if the error is not resolved quickly in the material, support tickets will begin to flood our system, as hundreds or thousands of students begin to approach that same material. This situation creates built-in pressure to fix errors quickly. The support team often can determine if indeed an error exists. If not, they contact a content expert within the company. If the issue still isn't resolved, they contact the authors, who are expected to take part in continual improvement of the material. Upon determining an error exists and agreeing upon a correction, the team carefully updates the source material, and then pushes out a new release of that particular item. Our system is designed to allow fine-grained updates of material, so that such pushes can only impact tiny portions of a book's material.

In fact, even if it is determined that the user was mistaken and that in fact the material was correct, the support team may still request that the authors make an update to the material, lest large numbers of students make the same mistake and submit bug reports. The authors might add clarifying text, improve an activity's instructions, or improve wording, with the goal of minimizing bug reports. In this way, the content becomes clearer and clearer for more and more students.

Feedback marked as a bug that comes from an instructor is flagged as such. While all bug reports are treated with priority, reports from instructors are given even more attention, as instructors are more likely to be correct in believing an error exists and typically read the material ahead of students. Fixing an instructor reported bug as soon as possible, e.g., before students read a section, helps avoid potential misunderstandings and misconceptions by students.

One can see that aggressively soliciting feedback and allowing users to mark some feedback as a bug, and then treating such bugs as support tickets, provides a systematic means for quickly fixing errors or clarifying content, thus ensuring that content quickly becomes clearer and less subject to misinterpretation.

Table 1 shows that instructors and students actively provide feedback. About 4% of all instructors and 10% of all students provide feedback (compared to nearly 0% in traditional publishing paradigms). Most feedback consists of general "non-bug" suggestions. Of the "bug" feedback items, roughly 75% are not actual errors, but authors usually clarify the material anyways, to reduce chances of future students reporting the same issue.

Table 1: Feedback amounts received from instructors and students (normalized per every 100 instructors and every 10,000 students). The semester had many hundreds of instructors and tens of thousands of students.

Spring 2015 semester	Instructors (per 100 instructors)	Students (per 10,000 students)
Number that reported feedback	4.3*	952*
Avg. number of feedback items for persons that submitted at least once	4.4	2.0
Feedback marked as "bugs"	7	631
Feedback (non-bug)	12	1,295

* Actual number of feedback items is roughly 20-30% higher since the reported numbers are only via the feedback button, but we also get feedback via email.

3.3 Soliciting instructor feedback via survey, emails, and phone

We also aggressively solicit feedback from instructors via email and phone. Instructors are encouraged to contact their account executives, or our support team, with suggestions. At the end of each semester, we also survey instructors who taught from a zyBook. In several classes by request of the instructor, we anonymously survey the students too. Based on such feedback, we will sometimes arrange phone calls to hear more detailed instructor feedback. Through discussions, items may be added to our feedback list that is then examined by authors when doing their regular revisions.

In summary, obtaining input from various sources, and paying attention to such input, is a critical part of a continual improvement publishing paradigm.

4 OUTPUT OF CONTINUAL IMPROVEMENT

Incremental updates: Updating live textbook material must be done with great care. Stability of the material is important. Updating an entire chapter or even an entire section because of one typo is potentially dangerous. Thus, we implemented our system such that each section is composed of numerous individual resources. When an update is made, the update is only made to a particular resource. A resource may be a question set, an animation, or a paragraph of text, for example. The system is designed such that technical support staff can make necessary updates via a simple process. For all but the most obvious of updates, support staff usually consult with authoring staff to verify changes were correct. Attention is paid to making incremental updates that would be widely viewed by instructors as acceptable to make mid-semester, such as corrections, and clarifications. More substantial changes (like adding a new animation or learning question to clarify a concept) are withheld until the next release.

Releases: On occasion (perhaps once per year), authors work on a new release of the material. A new release may involve new or rewritten sections, and new or revised animations, question sets, or other activities. Significant changes are listed in the material's "About this Material" page. Once released, instructors requesting evaluation copies will receive the new release, and classes adopting the material get the new release too. Because semesters usually don't last more than 6 months, the number of living older releases soon diminishes to zero. Students or instructors wishing to renew are typically provided with the latest release. This approach is similar to modern software, where new software releases occur frequently, and old releases diminish quickly.

Interactive web-based material typically requires a subscription for access, due to the interactive nature of the content, and the desire for instructors to view student activity so as to assign homework points for such activity. As such, interactive web-based material does not suffer from many of the issues facing the textbook industry, due to used-book sales, book rentals, illegal PDFs, etc. Thus, new releases are driven almost entirely by what is best for student learning and teachers' goals, and not based on trying to increase sell through.

5 RELATED WORK

Continual improvement is widely used in modern software. Designers of software such as web pages like amazon.com or gmail.com, of smartphone apps, web browsers, operating systems, and more, typically monitor software usage, automatically receive reports of software crashes, and solicit/monitor user feedback through random surveys, feedback forms, or review sites. Designers then frequently fix bugs, improve features, or introduce new features, perhaps weekly or even daily, and usually updating the software transparently to the user (as for a website), or via a software update option presented to the user. The agile software development methodology also emphasizes continual improvement [AG15].

In publishing, a recent trend is towards open education resources (OER's) [Se08], such as OpenStax [OS15], largely in reaction (and some would say over-reaction) to rising textbook prices. OER's commonly receive grants from governments or private foundations, to develop online textbooks that are made available for free to students. While free is clearly attractive, we note that OER's do not tend to maximally utilize web technology, instead relying on text and figures like traditional books, perhaps with some embedded questions and videos, because utilizing web technology is hard and expensive, typically requiring software professionals familiar with state-of-the-art web and cloud technology. Furthermore, OER's typically do not have an aggressive continual improvement process, since initial grant money may only cover initial development, and importantly because OER's tend to not focus on customer support since customers are not paying. Without a focus on customer support, the continual improvement process (with aggressive monitoring and soliciting of feedback, and fast and regular updating of material) is difficult.

A related trend is that of crowd-sourced OER's, wherein instructors or other contributors create parts of material. However, for students to effectively learn, publishers put extensive effort into quality control, including striving for consistency and quality in terminology, style, formatting, exercises, and more. Crowd-sourced OER's tend to lack such quality control. Creating guidelines or processes to increase quality of crowd-sourced OER's may help for some materials, and is a promising direction. However, for really core learning content like "Algebra", one may want material developed professionally. The situation is akin to how guidelines and processes provided to contributors of a crowd-sourced movie, no matter how good, could not result in a Steven-Spielberg-quality movie.

Clearly, it is our opinion that a process that incentivizes a publisher to serve the student's and teacher's needs is necessary to obtain high quality modern learning materials, including through a continual improvement paradigm.

Many new online learning websites, such as MOOCs (massively open online courses), tend to emphasize video-based instruction. While our material does include some videos, we encourage instructors to only use video when absolutely necessary. A typical zyBook may only contain a handful of short videos; most have none. The reason is because video is *extremely difficult to maintain.* Of all the activities in our material, videos are by far the hardest to maintain. If a mistake is found, or if students indicate something is confusing, remaking the video is time-consuming and costly. Making localized updates within a video is also hard. As a result, for example, one of the most popular MOOC courses (on "Circuits") begins with video that refers to various 2014 items; text alongside the video says to ignore certain portions of the video as those portions are no longer relevant. Such a learning experience is clearly not ideal.

When parts of a video are changed, the overall quality is degraded, due to different faces, voices, whiteboards, video resolution, tablet form factors, etc. Furthermore, many videos become outdated quickly, as computer monitors change (from large CRTs to today's flat screens), hairstyles and eyeglass styles change (making videos hard to watch or take seriously, no matter how great the content), video recording quality changes, etc. We warn makers of online materials to think twice before making videos; videos are a useful tool, but only one of many, and the ability to maintain the videos should be given high priority.

6 CONCLUSIONS

We described the continual improvement publishing paradigm carried out by zyBooks over the past several years. The paradigm aggressively solicits feedback from users, via embedded feedback items, emails, surveys, and more. For every 10,000 users, we receive feedback from about 1,000 users, resulting in many thousands of feedback items. Those items are reviewed regularly to guide authors in making revisions and to guide us in advising instructors on how to best use our material. Items marked as "bugs" become support tickets, providing systemic pressure to quickly fix errors or clarify material. To be clear, our material goes through standard quality control processes before initial publication, but as every publisher knows (and errata sheets confirm), errors do slip through, plus even error-free material can always be improved.

We express some concern over new learning resources created largely in reaction to rapidly-rising textbook prices, as such resources usually not only under-utilize the interactive learning power of the web, but may also overlook the importance of quality control and especially of continual improvement. We believe students deserve the very best learning material possible, and that while prices should be kept reasonable (which is natural in an interactive web-based system due to no siphoning due to rentals, used books, illegal pdfs, etc.), of paramount importance is putting processes in place that enable high-quality, consistent, lucid, and continually-improving learning content.

ACKNOWLEDGEMENTS

The continual improvement paradigm at zyBooks has been largely made possible by grants #1315094 and #1430537 from the National Science Foundation's SBIR program. We are extremely grateful for their support. This work has also been funded in part by a Google Faculty Research Award, for which we are also grateful.

REFERENCES

[AG15] Agile methodology. 2015. http://agilemethodology.org/.

[CSA08] California State Auditor. Affordability of College Textbooks. 2008. http://www.bsa.ca.gov/pdfs/reports/2007-116.pdf

[Ed14] Edgcomb, A., F. Vahid. Effectiveness of Online Textbooks vs. Interactive Web-Native Content American Society of Engineering Educators Annual Conference, ASEE 2014. Received best paper award.

[Ed15] Edgcomb, A., F. Vahid, R. Lysecky, A. Knoesen, R. Amirtharajah, and M.L. Dorf. Student Performance Improvement using Interactive Textbooks: A Three-University Cross-Semester Analysis, Proc. of ASEE Annual Conference, June 2015. Received best paper award.

[Gr07] Greco, A.N., C.E. Rodriguez, R.M. Wharton. The Culture and Commerce of Publishing in the 21st Century. Stanford University Press, 2007 (pg 136).

[HP13] Huffington Post. College Textbook Prices Increasing Faster than Tuition and Inflation. 2013. http://www.huffingtonpost.com/2013/01/04/college-textbook-prices-increase_n_2409153.html

[Mo04] Moreno, R. Decreasing Cognitive Load for Novice Students: Effects of Explanatory versus Corrective Feedback in Discovery-Based Multimedia. J Instructional Science V 32 N 1-2. Kluwer Academic Publishers, 2004, pp. 99-113.

[Mu08] Muller, D.A. J. Bewes, M.D. Sharma, P. Reimann. Saying the wrong thing: improving learning with multimedia by including misconceptions. Journal of Computer Assisted Learning, 24:2, Blackwell Publishing Ltd, pp. 1365-2729, 2008.

[OS15] OpenStax College, OpenStax.org, 2015.

[Se08] Seely Brown, John. Open education, the long tail, and learning 2.0. Educause review 43.1 (2008): 16-20.

[WKCIP15] Wikipedia. 2015. Continual improvement process. https://en.wikipedia.org/wiki/Continual_improvement_process