Student perceptions on future components of electronic textbook design

Kimberly Anne Sheen · Yan Luximon

Abstract Electronic textbooks have been a subject of research for decades, yet student perceptions of interface components tend to be investigated in hindsight, and findings are not commonly taken into consideration for textbook design. This paper shifts the focus of electronic textbook design back toward students by identifying components that should be included in future electronic textbooks based on student perceptions in relation to the task of academic reading, as well as identifying associations with gender, experience level, academic level, and academic discipline. Findings from a university-wide online questionnaire that received more than 700 responses indicated that text, highlighting tools, bookmarks, multimedia, translation tools, dictionaries, and encyclopedias should all be incorporated in future electronic textbooks, as well as provided evidence to suggest that electronic textbooks should be tailored based on academic discipline. Understanding what students require for academic reading can facilitate the development of more suitable educational tools, and through the identification of suitable components, can enable the design of more standardized electronic textbooks.

Keywords Electronic textbooks · Future design · Interface design · User experience · Human–computer interaction · Interface components

Introduction

Electronic textbooks have been a subject of academic research and design discussion for several decades in all levels of education (Liang 2015; Chan 2010; Chong et al. 2009). Yet current and previous research on student perceptions of

electronic textbooks has been heavily influenced by the hardware and software employed for the investigation. This paper investigates the future of electronic textbooks in a more forward-thinking manner and with an emphasis on task necessity. The purpose of this study was to identify which components students deem necessary for future electronic textbooks based on their various academic reading requirements and habits. The paper also investigates whether any aspects of academic study exist that may indicate whether electronic textbook design should move away from the one-size-fits-all approach that has dominated the industry to date.

In the past, studies devoted to the identification of student preferences have been specific to the design of interfaces that students are frequently in contact with, and this may have influenced their perceptions of electronic textbooks. The majority of these studies have adopted questionnaires in laboratory settings, employed electronic textbooks accessed on desktop computers, and collected data after design implementation for post-experimental classroom usage, thus limiting how the findings could be applied for the design of future technologies. However, research has indicated that changes in interface design do affect a person's reading experience and performance, and therefore should be taken into account when designing electronic textbooks. Previous studies have demonstrated the following: (1) organization and layout of search functions and text, as well as page turning, can engender negative opinions regarding electronic textbooks (Kropman et al. 2004), (2) students prefer utilizing hyperlinks during navigation, favor the inclusion of more graphics to complement content, and experience issues when reading long blocks of text (Chong et al. 2009), and (3) students prefer reading shorter sections of text in electronic form (Nicholas et al. 2008; Brunet et al. 2011). Scrolling through text in electronic textbooks was observed to negatively affect reading performance and was recommended to be limited (Wilson et al. 2003).

In addition to these findings, it has been observed that students often treat electronic textbooks as reference material as opposed to reading material (Abdullah and Gibb 2008; Butler 2009), which negates the learning goals associated with textbooks, namely becoming well-versed in the material and the memorization of passages (Daniel and Woody 2013). Previous studies have determined that there are no firm boundaries between deep learning and surface learning when students utilize mobile technology for study purposes; but rather the existence of a fluid movement without sustained sessions of deep learning (Chan et al. 2015). In addition, tablets and e-readers are not designed to enable the quick referencing of books, although recent search and navigation functions have attempted to mitigate this deficiency (Butler 2009). Such search functions are considered to be beneficial in electronic textbooks (Brunet et al. 2011), as well as being reported to facilitate both exploration of and engagement with the material (Dominick 2005).

Although students have been known to report dissatisfaction regarding aspects of electronic textbooks, statistics indicate that over the past decade, usage of electronic textbooks has continued to become more common. Educause (2012) reported that between 2010 and 2012, student usage of electronic textbooks has increased. Even amidst lawsuits against distributors regarding continued access to electronic textbooks (Fowler 2009), statistics of student usage still continued to increase.

However, despite both this increase and the fact of students becoming ever more comfortable with interactive technology, often spending between 30 min and 4 h utilizing smartphones for coursework (Chan et al. 2015), it has been observed that students commonly still prefer physical textbooks to electronic ones (Woody et al. 2010). This complexity has been highlighted in the past with researchers positing that it is agency rather than prior technological experience which shapes their usage of technology (Jones and Healing 2010).

The future direction of electronic textbooks is yet to be determined, with some publishers implementing a design where textbooks are integrated into the eLearning platform, thereby creating an online learning experience (Tian and Martin 2013). Several projects for electronic textbook standardization have been created and discussed, but they are often related to one specific format of textbook (Hoel 2013; ISO/IEC JTC 1/SC 34 2013) or are quite general (Arenas et al. 2013; Belfanti and Gylling 2014). While there are many strategies and guidelines, the majority of electronic textbook publishers are currently still producing simple digital representations of existing texts, as well as suites of software that are yet to take on a form similar to that of the original textbooks (Gu et al. 2015). No matter which path is chosen, new design challenges for textbook creators continue to emerge, such as identifying, selecting, and implementing appropriate supplementary material (Defazio 2012), as well as taking full advantage of the change in medium to allow students to feel capable of successfully completing academic readings based on their academic goals. Models such as the Technology Acceptance Model (TAM) postulate that ease of use and the perception of usefulness affect adoption of new technology (Yi and Hwang 2003). In addition, Jones and Healing (2010) have found that the usage of technology is related closely to the requirements of individual classes. On the basis of these concepts, identifying the components for inclusion in future electronic textbook design that students feel will most adequately support their reading tasks may help to mitigate current resistance to new technology.

Method

This study utilized a 10-item questionnaire including three compulsory questions as the main method for analyzing student perceptions on possible components of future electronic textbooks. A questionnaire was adopted because of its potential ability to efficiently gather quantitative data among a diverse population, as well as to enable a general understanding of student perceptions regarding individual components, rank which they would find most beneficial, and whether or not they would make use of the proposed components. Establishing a set of components as an entry point for discussion rendered it easier for students to express their perceptions regarding such a complex topic. The questionnaire was distributed via email to the entire student population of an English-language university in Hong Kong.

Before development of the questionnaire, an extensive review of the literature and current electronic textbook capabilities facilitated the identification of components currently on offer in technology such as the Kindle app and Google books, as well as those that could be offered in the future (Gu et al. 2015; Kropman

et al. 2004; Chong et al. 2009; Dominick 2005; zSpace 2017; Abramson 2012; MacWilliam 2013). Semi-structured discussions consisting of three groups of four students from academic disciplines across the university were also held to identify which other components the students felt to be necessary to help them achieve academic success. These discussions started with a discussion of current electronic components and how they met the academic reading tasks and moved on to what these students felt could be a part of future electronic textbooks to meet their academic needs. All of the information gained was grouped and analyzed to define 17 components, which were subsequently presented to the questionnaire respondents. Although several of these components do not yet exist in electronic textbooks, some have been implemented in existing e-reader interfaces (Fig. 1). The components were defined as follows: text; multimedia (videos and podcasts); manipulatable and three-dimensional (3D) images; interactive equations; highlighting tools; annotation tools; bookmarks; integration with eLearning platforms (Blackboard and Moodle); interdevice synchronization; project or print annotations; translation tools, dictionaries, and encyclopedias; links to experts for answers to questions; text-to-speech tools; speech-to-text tools; time-management systems; supplementary materials (PowerPoint, chapter summaries, and quizzes); and hiding unimportant aspects of the book. The results were subject to descriptive statistics analysis through an exported Excel spreadsheet of the non-parametric data, as well

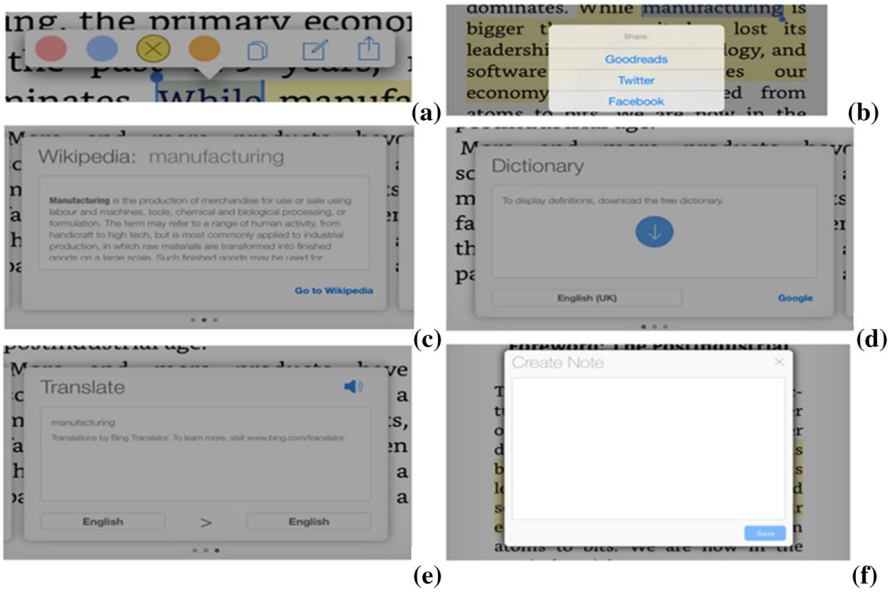

Fig. 1 Current components: **a** toolbar, **b** share feature, **c** encyclopedia, **d** dictionary, **e** translation tool, **f** annotation tool

as Pearson's χ^2 testing with a statistical test calculator employed to identify associations.

Student desires for the inclusion or exclusion of individual components were measured with two questions. For these two questions, respondents were asked to think beyond the current technological restrictions placed on electronic textbooks. The questions were as follows: (1) Now thinking to the future of electronic textbooks, please check all of the features you would want in an electronic textbook. (2) Are there any features you would not want to see in your electronic textbook? Both of these were multiple-choice reverse-order questions presented in a similar way to each other to offer validation for the responses given. If a respondent listed any of the same components for both questions, it would be apparent that the data obtained for that respondent could not be considered in the final analysis. These two questions also acknowledged that a respondent not listing a certain component that he or she wished to be included did not necessarily indicate that he or she wanted it excluded, and vice versa.

Component rankings were determined by the following ordinal-scale question: Please rank the features from most important (1) to least important (17). Each component was subsequently assigned a unique rank. This question also enabled validation of the data obtained from the questions regarding inclusion and exclusion to avoid answer bias (Morrel-Samuels 2002). It was anticipated that the components students would rank highly would be listed when answering the inclusion question, and that the components ranked lower would be listed when answering the exclusion question. These two questions were designed to reveal the most popular and least popular components.

Demographic data regarding gender, age, nationality, current educational level, and current academic discipline were obtained. The respondents were not required to answer all the classification questions because the demographic data could still be referenced for generalized findings. Approximately 9% of the respondents did not answer one or more of the classification questions, but no respondents skipped all of them. The age demographic ratio-scale question consisted of the following age range anchors: under 18, 18–24, 25–34, 35–50, and over 50. Questions regarding gender, nationality, educational level, and academic discipline were multiple choice. Two questions based on prior electronic usage were designed to determine if such usage might influence a component's rank. These two questions were as follows: (1) Have you ever used an electronic textbook? (multiple choice) and (2) What percentage of the time do you use electronic textbooks? (ratio scale).

Gender, prior experience, current educational level, and academic discipline were examined to identify associations with component selection. Nationality and age were not analyzed because the limited number of responses received for these categories could not provide statistical significance.

Results

Respondent description

Among the 705 students who responded to the questionnaire, 145 questionnaires were determined to contain invalid data based on the built-in aspects outlined in the method section. Therefore, 79.4% of the questionnaires were deemed valid. Analysis was conducted on the 560 valid questionnaires. Among these, 473 respondents (84.5%) identified themselves as Chinese. Male respondents accounted for 50.0% (280 responses), and female respondents for 49.8% (279 responses). After validating the remaining data, 83.9% (470 responses) of students reported having prior experience using electronic textbooks, whereas 15.5% (87 responses) reported having no such prior experience. Educational level was adjusted to account for 346 undergraduate respondents (61.8%), 114 master's level respondents (20.4%), 63 PhD respondents (11.3%), and 36 higher diploma respondents (6.4%). Valid questionnaires from engineering students comprised 185 respondents (33.0%), those from business students comprised 85 respondents (15.2%), and those from medical students comprised 70 respondents (12.5%).

Although the response rate could be perceived as low, with 705 responses from a university with approximately 30,000 students enrolled, similarities were observed between the description of the respondents and the description of the university's student population. The three primary disciplines at the university in question are engineering, business, and medicine (PolyU in Figures 2012/13 2013). This information correlates with the high response rate from students within these academic fields. Percentages of students within the various educational levels were also similar to their respective response rates; for example, a slightly higher number of PhD students and a lower number of higher diploma students were noted. The gender ratio of the study cohort was also similar to that of the university as a whole, with a 0.9 to 1 ratio of male to female students; however, this study received one more response from male students than from female students (PolyU in Figures 2012/13 2013).

Reported desirable components

Frequencies of desirable components in responses are sorted by gender, prior experience, educational level, and academic discipline in Table 1. The frequencies are reported in simple percentages. As illustrated in Table 1, the most popular four components were text (83.6%), highlighting tools (82.7%), bookmarks (77.7%), and multimedia (75.5%). These components had been previously identified as being desirable by Sheen and Luximon (2015a), who adopted a smaller dataset than that of the present study. Only minute percentage variations were observed between the smaller and larger datasets. Variations in frequencies of the reported components can be observed by examining the four primary demographic categories the questionnaire inspected.

Although variations in percentage were noted between the genders, the four most reported components remained the same for both genders, with variations only in

Table 1 Breakdown of frequencies of desired components based on general respondent population and four demographic categories

	General ($n = 560$)	Gender		Experience level		Education level				Discipline		
		Female ($n = 279$)	Male ($n = 280$)	Prior exp. ($n = 470$)	No Prior Exp. ($n = 87$)	Undergrad ($n = 346$)	Masters ($n = 114$)	PhD ($n = 63$)	Higher diploma ($n = 36$)	Engineering ($n = 185$)	Medicine ($n = 70$)	Business ($n = 85$)
Text	468	232	235	395	70	294	94	53	26	152	61	72
Highlighting tool	463	234	228	388	72	291	85	55	31	150	59	67
Bookmarks	435	232	202	368	64	267	85	55	27	138	55	67
Multimedia	423	216	206	351	70	269	79	48	26	143	57	61
Translation, dictionary, and encyclopedia	413	216	196	352	59	258	83	45	26	131	52	68
Supplementary materials	359	185	173	303	54	220	71	47	20	121	46	56
Manipulatable and 3-D images	308	141	166	262	45	201	47	39	20	107	44	33
Annotation tool	301	140	160	254	44	189	53	42	16	113	33	40
Link to experts	262	126	135	217	42	166	46	33	17	88	28	40
Sync across devices	256	117	138	214	40	156	49	36	14	100	23	33
Interactive equations	244	112	131	197	46	153	44	30	17	89	18	32
Integration eLearn	239	129	109	196	40	154	44	23	17	73	26	40
Project or print annotations	217	105	111	186	29	134	39	30	13	80	19	28
Text to speech	359	106	93	165	32	125	38	19	16	65	24	26
Hide aspects	175	97	78	151	23	111	33	21	10	64	9	30
Speech to text	169	84	85	139	28	103	33	17	15	57	14	22

Table 1 continued

	General ($n = 560$)	Gender		Experience level		Education level				Discipline		
		Female ($n = 279$)	Male ($n = 280$)	Prior exp. ($n = 470$)	No Prior Exp. ($n = 87$)	Undergrad ($n = 346$)	Masters ($n = 114$)	PhD ($n = 63$)	Higher diploma ($n = 36$)	Engineering ($n = 185$)	Medicine ($n = 70$)	Business ($n = 85$)
Time-management system	158	73	84	130	26	97	31	20	9	56	12	27

order. Women listed highlighting tools (83.9%), text (83.2%), bookmarks (83.2%), and multimedia (77.4%) as the most crucial components. Men also listed text (83.9%), highlighting tools (81.4%), multimedia (73.6%), and bookmarks (72.1%) as the most desirable components.

The four most reported desirable components based on prior experience were text (84.0%); highlighting tools (82.6%); bookmarks (78.3%); and translation, dictionaries, and encyclopedias (74.9%). Respondents with no prior experience using electronic textbooks selected highlighting tools (82.8%), text (80.5%), multimedia (80.5%), and bookmarks (73.6%) as the four most desirable components.

The top four components reported as desirable began to vary when examining the frequencies based on educational level. Undergraduates, PhD students, and higher diploma students listed text (85.0, 84.1, and 72.2%, respectively), highlighting tools (84.1, 87.3, and 86.1%, respectively), bookmarks (77.2, 87.3, and 75.0%, respectively), and multimedia (77.7, 76.2, and 72.2%, respectively) as the most desirable components. Similarly, text (82.5%), highlighting tools (74.6%), and bookmarks (74.6%) were the three components most frequently reported as desirable according to master's students; but instead of multimedia, translation tools, dictionaries, and encyclopedias (72.8%) were determined to be the fourth most desirable.

When examining differences between the frequencies of desired components based on academic discipline, similar trends to those observed by Sheen and Luximon (2015b) were discovered. The four most frequently reported components listed by medical students were the same in the large dataset adopted for the present study and the aforementioned small dataset. They were text (87.1%), highlighting tools (84.3%), multimedia (81.4%), and bookmarks (78.6%); however, a slight difference in order between the two datasets was observed. This was due to how close the frequencies were. Engineering students selected text (82.2%), highlighting tools (81.1%), multimedia (77.3%), and bookmarks (74.6%) as their four most reported desirable components. Similar to the variations in frequencies between master's and higher diploma students, business students listed translation, dictionaries, and encyclopedias (80.0%), but still selected text (84.7%), bookmarks (78.8%), and highlighting tools (78.8%).

Association between desirable components and demographic categories

Pearson's χ^2 test was employed to identify whether any significant associations ($p < 0.05$) between the preference for inclusion of each component and the aforementioned four democratic categories were present. This statistical test enabled the identification of relationships between components and demographic categories in a manner that verified the findings were not random. Overall, a limited number of associations were observed between academic discipline, educational level, prior experience, and gender for the 17 components; however, there were components which did exhibit significant associations with the demographic categories.

Gender was observed to be associated with three components: translation tools, dictionaries, and encyclopedias ($\chi^2(1) = 3.969$, $\phi = -0.084$, $p = 0.046$); manipulatable and 3D images ($\chi^2(1) = 4.320$, $\phi = 0.088$, $p = 0.038$); and bookmarks

($\chi^2(1) = 9.760$, $\phi = -0.0132$, $p = 0.002$). Prior experience exhibited no significant associations with the four demographic categories. Educational level exhibited a significant association with the inclusion of two components: annotation tools ($\chi^2(3) = 8.001$, $\phi = 0.120$, $p = 0.046$) with an adjusted residual of 2.2 for PhD students, and manipulatable and 3D images ($\chi^2(3) = 11.286$, $\phi = 0.142$, $p = 0.010$) with an adjusted residual of −3.3 for master students. Finally, academic discipline was observed to have a significant association with the inclusion of the following components: interactive equations ($\chi^2(2) = 11.028$, $\phi = 0.180$, $p = 0.004$) with an adjusted residual of 3.0 for Engineering students and −2.9 for Medical students, hiding unimportant aspects of the book ($\chi^2(2) = 12.705$, $\phi = 0.193$, $p = 0.002$) with an adjusted residual of −3.6 for Medical students, manipulatable and 3D Images ($\chi^2(2) = 11.192$, $\phi = 0.181$, $p = 0.004$) with an adjusted residual of −3.3 for Business students, project or print annotations ($\chi^2(2) = 6.568$, $\phi = 0.139$, $p = 0.037$) with an adjusted residual of 2.5 for Engineering students, interdevice synchronization ($\chi^2(2) = 11.464$, $\phi = 0.184$, $p = 0.003$) with an adjusted residual of 3.3 for Engineering students and −2.5 for Medical students, and annotation tools ($\chi^2(2) = 6.656$, $\phi = 0.140$, $p = 0.036$) with an adjusted residual of 2.6 for Engineering students. Other than the initial four significant associations observed with a small dataset (Sheen and Luximon 2015b), the final two components that exhibited significant associations were detected when a larger dataset was adopted involving computer science students being included in the engineering field.

Reported undesirable components

The simple percentage frequencies of undesirable components are displayed in Table 2. As illustrated in Table 2, the four most reported undesirable components were hiding unimportant aspects of the book (22.0%), time-management systems (21.8%), speech-to-text tools (18.0%), and text-to-speech tools (16.1%). These components were identified previously by the aforementioned small dataset (Sheen and Luximon 2015a), and only minute percentage variations were observed between the large and small datasets.

Although frequency variations were observed between the genders, the four most reported undesirable components were the same for both genders. Women listed hiding unimportant aspects of the book (22.2%), time-management systems (21.5%), speech-to-text tools (15.1%), and text-to-speech tools (15.1%) as the four most undesirable components. Men also selected hiding unimportant aspects of the book (21.8%), time-management systems (22.1%), speech-to-text tools (20.7%), and text-to-speech tools (16.8%) as undesirable components.

Based on experience level, the frequencies of components deemed undesirable were similar to the general preferences observed, with hiding unimportant aspects of the book (23.0%), time-management systems (21.9%), speech-to-text tools (19.1%), and text-to-speech tools (17.2%) selected most frequently, whereas respondents with no prior experience using electronic textbooks selected the same first two components 17.2 and 21.8% of the time, respectively, but listed manipulatable and 3D images (13.8%), and speech-to-text tools (12.6%) in third and fourth positions,

Table 2 Breakdown of frequencies of undesirable components based on general respondent population and four demographic categories

	General perception ($n = 560$)	Gender		Experience level		Education level				Discipline		
		Female ($n = 279$)	Male ($n = 280$)	Prior exp. ($n = 470$)	No prior exp. ($n = 87$)	Undergrad ($n = 346$)	Masters ($n = 114$)	PhD ($n = 63$)	Higher diploma ($n = 36$)	Engineering ($n = 185$)	Medicine ($n = 70$)	Business ($n = 85$)
Hide aspects	123	62	61	108	15	80	23	15	5	44	16	22
Time-management system	122	60	62	103	19	80	23	11	8	43	18	12
Speech to text	101	42	58	90	11	65	18	11	7	27	14	13
Text to speech	90	42	47	81	9	59	14	13	4	25	16	9
Manipulatable and 3-D images	63	33	30	11	12	38	16	3	6	14	6	15
Integration eLearn	36	14	22	33	3	21	6	6	3	15	4	3
Link to experts	32	16	16	28	4	14	7	7	4	9	5	1
Project or print annotations	31	14	17	27	4	23	3	4	1	14	5	1
Interactive equations	27	16	11	27	0	13	8	4	2	8	3	3
Multimedia	18	5	13	17	1	9	5	1	3	6	0	4
Sync across devices	19	13	6	16	3	12	4	2	1	3	5	2
Annotation tool	17	6	11	14	3	8	5	4	0	6	4	1
Translation, dictionary, and encyclopedia	14	5	9	14	0	7	3	3	1	5	1	1
Supplementary materials	15	7	8	13	2	10	1	2	2	7	4	1

Table 2 continued

	General perception ($n = 560$)	Gender		Experience level		Education level				Discipline		
		Female ($n = 279$)	Male ($n = 280$)	Prior exp. ($n = 470$)	No prior exp. ($n = 87$)	Undergrad ($n = 346$)	Masters ($n = 114$)	PhD ($n = 63$)	Higher diploma ($n = 36$)	Engineering ($n = 185$)	Medicine ($n = 70$)	Business ($n = 85$)
Text	8	4	3	5	2	6	0	1	0	1	0	2
Highlighting tool	8	0	8	7	1	3	2	2	1	4	0	0
Bookmarks	6	1	5	6	0	4	0	2	0	1	0	1

respectively, and did not select text-to-speech tools as one of the four undesirable components.

The four most reported undesirable components varied based on educational level. Undergraduates and PhD students listed hiding unimportant aspects of the book (23.1 and 23.8%, respectively), time-management systems (23.1 and 17.5%, respectively), speech-to-text tools (18.8 and 17.5%, respectively), and text-to-speech tools (17.1 and 20.6%, respectively) most frequently. Master's and higher diploma students listed hiding unimportant aspects of the book (20.2 and 13.9%, respectively), time-management systems (20.2 and 22.1%, respectively), and speech-to-text tools (15.8 and 19.4%, respectively) as three of the most frequently reported undesirable components, but listed manipulatable and 3D images (14.0 and 16.7%, respectively) in place of text-to-speech tools.

When examining the frequencies based on academic discipline, similar trends were observed between the data obtained in the present study and those of the aforementioned small dataset with only small percentage variations in frequencies based on the increase in data (Sheen and Luximon 2015b). Engineering students selected hiding unimportant aspects of the book (23.8%), time-management systems (23.2%), speech-to-text tools (14.6%), and text-to-speech tools (13.5%) as their four most frequently reported components not to be included in electronic textbooks. Medical students rated time-management systems (25.7%), hiding unimportant aspects of the book (22.9%), text-to-speech tools (22.9%), and speech-to-text tools (20.0%) as the four undesirable components. Similar to the variations in frequencies for master's and higher diploma students, business students did not list text-to-speech tools, instead selecting manipulatable and 3D images (17.6%), but still selecting hiding unimportant aspects of the book (25.9%), speech-to-text tools (15.3%), and time-management systems (14.1%) as the undesirable components.

Association between undesirable components and demographic categories

As observed when determining the most desirable components, the level of association between gender, prior experience, educational level, and academic discipline was observed to be low. It was also observed that the four main demographic categories demonstrated no significant associations with educational level.

Gender was observed to have a significant association with highlighting tools ($\chi^2(1) = 8.087$, $\phi = 0.120$, $p = 0.004$). Prior experience exhibited significant associations with two components: interactive equations ($\chi^2(1) = 5.252$, $\phi = 0.097$, $p = 0.022$), and manipulatable and 3D images ($\chi^2(1) = 24.323$, $\phi = -0.209$, $p = 0.000$). Education level showed no association with the components reported as undesirable. Academic discipline only exhibited a significant association with the opinion of manipulatable and 3D images ($\chi^2(2) = 6.691$, $\phi = 0.140$, $p = 0.035$) being undesirable with an adjusted residual of 2.6 for Business students. This significance was also detected in the small discipline dataset (Sheen and Luximon 2015b).

Ranking of components

Respondents ranked all of the components from 1 (most desirable) to 17 (least desirable). Based on the mean ranking of the components, a general ranking of student perceptions was determined (Fig. 2). The five highest ranked components were discussed in a previous study (Sheen and Luximon 2015a). The large dataset discussed in the present study did not observe any variations in rank positions, but slight variations in the mean ranks of the components were noted. The variations were as follows: text (2.81); highlighting tools (5.79); multimedia (6.02); bookmarks (7.12); translation tools, dictionaries, and encyclopedias (7.69). These variations are a result of the increased number of respondents' personal perceptions regarding components.

When examining the ranks in terms of gender, female respondents listed the same five highest ranked components as those listed in the general findings: text (2.76); highlighting tools (5.30); multimedia (5.94); bookmarks (7.01); and translation tools, dictionaries, and encyclopedias (7.27). In contrast, male respondents selected text (2.83); multimedia (6.10); highlighting tools (6.27); bookmarks (7.21); and annotation tools (7.83) in the top five positions. The full rankings can be viewed in Fig. 3.

Compared to other demographic categories, experience level exerted less of an influence on the five highest ranking positions; the differences can be viewed in Fig. 4. Both groups selected the same five components in positions 1–5 with two of the components reversed. Respondents with prior experience listed text (2.73);

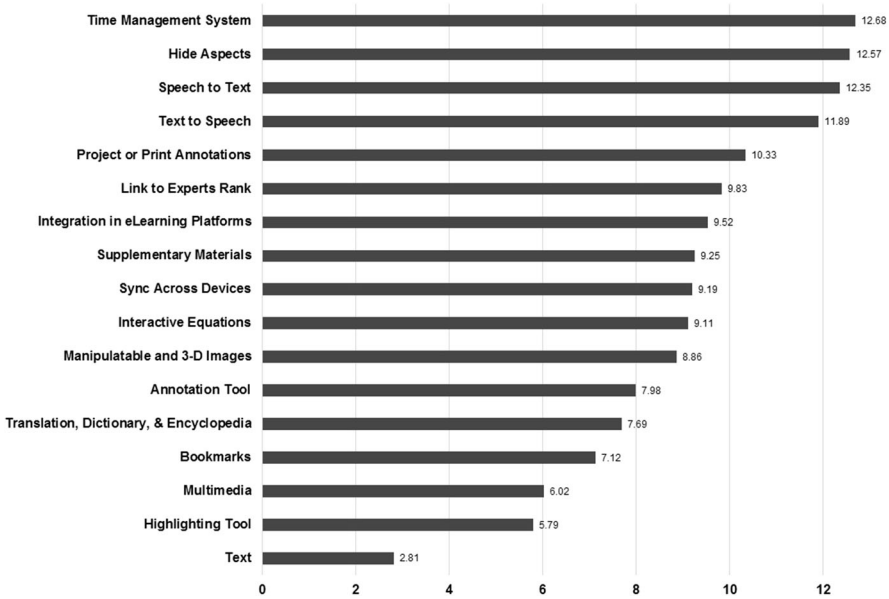

Fig. 2 Ranking of components based on general respondent population ($n = 560$)

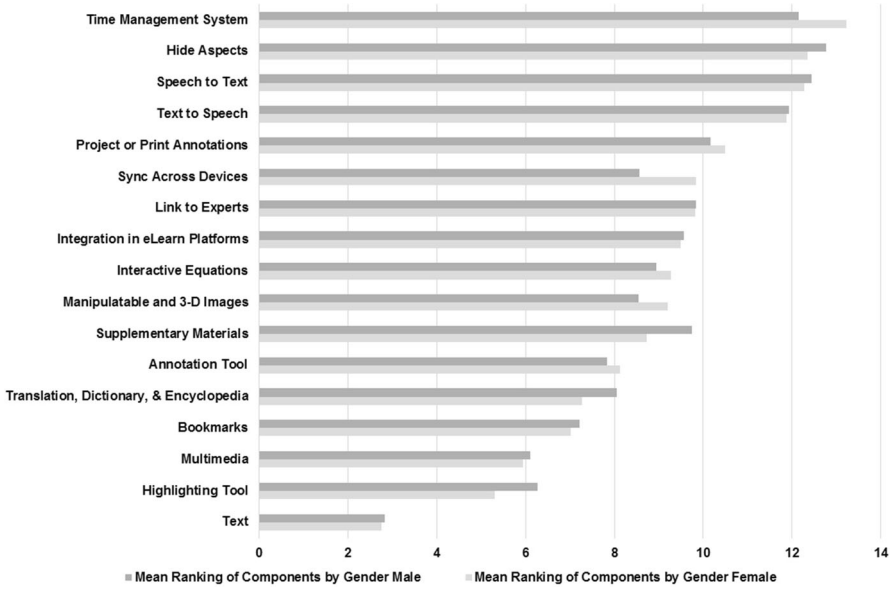

Fig. 3 Ranking of components based on gender: female respondents ($n = 279$) and male respondents ($n = 280$)

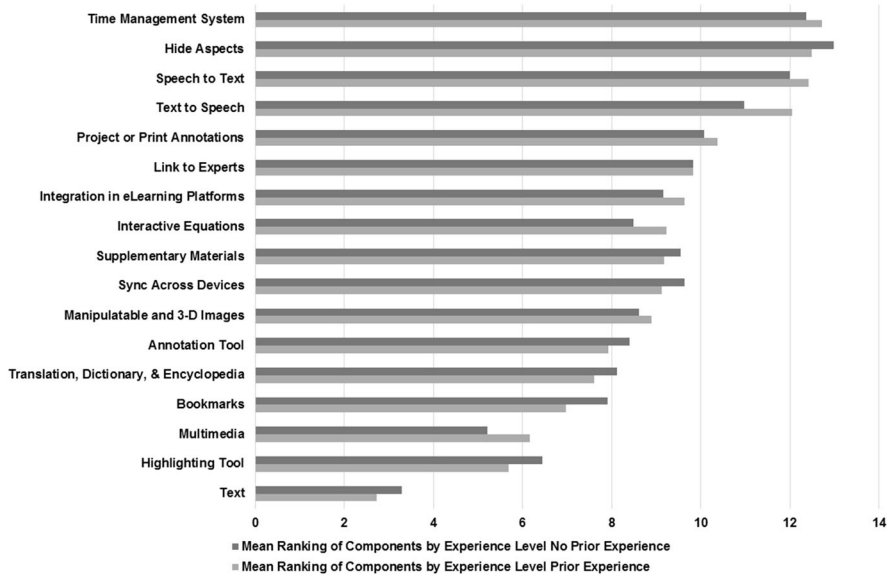

Fig. 4 Ranking of components based on prior experience ($n = 470$) and no prior experience ($n = 87$)

highlighting tools (5.68); multimedia (6.16); bookmarks (6.97); and translation tools, dictionaries, and encyclopedias (7.60) in the five highest positions in that order. Respondents without prior experience selected text (3.28); multimedia (5.21);

highlighting tools (6.44); bookmarks (7.90); and translation tools, dictionaries, and encyclopedias (8.11) in the five highest positions.

Figure 5 illustrates variations in ranks based on educational levels. The top ranking component for all four levels of education was text. Higher diploma students selected text (2.94); multimedia (7.25); translation tools, dictionaries, and encyclopedias (7.28); highlighting tools (7.36); and bookmarks (7.47) in positions 1–5 in that order. Undergraduates listed text (2.75); highlighting tools (5.46); multimedia (5.61); bookmarks (7.23); and translation tools, dictionaries, and encyclopedias (7.62) in the five highest positions. Master's students selected text (3.04); highlighting tools (6.28); bookmarks (6.75); multimedia (6.75); and translation tools, dictionaries, and encyclopedias (7.67) in positions 1–5, and PhD students listed text (2.56), highlighting tools (5.86), multimedia (6.17), bookmarks (7.03), and annotation tools (7.11) in the five highest positions.

Academic discipline was observed to have exerted the greatest influence on component ranks based on the mean ranking (Fig. 6). Business students selected text (2.18); highlighting tools (5.44); multimedia (6.32); bookmarks (6.51); and translation tools, dictionaries, and encyclopedias (7.73) in the five highest positions. For engineering students, the five highest components were ranked as text (3.14); highlighting tools (5.85); multimedia (6.50); bookmarks (7.06); and annotation tools (7.47). Medical students placed the greatest importance on text (2.69); multimedia (4.77); highlighting tools (5.14); translation tools, dictionaries, and encyclopedias (6.81); and manipulatable and 3D images (7.04). In all three of the aforementioned academic disciplines, text was the highest ranked component by far; whereas mean

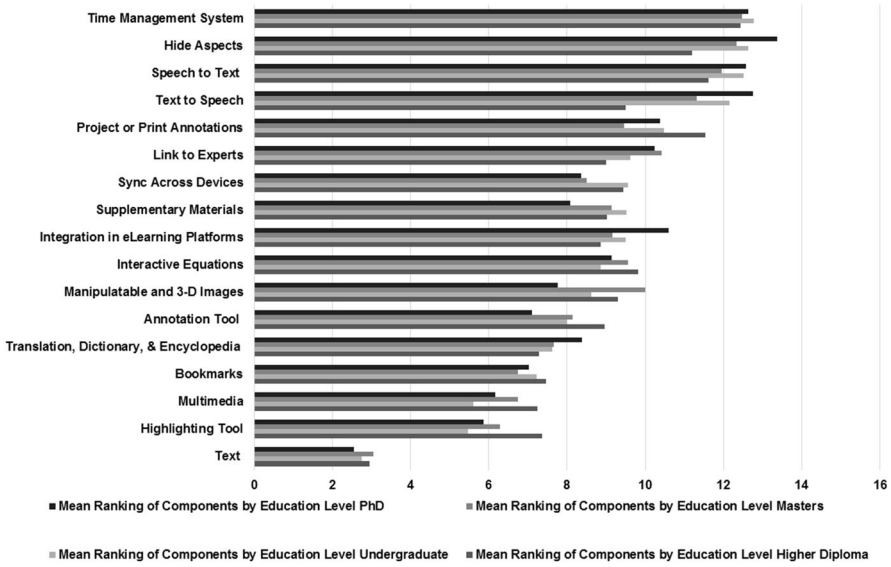

Fig. 5 Ranking of components based on education level: higher diploma ($n = 36$), undergraduate ($n = 346$), master's ($n = 114$), and PhD ($n = 63$)

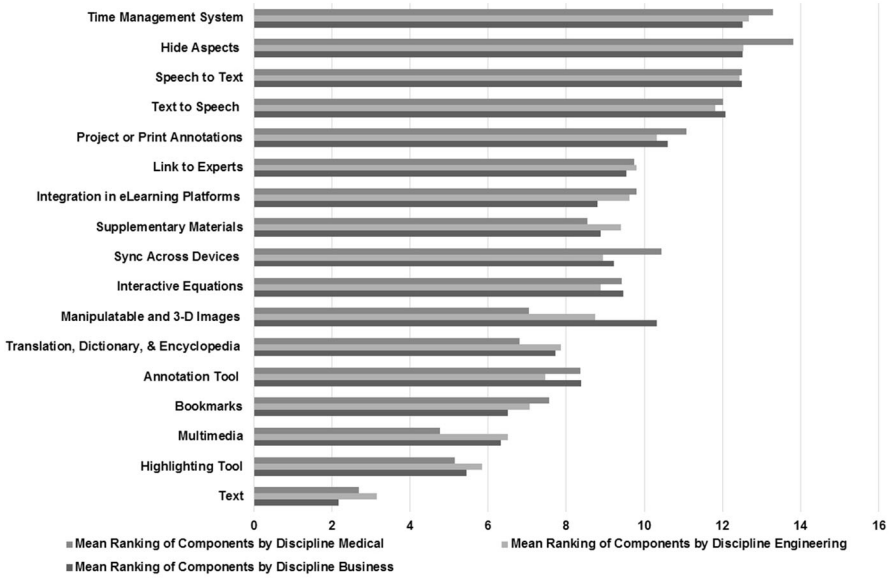

Fig. 6 Ranking of the components based on discipline: business ($n = 85$), engineering ($n = 185$), and medicine ($n = 70$)

variations were much closer lower down in the ranks. These findings are similar to those discussed in the aforementioned previous paper (Sheen and Luximon 2015b). The ranks discussed above exhibit slight variations between business and medical students when the large dataset was analyzed; however, the five highest components did not vary between the two datasets; only their mean ranks did. Variations were only observed for components that exhibited close mean rankings.

Discussion

General perceptions

The components generally reported to be desirable by the participants of this study varied from one respondent to the next. This trend correlates with the assertion put forward by Fairbairn and Fairbairn (2001), that students have no established method for engaging with material, and that many support methods may be employed to assist them. The majority of participants in the present study claimed that text; highlighting tools; bookmarks; multimedia; and translation tools, dictionaries, and encyclopedias should be built into future electronic textbooks. Current support methods are mirrored by the reported components listed for inclusion in this study. Similar to the findings of the questionnaire, Schcolnik (2001) observed that bookmarks and similar components were utilized more frequently than components such as annotation tools. Carroll et al. (2016) observed that science, technology, engineering, and mathematics (STEM) and non-STEM students alike frequently

reported the desire to highlight in their e-books. Technology changes may affect habits, but it would be beneficial to include highlighting tools to help students become accustomed to this new form of textbooks and avoid completely contradicting their existing mental models. Landoni et al. (2000) claimed that such an inclusion assists students in understanding and accepting the new technology. In addition, the identification of multimedia such as annotated embedded video for general inclusion has been shown to improve student learning (Dennis et al. 2015).

While employing the physical textbook as a metaphor may be crucial in the adoption of electronic textbooks, it is important to understand how the two main approaches to studying, the deep approach and the surface approach (Hartley 1990), may influence additional components and provoke complaints from students. Chan et al. (2015) indicated that mobile technology is erasing the firm boundaries between deep learning and surface learning. Because the divide between approaches is minimized in such a way, the inclusion of components such as dictionaries and encyclopedias may assist in making connections with existing knowledge that is necessary for deep learning.

Associations between demographics and perception

The four demographic categories adopted to analyze the questionnaire exhibited a small association between the perceived desirability of some of the components; however, none of the demographic categories exhibited associations with all the components. In addition, some components were found to be desired more than others based on the differences in frequency, examinations of residuals, and rankings within the demographic categories.

Two of the demographic categories investigated by the questionnaire exerted less influence on the perception of components than the other two categories did. Although some small associations between gender and experience level were detected, overall the number of associations observed was limited when compared to other demographic categories. In the past, Woody et al. (2010) indicated that gender had no significant impact on student preferences for physical textbooks over electronic textbooks. Findings from this survey partially support Woody's finding. Gender was observed to have no association in most of the components and only have a small association regarding 3 components—the desirability of bookmarks; translation tools, dictionaries, and encyclopedias; and manipulatable and 3D images. Female respondents generally wanted to include bookmarks and translation tools, dictionaries, and encyclopedias significantly more frequently than men did, whereas the component of manipulatable and 3D images was selected by significantly more male than female respondents. The component of highlighting tools was also observed to be associated with gender when undesirable components were reported. Fewer than 10 male respondents reported that they did not require highlighting tools in their future electronic textbooks, whereas no female respondents reported this. In line with findings from this survey, Gu et al. (2015) observed that opinions regarding electronic textbooks were not heavily influenced by prior usage. Prior experience from this survey exhibited associations with the components in only two of the seventeen components. Based on prior experience,

interactive equations and manipulatable and 3D images were associated as unpopular components. Students without prior experience more frequently reported not desiring manipulatable and 3D images, and those with prior experience more frequently reported that they did not want interactive equations to be included in future electronic textbooks. Various current technological constraints may have influenced some component results; for example, even with high-speed Internet access, images can still require long loading times. This negative association may have influenced student responses in those with no prior experience using electronic textbooks, or in observing how images are currently employed.

Educational level was also determined to have some association with both the inclusion of the more traditional learning component of note taking and the less traditional component of manipulatable and 3D images. Based on examination of the residuals, the component of annotation tools was chosen more frequently by PhD students than expected, whereas the component of manipulatable and 3D images was selected less frequently by master's students than expected. Such differences may be related to variations in reading task requirements between the educational levels. For example, PhD students have a different academic goal than other students at a university. PhD students will present the culmination of their academic work in a thesis which often requires a review of relevant literature, whereas higher diploma students often have smaller papers or exams with more immediate results.

Different academic disciplines were observed to have the most associations with the selection of components compared to the other demographic categories, and this supports the trend of creating course-specific electronic textbooks that can currently be observed at universities such as Oxford and the California State University system (Coughlan 2012; Nelson 2008). These findings also echo the sentiments conveyed in Jones and Healing's (2010) article which highlighted the strong association between courses and usage of technology in general. Part of the reasoning behind the extension of this association can be inferred, especially in cases of interactive equations; hiding unimportant aspects; annotation tools; and manipulatable and 3D images. Based on an examination of the residuals, the component of interactive equations was considered most desirable among engineering students. Because engineering textbooks rely heavily on equations, such as the textbook Modern Control Engineering (Ogata and Yang 1970), engineering students naturally requested the component more than business and medical students did. Engineering students also express a preference for task–technology fit regarding electronic textbooks, and Jou et al. (2016) stated that it is important to translate concepts into actual examples, which explains the association between academic discipline and that component. Hiding unimportant aspects was selected more often for inclusion by engineering and business students than by medical students, which examination of residuals showed that the component was chosen less often than expected. This could be related to the fact that engineering and business textbooks often include a broader spectrum of information that specialized students may feel they do not require, whereas medical students tend to study broadly before specializing in a particular area. Annotation tools were also observed to be associated with academic discipline with over half of the engineering

students requesting this component and residuals showing that these students chose the component more often than expected. Finally, the component of manipulatable and 3D images was requested for inclusion most frequently by medical students, followed by engineering students, and least frequently by business students with residuals showing that business students requested the component much less than expected. Images are vital for the presentation of information in medical textbooks, such as in Clinical Anatomy: Applied Anatomy for Students and Junior Doctors by Ellis and Mahadevan (2013), which coincides with the findings of this study. Images can often be vital for engineering students as well, for assistance with visualizing how systems work, whereas business students do not necessarily require images in their textbooks to assist their understanding of concepts. The reasoning behind the association with projecting or printing annotations and interdevice synchronization is slightly more obscure; it is possibly a result of the technical nature of the components, which therefore merits further investigation. The component of projecting or printing annotations was requested most frequently by engineering students, followed by business students, and least frequently by medical students. The component of interdevice synchronization was requested most frequently by engineering students, followed by business students, and least frequently by medical students.

Limitations and future work

To adequately interpret the results of a questionnaire, non-response bias should also be evaluated. Internet questionnaires tend to garner fewer responses from university students than traditional paper questionnaires do (Sax et al. 2003). Although low response rates might occur when employing Internet surveys, utilizing the survey advice from Ray and Tabor (2003), the survey was short, involved a few questions, and highly targeted to the student population. In the present study, the decision to conduct an online questionnaire as opposed to a face-to-face questionnaire was because of the online questionnaire's ability to reach a diverse student population, who may otherwise be difficult to track down in a spread-out campus (Wright 2005). This survey did not include any open-ended questions, but respondents were allowed to submit their own other options for future components, which many took advantage of.

Further research could be conducted to identify why students choose specific components for study, why they feel one component may be more necessary in their future electronic textbooks over others. Additional research is required to identify how students would interact with some of the components they requested for future electronic textbooks, as well as the actual appropriateness in relation to the task at hand, both of which were not investigated by the questionnaire in this study. Such an investigation would prove or disprove the existence of what Simon (2001) dubbed the "fickleness gap," a reported level of importance for components with reduced levels of actual usage.

Conclusion

The questionnaire designed for this study was conducted to identify which components students deem necessary for inclusion in the design of future electronic textbooks, based on their academic reading task requirements. The questionnaire also investigated whether any aspects of academic study may indicate that electronic textbook design should move away from the one-size-fits-all approach that up until now has dominated the industry. The obtained findings from this survey support this stance. It was observed that students believe that future electronic textbooks should include text, highlighting tools, bookmarks, multimedia, translation tools, dictionaries, and encyclopedias to enable the successful use of electronic textbooks to meet various academic reading needs. Evidence suggests that many demographic categories have significant associations with student perception of which components should be included in their textbooks; therefore, it would be advisable to design textbooks with these attributes in mind. The most significant demographic category that requires specific design is academic discipline. This finding is a realization of a concept proposed by Hartley (1990), who outlined different types of readers and argued that students in different disciplines adopted different approaches to studying. Current research has not yet affirmed the validity of this idea or recommended it as a basis for textbook designers. Through consideration of the student perceptions observed in the present study, designers could design a superior educational tool, especially when accounting for the association between components and various academic disciplines. Furthermore, as technology continues to advance, analyzing components outside the restrictions of technology would allow for greater flexibility in the design of future electronic textbooks.

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