



How engineering students use STEM e-textbooks

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Abstract

Higher education in South Africa has undergone a significant transformation in bringing unique challenges to both students and lecturers. One such challenge concerns the integration of digital technologies, particularly e-textbooks, into the teaching and learning process. In this study, I focus on first-year engineering students from two departments at a South African University of Technology. I employed a qualitative case study approach, drawing on data from fourteen students through individual semi-structured interviews, focus group discussions, classroom observations, and think-aloud protocols. Guided by the affordances framework, the analysis examined patterns of interaction with e-textbooks and the utilisation of their features. Findings reveal that, while students valued e-textbooks for accessibility and multimedia resources, many still relied on handwritten notes, thus reflecting prior schooling practices and limited digital literacy development. I conclude by emphasising the need for universities to provide targeted digital literacy training.

Keywords: digital literacy practices, reading e-textbooks for learning, affordances, patterns of interaction, engineering education

Introduction

In South Africa, most students at a University of Technology (UoT) come from marginalised communities and previously and currently disadvantaged backgrounds with limited resources (Czerniewicz & Feldman, 2023; Hammond et al., 2009). In South Africa, like many other countries with similar challenges that also brim with resilience, smartphones have become a significant source of hope. Their ubiquity has transformed them from mere communication devices into potentially potent learning tools (Cuillier & Dewland, 2014; Dlodlo & Foko, 2012; Embong et al., 2012; Fike et al., 2016; Gyllen et al., 2018; Hwang et al., 2018). This trend is not confined to South Africa alone; research indicates that smartphones have become indispensable in countries grappling with similar challenges. Thus, as the educational landscape continues to evolve, the pivot towards digital resources like e-textbooks, especially

those accessed via smartphones, is both timely and imperative (Arek-Bawa & Reddy, 2023; Czerniewicz & Feldman, 2023; Daniel & Woody, 2013; Uden, 2007)

In this research, focusing on their engagement with interactive features to learn engineering content, I aimed to understand how students interact with e-textbooks. The study begins by examining the literature on the affordances of e-textbooks, laying the groundwork for understanding their potential in educational contexts (Campbell & Kapp, 2020). Following this, in the methodology section I detail the participants in the study, including the criteria and processes used for their selection. The theoretical framework underpinning this research draws on affordances, providing a robust perspective through which to interpret the findings. The discussion section is divided into two key areas, the first of which will offer an analysis of five affordances of e-textbooks that I identified during the study, highlighting how students utilised these features. The second will examine patterns of interaction with e-textbooks, in which I categorise and discuss four distinct interaction patterns that I observed in the data. Lastly, in the conclusion I provide a comprehensive understanding of how e-textbooks can support learning in engineering education.

Literature review

The concept of affordance has become increasingly prevalent in various academic fields, including educational design and human-computer interaction, as noted by Scarlett and Zeilinger (2019). This term was first introduced by J. J. Gibson, a cognitive and ecological psychologist whose perspective on affordance (1966, 1979, 1982) pertained to the ways in which entities navigate, understand, and generally interact with their surroundings. Notably, Norman (1988) expanded on this concept by applying the theory of affordances to digital artefacts and environments. As Leonardi (2013) posited, viewing affordances relationally deepens our understanding of human-technology interactions.

Norman (1999) categorised affordances as being either real or perceived. Real affordances are inherent functions of an object—the potential actions it can facilitate (Arek-Bawa & Reddy, 2023). In contrast, perceived affordances are those that are immediately apparent to users, as discussed by Davis and Chouinard (2016). In this study, I examine the digital literacy practices in e-textbooks and the real affordances that are shaped by their design. Beyond noting real and perceived affordances, there is also a need to explore hidden affordances. These are not deliberately obscured by e-textbook design but stem from users' lack of awareness or reluctance to engage with certain features. Some readers, for instance, remain unaware of the interactive capabilities of e-textbooks simply because they have never used them.

E-textbooks are characterised by an array of interactive features that are specifically designed to cater to the needs of both students and lecturers. These features range from basic to advanced. At a fundamental level, they offer customisation tools akin to PDF reading, like note-taking functions, built-in dictionaries, and website links (Dobler, 2015; Rockinson-Szapkiw et al., 2013). More advanced features promote engagement with digital texts in encompassing interactive diagrams, live hyperlinks, social networking capabilities, and

multimedia content. Such tools empower readers with diverse learning preferences to engage with content in ways that are most suited to them.

Conceptual framework

In this study, I adopt an interpretive framework that draws on affordances. This framework offers guiding principles for implementation of the study, in providing a perspective from which to examine students' engagement with e-textbooks. Affordances refer to the actions or activities that a cultural tool enables in a specific environment. In this study, the e-textbook serves as a technological affordance, offering various functional possibilities that influence how students navigate, interact with, and comprehend mathematical content.

The affordances of e-textbooks can be categorised into different dimensions, including the following:

- Navigation affordances: features that allow students to move efficiently in the text (e.g. hyperlinks and search functions).
- Emphasis affordances: tools that enable highlighting, annotating, and emphasising key points.
- Media affordances: interactive elements such as embedded videos, animations, and simulations that enhance understanding.
- Spatial and temporal affordances: the flexibility of accessing content anytime and anywhere, shaping individualised learning experiences.

These affordances are not static; they vary based on users' preferences, expertise, background and cultural context (Jeong & Hmelo-Silver, 2016).

Methodology

I adopted a qualitative research approach, employing a case study methodology (Stake, 2013) to explore students' learning experiences with STEM e-textbooks, specifically in mathematics and physics. I focused on two engineering departments, Chemical Engineering and Maritime Studies, at a University of Technology (UoT) in South Africa with a particular emphasis on first-year engineering students enrolled in 2022. Many South African students who enter UoTs experience financial difficulties, not only in paying tuition fees but also in purchasing costly engineering textbooks. In response to these challenges, the two departments signed an agreement with a publisher to provide students with licences for e-textbooks to cover the cost of these books.

I first consulted with lecturers who are responsible for the targeted subjects and who had had prior experience using e-textbooks and subsequently organised demonstration sessions to familiarise students with these resources. I also allocated time for students to familiarise themselves with both the course requirements and the e-textbook platform before the commencement of formal data gathering. I conducted the study over the course of three months.

In qualitative research, debates about sampling and sample size remain a major consideration, yet the literature offers no straightforward rules or universal guidelines (Subedi, 2021). Instead, many factors influence sample decisions. Many qualitative scholars argue for thick description and for achieving saturation, often recommending sample sizes between five and seven participants (Dahal et al., 2024).

Following this reasoning, I involved 14 participants, seven students from each department. All participants were enrolled in the same year and qualification. They voluntarily agreed to participate in the study without receiving any form of compensation. Demographic data was not collected since the focus was specifically on students' digital literacy practices rather than on personal characteristics.

I adopted a multi-method strategy to capture rich and nuanced perspectives. First, one-on-one semi-structured interviews were conducted to explore individual student experiences with mathematics and physics e-textbooks. Following the interviews, two focus group discussions were organised (one per department, with seven participants in each) to allow participants to reflect collectively on their engagement with e-textbooks and on how these digital resources influenced their learning of mathematical and physical content.

Ethics

This research was ethically reviewed and approved by the Ethics Research Committees (ERC) of the Faculty of Engineering and the Built Environment (FEBE) at the University of Cape Town (UCT) and Cape Peninsula University of Technology (CPUT) in 2022.

Findings

In this section, I discuss the five main affordances that are available in e-textbooks and whether, and how, students engaged with them.

Navigation affordances

The e-textbooks offer navigational affordances (Bower, 2008), i.e., the ability to browse through sections of the e-textbook, move between chapters, and conduct a search in the e-textbook. It is not surprising that students utilise affordances for navigation since this enables simple chapter, page, and section navigation. However, I observed that navigational affordances were not utilised to their full potential by all students because they did not always know how to quickly locate information in other chapters. They tended only to scroll down and up. For example, even the search button was used by only a few students¹ such as Student 1, who reported using it while “looking for resources inside of the e-textbook.” However, Student 2 stated, “At first, I used Google to search. I was not aware that there was an option of just searching by definition, so it’s a helpful function when you do not have enough time.” In this statement, Student 2 described choosing to move away from the e-textbook and use Google rather to search for the meaning of a word despite the fact that the e-

1 The student comments have not been edited.

textbook provided a function to obtain the definition in the e-textbook itself. Student 2 was aware of the e-textbook's features, including the option to watch a video that explains a concept, but, at that moment, students were less familiar with these functions, so they opted for strategies with which they were more comfortable.

The navigation affordances allow readers of e-textbooks to have the option to click on a link that leads away from the e-textbook and onto the internet for further exploration of a topic. For example, Student 11 mentioned, "A hyperlink . . . redirects you in the book", and Student 5 noted, "Yeah, and the hyperlinks as well, to be able to search." Students demonstrated knowledge about the functions of hyperlinks and their affordance. For example, while reading, Student 9 commented, "I am going to use hyperlinks because it can take me [to] the information", and Student 13 added, "I use a hyperlink. Yeah, sometimes for reference. I do click on it and see if it helps." Students thus demonstrated knowledge of the functions of hyperlinks and their affordances. However, many other students did not use the hyperlinks that are provided in the e-textbook. During discussions, a number of participants demonstrated little or no understanding of the purpose or functionality of hyperlinks despite the fact that these can be advantageous for them because they enable them to be redirected to new and old concepts across the chapters. Student 1 said, "I was not aware about a blue text [hyperlink]."

At the beginning of the meeting and discussion with students, it became clear that some students had not used e-textbooks prior to being at university, and it was their first time studying with an e-textbook so they reported benefiting from having participated in this research study. Student 14 mentioned, "It is no longer confusing anymore. Now I can easily navigate the e-textbook" and Student 7 noted, "No, now the thing [e-textbook] is like it is new for me. So, like I don't know everything about it. Okay, but I think I'm getting there."

The rise of digital reading and e-textbooks underscores the need for coherent curriculum provision in the university system. Access to e-textbooks as well as how to operate e-textbooks as educational tools should not be taken for granted since students need to know how to use e-textbooks so instruction in this aspect should be built into the curriculum.

Emphasis affordances

Emphasis affordances form another set of affordances (Bower, 2008) that give the student the opportunity to highlight digital text and direct their own attention to important concepts and information explicitly. Emphasis affordances are dynamic in that they emerge from the interaction between the student and the digital text to promote reading for understanding (Kannengeisser & Gero, 2012). The keywords or concepts of a digital text can be highlighted by using the digital text's emphasis affordances, such as the highlighter function. Student 5 referred to this function as an advantage to understanding reading in saying, "I need now to understand properly, that's when I do my highlighting. And then, after the highlights, now I sit down [and] just break it down for myself. I wrote it down on paper." Student 5 reads the e-textbook on the computer and then writes the content down. What is notable here is that this student reverts to a non-digital format of processing the affordance instead of copying and

pastings the sentences into a word processing document file, which could, at least potentially, save time and allow them to take notes more quickly, in moving to a paper-and-pen activity. For some students, the act of physically writing presents certain advantages for reading for understanding even though it could be argued that this presents a less efficient way. Each student has a personal preference for interacting with an e-textbook.

E-textbooks allow students to highlight text with just a few clicks or taps. This convenience potentially saves time and effort when compared with manual writing and highlighting, which can be slower and more tedious. This can be seen in the fact that, as Student 6 argues, “Highlighting is saving time.” Additionally, the highlighting allows students to customise their highlighting based on their preferences or specific study needs. For instance, potentially, they can use different colours to signify different types of information (e.g. main ideas, supporting details, or definitions) or use highlighting styles to differentiate between important and less important content. However, Student 11 stated, “. . . highlighting, that is my favourite because it makes it colourful, so I usually use it.” This student’s response can be understood in two ways: first, their reason for using the highlighter is to make it colourful, which can then be used to assist with reading through a colour-coding technique or mind map, or the colourful highlighting can be used for aesthetic reasons.

Media affordances

Every day, students interact with digital text by using various digital devices, which significantly impacts their learning process, including completing tasks like learning new words that are specific to engineering and applying theoretical knowledge to practical situations (Van Joolingen et al., 2005). Certain learning concepts are more effectively presented through multimedia formats. Digital media has the potential to offer more comprehensive and authentic representations, preserving the accuracy and quality of the learning materials (Ritchie & Hoffman, 1997). Media affordances in e-textbooks present opportunities for both enhancing content understanding and increasing accessibility. In this subsection I scrutinise the significance of these distinctions, particularly in relation to accommodating the needs of students with disabilities and ensuring equitable access to educational resources. From the findings of this study, I noticed that media affordances can be categorised into two levels—those focused on enhancing content understanding and those aimed at increasing accessibility. In e-texts, various multimedia modes and opportunities exist for engaging with content.

The first level of media affordance is engaging with content

Multimedia presentations, such as the video function, can facilitate a deeper comprehension of intricate engineering concepts, particularly for first-year students, some of whom may come from previously or currently disadvantaged communities. The participants from both groups appreciated the embedded videos in e-textbooks. For example, Student 1 said, “The videos is very helpful for understanding.” Student 1 indicated that the media afforded by e-textbooks, such as videos, helped them, particularly in relation to understanding concepts. In the focus group with the chemical engineering students, Student 3 commented, “When I

didn't understand this 'diffusion', I am looking for a video to explain it [to] me . . . for the video, so you can listen to and watch how he or she explained the concept." A similar view was expressed by Student 5 in the focus group interview with nautical science: "When I did not understand, I tried to find out in another resource [video]."

Using an e-textbook with media affordances such as videos gave students the feeling of being taught. For Student 3,

Because it's like a teacher, he or she is teaching you. So, I guess we have to understand everything that they say. Unlike when you're alone, sometimes the certain knowledge that you aren't, maybe on that level. So maybe if someone does it for you, and then you understand.

Some students preferred a video with animation. Student 12 stated,

I prefer videos, but not the videos with the presence of someone just looking at you and talking and talking everywhere, and I prefer videos with animation. Yeah, animation video.

An animated video that demonstrates an engineering concept can enhance students' understanding by allowing them to visualise the phenomena and dynamic relationships more effectively than can be represented in static images (Van Joolingen et al., 2005).

In summary, the first set of media affordances focuses on enhancing content understanding. For example, the videos in e-textbooks also play a vital role in supporting comprehension because they provide explicit explanations of concepts. Animation videos further enhance the learning experience by allowing students to visualise dynamic relationships and phenomena. Diagrams and graphs in e-textbooks provide visual representations that go beyond traditional textbooks, aiding in the explanation of engineering concepts.

The second level of media affordances is accessibility of e-text

Features such as read-aloud functionality cater to students with different learning preferences and abilities. For students who prefer listening to reading, the audio component of e-textbooks proves crucial in understanding complex topics. Additionally, offering choices between print literacy and multimodal literacy allows students to switch between reading text and engaging with videos, images, and graphs. This flexibility caters to different learning styles and helps students grasp concepts more effectively. The integration of various modes of presentation, including static and dynamic representations, aids in connecting theoretical knowledge to real-life applications and problem-solving scenarios.

For example, for Student 5 listening is important; they said,

I don't think necessarily about the e-textbook. I just love listening. And then I get to the problems. I mean, studying. I must listen. That's like what's in the videos first. I

must listen. And the other things that just refer me to your formulas on the extra information to understand what increases, what happens, all those things.

Some students find it difficult to process information by reading text only, even when actively attempting to do so. For them, the audio component in the e-textbook for explaining a concept is important. As Student 12 argued,

I prefer reading aloud. It helps me. If someone talks to me about it, because normally I live with [Student 15], and so every time we have a test, we study, I always say, 'Please tell me what's happening. Read my book. Tell me your understanding.' That's how I learned by testing everything.

Additionally, accessibility of media affordances allows students to learn new technical language pronunciations. For example, the read-aloud function in e-textbooks assists students with the pronunciation of unfamiliar engineering concepts. For example, Student 14 stated, "If I come across a word that I cannot read and understand its meaning, I can just choose that read-aloud option and get to know the new word."

Another example of accessibility of media affordances is to cater to student choices for reading, such as moving between print literacy (reading text) to multimodal literacy (videos, images, and graphs). For example, Student 13 explained how digital e-textbooks assist with understanding and verification in saying, "If the text was not clear I verify by watching a video." And Student 4 stated,

I always start with the e-textbook. And then when I get lost [I] go to videos to kinda have a verbal explanation like more into kind of interactive, although you're not gonna talk anything for it. So, I first go [to the] book and then I listen to videos and then additional information afterwards.

Media affordances in e-textbooks, therefore, have the potential to enhance understanding and improve accessibility. By incorporating features that enhance content understanding and provide accessibility options, e-textbooks have the potential to provide equitable access to educational resources for all students. The integration of multimedia elements allows for diverse modes of engagement with content that caters to different learning styles and preferences.

Temporal affordances

Temporal affordances include the ability to access the e-textbook at any time and from any location as well as the ability to adjust the playback. All participants appreciated the fact that they could study at any time of day, in any location, and at any time. Student 12 said, "The person [in the video] can talk really fast, so I have to listen to what they say. I pause the video or adjust speed of the video and take notes . . . try to remember what they say." Students study with e-textbooks by watching videos and taking notes from them. The ability to adjust the speed of the video and pause it allows students to take notes while the presenter is speaking and to repeat the information.

Spatial affordances

Spatial affordances, as identified by Bower (2008), refer to the capacity to adjust elements in the interface, enabling users to resize or modify the layout according to their preferences. An example of this is the option to adjust the settings in an e-textbook for comfortable night-time reading or to configure a dyslexia-friendly format of the text. The ability to resize the text font of the interface and set the size of the letters and background of the interface of e-textbooks was used by participants for comfortable reading and for visual issues. Student 5 stated, “I think because of issues of vision I change the size and background” Student 12 added that they like to use the read-at-night function. “My eyes are sometimes tired to see things like that, and I prefer a black background.” Student 13 agreed that they use the reading-at-night features for comfortable reading.

Several categories of young people with disabilities are still largely excluded from society. This makes it difficult for these students to study in the same ways and at the same pace as their peers. Furthermore, because of resource limitations, these disabilities are often underdiagnosed in countries such as South Africa. Reading digital text in which space, contrast, letter size, background, and spacing can be used to make reading and note-taking easier for preparation and review, minimises confusion and fatigue. The text can be easily changed (in terms of font, size, and background), copied, dismantled, and reassembled for creating student notes (Kannengiesser & Gero, 2012).

Patterns of interaction with e-textbooks

From the think-aloud protocol, which I conducted with students during the reading activities and then followed up with interviews, I noted that students engage with e-textbooks using different orders of interaction² (and different linkages of practices), which reframes how the e-textbook is taken up as a mediational tool. In this section, I report on the literacy practices students employed and their interaction order when they were observed in the computer laboratory. For a better understanding of how students read the e-textbook, I analysed the interaction order, during which I categorised the ways in which students interacted with the e-textbooks. These interaction orders fit into four main categories (conventional practice, preference for multimedia, navigating and engaging with multimedia texts, and participating in practical exercises) according to their engagement with the affordances of the e-textbook. Prior to the interviews, students participated in a reading activity in which they engaged with an e-textbook to demonstrate how they read an e-textbook for learning purposes.

Additionally, this section does not categorise the students but rather the forms of interaction, which means that different students may exhibit different types of interaction when reading individually and working in groups. In this section, I describe the four types of student interaction. These interaction order patterns are sorted hierarchically in terms of their levels

2 According to Goffman's (1983) perspective, the interaction order serves as the space in which individuals shape their self-concept and identity through various unspoken routines, performances, and rituals during social interactions with other members of society.

of engagement with the affordances of the e-textbooks (e.g. Category 4 is more engaged than Category 1).

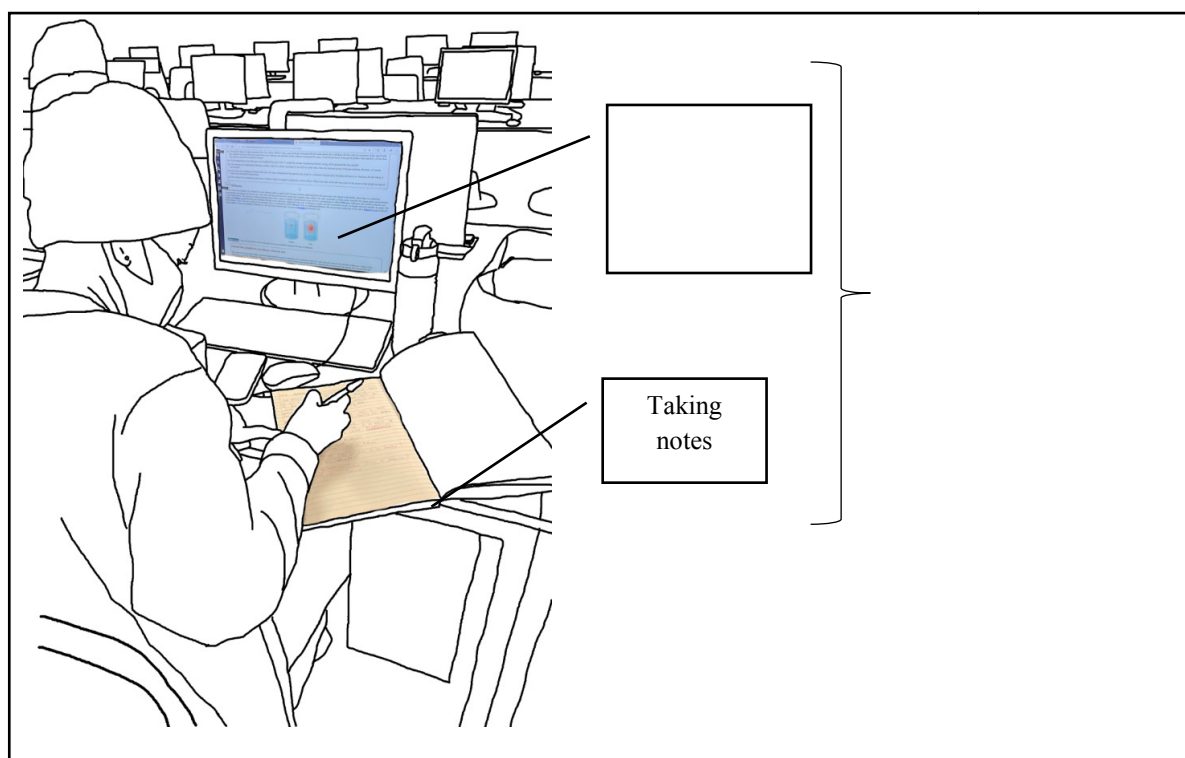
It is important to note that during data collection from the think-aloud protocol, students demonstrated certain patterns of practices of reading and engaging with e-textbooks that were limited or less interactive (see categories 1–4 below), but after the individual interviews, group reading and follow-up focus-group interviews, some students explained an interaction order that was more interactive. For this reason, some participants can be represented in more than one category.

Category 1: Mimicking conventional reading practices for digital texts

The first category includes moments from the think-aloud protocol and interviews where students read the text and made handwritten notes but did not use the additional affordances of e-textbooks. In these moments, students mainly used conventional ways of reading such as the reading practices that are associated with hard copy texts, as shown in Figure 1 and the two textboxes that follow (1.1 and 1.2), and neglected the affordance features of the e-textbook. In this category, participants showed traditional, or conventional, reading and interaction practices with e-textbooks.

Figure 1

Line drawing of digital reading of the student participant from this category



Textbox 1.1: Description of Student 1's interaction during think-aloud protocol

Student 1 attempted to open an e-textbook by logging into the LMS, but he spent three minutes looking for the e-textbook tab and opening the requested chapter and

topic. The student read the section for ten minutes. When the text in an e-textbook referred to a figure, the student scrolled down for one minute to examine the figure before continuing to read for three minutes. The next portion of text in the e-textbook referred to the same figure so the student scrolled down to look at the figure for one minute and continued reading for two minutes. The cycle of reading and looking at figures continued for another round during which the student spent another three minutes. The student then read the text for another five minutes, focusing on formulas and symbols in the formulas. The important formulas and symbols were noted in the student's hard copy notebook for four minutes.

Textbox 1.2: Description of Student 13's interaction during think-aloud protocol

Student 13 opened his e-textbook in the LMS and scrolled manually down until he reached the requested chapter and topic, which took about two minutes. The student then began reading the digital text for eight minutes, and, at the same time, he was taking notes in his personal notebook. When the text referred to the same figure, he scrolled down to look at the figure (one minute). After that, he continued reading as before he went to look at the figure. The student read the digital text for another six minutes. When the student read the text and the text referred to the graph, he scrolled down and looked at the graph to examine cycles of thermodynamic processes and then drew the graph in his notebook for three minutes.

These students did not fully engage with all the facilities offered in the e-text: Students 1 and 13 could have used the navigation function to move to the relevant sections in the e-textbook without scrolling only down and up. They could have interacted with media files such as images and videos. They could have highlighted important information and used the comment or flashcard option to annotate the text digitally.

Another example of the Category 1 interaction order came from a focus-group interview with the nautical science students. Student 12 described the following interaction pattern: "When I started with the chapter, I just scanned the whole chapter to check the amount of work. . . then I read the whole chapter." This participant scanned the chapter; this was done in order to understand the amount of work and time needed for this task. Student 9 had the same traditional approach to reading: "I tried to read the whole chapter and from the beginning and so I would then go back and just figure out if I understood." In interacting with only digital text in this way, this student demonstrated conventional reading practices. This is likely because students' interaction order is influenced by their cultural and historical practices before they enter university. These students showed a strong preference for reading texts as they would hard copy text and avoided using the features of e-textbooks (hence their classification into Category 1 – conventional practice).

Category 2: Preference for multimedia over text

In this category, I focused on participants who showed a preference for watching videos over reading the text, or students who explained during the interviews that they study by watching

videos. Students from this category did not engage completely with digital text. Instead, they immediately went to watch videos inside the e-textbooks or opened a browser to do a manual search of available videos on YouTube and other websites.

In the textboxes below, Students 5 and 10 immediately went to watch videos outside of the e-textbook on YouTube and sometimes completely ignored the written text.

Textbox 1.3: Description of Student 5's interaction during think-aloud protocol

Student 5 opened the e-textbook in LMS and went to the folder of the e-textbook for watching videos that is provided by the publisher for this particular topic, for six minutes. After that, this student watched the same video for another three minutes, then paused it and took notes in a hard copy notebook for another four minutes. Following that, he went to Google and searched for more videos on the same topic, which he watched for five minutes. While watching videos, he continued taking notes by writing in his notebook for four minutes.

Textbox 1.4: Description of Student 10's interaction during think-aloud protocol

Student 10 first opened the Google browser and searched for thermodynamics concepts, then opened the first video from the list and watched it for seven minutes. At the same time, she paused and played back the video to write down notes. After this, she opened the e-textbook and looked at the titles of the sections and subsections for three minutes. In order to find the requested topic, she scrolled down to page 105. Then she looked at the figure and clicked on it to enlarge its size. After that, she went on to look at the notes for three minutes.

Neither Student 5 nor Student 10 spent time reading the text in the e-textbook. Instead, they spent their time watching videos. However, at the end of the reading activity, Student 10 opened the e-textbook and looked at a figure in it, possibly to clarify his notes on the information that was presented in the image. The interactions of these students showed a preference for multimedia modes, such as videos and looking at figures. They did not utilise the navigation or emphasis affordances.

Some students, during the interviews, discussed their choice of watching videos as opposed to reading the digital text. For example, Student 14 stated, "I chose to watch the first video, yeah. I think videos for me, it is mostly listening to videos." And Student 5 explained his choice of preference for videos over reading in saying, "I want to listen to someone tell me about what I'm about to do before I actually go to the e-textbook and try to work it out myself." These students preferred to start by watching videos and then reading the digital text. In this category of student interaction, other possibilities for engagement that were not taken up include highlighting and annotating the written text in the e-textbook to support their understanding of the content and how it relates to the videos they were watching. The written text could potentially have introduced them to the discipline-specific concepts with the videos supplementing that content with examples.

Additionally, the students explained how video can allow them to understand the topic. For example, Student 9 explained, “YouTube might save your life. My first instinct on understanding Khan academy³ is video.”

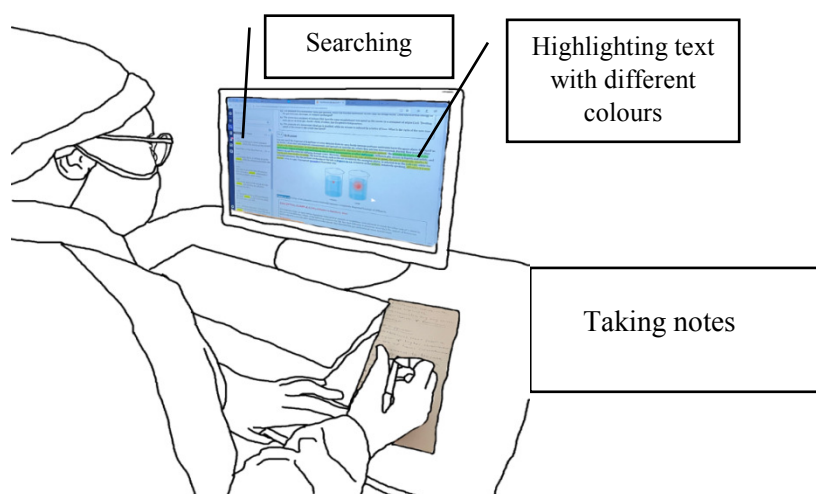
In summary, the participants of this category used a particular set of practices (and particular linkages of practices) that reframes how the e-textbook, as a mediational means, is employed in the particular social action of reading.

Category 3: Navigating and engaging with multimedia texts

The third category of students’ interaction order patterns occurred when students read the text in the e-textbook and also watched videos. In this category, a combination of the two previous categories was shown i.e., reading the digital text and watching videos. Also, when the students read the digital text, they also used some of the affordances such as the read-aloud and navigation affordances (searching) and the highlighting function (see Figure 2). The detailed interaction order for this category is presented in Textboxes 1.5–1.7.

Figure 2

Line drawing of digital reading from student participant (searching, highlighting (green and yellow)) and taking notes



Textbox 1.5: Description of Student 9’s interaction during think-aloud protocol

Student 9 opened the LMS and then used the search function to find the chapter and topic. After that, she started reading for four minutes and, at the same time, made notes by writing formulas in the notebook. Then she continued reading the text in the e-textbook for another ten minutes. At some point, she went outside the e-textbook and opened Google to search for the meaning of the physical concept *diffusion* for two minutes. Following that, she searched for videos on the same topic and watched them for three minutes.

3 This is a nonprofit educational platform offering free online resources in a variety of subjects, founded by Salman Khan in 2008.

Textbox 1.6: Description of Student 11's interaction during think-aloud protocol

Student 11 used the search function to open the relevant chapter and topic, scrolled down to the section of the requested chapter and then read the text for ten minutes. After reading, this student started watching videos related to the topic for ten minutes inside the e-textbook. While watching videos, he stopped the video to take notes from the video. He spent approximately the same time on reading and watching videos.

Students 9 and 11 read the text in the e-textbooks and then watched the videos related to the topic. Some of them watched the video in the e-textbook while others accessed it by using Google and YouTube.

From the focus group interview with nautical science students, Student 10 explained his interaction order that is related to this category in explaining, "I highlighted some of the things that seem to be important then I watched the videos to understand the definition that is represented there." A similar interaction order saw Student 13 state, "When I use an e-textbook, I note things down [while reading] . . . I watched the videos and then moved out after I combined the information from what I had learned and interacted with the equations." As an example of interaction order for reading e-textbooks, this can include movement or navigation of the text, watching videos and simulations, listening to the read-aloud voice and making notes. Another example of an interaction order of this category, with specific focus on generating questions, was noted by Student 11 who said,

Since I use the e-textbook, I usually draw it down and then just interpret how they plotted the graph in the paragraph, trying to get an understanding of the paragraph. What does this paragraph mean? Like the context for this paragraph? I ask many questions. Why are they saying this? And then, since I have this basic knowledge, I should be able to answer my 'Why' questions. And even if the paragraph doesn't answer my questions, I will still be curious. I'll ask many people [classmates or lecturer], 'Why do they say this?'

This student's interaction began with visual actions and noting the graph, but it continued with trying to find answers to questions that are generated by her while reading the text. As learning/literacy goes, this is high-level engagement, evident in the asking of *why* questions as mentioned by her. The student sought assistance from others in order to comprehend the graphic representation.

In contrast to the two previous examples, some students prefer different patterns of interaction with e-textbooks. Student 5 stated, "I go to diagrams, then read the tips there. So, in order for me to know what to read . . . I have to take things from tips and then use Google to make notes." This participant went through a different interaction order where engagement started not from the text but from the visual modes of communication (diagrams) and a short summary (tips). The participant did not engage with the whole chapter but looked only at tips in which the authors summarised the main idea of the chapter and then went to Google to watch videos and make notes.

Category 4: Engaging with practical examples

The last category of students not only read and watched videos but also attempted to do calculations and even measure their understanding by completing a short quiz after the calculation. The main difference between those in this category compared with those in the previous categories was that these students did calculations, solved practical examples, and attempted short quizzes. The steps in the interaction order of this category were similar to one another.

Textbox 1.7: Description of Students 2, 3, 4, 7, 8 and 14's interaction during think-aloud protocol

Students 2, 3, 4, 7, 8, and 14 opened their e-textbook on Blackboard, scrolled down to the chapter and read for about seven minutes. Students 3, 4, 7, and 8 started writing notes. Students 8 and 2 also highlighted the text in the e-textbook, and students 2 and 3 looked at animated videos for three minutes. Some students (2, 4, and 14) read the text in the e-textbook for the second time for seven minutes. After that, all the students went on to solve practical examples. After calculating the questions, Students 4 and 7 decided to go to Google to watch more videos.

In this last category, students not only read the text in the e-textbook, highlighted text and watched videos inside and outside the e-textbook but also went on to solve example problems related to the topic and even attempted to answer the quiz. By engaging in all these literacy practices, students in this group used more affordances and showed more engagement with the e-textbooks and their affordances.

The example of interaction order that emerged from the focus-group discussion with the nautical science students was mentioned by Student 3 who said, "So, first I read the text and took notes. I also tried to find some questions. I was up for activities. If it was offered, I didn't go outside the subsection [because] first I want to find my understanding." while Student 8 added, "I'll find some quizzes, then I'll access examples. So now I'll start writing answers for the questions. After that I see where I understand or not." These students measured their understanding by attempting the practical exercises or answering quizzes after reading a section.

The pattern of interaction order that was involved when engaging with e-textbooks includes engaging with the different modes of presentation afforded by the digital text. As Student 4 stated, "Text, picture, question [practical example], videos, only if I don't understand what's going on." It is important to mention that the aim of the study was to investigate the students' interaction with e-textbooks for studying purposes. The reading material that was provided to the students was intentionally focused on thermodynamics since this subject is taught only in the second year. In this category, these students were moving beyond just reading; they were learning and assessing their understanding by attempting to solve the practical problems from the e-textbooks.

These four categories show different interaction orders as well as how some students are more comfortable and confident with e-textbooks than others. Students in Categories 3 and 4 were more comfortable using e-textbooks and their affordances for learning purposes whereas students in Categories 1 and 2 used fewer affordances and even fewer did so frequently.

Conclusion

The findings of this study provide critical insights into the ways in which engineering students interact with e-textbooks in a higher education context, particularly from the perspective of Affordances Theory. The study revealed that navigational affordances were underutilised by some students because of unfamiliarity with embedded search functions and hyperlinks. Instead of leveraging internal search tools, students often resorted to external searches (e.g. Google), suggesting a gap between perceived and actual affordances. This disconnect underscores the need for explicit digital literacy training to help students make full use of the technological features that are available to them.

Multimedia affordances, particularly videos and interactive animations, emerged as critical tools for knowledge acquisition. Students who engaged deeply with multimedia elements exhibited a preference for visual and auditory learning over traditional text-based comprehension. This aligns with the cognitive theory of multimedia learning, which posits that students learn more effectively when information is presented through dual channels (visual and verbal). For students in Categories 2, 3, and 4, videos and animations functioned as scaffolding tools, allowing them to grasp complex engineering concepts more effectively.

The study identified four distinct patterns of interaction with e-textbooks: mimicking conventional reading practices; preference for multimedia over text; navigating and engaging with multimedia texts; and engaging with practical exercises. Each of these patterns aligns with specific digital literacy practices and highlights varying levels of engagement with the affordances that are embedded in e-textbooks.

The findings indicate that, across all four modes of interaction, students consistently made handwritten notes. Note-taking served as a form of summarisation and emphasis, reinforcing key concepts and supporting memory retention. Although the e-textbooks offered features that allowed students to copy and paste important passages into digital notes, most participants preferred handwriting. This preference was rooted in their prior schooling experiences during which manual notetaking was the dominant practice. The results suggest that many students have not yet developed advanced digital literacy practices in relation to note-making. Consequently, universities should consider providing targeted training to support students in developing effective digital literacy strategies, thereby enhancing their ability to engage with e-textbooks as part of the learning process. For future research, greater attention should be directed towards lecturers and their approaches to e-learning. Existing literature indicates that many academics have transitioned from print to digital formats largely for the sake of convenience without fully exploring or utilising the functionalities that

digital platforms provide. Moreover, lecturers themselves may be unaware of the additional guidance and scaffolding that needs to be embedded in their teaching practices.

References

- Arek-Bawa, O., & Reddy, S. (2023). E-textbook pedagogy in teacher education beyond the COVID-19 era. In U. G. Singh., C. Sid Nair & S.Gonçalves (Eds.), *Digital teaching, learning and assessment: The way forward* (pp. 179–198). Chandos Publishing.
- Bower, M. (2008). Affordance analysis – Matching learning tasks with learning technologies. *Educational Media International*, 45(1), 3–15.
<https://doi.org/10.1080/09523980701847115>
- Campbell, E., & Kapp, R. (2020). Developing an integrated, situated model for digital literacy in pre-service teacher education. *Journal of Education (University of KwaZulu-Natal)*, 79(1), 18–30. <https://doi.org/10.17159/2520-9868/i79a02>
- Cuillier, C. A., & Dewland, J. C. (2014). Understanding the key factors for e-textbook integration into a business course: A case study. *Journal of Business & Finance Librarianship*, 19(1), 32–60.
- Czerniewicz, L., & Feldman, J. (2023). ‘Technology is not created by the sky’: Datafication and educator unease. *Learning, Media and Technology*, 49(3), 428–441.
<https://doi.org/10.1080/17439884.2023.2206137>
- Dahal, N., Neupane, B. P., Pant, B. P., Dhakal, R. K., Giri, D. R., Ghimire, P. R., & Bhandari, L. P. (2024). Participant selection procedures in qualitative research: Experiences and some points for consideration. *Frontiers in Research Metrics and Analytics*, 9, Article 1512747.
- Daniel, D. B., & Woody, W. D. (2013). E-textbooks at what cost? Performance and use of electronic vs. print texts. *Computers & Education*, 62(1), 18–23.
<https://doi.org/10.1016/j.compedu.2012.10.016>
- Davis, J. L., & Chouinard, J. B. (2016). Theorizing affordances: From request to refuse. *Bulletin of Science, Technology & Society*, 36(4), 241–248.
- Dlodlo, N., & Foko, T. E. (2012). Challenges facing e-textbook provision to South African schools. *Proceedings of the 11th World Conference on Mobile and Contextual Learning*, Helsinki, Finland, 16–18 October. <http://hdl.handle.net/10204/6340>
- Dobler, E. (2015). E-textbooks: A personalized learning experience or a digital distraction? *Journal of Adolescent & Adult Literacy*, 58(6), 482–491.
<https://doi.org/10.1002/jaal.391>

- Embong, A. M., Noor, A. M., Hashim, H. M., Ali, R. M., & Shaari, Z. H. (2012). E-books as textbooks in the classroom. *Procedia – Social and Behavioral Sciences*, 47(1), 1802–1809. <https://doi.org/10.1016/j.sbspro.2012.06.903>
- Fike, D., Fike, R., & St. Clair, N. (2016). Do e-textbooks impact learning outcomes? *International Journal on E-Learning*, 15(3), 313–325.
- Gibson, J. J. (1966). *The senses considered as perceptual systems*. Houghton Mifflin.
- Gibson, J. J. (1979). *The ecological approach to visual perception*. Houghton Mifflin.
- Gibson, J. J. (1982). Affordances and behavior. In E. S. Reed & R. Jones (Eds.), *Reasons for realism: Selected essays of James J. Gibson* (pp. 410–411). Lawrence Erlbaum.
- Goffman, E. (1983). The interaction order: American Sociological Association, 1982 presidential address. *American Sociological Review*, 48(1), 1–17. <https://doi.org/10.2307/2095141>
- Gyllen, J., Stahovich, T., & Mayer, R. (2018). How students read an e-textbook in an engineering course. *Journal of Computer Assisted Learning*, 34(6), 701–712. <https://doi.org/10.1111/jcal.12277>
- Hammond, T., Clayton, B. M., & Arnold, P. J. (2009). South Africa's transition from apartheid: The role of professional closure in the experiences of Black chartered accountants. *Accounting, Organizations and Society*, 34(6/7), 705–721. <https://doi.org/10.1016/j.aos.2008.09.002>
- Hwang, G. J., Tu, N. T., & Wang, X. M. (2018). Creating interactive e-books through learning by design: The impacts of guided peer-feedback on students' learning achievements and project outcomes in science courses. *Journal of Educational Technology & Society*, 21(1), 25–36. <http://www.jstor.org/stable/26273865>
- Jeong, H., & Hmelo-Silver, C. E. (2016). Seven affordances of computer-supported collaborative learning: How to support collaborative learning? How can technologies help?. *Educational Psychologist*, 51(2), 247–265.
- Kannengiesser, U., & Gero, J. S. (2012). A process framework of affordances in design. *Design Issues*, 28(1), 50–62.
- Leonardi, P. M. (2013). Theoretical foundations for the study of sociomateriality. *Information and Organization*, 23(2), 59–76. <https://doi.org/10.1016/j.infoandorg.2013.02.002>
- Norman, D. A. (1988). *The psychology of everyday things*. Basic Books.
- Norman, D. A. (1999). Affordance, conventions, and design. *Interactions*, 6(3), 38–43. <https://doi.org/10.1145/301153.301168>

- Ritchie, D. C., & Hoffman, B. (1997). Incorporating instructional design principles with the World Wide Web. *Web-based instruction*, 135-138.
- Rockinson-Szapkiw, A. J., Courduff, J., Carter, K., & Bennett, D. (2013). Electronic versus traditional print textbooks: A comparison study on the influence of university students' learning. *Computers & Education*, 63, 259–266.
- Scarlett, A., & Zeilinger, M. (2019). Rethinking affordance. *Media Theory*, 3(1), 1–48.
- Stake, R. E. (2013). *Multiple case study analysis*. Guilford press.
- Subedi, K. R. (2021). Determining the sample in qualitative research. *Online Submission*, 4, 1–13.
- Uden, L. (2007). Activity theory for designing mobile learning. *International Journal of Mobile Learning and Organisation*, 1(1), 81–102.
- Van Joolingen, W. R., de Jong, T., Lazonder, A. W., Savelsbergh, E. R., & Manlove, S. (2005). Co-Lab: research and development of an online learning environment for collaborative scientific discovery learning. *Computers in Human Behavior*, 21(4), 671–688.