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A Model of Digital Textbook Quality from the Perspective of College Students

TJ Bliss
Brigham Young University - Provo

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TJ Bliss

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Richard R Sudweeks, Chair
Lane Fischer
Joseph A. Olsen
David A. Wiley
David D. Williams

Educational Inquiry, Measurement, and Evaluation Program

Brigham Young University

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ABSTRACT

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TJ Bliss
Educational Inquiry, Measurement, and Evaluation Program, BYU
Doctor of Philosophy

The cost of textbooks is a financial burden on many college students. Fortunately the advent of open educational resources (OER) has allowed for the development of textbooks and other materials at significantly reduced costs to students. Many faculty are using OER to develop customized textbooks for their students, usually published digitally online. These faculty desire high fidelity feedback from their students to help them improve their texts. However, there is no general model of what digital textbook quality means to college students. Such a model would allow for the development of a measure of digital textbook quality that could provide highly valid and reliable student feedback for faculty to use in improving their open textbooks. This study describes a mixed-methods approach for developing a model of digital textbook quality from the college student perspective. An instrument for measuring the components of this model is also described. This dissertation can be freely accessed and downloaded from http://etd.byu.edu/ or from http://tjbliss.org/dissertation.

Keywords: open educational resources, thematic analysis, confirmatory factor analysis, instructional materials, educational technology, Digital Textbook Quality Questionnaire

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Chapter 1

Introduction

Any philosophic explanation of Quality is going to be both false and true precisely because it is a philosophic explanation.

– Robert M. Pirsig

Education is vital to all people, both individually and collectively. Indeed, there is little argument about the importance of education as a means of enriching individuals and societies (Dewey, 1897). Because so many agree on the importance of education, in many countries a great deal of public money is spent on schooling. It is becoming rapidly apparent, however, that the education received in grades K-12 is not sufficient to provide children with the skills they need to succeed in their careers and to maximize their potential to advance society. Thus, a growing number of high school graduates are seeing the need for higher education. In most cases, students do not receive higher education as a public good, but must find means of their own to cover its costs. These costs can include (a) tuition, (b) fees, (c) housing, (d) transportation, (e) technology, and (f) instructional materials. Costs continue to rise in each of these areas.

The cost of tuition specifically has seen a dramatic increase in the past few years with the average annual cost of college tuition (including room and board) now at $17,464, up from $7,685 in 1980 (U.S. Department of Education, 2011). Similarly, the costs of textbooks are also rising quickly. In fact, the average college student in the United States now spends over $900 per year on textbooks (Allen, 2010), and this expense can be a large fraction of the overall cost of a college degree. Indeed, the increasing textbook costs are making a college education

prohibitively expensive for many students (Kingkade, 2011). Partly in response to the rising cost of textbooks, Open Educational Resources (OER) have been developed to reduce the cost of educational content, including textbooks. Recent research has shown that high quality, openly licensed textbooks can be made available to students at dramatically reduced costs, essentially eliminating the "textbook barrier" to a college education (Caswell, 2012).

OER are defined as "digitized materials freely and openly available for educators, students, and self-learners to use and reuse for teaching, learning, and research" (OECD, 2007, p. 2). Currently, OER are being implemented as digital textbooks at colleges and universities around the world, providing great economic benefits to scores of students. Moreover, faculty who write or piece together their own open digital textbooks are able to continuously edit and improve these resources to meet the specific learning needs of their students.

Because digital open textbooks can be iteratively edited and improved by teachers, the impact of valid student feedback on the development process is potentially great. However, there is no model of the quality of digital open textbooks from college students' perspectives. Without such a model, getting the most useful and important information from students is more difficult because they often don't know what kind of feedback would be most helpful to their instructors.

To resolve this issue, I used qualitative and quantitative methods to develop an initial model of open digital textbook quality from the perspective of college students. My research lays the groundwork for the development of a measure of digital textbook quality that faculty and others can use to collect valid and reliable feedback from their students. This feedback could then be used by faculty to aid in the development and revision of open digital textbooks.

Textbook Quality

At all levels of education, textbook development and distribution has historically been the purview of powerful, for-profit publishing companies. At the K-12 level, schools, districts and states have been at the mercy of these companies to provide high quality textbooks to their students. One of the only powers these educational entities retain is the right to chose among products: the power of textbook selection. In most cases, a few teachers, administrators, and parents come together in a selection committee to make the final decisions about which textbooks will be used in a school, district, or state. In higher education, the situation is similar, except that selection committees are often comprised of a single faculty member, with the occasional input from colleagues.

Teachers, administrators, parents, and faculty are rarely directly involved in the actual development of the textbooks chosen for their students. Thus, the vast majority of research and commentary on the issue of textbook quality has dealt with criteria by which selection committees, whatever their composition, evaluate their options. Watt (2009) conducted a literature review of the textbook selection process at the K-12 level in the United States and concluded that most textbook selection criteria promoted by states were related to cost. Other selection criteria commonly mentioned in the literature include (a) sensitive to cultural diversity (Cruz, 2002), (b) content coverage (Falduto, 2009), (c) content accuracy (Steuer & Ham, 2008), (d) readability (Gunning, 2003), (e) educational impact (Durwin & Sherman, 2008), and (f) pedagogical aids (Honeycutt, 2007).

A few authors have discussed the role of student perceptions in evaluating textbook options. The student viewpoint is important because students are the ones most affected by the

final choice made by the selection committees. In higher education, students also have to pay for whatever textbook is selected for their use. Moreover, at least one study has shown that many students desire to be consulted about decisions that affect their education (Shields, 2003). Yet, only a handful of studies on textbook quality have considered students' points of view. In these studies, students have been asked about many different aspects of their textbooks within a variety of subjects. These aspects include (a) overall value (Baker-Eveleth, Miller, & Tucker, 2011), (b) format (Kelley &Warburton, 2011), (c) usability (Petrides, Jimes, Middleton-Detzner, Walling, & Weiss, 2011), (d) pedagogical aids (Altman, Ericksen, & Pena-shaff, 2001), (e) educational importance (Hewinson, 2007), (f) content (Besser & Stone, 1999), (g) readability (Griesinger & Klene, 1984), (h) learnability (Britton, Van Dusen, Gulgoz, Glynn, & Sharp, 1991), and (i) human interest (Jones & Evanciew, 1995).

Despite these examples of the use of student perspectives to evaluate textbooks, no one has developed a general model of textbook quality from students' point of view. In almost every situation, the criteria for evaluating textbooks have been externally imposed on the students by the experts, rather than asking students to indicate what characteristics of textbooks are important to them.

Open Digital Textbooks

The usefulness of a model of textbook quality among students is magnified by the advent of OER, which have brought the textbook development process closer to the teacher, school, district, and state (Wiley, Bliss, & McEwen, in press). As explained earlier, there is potential for student perceptions of textbook quality to positively influence open textbook development and revision. In fact, a recent survey of 36 community college faculty using open textbooks showed

that highly valid student feedback would be somewhat or very useful to most of these faculty (94 percent) in making textbook development decisions (Bliss, Hilton, Wiley & Thanos, 2013).

Many of the open textbooks developed or implemented at the college level have been distributed free of cost to students in a digital, online format (Petrides, et al., 2011). Some books have also been made available for download to portable electronic devices. However, aside from the occasional study exploring student preferences for print versus digital textbooks (Kelley & Warburton, 2011), as with textbooks in general there is no validated theory about what makes a digital textbook high quality from the college student point of view. Hence, even though faculty recognize the potential value of student feedback for improving their open textbooks, getting the most useful and important information from students is challenging. The development and empirical validation of a general model of digital textbook quality from the perspective of college students could lead to the development of an instrument that reliably measures students' perceptions of quality. Results from administration of the instrument could then be used by faculty to inform their textbook development and revision decisions.

Study Purpose and Questions

The main purpose of this study was to develop and empirically validate a model of digital textbook quality from the perspective of college students. Hopefully, this research will contribute to the development of a measure of digital textbook quality that faculty can be used to collect valid feedback from their students. This feedback can then be used to inform the ongoing development of open digital textbooks by faculty.

This study focuses on two main research questions:

1. What are the most desirable characteristics of a high quality digital textbook from the perspective of college students?
2. How do these desirable characteristics translate into a model of students' perceptions of digital textbook quality?
    a. What is the best first-order model in terms of interpretability, fit, and parsimony?
    b. What evidence is there that a higher-order structure explains the relationships among the characteristics better than a first-order model?

Delimitations

There are several perspectives by which textbooks and other instructional materials are commonly evaluated, including the perspective of teachers, publishers, selection committees, and students. I acknowledge that each of these perspectives is important and relevant in its own way and context. However, this study focuses exclusively on the student perspective, particularly the perspective of community college students.

Chapter 2

Literature Review

The textbook has been a key pedagogical technology in the United States since the early 1800s, and educators have long been interested in using the best textbook they can to their students (Brandt, 1964). The desire to use high quality textbooks has meant that textbook evaluation has been an important area of research and discussion in education for many years. In fact, an entire book was published on the topic of textbook evaluation and selection nearly a hundred years ago (Franzen & Knight, 1922). Indeed, there is a solid literature discussing the criteria by which to judge and select textbooks. A very small subset of this literature also deals with using students' perceptions of textbook quality in making selection decisions.

Recently, the proliferation of Open Educational Resources (OER) has dramatically changed the way textbooks are developed and used. Teachers and faculty, as well as schools, districts and states, are now able to draw upon OER to create their own textbooks at dramatically reduced costs. These open textbooks can also be iteratively improved by the authors from year to year or from course to course. To make these improvements most effectively, educators need data about the textbooks themselves. One source of this data could be students, since they are the primary intended users and are the ones who, presumably, have spent the most time with the textbooks. However, it is not likely that students always provide the most useful feedback, especially when evaluation criteria are externally imposed – which is usually the case in student textbook evaluations. There is a great need to articulate evaluation criteria that draw specifically upon actual student perceptions of textbook quality. This is especially true for understanding student perceptions of digital textbook quality, given the ever-increasing use of electronic resources in the classroom.

The purpose of this literature review is to identify criteria (a) commonly used or advocated for use in making textbook selection decisions, (b) commonly imposed on students when they are asked to evaluate textbooks, and (c) unique to evaluating digital or open textbooks, if any.

Search Strategy

The literature on textbook quality was searched using the following nine EBSCO databases:

- Academic Search Premier
- Education Full Text (H.W. Wilson)
- ERIC
- PsycARTICLES
- PsycBOOKS
- PsycCRITIQUES
- PsycEXTRA
- Pyschology and Behavorial Sciences Collection
- PsycINFO.

All searches were refined using thesaurus and subject terms as prompted by the database. Only articles related to textbook evaluation or criteria for selecting textbooks were retained. Searches on variants of the terms *textbook quality*, *textbook*, *electronic textbooks*, *textbook research*, *textbook evaluation*, *textbook selection*, *textbook criteria*, *digital textbooks, textbook student*, *textbook rating*, *textbook standards*, *open textbooks*, and *textbook readability* yielded 189 relevant articles, newspaper reports, and conference presentations. Only articles published in

peer-reviewed journals or academic news outlets (e.g. *Chronicle of Higher Education*) were included in this review.

Criteria for Evaluating Textbooks

The literature revealed several key criteria by which textbooks are commonly evaluated. These include (a) cost, (b) diversity, (c) content, (d) readability, (e) educational impact, (f) pedagogical aids, and (g) interaction.

Cost. Many policy makers view cost as the most important criterion for selecting textbooks (Watt, 2009). The literature suggests that this viewpoint is more common at the state level than at the local level, but financial constraints almost certainly influence selection committees in K-12 contexts. Cost does not seem to be as important a criterion to those who select textbooks in higher education, as only a few studies have explored faculty perceptions of textbook cost.

Ko (2010) reported results from his dissertation on the criteria and rationale that college English faculty in Taiwan use to select textbooks. Ko's study identified 15 main criteria important to these faculty, including *cost-effectiveness.* This criterion was not among the top five most important identified, however, falling behind *level*, *learners' needs*, *authenticity*, *ancillary materials*, and *communicative ability*.

In another study, Petrides, Jimes, Middleton-Detzner, Walling, and Weiss (2011) used survey data to show that cost was a significant factor in faculty decisions to select *open* textbooks for their students, even though such adoption meant more work for the faculty. Other criteria important to these educators in selecting open textbooks included dependable quality and ease of use.

Most recently, Silver, Stevens, and Clow (2012) reported the results of a survey of 264 marketing professors from universities across the United States. On the survey, faculty were asked to rank a set of five textbook selection criteria on a scale of 1 (*most important*) to 5 (*least important*). *Cost* received an average ranking of 3.07 (SD 1.030), somewhat higher than *edition of the text* (3.77, 0.921) and slightly lower than *ancillary materials* (3.00, 1.232). The most important selection criterion of the five presented to these faculty was *content coverage* (1.28, 0.654).

The results from these few studies indicate that cost is something that college faculty consider when selecting textbooks, but that it generally isn't the most important criterion. At the same time, the Petrides et al. (2012) study raises the interesting question of whether faculty who opt to use open textbooks place greater importance on cost than those who don't use open textbooks. More research is needed to answer this question.

Sensitivity to diversity. Another criterion for textbook selection mentioned in the literature is sensitivity to diverse cultures and viewpoints (Cruz, 2002; Etlin; 1994; Fiore & Cook, 1994; Griggs, Jackson, Christopher, & Marek, 1999; Thomas, 1990). Cruz (2002), for example, conducted an ethnic analysis of popular American History textbooks to understand how Latinos and Latin Americans are portrayed to students. This study revealed "that school history textbooks tend to portray Latin Americans as alternately violent, passive, lazy and unwilling to assimilate into mainstream US society — when they are included at all" (p. 1). Cruz argued for more analyses like hers and for greater consideration of cultural diversity in textbook selection decisions.

Similarly, Etlin (1994) discussed efforts made by the National Education Association (NEA) to promote greater representation of students' cultural and ethnic diversity in textbooks nationwide. Indeed, diversity ranks high on the NEA's list of textbook selection criteria. While it seems that few would argue that diversity is an unimportant criterion in textbook selection, I found no studies in higher education that show faculty considering it in their decisions.

Content. Results from the survey of marketing professors by Silver et al. (2012) discussed previously highlight the importance of content as a textbook selection criterion. Many other authors have also addressed the consideration of content in both K-12 and higher education selection decisions (Armstrong & Bray, 1986; Falduto, 2009; Griggs & Koenig, 2001; Meyer, 1988; Quereshi & Sackett, 1977; Rose & Lessen, 1980; Suh, 1970).

Meyer (1988) conducted an analysis of several science textbooks written for elementary school students, and focused primarily on comparing the content coverage of the books as a measure of their acceptability for use. Results from this study indicated that elementary science textbooks varied widely in the content they covered, as well as in how this information was presented. Meyer argued that because of these differences, content should be a key consideration in the textbook selection process.

In a higher education study, Griggs and Koenig (2001) compared 15 psychology textbooks in terms of content, length, and pedagogical aids. They found considerable variability in the texts, especially in the content focus of each book. While such variability is often viewed as problematic in the K-12 setting, these authors believed that such differences actually serve to "accommodate teachers' preferences and needs" (p. 1). It is interesting to note that students'

"preferences and needs" were not included in the discussion, but seemed to be subsumed within faculty preference.

In addition to content coverage, one study looked at content accuracy as a textbook selection criterion (Steuer & Ham, 2008). These authors contended that content accuracy is difficult and time-consuming to evaluate because it requires high-levels of expertise and thorough reading. To address this concern, they described a technique for efficiently evaluating the accuracy of textbook content by random sampling of textbook chapters, followed by random sampling of passages under second-level headings within selected chapters. These passages can then be thoroughly examined by experts and evaluated for accuracy. Steuer and Ham also described the results of using their technique to analyze a number psychology textbooks. In their study, they isolated an average of nine passages per textbook and found numerous errors in the content. This study underscores the importance of considering content accuracy in addition to content coverage, but also provides an efficient way to do so.

Readability. A large number of textbook evaluation studies have focused on readability issues (Gillen, 1973; Hartley, Sotto, & Fox, 2004; Jones & Evanciew, 1995; Landrigan & Palladino 1974; Maddux & Candler; 1990; Meyer, 2003; Quereshi & Buchoski, 1979; Reitenour, 1984; Rose & Lessen, 1980; Spinks & Wells, 1993; Strunk, 1957). This criterion is so often used and promoted that textbook evaluators employ scales to objectively measure it (see Flesch, 1948). A few example studies highlight this point.

Hartley, Sotto, and Fox (2004) used a computer-based readability scale to compare textbooks from multiple genres, including the sciences, social sciences, and arts and humanities.

They found that scientific textbooks had higher readability scores because they used shorter sentences and clearer, descriptive prose.

Jones and Evanciew (1995) used a variety of readability measures to compare the 15 most commonly used technology education textbooks in high school and college classrooms. In addition to readability, the authors also examined human interest and writing style and ranked the books according to their scores on all three factors. They found that all of the readability formulas provided roughly equivalent estimates and could be used interchangeably.

While most authors argue that readability is important to consider when selecting a textbook, some believe that there are pitfalls to relying too exclusively on such measures because they can negatively affect overall textbook quality (Armbruster et al. 1985). The debate continues over how much emphasis selection committees should give to readability scores (Cunningham, 1984; Gunning, 2003).

Educational impact. Some researchers have focused their attention on exploring how textbooks impact learning (Durwin & Sherman, 2008; Davis, 2009; Meredith, 1980; Petrides et al., 2011; Reys, Reys, & Chavez, 2004; Spinks & Wells, 1993; Terwiliger, 1989). These studies have explored a wide range of outcomes including knowledge, comprehension, motivation, learning behaviors, collaboration, grades, and assessment performance.

Durwin and Sherman (2008) compared the impact of two competing physics textbooks on student comprehension. In this study, the authors recruited 48 students enrolled in their introductory physics courses and assigned them to use one or the other textbook. They then constructed comprehension tests based on randomly sampled passages from the respective

books. Results from the tests showed that students exhibited no significant differences in comprehension levels depending on which textbook they used.

Another recent study focused on the impact of two different mathematics textbooks on pre-service teacher knowledge (Davis, 2009). Here, students were given a pretest and a posttest that covered both content and pedagogical knowledge. The author reported that teachers who used one text experienced increased content knowledge, while students using the other textbook gained more pedagogical knowledge.

Pedagogical aids. A number of authors have explored pedagogical aids (e.g. illustrations, online tools, glossaries) as a criterion for textbook selection (Griggs, Bujak-Johnson, Proctor, 2004; Honeycutt, 2007; Jackson, Lugo, & Griggs, 2001; Weiten, Deguara, Rehmke, & Sewell, 1999; Yasar & Seremet, 2007). In one example, Griggs et al. (2004) conducted a thorough analysis of the glossaries of 44 introductory psychology textbooks. In this study, the authors were interested in evaluating common core vocabulary used across the books, as well as the size and uniqueness of the glossaries. They found very little commonality among the glossaries, including a total of 6,269 unique terms. Most striking, the authors reported that only 14 terms showed up in all 44 glossaries. This study is an example of how analysis of pedagogical aids can provide information for comparing textbooks and making selection decisions based on selection committee preferences.

Interaction. Research regarding the theory of generative learning also has some application to evaluation of instructional materials. The generative learning theory relates to the idea that learners actively participate in the learning process and work to construct meaningful understandings of the information in their environment (Wittrock, 1974). This position is based

on the assumption that the design of instructional materials, including textbooks, can affect learning if such materials are designed to promote mental engagement and deep interaction with the ideas presented (Grabowski, 2004). Specifically, textbooks that (a) provide objects and adjunct questions (Wittrock, 1989), (b) include interpretation of the importance of the topics selected (Grabowski, 2004), (c) present problems, mysteries, inconsistencies, suspense, and enigmas (Grabowski, 2004), and (d) direct students' voluntary attention to engagement (Kourilsky & Wittrock, 1992) are predicted to have a greater effect on student learning than textbooks that do not include these design elements.

Criteria Imposed on Students for Evaluating Textbooks

A few published studies have examined the textbook evaluation from the student perspective. By far, the most common criterion students have been asked to consider in evaluating their textbooks is readability. All of the studies cited and described above on this topic, of necessity, use student ratings to calculate traditional readability indices. However, given the objective nature of this criterion and its previous discussion, no more will be said about it here.

Human interest. Many of the readability studies described in the literature also include a measure of human interest (Croll & Moskaluk, 1977; Gillen, 1973; Gillen, Kendall, & Finch, 1977; Jones & Evanciew, 1995; Klein, Bryant, & Zillman, 1982; Maddux & Candler, 1987; Maddux & Candler, 1990; Maddux, Irons, Candler, & Irons, 1983; Quereshi & Buchkoski, 1979). This is the second most common criterion imposed on students, though it appears to have gone out of vogue in recent years. The readability study by Jones & Evanciew (1995) described above also included measures of human interest, and is the most recent study to have done so.

Despite the finding that readability is a useful criterion for evaluating a textbook, these authors concluded that human interest scores are not a reliable measure of reading appeal for most students. The only exception to this is for students who have low levels of motivation or subject interest to begin with. Most of the other studies using measures of human interest do not question their utility or relevance, but simply report scores and make textbook recommendations based, in part, upon those scores.

Learnability. A small number of authors have discussed the concept of learnability (Britton, Van Dusen, Gülgöz, Glynn, & Sharp, 1991; Klein et al., 1982; Muther & Conrad, 1988; Simpson, 1947). In these studies, learnability is operationalized as students' perceptions of their own content retention, but not on the depth or breadth of their understanding. Britton et al. (1991) conducted research that explored learnability by measuring the accuracy of students' judgments about their own retention. The authors used 20 pairs of textbook passages, with each pair consisting of an original version and a re-written version of the passage. Empirical data about which version was retained better allowed the authors to measure the accuracy of student judgments. Results showed that 95 percent of students in the study were accurate in their judgments. The authors then used this result as evidence to claim that learnability should be used in textbook selection decisions.

Pedagogical aids. A few studies have explored student perceptions of the effectiveness of pedagogical aids, though this literature is quite sparse (Altman, Ericksen, & Pena-shaff, 2001; Sellnow, Child, & Ahlfeldt, 2005; Weiten et al. 1999). Sellnow et al. (2005) conducted one of the only studies to date that focused exclusively students' feedback about the use of pedagogical aids, specifically supplements like self-guided quizzes and internet activities. In this study, students in a public speaking course were asked about their perceptions of the technology

supplements that accompanied their textbook. The authors reported that these kinds of pedagogical aids were perceived as most useful to students when the aids were required, related directly to course objectives, and functioned properly.

Other criteria. A handful of additional criteria imposed on students are mentioned in the literature, but only once or twice. These include text format (Kelley, Warburton, 2011), usability (Berry, Cook, Hill, & Stevens, 2010; Weisberg, 2011), content coverage (Altman et al., 2001; Besser & Stone, 1999), overall value (Baker-Eveleth et al., 2011), and importance as a pedagogical tool (Hewinson, 2007). Given the isolated nature of these studies, no more will be said about these criteria in this review.

Criteria for Evaluating Digital Textbooks

The recent proliferation of digital and open textbooks has not led to a similar rise in the number of studies that have examined or discussed criteria for choosing among such texts. Of course, most of the criteria mentioned above also apply to digital texts. However, the only unique factor mentioned in the few studies on digital textbook evaluation related to whether students preferred print or digital versions (Baker-Eveleth et al., 2011; Kelley & Warburton, 2011; Petrides et al. 2011; Pomper, 2008; Weisberg, 2011; Woody, Daniel, & Baker, 2010; Young, 2009). The answer to this question is inconclusive. In some cases, most students preferred digital versions. In others, most students preferred print versions. For now, the only answer that can be given about student preference for digital books is that it depends on the context and the students, and perhaps on how teachers use the textbooks.

Still, none of these studies addressed other criteria that might be important for evaluating digital textbooks that don't apply to print versions, including navigability, accessibility, or

enhanced graphics. Indeed, much work remains in order to understand the most relevant criteria for evaluating digital textbooks. This knowledge would be useful in choosing among digital textbooks in general, and would also assist those using digital open textbooks in their development decisions. The study described in this dissertation is an attempt to clarify some of the criteria for evaluating digital textbooks through the development and empirical validation a model of digital textbook quality from the perspective of college students.

Chapter 3

Method

Both qualitative and quantitative methods were used to develop and evaluate a model of digital textbook quality from the perspective of college students. In this chapter, the study context is described first, followed by the qualitative approach used to identify the desired characteristics of a high quality digital textbook. The quantitative approach used to develop a conceptual model of digital textbook quality and empirically evaluate this proposed model is described last.

Study Context

Student data for this study were collected from students in Project Kaleidoscope (http://www.project-kaleidoscope.org), a privately funded initiative that brings together eight community colleges to create course designs using open digital textbooks. Project partners include five colleges in California, one college in Nebraska, and two colleges in New York. These partner institutions collectively serve over 100,000 students per year. During the 2012 Spring Semester, 80 faculty across 31 subjects used Project Kaleidoscope open digital textbooks. Over half of these faculty were also involved in the development of the textbooks. These core project faculty teamed-up across the colleges to identify and evaluate existing OER for incorporation in the Kaleidoscope course designs and texts. The emphasis on open resources in Project Kaleidoscope is driven by two project objectives: (a) eliminating textbook costs as an obstacle to the success of low-income students, and (b) allowing faculty greater flexibility in sharing and improving the course resources.

A pilot study was conducted during the Fall 2011 semester that included a questionnaire completed by about 130 community college students who were using digital open textbooks as part of Project Kaleidoscope (Bliss et al., 2012*)*. Most of these students indicated a preference for online textbooks. A handful of themes also emerged from student responses to the question "Overall, what did you think of the [online] textbook used in your course?" These themes included aspects of how the material was presented (readability, organization, clarity, concision, engagement), accessibility, content (informative, useful, effective), and cost. These preliminary results were used as a springboard into a more in-depth qualitative and quantitative exploration of student perspectives of digital textbooks.

Qualitative Method

Questionnaires, interviews, and published journal articles were used to identify desired characteristics of digital textbooks from the perspective of college students.

Sample. Community college students enrolled in Project Kaleidoscope courses during the Spring 2012 term were sampled for this study, and 365 of these students completed the questionnaire items. Students from each of the eight PK partner institutions responded to the questionnaire in variable proportions (Table 1), but these proportions were representative of the differential participation in the PK initiative in general. That is, most students who responded to the questionnaire were enrolled at Cerritos College, and this college had the largest number of PK participants and courses to begin with. A subsample of 10 students from the sample of 365 participated in the interviews. Interviewees self-selected into the study by indicating a willingness to be interviewed when they completed the questionnaire.

Table 1
Sample Characteristics of the Qualitative Study

	Gender		
Institution	Male	Female	Total
Cerritos College	58	83	141
Chadron College	8	12	20
Mercy College	21	41	62
Palo Verde College	2	0	2
College of the Redwoods	29	40	69
Santa Ana College	17	19	36
Santiago Canyon College	13	13	26
Tompkins-Cortland College	1	8	9
Total	149	216	365

Questionnaires. The questionnaire consisted of several open-ended, constructed response items that asked students about their perceptions of the textbooks they were using. The exact number of respondents to each item on the questionnaire varied. This questionnaire was a modified version of the pilot questionnaire, using pilot results to improve item wording and focus. At least one additional item was included on the modified questionnaire where students were asked about digital textbooks in general. Responses to the following two open-ended items on the modified questionnaire were used in this study:

- From your perspective, what are the characteristics of a high quality digital textbook?
- Overall, what did you think of the digital textbook you used in your course?

Interviews. Students who completed the questionnaire were given an opportunity to choose to be interviewed by phone or online chat about their perceptions of the quality of digital textbooks. Eight students were interviewed by phone and two students were interviewed via Google chat. One or two prompts that addressed student perceptions of digital textbook quality were used in the interviews, but all interviews followed an unstructured format to allow students

and myself more freedom to explore student perceptions as they arose. Each interview lasted from 15-30 minutes and attempted to engage the students in a discussion about what made digital textbooks useful and interesting to them. Interviewing allowed for a much deeper exploration of students' perceptions of textbook quality than could be obtained by questionnaire alone. For example, conducting interviews with students allowed for focused, clarifying discussions on the most-often mentioned characteristics of digital textbooks in the questionnaire responses.

While it is customary in qualitative studies to conduct interviews first to identify issues and concerns in depth and then use questionnaires to assess the breadth and pervasiveness of the interview findings, this study was constrained by access to the college student population. The opportunity to administer questionnaires arose first and led directly to an opportunity to recruit students to be interviewed. Hence, in this study, the questionnaires were used to identify broad issues and the interviews were used to explore some of those issues in more depth.

Literature survey. In addition to the questionnaire and interviews, the literature on textbook evaluation was also surveyed, with specific focus on student perceptions of textbooks. The literature review in Chapter 2 of this dissertation is the result of this survey. The archival data from the literature was valuable in framing the results that came from the student data collected through interviews and questionnaires. Specifically, the results from the published literature were compared with the themes and concerns expressed by the students. While not much has been written about students' perceptions of digital textbooks, beyond exploring their preference for print versus digital formats, the literature related to students' perceptions of textbooks in general provides valuable insight to this study.

Data analysis. Data from the questionnaires, interviews, and the literature review were explored using thematic analysis (Benner, 1985; Leininger, 1985; Taylor & Bogdan, 1984.) This analysis occurred in seven main steps:

1. Preparation of the data for analysis by transcribing interview results, compiling questionnaire results, and organizing summaries of relevant published articles.
2. Reading of the texts (questionnaire responses, interview transcripts, and literature summaries) to note items of interest, get a sense of the data, and identify initial topics.
3. Sorting of the initial topics to identify and organize emergent themes relating to similar topics.
4. Writing of provisional names and definitions for each theme.
5. Conducting of axial coding, which entails going back through the data a separate time for each theme to further clarify thematic definitions in the context of the data and the other themes.
6. Combination or disaggregation of themes as necessary.
7. Finalization of each theme by writing full descriptions and providing illustrations using quotes from the data.

In this study, the finalized themes in Step 7 became the target constructs of the initial measurement model of digital textbook quality from the perspective of college students.

Standards for qualitative studies. The qualitative portion of this study met many of the standards for qualitative research, as defined by Williams (2013). In particular, a study designed to explore student perceptions of digital textbook quality could potentially make a meaningful contribution to the literature on textbook evaluation. It could also be useful for informing theory

that could then be used to develop a model of digital textbook quality and an instrument to measure the components of this model. In addition, the study used several sources of data in an effort to triangulate perceptions of textbook quality and improve study credibility. Finally, the data collection and analysis procedures used in this study were appropriate to answer the research question about what students perceive to be the desirable characteristics of a high quality digital textbook. Any limitations to these procedures are discussed in detail in Chapter 5.

Quantitative Method

The themes derived from the qualitative analysis described above were used to generate a model of digital textbook quality from the perspective of college students. Model development and improvement occurred in three main steps:

1. Item writing
2. Conceptual model development
3. Model evaluation

Sample. Community college students enrolled in Project Kaleidoscope courses during the Fall 2012 term were sampled for this study, and 235 students provided complete responses to the measurement instrument described in a later section. Students from six of the eight PK partner institutions responded to the instrument in variable proportions (Table 2). These proportions were not representative of the differential participation in the PK initiative in general. Rather, most responses came from two colleges, Cerritos and Santa Ana. This difference was likely due to decreased research intensity on the part of Project Kaleidoscope researchers in general during the Fall 2012 semester. However, the variety of courses and textbooks among the

participating PK faculty was quite large at these two institutions, decreasing the potential for problematic sampling bias.

Table 2
Sample Characteristics of the Quantitative Study

	Gender		
Institution	Male	Female	Total
Cerritos College	43	84	127
Chadron College	0	1	1
Mercy College	0	1	1
Palo Verde College	0	0	0
College of the Redwoods	0	0	0
Santa Ana College	52	49	101
Santiago Canyon College	0	1	1
Tompkins-Cortland College	1	3	4
Total	96	139	235

Item writing. For each theme derived from the qualitative data, several questionnaire items were written to measure student perceptions of their open digital textbooks. A total of 44 items were constructed, with an average of 5.5 items per theme. Experienced measurement specialists reviewed all items as a check on general item quality and revisions were made as necessary. In addition, cognitive interviewing (Willis, 2005) was conducted with five college students who were using digital textbooks in a current course, but who were not part of the Project Kaleidoscope sample.

Cognitive interviews were conducted for the purpose of improving the questionnaire by elucidating the mental process students used to answer each item. Students were asked to read each item aloud and then describe the thought process they used as they attempted to answer each item. Several minor revisions to the items, including some revisions to item ordering, were made based on results from the cognitive interviews.

Conceptual model development. The final themes and items were used to posit two initial hypotheses about the structure of the measurement model of student perceptions of digital textbook quality. The first hypothesis ignored any potential relationships among the themes themselves and consisted of a first-order factor structure including eight separate factors (Figure 1). The second hypothesis posited potential relationships among the themes and consisted of a more complex second-order structure to explain these relationships (Figure 2). In each case, path diagrams are presented in Figures 1 and 2 to portray mathematical models that depict the hypothesized conceptual models. In both diagrams, ovals represent the themes as latent factors, rectangles represent the questionnaire items as manifest variables of the corresponding latent factor, single-headed arrows between the factors and the variables (or between higher- and lower-order factors) represent the pattern of item-factor or factor-factor relationships (known as factor loadings), and double-headed arrows between factors represent factor covariances. Residual variance, or error, is symbolized by circles and single-headed arrows between the circles and the manifest variables.

The main advantage of representing conceptual models in a path diagram is that factor analytic procedures, especially confirmatory factor analysis (CFA), can be used to empirically explore the relationships between factors and variables, as well as compare and evaluate model variations (Brown, 2006). CFA is the measurement portion of structural equation modeling and is the main quantitative method used in this study.

Item Analysis. In order to evaluate the hypothesized conceptual models using CFA, responses to the questionnaire items were first obtained from college students who were using a digital textbook in one of their current courses. The 44 items were compiled into a single online instrument (Appendix A) and an email with a link to the questionnaire was sent to all faculty

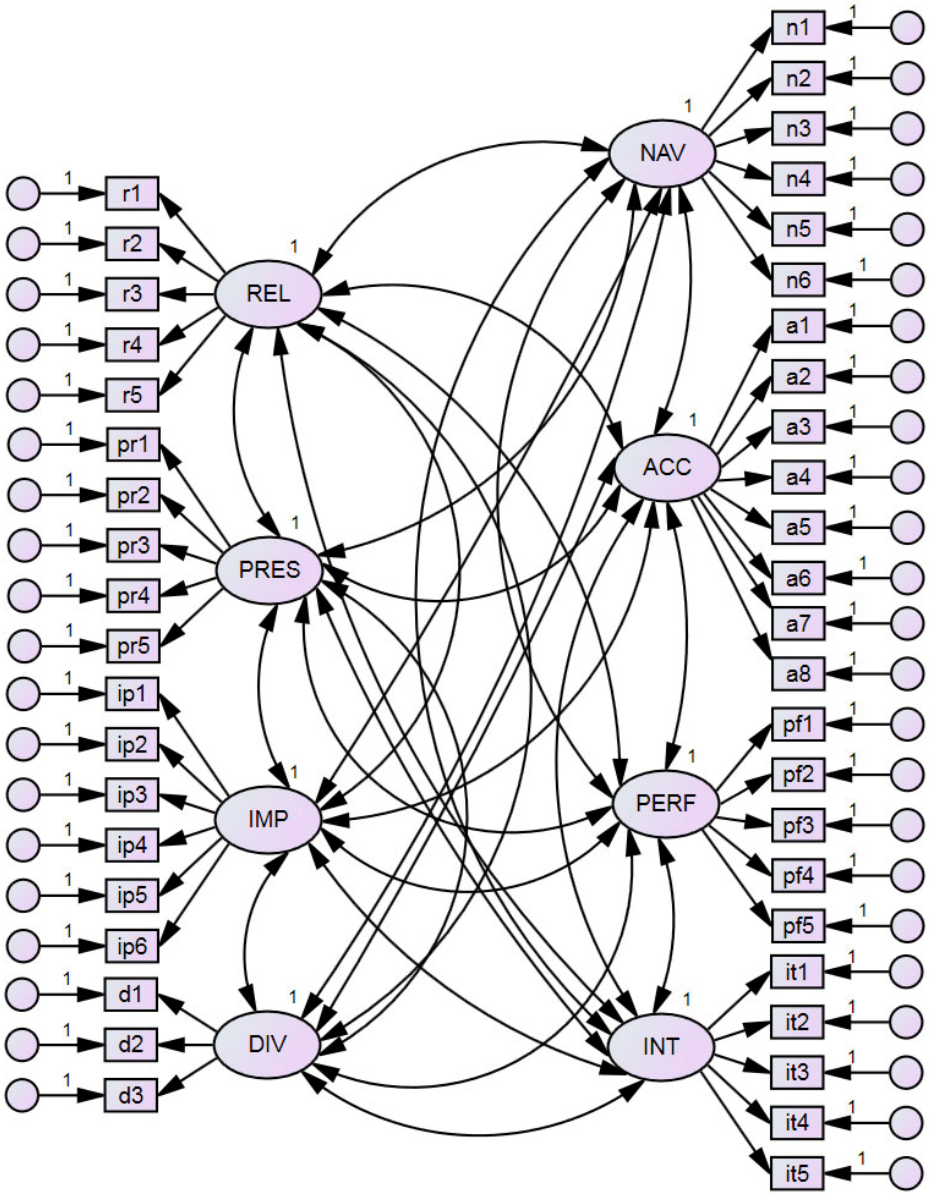


Figure 1. A first-order path diagram representing mathematical relationships between the eight major themes (ovals) and the 44 questionnaire items (rectangles). Single-headed arrows between the themes (or factors) and items represent the pattern of item-factor relationships. Double-headed arrows between factors represent factor covariances. Circles represent residual errors. NAV=navigation, ACC=access, PERF=performance, INT=interaction, REL=relevance, PRES=presentation, IMP=impact, and DIV=diversity.

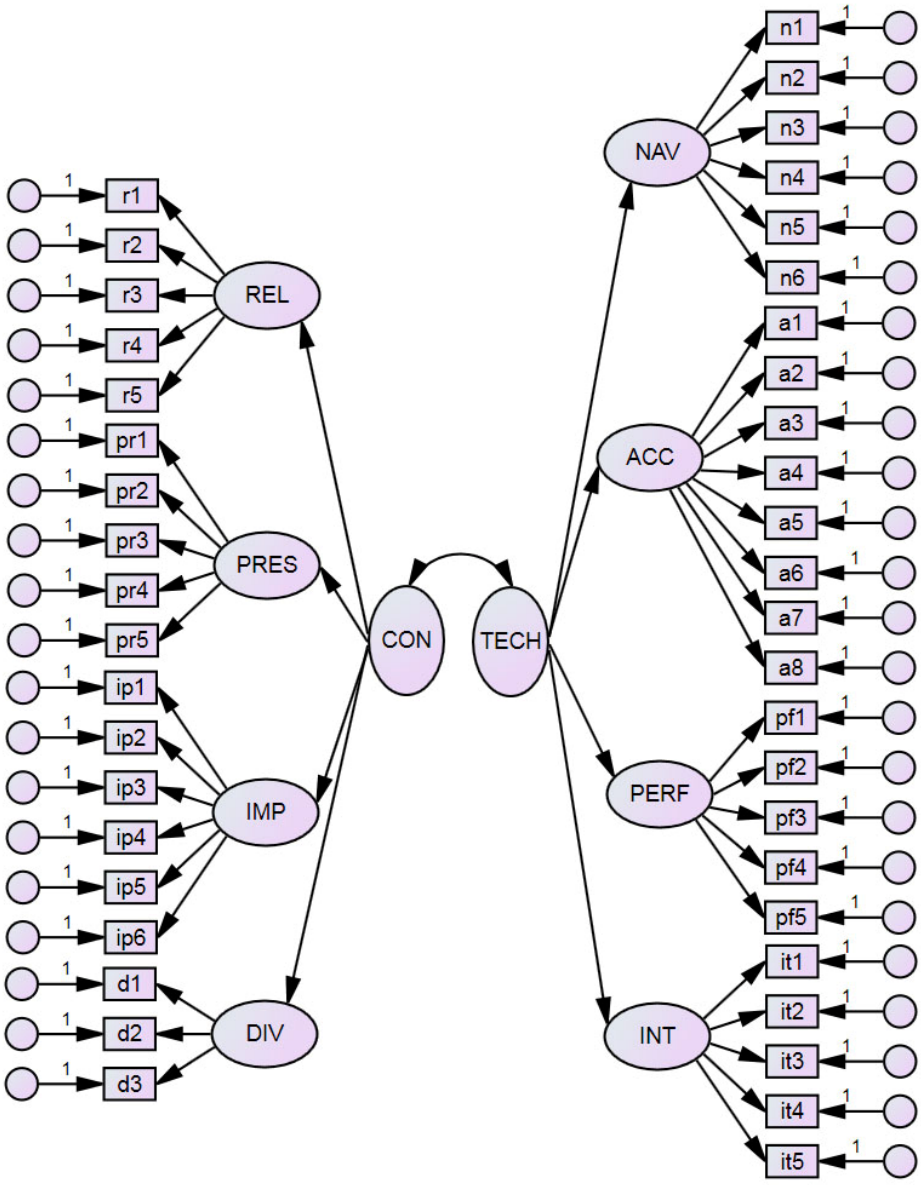


Figure 2. A second-order path diagram representing mathematical relationships between the eight major themes (ovals), the 44 questionnaire items (rectangles) and two higher-order factors (central ovals). Single-headed arrows between the factors and items and between the higher- and lower-order factors represent the pattern of item-factor and factor-factor relationships, respectively.

members participating in Project Kaleidoscope in Fall 2012. The email included a request for faculty to pass the link on to their students, and students were offered a chance to win one of five $25 gift certificates upon completion of the questionnaire. Follow-up emails were sent once a week for three weeks, until the end of the semester.

The students' responses to the 44 polytomous questionnaire items were initially analyzed with the Graded Response Model (Samejima, 1969) in the Item Response Theory (IRT) framework using the statistical software package IRTpro (Cai, Thissen, & du Toit, 2011). This analysis was used to identify any poorly functioning items that may need to be removed prior to evaluating the model using CFA. Three poorly functioning items were removed at this stage, leaving a total of 41 items.

Twenty-two (53.7 percent) of the remaining 41 items in the questionnaire contained an option allowing students to indicate that the issue referenced in the item did not apply to their particular textbook or course (an option referred to hereafter as a "Does Not Apply"). For example, Item 1 ("How useful to your learning is the search function in your digital textbook?") contained the option "There is no search function." A similar "Does Not Apply" option was included with each item that referred to aspects of a textbook (page numbers, interactive quizzes, search functions, etc.) or course (exams, assignments, lectures, etc.) that could possibly be absent. In general, the "Does Not Apply" option was used in hopes that including this option would reduce student frustration in being expected to respond to items when such aspects were absent from their books or courses. Decreasing student frustration was seen as vital to improving the completion rate of the fairly lengthy questionnaire.

The issue of how to code responses in the "Does Not Apply" category is an important question that has received some attention in the literature. Several different approaches have been recommended for treating "Does Not Apply" responses when analyzing data. First, such responses could be treated as meaningful within the context of the continuum defined by the ordered response categories associated with an item, either as an extreme value on that continuum or as a value equivalent to the next most extreme value (Pruchno, Kleban, & Resch, 1988). For example, the option "There is no search function" on Item 1 in my questionnaire could be interpreted as the most extreme negative indicator of textbook quality in the context of the item's other options. On the other hand, the option could be collapsed into the next most extreme option ("Not at all useful"), indicating that an endorsement of "There is no search function" is essentially equivalent to an endorsement of "Not at all useful." Use of this first approach requires strong substantive justification for a meaningful interpretation of the "Does Not Apply" option.

A second approach is to simply delete all cases who endorsed the "Does Not Apply" option in a listwise fashion (Helmes & Campbell, 2010). Listwise deletion involves completely removing any student from the analysis who selected "Does Not Apply" for one or more items. This option is the least desirable, however, as it often reduces the sample size substantially and has the potential to introduce systematic bias into the dataset.

A third approach is to treat responses in the "Does Not Apply" category as missing data, indicating that such responses are not interpretable within the scale (Wolfe, 2010). Treating responses in the "Does Not Apply" category as missing data requires pairwise deletion of student responses. Pairwise deletion involves removing a student's responses to any items on which he endorsed the "Does Not Apply" option, but retaining that student's responses to all other items.

If the percentage of "Does Not Apply" endorsements is relatively small within the dataset, this option avoids the sample size reduction and potential for bias introduced by listwise deletion. The missing data approach requires substantive justification that the "Does Not Apply" option possesses little interpretability within the continuum of the scale for a particular item.

A fourth option for handling the "Does Not Apply" option is to analyze the data using two-part growth modeling (Muthen & Asparouhov, 2002). This approach involves creating a second binary item for each item containing a "Does Not Apply" option. For each case in the data, these secondary items are scored "0" if the subject endorsed the "Does Not Apply" option and "1" if the subject endorsed any other option. All items (primary and secondary) are included in the subsequent item analysis. While more informative than the other approaches, the two-part growth modeling approach is somewhat limited in that it requires continuous data, maximum likelihood estimation, and a larger sample size.

A fifth and final approach is to use IRT analysis to evaluate how the "Does Not Apply" option actually functions within each item (Helmes & Campbell, 2010). If clear results are obtained, this information can potentially be useful in interpreting the meaning of such an endorsement.

In this study, the "Does Not Apply" option was handled using a combination of three of the approaches described above. For 19 (46 percent) of the 41 remaining items, the "Does Not Apply" option was recoded to have a numerical value equal to the next most extreme value. In each of the items handled this way (e.g., Item 1 described above), the "Does Not Apply" option indicated that a feature was absent from the textbook. In all of these cases, I argue that the absence of the function or feature in the textbook is an indicator of poor quality. However, it is

impossible to know whether the absence of the feature indicates any poorer quality than non-usefulness of a present feature, justifying the use of this recoding approach. IRT analysis was then used to empirically evaluate the substantive decisions to combine the "Does Not Apply" categories with the next-most extreme category for these items. In no case did the IRT results indicate that the "Does Not Apply" option was located at a more extreme location than the next most extreme category. This result supports the decision to collapse the two categories into one.

For 3 of the 41 items (7 percent), the "Does Not Apply" option indicated that some aspect of the course was not present (like assignments, lectures, or exams). Since presence or absence of course features is not directly related to textbook quality, "Does Not Apply" endorsements for these items were treated as missing data.

The two-part growth modeling approach was not used to handle the "Does Not Apply" issue because the data in my study are categorical and thus violate the assumptions of maximum likelihood estimation. In addition, increasing the number of items by nearly 50 percent would lead to a significantly more complex model and substantially decreased power.

Confirmatory factor analysis (CFA). The recoded dataset was analyzed using CFA in the statistical software program Mplus (Muthen & Muthen, 1998-2001). Specifically, CFA was used to evaluate the proposed hypothetical models of digital open textbook quality. The purpose of this evaluation was to (a) determine the best first-order model in terms of interpretability, fit, and parsimony, and (b) acquire evidence for or against using a higher-order model to explain any significant relationships among the lower-order factors. The initial conceptual first-order model is depicted in Figure 1. This model contains eight factors, with several items loading on each

factor in a congeneric structure (no items load on more than one factor). Figure 2 depicts a higher-order model, with the eight first-order factors loading on two second-order factors.

CFA requires estimation of multiple parameters. Because the item response data in this study are categorical, they violate the assumption of multivariate normality necessary to justify using maximum likelihood estimation. Hence, the nonparametric robust Weighted Least Squares (WSLMV) estimator was used instead. The most common nonparametric estimator for categorical data is Weighted Least Squares (WLS). However, WLSMV has two advantages over WLS. First, WLSMV is more robust to small sample sizes than WLS. Preliminary research has shown that accurate test statistics and parameter estimates can be obtained in samples ranging from 100 - 1000 and under various levels of model complexity (Flora & Curran, 2004). Second, WLSMV places fewer restrictions on how matrices are treated in the estimation process (Brown, 2006). In particular, WLSMV estimation does not require the initial variance-covariance matrix to be positive definite, increasing the likelihood of model convergence when sample sizes are small.

CFA results include estimates for a variety of model parameters including estimates of factor loadings for each item and covariances between factors. Importantly, CFA provides an standard error for each parameter estimate, allowing for tests of significance. In addition, CFA provides several estimates of global and local fit which indicate how well the data fit the specified model. Finally, CFA provides modification indices which indicate how much the model-data fit is predicted to improve if specified modifications are made to the model. Taken together, the standard errors, fit statistics, and modifications indices allow for a comprehensive evaluation of the model and provide a basis for making informed decisions about how the model might be improved.

First-order confirmatory factor analysis. In this study, standard errors, fit statistics, and modification indices were used together to make adjustments and improvements to the proposed first-order model, in an iterative fashion. The χ^2 Difference Test (DIFFTEST) in Mplus was used to make statistical comparisons between nested models, and the substantive interpretability of each modification was also considered. The χ^2 Difference Test provides a χ^2 value and a p-value for each model comparison. A significant χ^2 value indicates that the less restrictive model has better fit.

Second-order confirmatory factor analysis. The best first-order model in terms of interpretability, fit, and parsimony was used as the basis for evaluating the a priori second-order model. This evaluation occurred in two separate, but related stages. The first stage involved imposing the proposed second-order structure on the improved first-order model as shown in Figure 2. The second stage involved the use of exploratory factor analysis (EFA) in the confirmatory framework (E/CFA). EFA involves conducting a factor analysis where no a priori model is specified, all possible parameters are estimated, and no standard errors or modification indices are calculated. In a first-order model, EFA produces an estimated factor loading for every item on every extracted factor. In a higher-order model, EFA produces a loading estimate for every first-order factor on every second-order factor extracted, in addition to the first-order item-factor loadings.

Second-order exploratory factor analysis in the confirmatory framework (E/CFA). In this study, an EFA using the correlations among the first-order factors from the improved first-order model was also used to establish the number and composition of salient second-order factors present in the data and to inform the structure to be specified in a subsequent second-order CFA. The second-order EFA in this study was conducted using the FACTOR procedure in

SPSS Version 21.0 (IBM Corp., 2012), with Principal Axis Factoring as the extraction method and Promax as the rotation method. Parallel analysis (Hayton, Allen, & Scarpello, 2004) was used to determine the number of salient second-order factors to retain. Parallel analysis uses a simulation procedure to generate many sets of random eigenvalues based on the sample size and number of variables in the dataset to be compared. The mean or 95th percentile of these sets of simulated eigenvalues can then be used in a comparative fashion to determine how many of the eigenvalues in the EFA results are larger than would be predicted by chance. The number of higher eigenvalues is equal to the number of salient factors.

Once the number and composition of the salient factors was determined, a subsequent second-order CFA based on the EFA results was conducted in Mplus. A similar E/CFA approach was attempted for the first-order model, but the interpretability of the resulting EFA structures was low, favoring the direct CFA approach described previously.

Finally, the reliabilities of the subscales (factors) of the best-fitting model were calculated using the procedure developed by Raykov (1997). This CFA-based approach to estimating reliability uses factor loadings and error variances to estimate the true-score variance and error variance. Raykov claims his coefficient provides a more accurate estimate of true reliability than Cronbach's alpha. Results from all analyses described in this chapter are described in the next chapter.

Chapter 4

Results

In this chapter, results from the qualitative analysis used to identify the desired characteristics of a high quality digital textbook are described first, followed by results from the subsequent quantitative analysis used to develop and evaluate a model of digital textbook quality based on the identified characteristics.

Themes Derived from Qualitative Analysis

Thematic analysis of student responses to the questionnaire and the interviews, as well as the literature review, revealed eight major themes related to the quality of open digital textbooks from the perspective of college students. These themes included (a) navigation features, (b) access features, (c) technical performance, (d) relevance, (e) interaction characteristics, (f) presentation characteristics, (g) impact, and (h) sensitivity to cultural diversity. In this section, each theme is defined in some detail and then exemplified with several direct quotations from students and/or summaries of the literature.

Navigation features. This theme relates to characteristics of a digital textbook that assist or facilitate students in their attempts to maneuver through the text or to locate specific components in the text. Students indicated that they prefer a digital search functionality, especially one that is specific, simple, fast, easy to use, and has an option for advanced searching. Students also indicated that high quality digital textbooks should have page numbers, internal linking (i.e. between chapters), and bookmarking that allows students to pick up reading where they left off. Below are several student comments related to the theme of navigation within the context of an open digital textbook.

"Rather than flipping through each page, page by page by page, you can just search straight to what you're looking for and it just saves a lot of time when you're trying to study the night before a test or something."

"[I like being] able to search for specific words and concepts."

"Being able to search the document is a characteristic that puts the digital format above the written format."

"I also feel that the page number being on the textbook [sic] are important."

"[I need] something where I can bookmark where I left off. That's kind of like a key. You have to remember where you leave off."

Access features. This theme relates to how students retrieve and read a digital textbook. Students identified four main aspects of access that are important to them in a high quality digital textbook: (a) options, (b) mobility, (c) convenience, and (d) longevity. First, students desired multiple options for accessing their texts, including the right to (a) print the book (in part or in whole), (b) download an electronic copy of the book, (c) buy a printed copy of the book, or (d) listen to the book in audio format. Second, students desired increased mobility through the right to access the book on multiple devices, especially on e-readers that can reduce screen fatigue. Third, students mentioned the convenience of "anytime, anywhere" access to their digital textbooks, made possible by download capability or online hosting. Finally, students desired the right to access the book even after the course had concluded. Below are several student comments related to the theme of access.

"The best thing I've liked is the availability. I can, if I'm at a computer, I can get it really quick. I can pull up the chapter or the page or whatever I need to reference. That's great. That's like the greatest thing about it."

"The only thing I guess I could ask for is maybe that whole textbook be downloadable to a PDF file or something like that. That way you could perhaps put it on a mobile device or something…If it was downloadable to a PDF it would make it easier to print, it would make it easier for a lot more other mediums, of ways of using or reading the book."

"[I want] a book that can be accessed in any device and that has printable pages"

"[A high quality digital textbook] should be accessible anywhere- just as long as you have a computer."

"[I want to be able] to purchase printed chapters."

Technical performance. This theme relates to the technical functioning of the digital textbook itself, including technical problems that might hinder access and usability. Students mentioned that high quality digital textbooks should have minimal technological problems. They also desired that such books be (a) easy to find and log in to, (b) be compatible with many different web browsers and device operating systems, and (c) have fast download and upload speeds. In short, students believe that the technology of the textbook should enhance, not hinder, learning from a digital textbook. Below are several student comments related to the theme of performance.

"[A high quality digital textbook] should function well in any browser. "

"[A high quality digital textbook] should be easy to log into and find."

"[A high quality digital textbook] doesn't have any problems (downloading, uploading pages, etc.)."

"[There should be] no lagging when I access the book."

"[A high quality digital textbook] has no bug problems."

"The pages [should] load quickly."

"The only things that I would come across would be every so often I would get an error page saying that whole system was down…it only took about 30 minutes for it to come back up. But it was kind of nerve racking [sic] for those 30 minutes."

"[The digital textbook] must not consume too much memory and CPU resources to render a page."

Relevance. This theme relates to how current the content of a digital textbook is and how well the content aligns with what is being taught in the course by the instructor. Students indicated that high quality digital textbooks are clear, up-to-date, and contain no superfluous pages or content. Students also recognized the value of an instructor being able to customize and update the textbook. Below are several student comments related to the theme of relevance.

"If any information is more current, [then the teacher] can add to it or if anything needs to be updated."

"[A high quality digital textbook] flows well with what the instructor teaches in class as well as the way he or she teaches."

"[A high quality digital] textbook is relevant."

"[A high quality digital textbook] should have all of the same information as what you are learning in class."

"The book that I used that had the online version, everything corresponded with the chapters and we used the whole book versus, like, some classes where you get a book you only use like maybe half it. So you waste the money on buying the whole book…[My professor] integrated it perfectly so each chapter in that topic reflected what we were learning that lesson."

"At the end of the chapters you would get a lot more up-to-date websites, more up-to-date references and stuff like that, which allowed me, as a student, to have better and more reliable resources, which I thought was great."

"Up-to-date and relevant information is the most important aspect of the textbook…There have been classes that I've been in where you look and the book was published like eight or ten years ago. And, with this digital book, it's a lot easier to not have to be forced to have a book that's been out for ten years."

"All the chapters did have to do with what we were doing. Usually when I have a class with a textbook, we'll be skipping over this or that, or my teacher will be teaching it in a really different way than the textbook."

Interaction characteristics. This theme relates to how technology interfaces with the content of a digital textbook. Students mentioned that high quality digital textbooks should allow for on-screen highlighting and note-taking to enhance studying. They also cited embedded supplementary material, including links to external content, videos, and tutorials, as important features. Finally, students indicated that responsive quizzing with instant, directed feedback and

hints would improve the quality of their experience with digital textbooks. Below are several student comments related to the theme of interaction.

"Students need to be able to take notes on the readings and make highlights if needed."

"Interactive tutorials would be a major benefit [to a digital textbook]"

"Web links to current statistics (i.e. Department of Labor stats, unemployment stats) and an interactive way to answer end of chapter review questions [are important characteristics of a high quality digital textbook]."

"The material combines both video and textual content – [the textbook] should take advantage of the technology."

"Like the questions at the end of a chapter, maybe like in the summary, if somehow there was a way to answer it and if you don't get the answer it kind of directs you where you can find it."

"I love that [my digital textbook] has the videos on there, like links, like it shows little videos and when it talks about a subject and then it says, 'Well this would happen in the news.' And then they show the clip, like a YouTube clip or whatever video and it has more links. Yeah, that is really, it's like, like Harry Potter, you know…it just starts coming on and people are talking to you…right there it just does it for you, the link, so you can watch videos pertaining to the subject or to the chapter."

Presentation characteristics. This theme relates to how the content of the textbook is organized and displayed to the reader. Students mentioned that high quality digital textbooks are clear, easy to read and use, understandable, well-written, and well-organized. Students desired

content that was comprehensive, informative, and detailed. Students also mentioned that high quality digital textbooks should include definitions of key words, extended glossaries, summary sections, study guide sections, and appropriate examples. Finally, students mentioned that high quality visual aids are an important component of digital textbooks. Below are several student comments related to the theme of presentation.

"[A high quality digital textbook] should have a lot of examples of all the different types of problems, not just easy ones."

"A quality digital text book has to do with the material."

"[A high quality digital textbook] has all of the information you need to study and complete required assignments for the course."

"[A high quality digital textbook has] detailed content."

"A characteristic of a high quality digital textbook is its presentation of information."

"I want the option to make the fonts bigger."

"[High quality digital textbooks have] Illustrations, good colorful graphics. Charts, statistics that are easy to understand. Logical table of contents, extensive index."

"[A high quality digital textbook has] large print for older students, easy to comprehend language, organized in a way that addresses the needs of disabled students and assistance phone numbers available for questions."

"[A high quality digital textbook has] balance in length of sections."

"[My digital textbook] wasn't hard to get through. None of the material was difficult to understand or you have to, like, go back and re-read things to try and understand them. So it was very clear and concise."

Educational impact. This theme relates to the perceived or real effects a digital textbook has on learning, motivation, or behavior. One student discussed her own perception of the impact of her digital textbook, stating that using a digital book seemed to improve her test scores and comprehension. A number of studies in the literature have explored textbook learning impacts, though none has focused exclusively on digital books. These studies indicate that learning can be impacted by the textbook used and that students can perceive these impacts. Below are several comments from students and the literature related to the theme of impact.

"When I started to use the digital books my test scores improved drastically. I have a learning disability and it seemed like I was doing better in my grades reading the texts online than in my [printed] books . . . It seemed like I comprehended the material better."

Davis (2009) reported that teachers who used one text experienced increased content knowledge, while students using another textbook gained more pedagogical knowledge. Other researchers have focused their attention on exploring how textbooks impact learning (Davis, 2009; Durwin & Sherman, 2008; Meredith, 1980; Petrides et al., 2011; Reys, Reys, & Chavez, 2004; Spinks & Wells, 1993; Terwiliger, 1989). These studies have explored a wide range of outcomes including knowledge, comprehension, motivation, learning behaviors, collaboration, grades, and assessment performance.

A small number of authors have discussed the concept of learnability (Britton, Van Dusen, Gülgöz, Glynn, & Sharp, 1991; Klein et al., 1982; Muther & Conrad, 1988; Simpson,

1947). In these studies, learnability is defined as students' perceptions of their own content retention. Britton et al. (1991) conducted research that explored learnability by measuring the accuracy of students' judgments about their own retention. The authors used 20 pairs of textbook passages, with each pair consisting of an original version and a re-written version of the passage. Empirical data about which version was retained better allowed the authors to measure the accuracy of student judgments. Results showed that 95 percent of students in the study were accurate in their judgments. The authors used this result as evidence to claim that learnability should be used in textbook selection decisions.

Sensitivity to diversity. This theme relates to a textbook's sensitivity to differences in diverse cultures and viewpoints. No student mentioned diversity as an important theme to consider in a high quality digital textbook, but some of the literature on textbook quality has addressed this theme. These studies indicate that paying attention to diversity is important in textbook development and selection, but that faculty in higher education generally do not consider it. This theme was included in this study because it was anticipated that students would be capable of providing a relevant and important perspective on this issue.

Two examples from the literature exemplify the theme of diversity. Cruz (2002) conducted an ethnic analysis of popular American History textbooks to understand how Latinos and Latin Americans are portrayed to students. This study revealed "that school history textbooks tend to portray Latin Americans as alternately violent, passive, lazy and unwilling to assimilate into mainstream US society — when they are included at all" (p. 1). Cruz argued for more analyses like hers and for greater consideration of cultural diversity in textbook selection decisions. Similarly, Etlin (1994) discussed efforts made by the National Education Association

(NEA) to promote greater representation of students' cultural and ethnic diversity in textbooks nationwide. Indeed, diversity ranks high on the NEA's list of textbook selection criteria.

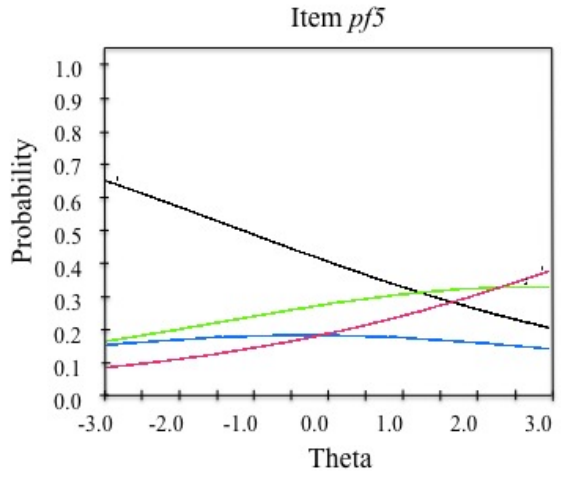
Quantitative Analysis

In this section, the results of the initial item analysis using IRT are presented first, followed by the results of CFA of the first-order models and then the results of CFA and E/CFA of the higher-order models.

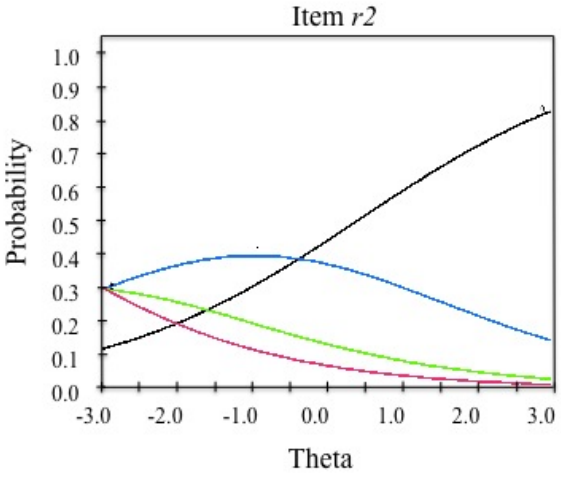
Item analysis. Initial analysis of student responses to the 44 items on the questionnaire using the Graded Response Model revealed three items with poorly functioning response options: *pf5*, *r2*, and *d1*. While hypothesized to load on three separate factors, these three items all shared the common feature of reverse ordering of the response options. In all other items, option A was the most negative indicator of textbook quality and option D was the most positive indicator. In the three items with poor functionality, option A was the most positive indicator and option D was the most negative. Category probability curves for each of the three poorly functioning items are shown in Figure 3. Category probability curves for three well-functioning items are displayed in Figure 4. Each curve in these figures represents the probability of endorsing a particular response option relative to a students' perceptions of digital textbook quality as operationalized by each theme. The flattened curves in Figure 3 indicate poorly functioning items and justify removal of these items from further analyses.

Confirmatory factor analysis (CFA). The results of the first-order CFA, second-order CFA, and second-order E/CFA are reported next, along with reliability estimates for each model.

First-order confirmatory factor analysis. The a priori first-order model (Figure 1) postulates that each of the 41 items would load exclusively on its respective factor. CFA of the



A



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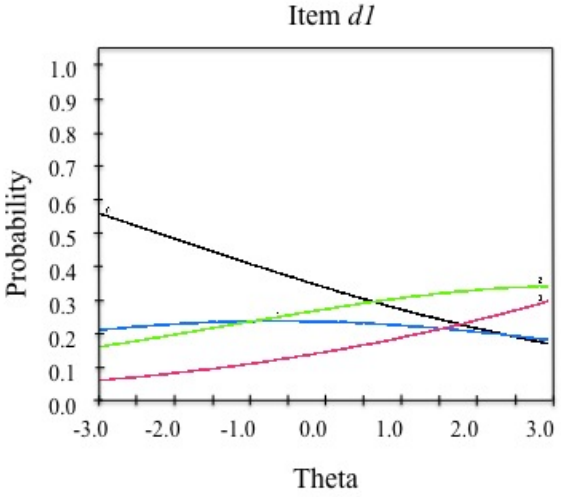

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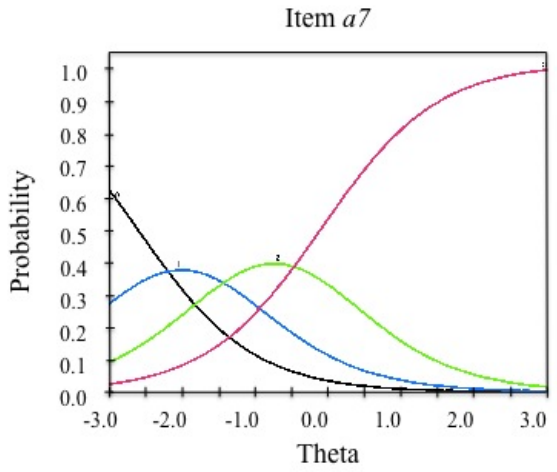
Figure 3. Category probability curves for item *pf5*, item *r2*, and item *d1*.



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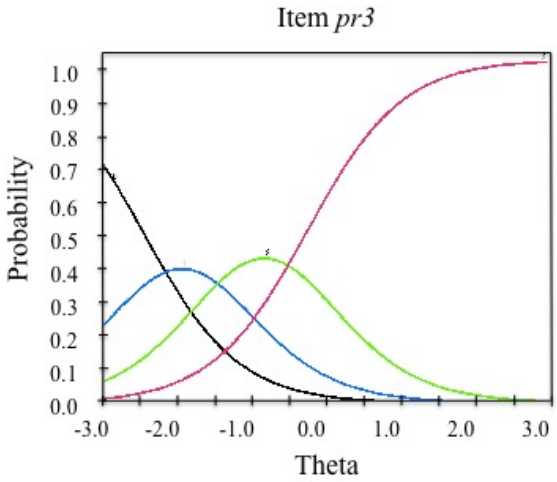

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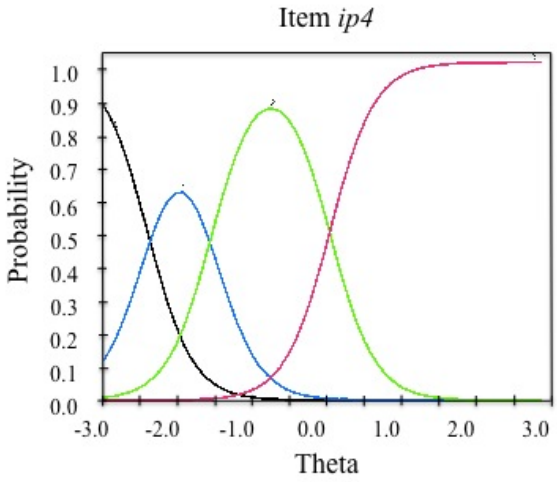

C

Figure 4. Category probability curves for item *a7*, item *pr3*, and item *ip4*.

responses to the 41 items from the 235 students showed that this proposed first-order model (Model 1) had fairly good fit (Table 3), but that this fit would be improved if item *n6* were allowed to freely load on the PERFORMANCE factor in addition to the NAVIGATION factor. The modified model (Model 2) with *n6* freely loading on PERFORMANCE had significantly better fit than Model 1 ($\chi^2 = 60.703$, $p < 0.001$). However, in Model 2 the loading of item *n6* on the NAVIGATION factor was not significant (i.e. the factor accounted for less than 10 percent of variance in the item), so the loading was constrained to zero in Model 3.

Pairwise comparisons of the models indicated that Model 3 was not significantly worse than Model 2 ($\chi^2 = 2.779$, $p = 0.094$), but modification indices indicated that this fit could be improved by allowing item *pr6* to freely load on the INTERACTION factor in addition to the PRESENTATION factor. The resulting modification (Model 4) had significantly better fit than Model 3 ($\chi^2 = 50.903$, $p < 0.001$). However, in Model 4 the loading of item *pr6* on the PRESENTATION factor was low, so the loading was constrained to zero in Model 5. The resulting fit of Model 5 was significantly better than Model 4 ($\chi^2 = 12.649$, $p < .001$).

Modification indices in Model 5 indicated that model fit could be significantly improved by allowing item *a1* to freely load on the PERFORMANCE factor in addition to the ACCESS factor. The resulting modification (Model 6) had significantly better fit than Model 5 ($\chi^2 = 45.936$, $p < 0.001$). However, in Model 6 the loading of item *a1* on the ACCESS factor was low, so it was constrained to zero in Model 7. The resulting fit of Model 7 was significantly worse than Model 6 ($\chi^2 = 11.389$, $p < 0.001$). However, modification indices in Model 7 indicated that fit could be improved by allowing item *a2* to freely load on the PERFORMANCE factor in addition to the ACCESS factor. The resulting modification (Model 8) had significantly better fit than Model 7 ($\chi^2 = 32.869$, $p < .001$). However, in Model 8, the loading of item *a2* on the

Table 3

First-Order Model Fit and Comparative Statistics

Model	Chi-square[a]	CFI[b]	TLI[c]	RMSEA[d]	χ^2 Difference Test[e]	Significance[f]
Model 1	395.764	.832	.946	.114	n/a	n/a
Model 2	356.535	.854	.954	.106	60.703	< .001
Model 3	356.109	.854	.954	.106	2.799	.094
Model 4	324.913	.873	.960	.099	50.903	< .001
Model 5	330.768	.869	.959	.100	12.659	< .001
Model 6	309.874	.882	.963	.095	31.406	< .001
Model 7	306.857	.883	.963	.095	11.389	< .001
Model 8	281.485	.898	.968	.088	32.869	< .001
Model 9	287.746	.894	.967	.089	11.809	< .001
Model 10	293.969	.891	.966	.091	23.704[g]	< .001

Note. [a]χ^2 is a measure of absolute fit. [b]CFI is a measure of comparative fit with good fit indicated by values near .90. [c]TLI is a measure of comparative fit with good fit indicated by values above .90. [d]RMSEA is a measure of parsimony with good fit indicated by values below .10.[e] The χ^2 Difference Test for a given model is in reference to the previous model (e.g. Model 2 vs. Model 1; Model 3 vs. Model 2, etc.). [f]P-values relate to the χ^2 Difference Test .[g]Model 10 vs. Model 8. The Degrees of Freedom for each difference test was equal to 1 in all cases.

ACCESS factor was low, so it was constrained to zero in Model 9. The resulting fit of Model 9 was significantly worse than Model 8 ($\chi^2 = 32.869$, $p < .001$).

Aside from the low loadings of item *a2* on the ACCESS factor and item *pr6* on the PRESENTATION factor, Model 8 had no other low loadings or high modification indices. Yet, while retention of the low loadings of items *a2* and *pr6* on their original factors improved overall model fit, such cross-loadings on multiple factors decreased parsimony. Thus, in a final model (Model 10) these cross loadings were removed, resulting in significantly worse fit compared to Model 8 ($\chi^2 = 23.704$, $p < .001$) but increased parsimony.

In sum, the modifications made between Model 1 to Model 10 included moving items *n6, a1,* and *a2* to the PERFORMANCE factor and item *pr6* to the INTERACTION factor. These modifications were each justifiable in terms of interpretability of the factors, parsimony of the model, and local and global fit. Thus, in terms of interpretability, fit, and parsimony, Model 10 (Figure 5) is the preferred first-order model of digital textbook quality from the college student perspective. Standardized parameter estimates for Model 10 are listed in Table 4, the estimated factor correlation matrix for this model is shown in Table 5, and estimated reliabilities for each factor (subscale) are listed in Table 6.

Second-order confirmatory factor analysis. A second-order structure was proposed based on Model 10 described above (Figure 6). The difference from this second-order model (Model 1h) and Model 10 was that the NAVIGATION, ACCESS, INTERACTION, and PERFORMANCE factors were hypothesized to load together on one second-order factor (TECHNOLOGY) and the RELEVANCE, PRESENTATION, IMPACT, and DIVERSITY

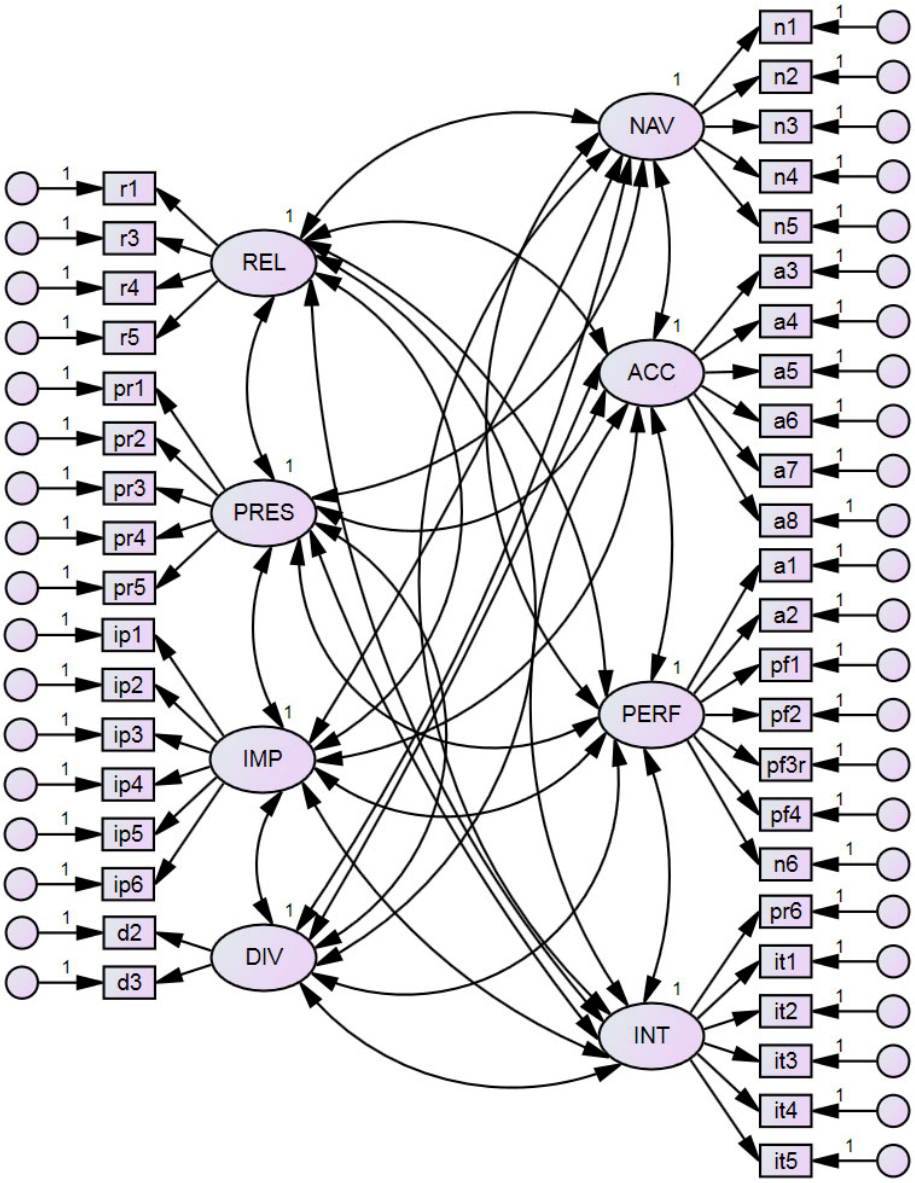

Figure 5. The path diagram of Model 10. The modifications from Model 1 include transfer of items *a1, a2*, and *n6* to the PERFORMANCE factor and item *pr6* to the INTERACTION factor. NAV=navigation, ACC=access, PERF=performance, INT=interaction, REL=relevance, PRES=presentation, IMP=impact, DIV=diversity, TECH=technology, and CON=content.

Table 4

Standardized Parameter Estimates for Model 10

Factor	Item	Loading Estimate	S.E.[a]	*Z*-value	Significance
NAVIGATION	*n1*	.811	.036	22.535	< .001
NAVIGATION	*n2*	.760	.041	18.365	< .001
NAVIGATION	*n3*	.803	.040	20.044	< .001
NAVIGATION	*n4*	.711	.047	15.163	< .001
NAVIGATION	*n5*	.666	.052	12.826	< .001
ACCESS	*a3*	.698	.046	15.276	< .001
ACCESS	*a4*	.638	.051	12.527	< .001
ACCESS	*a5*	.708	.055	12.875	< .001
ACCESS	*a6*	.690	.046	14.989	< .001
ACCESS	*a7*	.697	.051	13.578	< .001
ACCESS	*a8*	.805	.039	20.560	< .001
PERFORMANCE	*pf1*	.608	.052	11.690	< .001
PERFORMANCE	*pf2*	.820	.036	22.948	< .001
PERFORMANCE	*pf3*	.683	.054	12.534	< .001
PERFORMANCE	*pf5*	.746	.045	16.674	< .001
PERFORMANCE	*a1*	.762	.044	17.144	< .001
PERFORMANCE	*a2*	.745	.052	14.401	< .001
PERFORMANCE	*n6*	.802	.041	19.408	< .001
INTERACTION	*it1*	.759	.041	18.327	< .001
INTERACTION	*it2*	.708	.043	16.364	< .001
INTERACTION	*it3*	.771	.037	20.606	< .001
INTERACTION	*it4*	.878	.028	31.033	< .001
INTERACTION	*it5*	.820	.031	26.064	< .001
INTERACTION	*pr6*	.809	.040	20.283	< .001
RELEVANCE	*r1*	.830	.047	17.670	< .001
RELEVANCE	*r3*	.844	.037	22.912	< .001
RELEVANCE	*r4*	.868	.031	27.963	< .001

Note. [a]Standard error.

(Table continues)

Table 2 (continued)

Standardized Parameter Estimates for Model 10

Factor	Item	Loading Estimate	S.E.[a]	*Z*-value	Significance
RELEVANCE	*r5*	.783	.041	19.280	< .001
PRESENTATION	*pr2*	.865	.026	32.633	< .001
PRESENTATION	*pr3*	.683	.046	14.860	< .001
PRESENTATION	*pr4*	.741	.035	21.209	< .001
PRESENTATION	*pr5*	.821	.029	28.489	< .001
IMPACT	*ip1*	.866	.029	30.133	< .001
IMPACT	*ip2*	.817	.029	28.220	< .001
IMPACT	*ip3*	.832	.028	29.768	< .001
IMPACT	*ip4*	.938	.017	55.819	< .001
IMPACT	*ip5*	.865	.024	35.655	< .001
IMPACT	*ip6*	.876	.022	39.690	< .001
DIVERSITY	*d2*	.883	.047	18.685	< .001
DIVERSITY	*d3*	.958	.054	17.786	< .001

Note. [a]Standard error.

Table 5

Estimated Factor Correlation Matrix for Model 10

Factor[a]	NAV	ACC	PERF	INT	REL	PRES	IMP	DIV
NAV	1.000							
ACC	.752	1.000						
PERF	.580	.543	1.000					
INT	.715	.826	.463	1.000				
REL	.478	.498	.737	.415	1.000			
PRES	.599	.609	.812	.657	.839	1.000		
IMP	.567	.540	.675	.534	.761	.885	1.000	
DIV	.242	.187	.366	.236	.362	.420	.369	1.000

Note. [a]NAV = Navigation, ACC = Access, PERF = Performance, INT = Interaction, REL = Relevance, PRES = Presentation, IMP = Impact, DIV = Diversity

Table 6

Subscale Reliabilities for Model 10

Subscale	Raykov's ρ Coefficient
NAVIGATION	.866
ACCESS	.857
PERFORMANCE	.894
INTERACTION	.910
RELEVANCE	.900
PRESENTATION	.894
IMPACT	.948
DIVERSITY	.920

Note. The estimated reliability of the entire 41-item scale is .980.

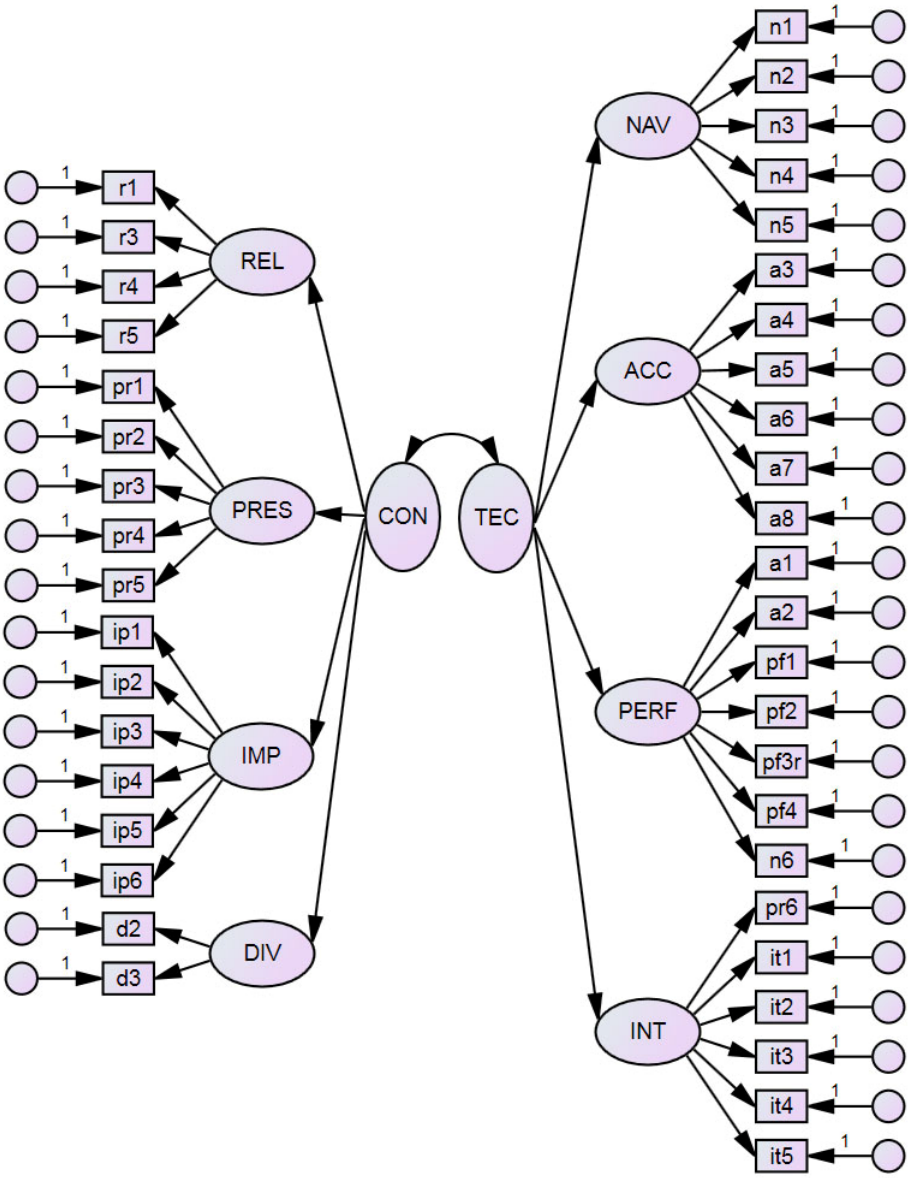

Figure 6. Path diagram of Model 1h, showing the loadings of the eight first-order factors on two hypothesized second-order factors, CONTENT and TECHNOLOGY. This higher-order model is based on the lower-order structure of Model 10 and an *a priori* hypothesis about the nature of the higher-order structure. NAV=navigation, ACC=access, PERF=performance, INT=interaction, REL=relevance, PRES=presentation, IMP=impact, DIV=diversity, TECH=technology, CON=content, TEC = technology and CON = content.

factors were hypothesized to load together on another second-order factor (CONTENT). This particular grouping was proposed because the TECHNOLOGY factors all seem to relate specifically to characteristics unique to digital textbooks and the CONTENT factors all seem to relate to characteristics germane to textbooks of any format.

CFA showed that Model 1h had reasonable fit, but that this fit was significantly worse than Model 10 ($\chi 2$= 121.735, $p < .001$). In addition, the loading of PRESENTATION on the TEC second-order factor was out-of-range (>1.000). This was due to a small negative residual error variance of -0.029 for the PRESENTATION factor. Since the estimated negative value was close to zero, this anomaly was handled by constraining the residual error variance of PRESENTATION to zero in a subsequent analysis. Table 7 displays the fit and comparative statistics for Model 1h with this minor modification included. Table 8 displays the factor loadings of the first-order factors on their respective higher-order factors in Model 1h. The estimated reliabilities of the higher-order factors in Model 1h were both equal to .884.

Second-order exploratory factor analysis in the confirmatory framework (E/CFA). An Exploratory Factor Analysis (EFA) using the factor correlation matrix from Model 10 (see Table 5) and subsequent parallel analysis revealed two salient second-order factors in the data. Table 9 presents the factor loadings obtained from the EFA and Table 10 displays results from the parallel analysis. Using the means of the simulated eigenvalues from the parallel analysis produced a result equivalent to that if the 95th percentiles of the eigenvalues had been used, so only the mean values are reported in Table 10. The data in Table 10 show that the first and second eigenvalues are larger than would be expected by chance, pointing to a two-factor solution. In this model (Model 2h) the relationship of the lower-order factors was slightly different than the a priori higher-order hypothesis had predicted (Figure 7). In particular,

Table 7

Second-Order Model Fit and Comparative Statistics

Model	Chi-square[a]	CFI[b]	TLI[c]	RMSEA[d]	$\chi 2$ Difference[e]	Significance[f]
Model 10	293.969	.891	.966	.091	n/a	n/a
Model 1h	353.566	.854	.952	.108	121.735	< .001
Model 2h	270.885	.900	.967	.090	35.230	< .001

Note. [a]$\chi 2$ is a measure of absolute fit. [b]CFI is a measure of comparative fit with good fit indicated by values near .90. [c]TLI is a measure of comparative fit with good fit indicated by values above .90. [d]RMSEA is a measure of parsimony with good fit indicated by values below .10.[e] The $\chi 2$ Difference test for each of the higher-order models is in reference to Model 10, the best first-order model. [f]P-values relate to the χ^2 Difference Test. The Degrees of Freedom for each difference test was equal to 1 in all cases.

Table 8

Standardized Parameter Estimates for Model 1h

Second-order Factor	First-order Factor	Loading Estimate	S.E.[a]	*Z*-value	Significance
TECHNOLOGY	NAVIGATION	.795	.035	22.411	< .001
TECHNOLOGY	ACCESS	.820	.033	24.690	< .001
TECHNOLOGY	PERFORMANCE	.840	.037	22.801	< .001
TECHNOLOGY	INTERACTION	.783	.031	25.625	< .001
CONTENT	RELEVANCE	.842	.029	29.207	< .001
CONTENT	PRESENTATION	1.000	.000	n/a	< .001
CONTENT	IMPACT	.882	.027	32.374	< .001
CONTENT	DIVERSITY	.411	.057	7.153	< .001

Note. [a]Standard error.

Table 9

Second-order EFA Factor Loading Estimates

Lower-order Factor	Higher-order Factor 1	Higher-order Factor 2
NAVIGATION	.137	.724
ACCESS	-.190	.938
PERFORMANCE	.794	.030
INTERACTION	-.085	.944
RELEVANCE	.929	-.085
PRESENTATION	.913	.101
IMPACT	.808	.090
DIVERSITY	.463	-.530

Table 10

Parallel Analysis of Higher-Order EFA Eigenvalues

Factor	Model Eigenvalue	Mean Eigenvalue
One	4.963	1.279
Two	1.187	1.177
Three	0.749	1.093
Four	0.377	1.022
Five	0.279	0.960
Six	0.235	0.900
Seven	0.151	0.826
Eight	0.069	0.744

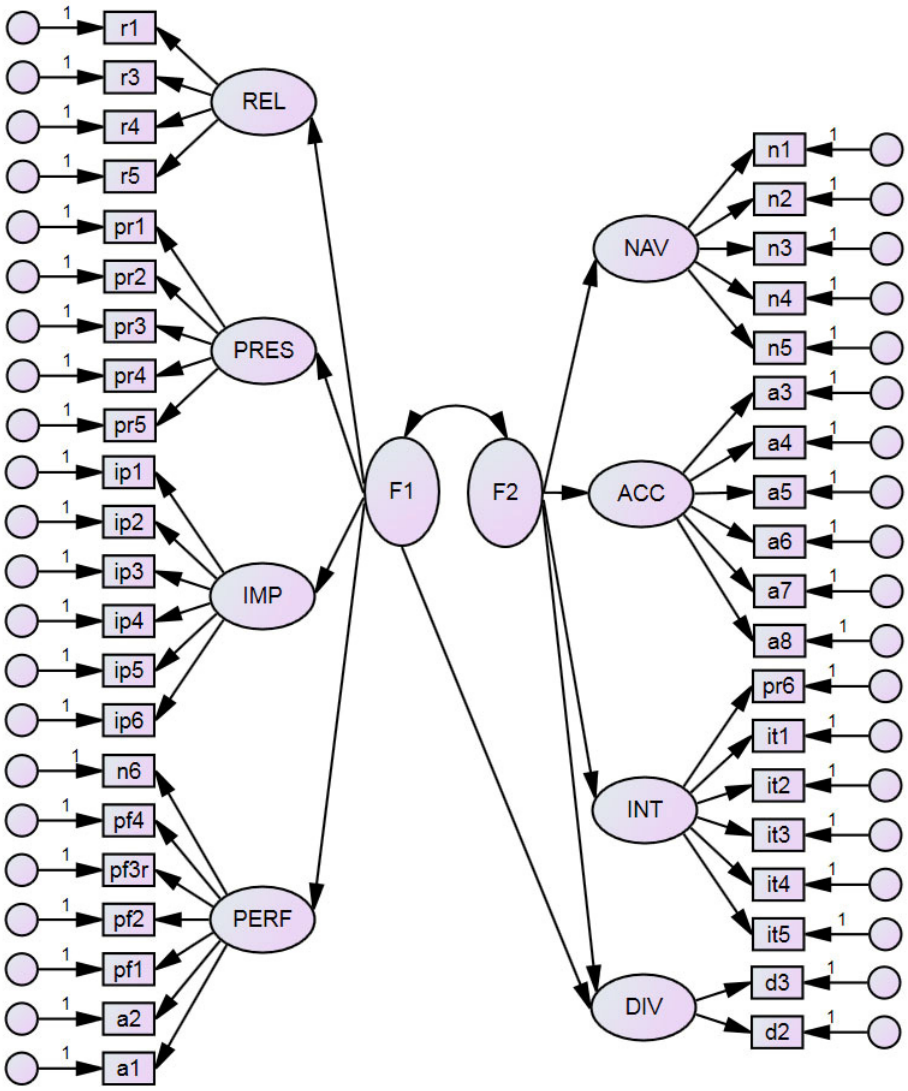

Figure 7. Path diagram of Model 2h, showing the loadings of the eight first-order factors on two second-order factors, F1 and F2. This higher-order model is based on the lower-order structure of Model 10 and the results of EFA using the factor covariance matrix of Model 10 (see Table 3). Note that PERF loads with IMP, PRES, and REL and DIV loads on both second-order factors. NAV=navigation, ACC=access, PERF=performance, INT=interaction, REL=relevance, PRES=presentation, IMP=impact, DIV=diversity, TECH=technology, CON=content, TEC = technology and CON = content.

PERFORMANCE loaded together with RELEVANCE, PRESENTATION, and IMPACT on one second-order factor (F1), while NAVIGATION, ACCESS, INTERACTION, and DIVERSITY loaded together on another second-order factor (F2). DIVERSITY also cross-loaded on the factor explaining PERFORMANCE, RELEVANCE, PRESENTATION, and IMPACT.

CFA showed that Model 2h had reasonable fit (see Table 4), but this fit was significantly worse than the fit of Model 10 (Chi-square = 36.060, $p < .001$). In addition, the loading of PRESENTATION on the TEC second-order factor was out-of-range (>1.000). This was due to a small negative residual error variance of -0.011 for the PRESENTATION factor. Since the estimated negative value was close to zero, this anomaly was handled by constraining the residual error variance of PRESENTATION to zero in a subsequent analysis. Table 7 provides the fit and comparative statistics for Model 2h with this minor modification included. Factor loadings for Model 2h are listed in Table 11. The estimated reliability of the second-order Factor 1 in Model 2h was .902 and the estimated reliability of higher-order Factor 2 was .910.

Table 11

Standardized Parameter Estimates for Model 2h

Second-order Factor	First-order Factor	Loading Estimate	S.E.[a]	*Z*-value	Significance
Factor 1	PERFORMANCE	.814	.032	25.089	< .001
Factor 1	RELEVANCE	.840	.029	29.268	< .001
Factor 1	PRESENTATION	1.000	.000	n/a	< .001
Factor 1	IMPACT	.876	.028	31.124	< .001
Factor 1	DIVERSITY	.412	.057	7.211	< .001
Factor 2	NAVIGATION	.864	.036	24.167	< .001
Factor 2	ACCESS	.903	.031	28.937	< .001
Factor 2	INTERACTION	.866	.029	30.318	< .001

Note. [a]Standard error.

It was not possible to directly compare the fit statistics of Model 1h and 2h statistically, because these models were not nested. In the end, since both higher-order models were equally parsimonious, interpretability became the most important aspect to consider in determining which higher-order model to retain and use going forward. Interpretability is also the main aspect to consider in comparing the higher order models with the preferred first-order model.

Summary

This chapter presented results from the qualitative and quantitative analyses used to develop and evaluate a model of digital textbook quality from the perspective of college students. The qualitative analysis revealed eight major themes related to digital textbook quality and these themes were subsequently used as the basis of a hypothesized mathematical model amenable to empirical evaluation. Factor analytic procedures were used to evaluate variations of the mathematical model and make improvements. The conclusions supported by this evaluation are discussed in the next chapter.

Chapter 5

Discussion

The purpose of this study was to develop and empirically validate a model of digital textbook quality from the perspective of college students. Such a model should potentially be useful to developers and consumers of digital textbooks as a guide to product evaluation. In the context of open educational resources, an understanding of what makes for a high quality digital textbook could potentially help faculty and content managers in their efforts to initially develop and/or subsequently revise their open textbooks and other openly licensed digital instructional materials.

Development and evaluation of the model of digital textbook quality was accomplished in two major steps. First, college students were asked directly to describe the characteristics of a high quality digital textbook and these responses were analyzed using qualitative methods. The results of the qualitative analysis were then used to develop a conceptual model of digital textbook quality, which model facilitated the creation of an initial measurement instrument. A separate group of college students were subsequently asked to respond to the items on the measurement instrument. The responses from these students were then used to evaluate and improve the initial model. Quantitative analysis also informed revisions and improvements to the initial measurement instrument. The results of this two-step approach were described in Chapter 4 and are discussed next.

Summary of Qualitative Analysis

The thematic analysis of the literature review and student responses to questionnaire items and interviews revealed eight major themes related to the quality of digital textbooks.

These themes related to (a) how students access their textbooks and navigate through them, (b) how the textbooks performed technically, (c) how up-to-date and well-aligned the content was with current knowledge and other aspects of the course, (d) how well technology interfaced with the content through interactive content, (e) how and what material was presented, (f) how the textbook impacted student performance, and (g) how sensitive the textbook was to diverse cultures and viewpoints. Most of the themes were derived from student responses to questionnaires and interviews and are characteristics of textbooks not mentioned in the literature on textbook evaluation. Two of the themes (impact and diversity) were derived mostly from the review of the literature and were included in the analysis because one or two students provided comments related to these themes.

Overall, student responses to the questionnaire and interviews appeared to be thoughtful and meaningful. The interviews especially revealed that students care about the quality of their instructional materials and are willing to provide feedback to their instructors if they think it will help improve the learning experience.

Summary of Quantitative Analysis

The results from the thematic analysis of the literature review and student responses provided a framework upon which to build an initial mathematical model of digital textbook quality from the perspective of college students. This initial mathematical model consisted of eight factors based on the eight themes from the qualitative data and provided the blueprint for constructing initial questionnaire items to measure each factor/theme. Student responses to these initial items provided an opportunity to empirically evaluate the items using IRT and improve the initial measurement model using CFA.

IRT results indicated that three items did not function well. The options of each of the poorly functioning items were presented in a reverse order relative to the options in all of the other items. Specifically, the first option in the poorly functioning items was an indicator of high textbook quality with indication of quality decreasing with subsequent options. The reverse was true of the other 41 items in the instrument. This particular characteristic of these three items likely contributed to their poor functioning, possibly because some students apparently did not pay close attention to the wording and inadvertently endorsed a category they may not have intended to endorse. The fact that all three poorly functioning items were reversed-ordered may imply an increased likelihood of response-sets. Response-sets occur when students are not sincere in their responding and simply use a random or systematic approach to completing the items. Technically, response sets occur when respondents provide response patterns that are not related to the construct being measured (Johnston & Hackmann, 2011). Such behavior can decrease the validity of an instrument. However, because the options in the instrument used in this study varied substantially from item to item, the likelihood of response sets probably decreased compared to instruments with more similar or identical response options across items. In addition, the within student variability in responses across the 41 items ranged from 0.37 to 1.92 (mean = 0.94), providing further evidence against decreased validity due to response sets. In the end, the IRT results were valuable for identifying those items that should be excluded from the subsequent model evaluation using CFA.

CFA results indicated that the initial measurement model could be improved by a few modifications. In particular, a couple of items originally designed to measure ACCESS and one item originally designed to measure NAVIGATION were actually shown to be better measures

of PERFORMANCE. In a similar manner, one of the items designed to measure PRESENTATION was shown to be a better measure of INTERACTION.

Closer inspection of the content of these items led me to conclude that these modifications were justifiable. Items *a1* and *a2*, for instance, both related to students' satisfaction with the performance of their accessibility options, while the remainder of the ACCESS items dealt primarily with the availability of the textbook. Similarly, item *n6* related to students' perception of the overall ease of navigation (a PERFORMANCE-related feature), while the other NAVIGATION items related to specific navigation functionalities like bookmarking and searching. Finally, item *pr6* related to students' perceptions of the usefulness of study helps in their textbook, similar to most of the INTERACTION items that related to specific pedagogical features like interactive quizzes and links to supplementary information. The remainder of the PRESENTATION items, on the other hand, related more generally to how content was presented.

Overall, the modifications made as a result of CFA improved the fit and interpretability of the initial model. This improved model was then used to explore the relationships among the factors themselves. In particular, it was hypothesized that four of the factors –NAVIGATION, ACCESS, PERFORMANCE, and INTERACTION – related primarily to characteristics of digital textbooks, like technical performance and search functions. The other four factors – RELEVANCE, PRESENTATION, IMPACT, and DIVERSITY – were characteristics germane to textbooks of any format, digital or otherwise. In addition, these factors all appeared to relate more particularly to the content of the textbook. A second-order CFA showed that these hypothesized relationships were reasonably justified. EFA, together with parallel analysis, confirmed the presence of two second-order factors, but indicated that PERFORMANCE was

mathematically more closely related to RELEVANCE, PRESENTATION, and IMPACT than to NAVIGATION, ACCESS, and INTERACTION. The EFA also indicated that DIVERSITY loaded together with NAVIGATION, ACCESS and INTERACTION on one second-order factor, with a cross-loading on the other second-order factor. It is difficult to interpret the meaning of these relationships, however, since none of the PERFORMANCE items relate to content and neither of the DIVERSITY items relate to the technical aspects of the digital textbook.

Conclusions

This section presents conclusions related to the research questions addressed by this study and to the measurement instrument developed as a result of this research.

Desirable characteristics of a high quality digital textbook. Eight key characteristics of high quality digital textbooks were derived from student responses to questionnaires and interviews, and from the literature. These characteristics included navigation features, access features, technical performance, relevance, interaction features, presentation features, educational impact, and sensitivity to diversity.

Preferred factor models. Based on the foregoing analyses, the best first-order model was Model 10 (Figure 5). However, there was evidence that a second-order model explained the relationships among the first-order factors better than the first-order model. Indeed, Model 1h (the second-order model based on *a priori* theory, Figure 6) was preferable to Model 10 (the best first-order model) and to a second-order model based on EFA (Model 2h, Figure 7). This conclusion is justified based on several reasons. Specifically, Model 1h (a) was more interpretable than Model 2h, (b) accounted for relationships among the factors better than Model 10, (c) had good fit, and (d) was reasonably parsimonious compared to the other models.

Evidence of reliability and validity. Scores obtained from the revised measurement instrument (Appendix B) based on Model 1h are estimated to have to have high subscale and composite reliability (see Table 6). The second-order factors also have high estimated reliability. In addition, the qualitative approach used in this study provided built-in content validity in a manner similar to that conferred by a table of specifications used in test construction. Furthermore, the CFA provided some evidence of construct validity. While further research is needed to provide even more evidence of validity, the instrument in its current form is recommended for use by developers and users of digital textbooks, especially open digital textbooks. Given the structure of Model 1h and the high scale-score reliabilities, it is recommended that a separate score be used for each first-order factor and for each second-order factor, in addition to a total score for the entire instrument.

Contributions of This Study to the Literature on Textbook Evaluation

The findings from this study are consistent with the literature on textbook evaluation in only a small number of ways. In particular, textbook selection committees have used aspects of some of the themes suggested by students as important indicators of textbook quality. These aspects include quality of pedagogical aids, educational impact, and content accuracy, which are aspects of the presentation, impact, and relevance themes in this study, respectively. In addition, the theme of interaction as defined by student responses was related to the general idea of interaction presented in the literature in that it dealt with particular components of digital textbooks designed to promote learning through interaction. These elements included things like interactive quizzes and links to external supplementary materials.

In general, however, textbook selection committees do not commonly use most of the characteristics that students identified as important criteria for evaluating digital textbooks. Similarly, the students in this study did not identify most of the criteria used by selection committees in their evaluation decisions. One reason for this discrepancy may be that most students are likely not capable of accurately using the textbook evaluation criteria commonly used by selection committees. For instance, textbook selection committees often focus on readability, content coverage, and cost. While some students may be capable of detecting readability differences, most are not knowledgeable enough to make evaluation decisions based on content coverage. In addition, it doesn't appear from this study that cost is something students associate with quality. Also, this study did not explicitly address cost because the Project Kaleidoscope textbooks were provided to students for free in most cases.

Another possible reason for the discrepancy between the textbook evaluation criteria important to students and the criteria important to selection committees may be that textbook selection committees have not, for whatever reasons, paid enough attention to student perspectives of textbook quality. It is particularly interesting to note that several textbook evaluation studies have focused on measures of human interest as a criterion for evaluating textbooks. Presumably, these evaluators see human interest as something that should be important to students. However, no student in my study indicated that it is important for a high quality digital textbook to be "interesting."

Finally, at least some of the criteria I have defined apply to a specific class of textbooks (i.e. textbooks presented in a digital format), while the criteria recommended in the literature for use by textbook adoption committees have been developed to apply primarily to traditional

printed texts. The focus on digital textbooks highlights one way that this study has extended the literature on textbook evaluation.

Indeed, this study has extended the literature on textbook evaluation in several important ways. First, this study has added another perspective relevant to textbook evaluation in general: the perspective of college students. In particular, the study has identified eight criteria that can be valuable when students are asked to evaluate their textbooks. These criteria could also be valuable to developers of textbooks and others involved in textbook design. Second, this study has added understanding to the evaluation of *digital* textbooks in particular, something that is lacking almost completely from the literature. As more and more digital instructional materials are developed, an accurate understanding of what makes for a high quality digital textbook will become increasingly important. Third, this study has provided a factor model and a measurement instrument that can be used together for development and evaluation purposes. Finally, this study has shown the usefulness of using a mixed-methods approach to instrument development. In particular, this study has shown that using end-user perspectives to inform quantitative analysis is a methodologically sound approach to product evaluation.

Limitations

This study had at least two main limitations that should be considered when interpreting results. These limitations included sampling inadequacies and lack of cross-validation.

Sampling inadequacies. There were several sampling inadequacies in this study. First, because student respondents were recruited through their instructors, there was little control over which instructors promoted the questionnaire and interview requests to their students. Faculty decisions to send the questionnaire on to their students could have been a factor of the

instructors' perceptions of textbook quality (or lack thereof). For instance, an instructor's motivation to pass the questionnaire request on to his students could have been influenced by the instructor's perception that the textbook he was using was of particularly high or low quality. In the end, the nature of the sampling design potentially limited the representativeness of the student sample.

Second, only community college students in a small number of institutions located in only a few parts of the United States were included in the sample for this study. The perspectives of other types of students (e.g. university, liberal arts college, K-12) and students from other parts of the country were not included, further limiting the representativeness of the sample. However, it is not clear why criteria would be expected to vary across type of student or geographic location. Further research would be needed to shed light on this issue.

Third, this study was limited to a single type of digital textbook: an open digital textbook developed as part of Project Kaleidoscope. Students in this study did not use other types of digital textbooks, especially those distributed by for-profit publishers. The differences between digital textbooks developed through Project Kaleidoscope and those developed by private, for-profit publishers have not been well studied. Thus, the results of this study apply particularly to open digital textbooks developed through faculty collaboration.

Finally, the most important sampling inadequacy was small sample size. While the sample size was quite large for the qualitative portion of the study, only 235 students completed the questionnaire based on the initial measurement model. In particular, the limited sample may have led to less stability in the CFA parameter estimates.

Lack of cross-validation. In a related way, the small sample size in this study prohibited a cross-validation study using a split-sample approach. It is often useful to randomly divide a sample in half and then analyze the data separately for each subgroup. The results of these analyses can then be compared to determine whether the findings are generalizable across subsamples. This approach may provide confirmation of the model fit and parameter estimates, but was not possible in this study. Because the models in this study were quite complex, a sample of 118 was not large enough for the estimation algorithm to reach convergence.

Recommendations

This section presents recommendations for (a) use of the preferred model of digital textbook quality, (b) use of the measurement instrument, and (c) further research.

Use of the model. The following recommendations for use of the model of digital textbook quality are made based on the findings of this study:

1. Authors and developers of for-profit digital textbooks should use the eight criteria identified in the model of digital textbook quality when considering how to produce high quality, educationally impactful, and profitable products.
2. Textbook selection committees should use the eight criteria to inform their evaluation decisions. In higher education, these committees generally consist of one or a few faculty members considering which textbook should be required for students in a particular course. Consideration of the student perspective in higher education seems particularly relevant.
3. Adopters and developers of open digital textbooks should use the eight criteria to inform development and revision decisions.

Use of the measurement instrument. The following recommendations for use of the measurement instrument (Appendix B) are made based on the findings of this study:

1. Authors and developers of for-profit digital textbooks should use the instrument to acquire student feedback about their products, if they are willing to make modifications based on such feedback.
2. Developers and adopters of open digital textbooks, like the faculty in Project Kaleidoscope, should use the instrument frequently to inform textbook revision decisions based direct feedback from their students. Student responses to items on the instrument should help focus an instructor's attention on particular characteristics of the book that could be improved. This feedback, combined with instructor expertise, should lead to potentially important revisions and improvements to the open digital textbooks.
3. Educational researchers should use scores from the instrument in comparative studies of digital textbooks, open or otherwise. It is possible that advocates of open educational resources could use the results of such comparative studies to debunk the frequent claims by for-profit publishers that OER are, by default, of lower quality than publisher-produced instructional materials.

Further research. The following recommendations for further research are made based on the findings of this study:

1. Future research on a model of digital textbook quality from the student perspective should be based on larger sample sizes. I recommend a sample size of at least 1000 students in order to ensure stable parameter estimates and to

allow for cross-validation studies. In addition to increasing the sample size, it is also important to further expand the range of the student sample to include university, liberal arts college, and K-12 students from a range of geographic locations. Such studies would extend the generalizability of the results of this study in the community college context.

2. Future research should include cross-validation studies. Such studies are important to further refine the model of digital textbook quality from the student perspective and provide more evidence of validity of the model.
3. Future research should explore the stability of the proposed model across subgroups and across time. Cross-group studies would determine whether or not the factor structure is the same across gender, ethnic, and student groupings (university, community college, high school, etc.). Such studies could also establish that the model is stable within groups and across time or administrations of the instrument. Overall, factor invariance studies are important for further establishing the generalizability of the model.
4. Future research should be conducted to improve the measurement instrument. Specifically, a future studies should explore student sincerity in responding to items (Browne, 2011), the effect of reverse-ordering response options on some items, and possible ways of reducing the total number of items needed to measure each factor. In addition, future studies should estimate the reliability of the measurement instrument using a hierarchal linear modeling approach (Yeo, Kim, Branum-Martin, Wayman, & Espin, 2011). Such an approach would

provide a more appropriate reliability estimate than a single reliability coefficient because the textbooks being evaluated are nested within courses.

Final Thoughts

This dissertation began with a quote about quality from the novel *Zen and the Art of Motorcycle Maintenance* by Robert M. Pirsig. In this quote, Pirsig claimed that "any philosophic explanation of Quality is going to be both false and true precisely because it is a philosophic explanation." The purpose of this research was to identify the desired characteristics that are indicators of high quality digital textbooks from the student point of view. The explanation of quality I have presented in this work is certainly Persigian, in that it is dependent on the context and the purpose for which it is used. In some contexts it will be truer than in others. Despite this, it is hoped that the criteria identified, the model evaluated, and the instrument developed will be useful to users and developers of digital textbooks – especially open digital textbooks.

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Appendix A

Initial 44-Item Digital Textbook Quality Questionnaire

NAVIGATION (n)

1. How useful to your learning is the search function in your digital textbook?
    a. There is no search function
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

2. How accurate is the search function in your digital textbook?
    a. There is no search function
    b. Not at all accurate
    c. Slightly accurate
    d. Moderately accurate
    e. Very accurate

3. How useful to your learning are the internal links (such as links between chapters or sections) in your digital textbook?
    a. There are no internal links
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

4. How useful to your learning are the page numbers in your digital textbook?
    a. There are no page numbers
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

5. How useful to your learning is the bookmarking or place-holding function in your digital textbook?
    a. There is no bookmarking function
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

6. How easy is your digital textbook to navigate?
    a. Very difficult
    b. Somewhat difficult
    c. Somewhat easy
    d. Very easy

ACCESS (a)

1. To what extent are you satisfied with your current options for accessing your digital textbook? Access options might include online, download, print, e-book, etc.
    a. Very dissatisfied
    b. Somewhat dissatisfied
    c. Somewhat satisfied
    d. Very satisfied

2. How convenient is it for you to access your digital textbook?
    a. Very inconvenient
    b. Somewhat inconvenient
    c. Somewhat convenient
    d. Very convenient

3. How useful to your learning is the option to print your digital textbook (or parts of it) yourself?
    a. There is no option to print my digital textbook
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

4. How useful to your learning is the option to download your digital textbook so that you can read it OFFLINE on a personal device such as a computer, phone, e-reader, etc.?
    a. There is no option to download my digital textbook
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

5. How useful to your learning is the option to read the ONLINE VERSION of your digital textbook on various mobile devices such as a laptop, phone, or tablet?
    a. There is no option to read the online version on various devices
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

6. How useful to your learning is the option to purchase a printed copy of your digital textbook?
    a. There is no option to purchase a printed copy
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

7. After you have completed this course, how useful to your learning do you think it will be to have continued access to your digital textbook?
    a. Not at all useful
    b. Slightly useful
    c. Moderately useful
    d. Very useful

8. How useful to your learning are the accessibility features in your digital textbook, such as the options to increase font size or listen to an audio version?
    a. There are no accessibility features
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

PERFORMANCE (pf)

1. How often do you experience technical problems with your digital textbook, such as website crashes, device issues, login problems, and software incompatibility?
    a. Regularly
    b. Frequently
    c. Occasionally
    d. Rarely
    e. Never

2. How easy is it for you to locate the ONLINE VERSION of your digital textbook?
    a. Very difficult
    b. Somewhat difficult
    c. Somewhat easy
    d. Very easy

3. How easy is it for you to log in to the online version of your digital textbook?
    a. I don’t need to log in to my digital textbook
    b. Very difficult
    c. Somewhat difficult
    d. Somewhat easy
    e. Very easy

4. How compatible is your digital textbook with the software you use to view it, such as web browsers, document viewers, and operating systems?
    a. Not at all compatible
    b. Slightly compatible
    c. Moderately compatible
    d. Very compatible

5. *To what extent does the download/upload speed of the online version of your digital textbook impede your learning?
    a. Does not impede at all
    b. Slightly impedes
    c. Moderately impedes
    d. Greatly impedes

INTERACTION (it)

1. How useful to your learning is the note-taking function in your digital textbook?
    a. There is no note-taking function
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

2. How useful to your learning is the highlighting function in your digital textbook?
    a. There is no highlighting function
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

3. How useful to your learning are the interactive quizzes (quizzes that provide immediate feedback) in your digital textbook?
    a. There are no interactive quizzes
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

4. How useful to your learning are the links to EXTERNAL materials in your digital textbook, such as websites, videos, etc.?
    a. There are no links to external materials
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

5. How useful to your learning are the EMBEDDED interactive materials in your digital textbook, such as embedded videos, tutorials, interactive charts, etc.?
    a. There are no embedded materials
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

RELEVANCE (r)

1. How up-to-date is the information in your digital textbook?
    a. Not at all up-to-date
    b. Slightly up-to-date
    c. Moderately up-to-date
    d. Very up-to-date

2. *In light of the stated goals for your course, how much material does your digital textbook contain that is unnecessary?
    a. Very little or no amount of unnecessary material
    b. A slight amount of unnecessary material
    c. A moderate amount of unnecessary material
    d. A great amount of unnecessary material

3. How well is the material in your digital textbook aligned with the instruction presented by your instructor?
    a. Very poorly aligned
    b. Somewhat poorly aligned
    c. Somewhat well aligned
    d. Very well aligned

4. How well is the material in your digital textbook aligned with the assignments given by your instructor?
    a. No assignments are given
    b. Very poorly aligned
    c. Somewhat poorly aligned
    d. Somewhat well aligned
    e. Very well aligned

5. How well is the material in your digital textbook aligned with the exams given by your instructor?
    a. No exams are given
    b. Very poorly aligned
    c. Somewhat poorly aligned
    d. Somewhat well aligned
    e. Very well aligned

PRESENTATION (pr)

1. To what extent is the information in your textbook confusing or unclear?
    a. Very confusing or unclear
    b. Fairly confusing or unclear
    c. Fairly straightforward or clear
    d. Very straightforward or clear

2. How well-organized is your digital textbook?
    a. Not at all well-organized
    b. Slightly well-organized
    c. Moderately well-organized
    d. Very well-organized

3. How useful to your learning are the visual aids in your digital textbook, such as graphs, pictures, charts, diagrams, maps, etc.?
    a. There are no visual aids
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

4. How detailed is the material in your digital textbook?
    a. Not at all detailed
    b. Somewhat detailed
    c. Fairly detailed
    d. Very detailed

5. How useful to your learning are the examples in your digital textbook?
    a. There are no examples
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

6. How useful to your learning are the study helps in your digital textbook, such as glossaries, study guides, review sections, summary sections, etc.?
    a. There are no study helps
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

IMPACT (ip)

1. To what extent has your digital textbook affected your learning?
    a. Greatly impeded my learning
    b. Slightly impeded my learning
    c. Slightly enhanced my learning
    d. Greatly enhanced my learning

2. To what extent has your digital textbook affected your motivation to learn?
    a. Greatly decreased my motivation
    b. Slightly decreased my motivation
    c. Slightly increased my motivation
    d. Greatly increased my motivation

3. To what extent has your digital textbook affected your exam scores in your course?
    a. No exams are given
    b. Very negatively affected my scores
    c. Somewhat negatively affected my scores
    d. Somewhat positively affected my scores
    e. Very positively affected my scores

4. To what extent has your digital textbook affected your retention of the subject matter in your course?
    a. Very negatively affected my retention
    b. Somewhat negatively affected my retention
    c. Somewhat positively affected my retention
    d. Very positively affected my retention

5. To what extent has your digital textbook BROADENED your understanding of the subject matter in your course? (Broad understanding means surface-level knowledge of many topics.)
    a. Not at all broadened my understanding
    b. Slightly broadened my understanding
    c. Moderately broadened my understanding
    d. Greatly broadened my understanding

6. To what extent has your digital textbook DEEPENED your understanding of the subject matter in your course? (Deep understanding means detailed knowledge the most important topics.)
    a. Not at all deepened my understanding
    b. Slightly deepened my understanding
    c. Moderately deepened my understanding
    d. Greatly deepened my understanding

DIVERSITY (d)

1. To what extent is your digital textbook biased toward a particular worldview or culture?
    a. Very unbiased
    b. Somewhat unbiased
    c. Somewhat biased
    d. Very biased

2. How sensitive is your digital textbook to your unique background, culture, and viewpoints?
    a. Very insensitive
    b. Somewhat insensitive
    c. Somewhat sensitive
    d. Very sensitive

3. How sensitive is your digital textbook to others' unique backgrounds, cultures, and viewpoints?
    a. Very insensitive
    b. Somewhat insensitive
    c. Somewhat sensitive
    d. Very sensitive

Appendix B

Revised 41-Item Digital Textbook Quality Questionnaire

NAVIGATION (n)

1. How useful to your learning is the search function in your digital textbook?
    a. There is no search function
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

2. How accurate is the search function in your digital textbook?
    a. There is no search function
    b. Not at all accurate
    c. Slightly accurate
    d. Moderately accurate
    e. Very accurate

3. How useful to your learning are the internal links (such as links between chapters or sections) in your digital textbook?
    a. There are no internal links
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

4. How useful to your learning are the page numbers in your digital textbook?
    a. There are no page numbers
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

5. How useful to your learning is the bookmarking or place-holding function in your digital textbook?
    a. There is no bookmarking function
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

ACCESS (a)

1. How useful to your learning is the option to print your digital textbook (or parts of it) yourself?
    a. There is no option to print my digital textbook
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

2. How useful to your learning is the option to download your digital textbook so that you can read it OFFLINE on a personal device such as a computer, phone, e-reader, etc.?
    a. There is no option to download my digital textbook
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

3. How useful to your learning is the option to read the ONLINE VERSION of your digital textbook on various mobile devices such as a laptop, phone, or tablet?
    a. There is no option to read the online version on various devices
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

4. How useful to your learning is the option to purchase a printed copy of your digital textbook?
    a. There is no option to purchase a printed copy
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

5. After you have completed this course, how useful to your learning do you think it will be to have continued access to your digital textbook?
    a. Not at all useful
    b. Slightly useful
    c. Moderately useful
    d. Very useful

6. How useful to your learning are the accessibility features in your digital textbook, such as the options to increase font size or listen to an audio version?
    a. There are no accessibility features
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

PERFORMANCE (pf)

1. How often do you experience technical problems with your digital textbook, such as website crashes, device issues, login problems, and software incompatibility?
    a. Regularly
    b. Frequently
    c. Occasionally
    d. Rarely
    e. Never

2. How easy is it for you to locate the ONLINE VERSION of your digital textbook?
    a. Very difficult
    b. Somewhat difficult
    c. Somewhat easy
    d. Very easy

3. How easy is it for you to log in to the online version of your digital textbook?
    a. I don't need to log in to my digital textbook
    b. Very difficult
    c. Somewhat difficult
    d. Somewhat easy
    e. Very easy

4. How compatible is your digital textbook with the software you use to view it, such as web browsers, document viewers, and operating systems?
    a. Not at all compatible
    b. Slightly compatible
    c. Moderately compatible
    d. Very compatible

5. How easy is your digital textbook to navigate?
    a. Very difficult
    b. Somewhat difficult
    c. Somewhat easy
    d. Very easy

6. To what extent are you satisfied with your current options for accessing your digital textbook? Access options might include online, download, print, e-book, etc.
    a. Very dissatisfied
    b. Somewhat dissatisfied
    c. Somewhat satisfied
    d. Very satisfied

7. How convenient is it for you to access your digital textbook?
    a. Very inconvenient
    b. Somewhat inconvenient
    c. Somewhat convenient
    d. Very convenient

INTERACTION (it)

1. How useful to your learning is the note-taking function in your digital textbook?
    a. There is no note-taking function
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

2. How useful to your learning is the highlighting function in your digital textbook?
    a. There is no highlighting function
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

3. How useful to your learning are the interactive quizzes (quizzes that provide immediate feedback) in your digital textbook?
    a. There are no interactive quizzes
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

4. How useful to your learning are the links to EXTERNAL materials in your digital textbook, such as websites, videos, etc.?
    a. There are no links to external materials
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

5. How useful to your learning are the EMBEDDED interactive materials in your digital textbook, such as embedded videos, tutorials, interactive charts, etc.?
    a. There are no embedded materials
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

6. How useful to your learning are the study helps in your digital textbook, such as glossaries, study guides, review sections, summary sections, etc.?
    a. There are no study helps
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

RELEVANCE (r)

1. How up-to-date is the information in your digital textbook?
    a. Not at all up-to-date
    b. Slightly up-to-date
    c. Moderately up-to-date
    d. Very up-to-date

2. How well is the material in your digital textbook aligned with the instruction presented by your instructor?
    a. Very poorly aligned
    b. Somewhat poorly aligned
    c. Somewhat well aligned
    d. Very well aligned

3. How well is the material in your digital textbook aligned with the assignments given by your instructor?
    a. No assignments are given
    b. Very poorly aligned
    c. Somewhat poorly aligned
    d. Somewhat well aligned
    e. Very well aligned

4. How well is the material in your digital textbook aligned with the exams given by your instructor?
    a. No exams are given
    b. Very poorly aligned
    c. Somewhat poorly aligned
    d. Somewhat well aligned
    e. Very well aligned

PRESENTATION (pr)

1. To what extent is the information in your textbook confusing or unclear?
    a. Very confusing or unclear
    b. Fairly confusing or unclear
    c. Fairly straightforward or clear
    d. Very straightforward or clear

2. How well-organized is your digital textbook?
    a. Not at all well-organized
    b. Slightly well-organized
    c. Moderately well-organized
    d. Very well-organized

3. How useful to your learning are the visual aids in your digital textbook, such as graphs, pictures, charts, diagrams, maps, etc.?
    a. There are no visual aids
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful

4. How detailed is the material in your digital textbook?
    a. Not at all detailed
    b. Somewhat detailed
    c. Fairly detailed
    d. Very detailed

5. How useful to your learning are the examples in your digital textbook?
    a. There are no examples
    b. Not at all useful
    c. Slightly useful
    d. Moderately useful
    e. Very useful
    f.

IMPACT (ip)

1. To what extent has your digital textbook affected your learning?
    a. Greatly impeded my learning
    b. Slightly impeded my learning
    c. Slightly enhanced my learning
    d. Greatly enhanced my learning

2. To what extent has your digital textbook affected your motivation to learn?
    a. Greatly decreased my motivation
    b. Slightly decreased my motivation
    c. Slightly increased my motivation
    d. Greatly increased my motivation

3. To what extent has your digital textbook affected your exam scores in your course?
    a. No exams are given
    b. Very negatively affected my scores
    c. Somewhat negatively affected my scores
    d. Somewhat positively affected my scores
    e. Very positively affected my scores

4. To what extent has your digital textbook affected your retention of the subject matter in your course?
    a. Very negatively affected my retention
    b. Somewhat negatively affected my retention
    c. Somewhat positively affected my retention
    d. Very positively affected my retention

5. To what extent has your digital textbook BROADENED your understanding of the subject matter in your course? (Broad understanding means surface-level knowledge of many topics.)
    a. Not at all broadened my understanding
    b. Slightly broadened my understanding
    c. Moderately broadened my understanding
    d. Greatly broadened my understanding

6. To what extent has your digital textbook DEEPENED your understanding of the subject matter in your course? (Deep understanding means detailed knowledge the most important topics.)
    a. Not at all deepened my understanding
    b. Slightly deepened my understanding
    c. Moderately deepened my understanding
    d. Greatly deepened my understanding

DIVERSITY (d)

1. How sensitive is your digital textbook to your unique background, culture, and viewpoints?
    a. Very insensitive
    b. Somewhat insensitive
    c. Somewhat sensitive
    d. Very sensitive

2. How sensitive is your digital textbook to others' unique backgrounds, cultures, and viewpoints?
    a. Very insensitive
    b. Somewhat insensitive
    c. Somewhat sensitive
    d. Very sensitive