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Design & Development Project Report: CHEM-105 OER Textbook

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Design & Development Project Report
Master's Project
Instructional Psychology & Technology, Brigham Young University

Purpose

The purpose of this project was to design and develop an open textbook for the BYU course CHEM-105, which was General College Chemistry. The primary audience for this textbook was BYU students who were enrolled in CHEM-105. The course was designed to be an overview of chemistry, and students often struggled with the amount of information covered. Keeping up with the course was critical for success, but certain elements of the previous course design had created added difficulties for students.

The main objective of this project was to remove those difficulties. One of the main issues was the cost of the required textbook, which had been over $100 in the past. This contributed to delayed or intermittent access to the textbook. Students waited until after the add/drop deadline to purchase the book, waited for it to be shipped, relied on the library's course reserve copy, or shared a copy with a friend. Ensuring immediate and persistent access to the textbook was vital to removing a barrier to students' success. Therefore, one of the key purposes of this project was to provide students with free, immediate, and stable access to their textbook by developing an open CHEM-105 textbook on open.byu.edu.

Another issue with the previous course design was that the reading schedule was not sequential. This made it difficult for some students to find the correct reading. This project addressed the problem by presenting readings sequentially and embedding them directly within the students' LMS for easy access and streamlined organization.

The project had two basic goals: providing greater access and streamlining organization. However, there were several other features that could have improved the student experience. Part of the design process was to determine which of these features was most valuable to the project sponsors/clients.

Sponsors/Clients

There were two sponsors/clients for this project: Dr. Rebecca Sansom and Dr. Royce Kimmons. Dr. Sansom was an associate professor in the BYU Chemistry Department, holding degrees in both chemistry and education, and had several years of teaching experience. She had researched and developed open resources for BYU's CHEM-106 course and was going to teach CHEM-105 in Fall Semester 2022. Her aim was to address some of the course design problems. She approached Dr. Kimmons for help with this.

Dr. Kimmons was the creator and maintainer of several OER publishing platforms. The site at open.byu.edu enables BYU faculty to create, publish, and share resources with their students. In addition to expanding the offerings of these OER sites, Dr. Kimmons was interested in using this project to explore the process of an IP&T graduate student assisting faculty from another department in creating OER.

Learning Goals/Objectives

Goals Related to OER

In addition to providing students with immediate access to the textbook, another goal was to provide them with persistent access, ensuring that they did not lose access to the book after completing the course.

Other Sponsor/Client Goals

Dr. Sansom was committed to supporting women in STEM fields and improving their experience in introductory STEM courses, such as CHEM-105. She also wanted to assist other students who struggled in their introductory STEM courses: returned missionaries, first-generation college students, and of course, the average college freshman.

For Dr. Kimmons, one of the key learning goals for this project was to determine whether a graduate student in learning design could assist a faculty member in creating OER for their course.

Department Objectives

The BYU Chemistry department had established instructional objectives that applied to every section of the CHEM-105 course, determined by a committee of faculty within the department. It was not within the scope of this project to influence the decisions of the committee since I was not working with the department. Instead, I was collaborating with Dr. Sansom, who did not have the authority to change the objectives. Therefore, it was outside the scope of this project to revise these objectives. However, the objectives were listed here for completeness to recognize the parameters within which we worked to create a new resource for students.

- Students will demonstrate a familiarity with the basic vocabulary and concepts of chemistry.
- Students will demonstrate a qualitative and basic quantitative understanding of the fundamental chemical laws which govern the material substances in our universe and which express how one variable in nature depends on another.
- Students will demonstrate the ability to manipulate quantitative descriptors of natural phenomena expressed both in the form of equations and of proportionalities, and solve chemistry problems using these skills.
- A successful Chemistry 105 student describes a chemical phenomenon by first focusing on properties of the elements at the atomic level. Chemistry 105 students will gain a knowledge base of reactivity patterns of elements and compounds.
- Chemistry 105 students will be able to use their chemistry experience, knowledge, and skills to better understand and work in their own field of study.

Project Needs and Constraints

Environmental Analysis

Class Environment

General chemistry serves as a foundational course for numerous STEM majors, acting as a gateway to further studies in those fields. According to students' self-reports to Dr. Sansom in previous semesters, she estimates that approximately 10% of students were found to be actively engaging with the textbook by the conclusion of the term. Former students have expressed their dissatisfaction with the assigned reading schedule and the high cost associated with the required textbook.

Digital Environment

The book would be hosted either on edtechbooks.org or open.byu.edu. The first site was marketed to an audience of students and professionals in the educational technology field, and anyone could author material on this site. On the other hand, open.byu.edu was marketed toward a BYU-specific audience, and only BYU faculty could author material on this site. The BYU-centric site seemed like a better fit for this book since it was not an educational technology book, and a BYU-centric site might be more appealing to other faculty in the chemistry department who would teach CHEM-105 in the future.

Client Environment

Dr. Sansom, an associate teaching professor, serves as the instructor for CHEM-105 within a committee-based framework. The committee holds authority over decisions related to the course's structure and outcomes. However, this project focused on collaborating with Dr. Sansom alone, without modifying the committee's learning outcomes or topic selections. Thus, the primary objective was to identify practical approaches that enhance students' learning experiences while adhering to the department's course specifications. Open Educational Resources (OER) offer a promising solution that maintains or improves student learning outcomes and throughput (Hilton et al., 2016; Fischer et al., 2015; Feldstein et al., 2012) while reducing students' financial burden. By replacing traditional textbooks, OER not only lowers costs but also increases accessibility to course materials and allows for customization. Consequently, OER seemed to be an ideal solution that operates within departmental constraints while enhancing the overall student experience. Dr. Sansom intended to adopt OER for her class; however, due to the time and effort required, she required design and development assistance to facilitate the process. This project aimed to make OER adoption feasible for Dr. Sansom's in her CHEM-105 course.

Constraints and Timeline

Dr. Sansom required a usable product for the Fall Semester 2022 CHEM-105 course that she would teach. In order to create a digital textbook in a short amount of time, we had to be selective about the additional features that were designed and built. It was less important that the textbook be feature-rich than that it fulfilled the course goals of a streamlined design and improved access.

Parts of the project presented a constraint due to the requirement for content expertise. Dr. Sansom undertook the task of revising her lecture slides, problem sets, and group work handouts before incorporating them into the book. Recognizing her limited time, she enlisted the assistance of TAs to aid in the revisions and other aspects that demanded content expertise. To ensure content accuracy and seek improvements, I devised a process for the TAs to review textbook modules upon their completion. This allowed them to verify the content and offer suggestions for enhancements.

Task Analysis

Dr. Sansom’s identified OER resources aligned with the department specifications for topics and learning outcomes. If needed, she wrote supplementary material. She provided me with a map between the required topic, the course schedule, and the selected OER readings (see following screenshot):

Date	Day	Lecture	Rec.	Homework	OpenStax	Topic	Lab
29-Aug	M	1			1.1	Introduction	
30-Aug	T		1				Safety Training
31-Aug	W	2			1.2-1.3, 2.4 (stop before the mole)	Matter	
1-Sep	Th		1				
2-Sep	F	3			1.4-1.6	Measurement	
3-Sep	S			HW 1			
5-Sep	M	No Class - Veteran's Day					
6-Sep	T	Add/Drop Deadline	2				
7-Sep	W	4			2.1-2.3 (through atomic mass)	The Atom	Avogadro's Number
8-Sep	Th		2				
9-Sep	F	5			2.3 to end, 3.6	Periodic Table	
10-Sep	S			HW 2			
12-Sep	M	6			2.4 (mole to end), 6.1	Moles & Mass	
13-Sep	T		3				
14-Sep	W	7			3.1 (through blackbody radiation)	Light	Atomic Spectra
15-Sep	Th		3				
16-Sep	F	8			sections on blackbody and photoelectric from 3.1	Blackbody Radiation, Photoelectric Effect	
17-Sep	S			HW 3			
19-Sep	M	9			rest of 3.1, 3.2	Atomic Spectra, Bohr Model	
20-Sep	T		4				
21-Sep	W	10			3.3	Orbitals & Quantum Numbers	
22-Sep	Th		4				
23-Sep	F	11			3.4	Electron Configurations	
24-Sep	S			HW 4			
26-Sep	M	12			3.5	Periodic Trends	
27-Sep	T		5				Polarity of

Alignment of Topics and OER selections.

I aligned what was created to what she wanted, while streamlining it and removing unnecessary information from the chapters (for example, removing extraneous sections on atomic mass and blackbody radiation).

In creating the textbook, I aligned the chapters with the topic map while streamlining and removing unnecessary information from the chapters or remixing it to align with the reading schedule.

Knowledge relevant to achieving project goals included analyzing needs, rapid prototyping and testing, designing in stages, HTML, project management strategies, user experience testing methods, Universal Design for Learning (UDL) principles, expert use of eLearning tools, creating eLearning objects, knowledge of Creative Commons licenses, and familiarity with precedent products and standard textbook formatting.

Important tasks for achieving project goals involved building content within an eLearning tool, debugging HTML, formatting and labeling chapter content (including figures, images, and reference links), incorporating various types of embedded content, creating a review process for content verification and improvements, conducting user experience and persona interviews, providing feedback for tool improvement, maintaining communication with the client, and setting milestones for successful progress.

Learner personas

CHEM-105 is a course that can be taken by students to fulfill the Physical Science requirement of the university's general education core. It is also a requirement for many students in engineering and biological sciences. As a result, freshmen and STEM majors, particularly those

in engineering and biological sciences, often take this course. Here are some learner personas, developed through interviews with representative students, information from Dr. Sansom, and research on certain student sub-populations of interest.

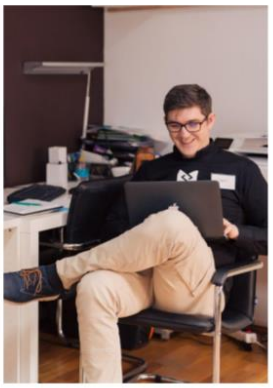
Standard Student

DEMOGRAPHICS
Age: 18
Grade: Freshman

TEXTBOOK USE
He's used digital textbooks throughout high school.

LEARNER INFORMATION
Taking 14 credits to maintain his scholarship.

MAJOR
STEM major



OTHER INFORMATION
Enjoyed his high school chemistry classes but has heard that CHEM-105 is a weeder class, so isn't looking forward to it too much.

END GOALS
Would like to enjoy the class if he can but mostly just wants to make it through.

Girls in STEM

DEMOGRAPHICS
Age: 18
Grade: Freshman

TEXTBOOK USE
Given the choice, She prefers to rent an eText because it is cheaper. However, she has trouble remembering her login information and sometimes wishes that she had a physical copy that she could highlight.

LEARNER INFORMATION
She is working 10 hours a week as a student employee and taking 14 credits.

MAJOR
She declared Dance as her major but is considering changing to a STEM field because of the career opportunities..

BACKGROUND IN CHEMISTRY
She took as much Chemistry as she needed to finish high school: one class on Chemistry in the Community. She is a capable student but feels intimidated by CHEM-105.

ONLINE LEARNING SUCCESS
She took an Independent Study course for AP English. She enjoyed the flexibility but missed the opportunity to socialize with classmates.

END GOALS
She wants to get an A in CHEM-105. She hopes that taking this class will help her to decide what she really wants to major in.

Returned Missionaries

DEMOGRAPHICS
Age: 21
Grade: Freshman

TEXTBOOK USE
He waits to purchase his textbooks until he has paid tuition. For that reason, he usually gets his textbook a week or two after the semester has started.

LEARNER INFORMATION
He works part time and is taking 12 credits.

MAJOR
He hasn't decided on a major yet, but he is considering something in the Engineering department.

OTHER INFORMATION
He took one semester at BYU before his mission. He took CHEM-105 and failed the course. He would have trouble keeping up with the course assignments and planning his limited study time effectively.

END GOALS
He wants to pass the course and learn what he needs to succeed in his future coursework.

First Generation Students

DEMOGRAPHICS
Age: 18
Grade: Freshman

She has lower reading, math, and critical thinking skills compared to non-first generation students (Ward, 2012).

LEARNER INFORMATION
Like other students, she underestimates how much reading will be required, "but because [she lacks] some of the preparation and parental wisdom about the college experience that other students enjoy, those impression may be farther off the mark and harder to dispel."(Ward, 2012).

OTHER INFORMATION
The process of registering for classes and getting books is a new and time-consuming process for her.

Has yet to develop help-seeking behavior such as reaching out to TAs, joining study groups, or visiting the professor's office hours.

MAJOR
Undeclared major. She signed up for Chemistry because it fulfills a GE credit. She did not take any high school courses in Chemistry, so this will be her first engagement with the topic. She has "insufficient knowledge about curricular offerings" (W, 2012) and does not realize that she has signed up for a weeder course. She will not recognize a need to re-order her course load until the add-drop deadline is past.

Additional Persona Details

Girls in STEM

One of the target groups of students we hoped this project would help was girls in STEM. These students might have less confidence in their abilities and lower self-efficacy than their peers.

First Generation College Students
Another target group of students was first-generation college students who typically came from low-income backgrounds. The financial burden of a commercial textbook may be more significant for them than for traditional students and their learning curve may be steeper when it came to navigating course resources and creating study plans. We anticipated that providing a free, easily navigable resource would remove some of the extra difficulty that these students faced.

Returned Missionaries
Other groups of students we were concerned about included students who may not be sufficiently familiar with the prerequisite material. For instance, returned missionaries often forgot significant portions of what they had learned in high school chemistry and college algebra (which is a prerequisite course for CHEM-105).

Product Design

Design Details

The core product that was created was an open textbook for general college chemistry that provided students with an easily navigable, streamlined reading schedule, as well as immediate and persistent access to textbook and in-class materials.

In addition to creating the textbook, the project involved establishing a system for collaborating with a faculty member who needed support in the design and development of learning resources. This system consisted of three stages, each delivering valuable results to the faculty member, along with defined processes and workflows. The stages involved analyzing the needs and creating a content map, creating and evaluating a prototype, developing the chapters, embedding material for the face-to-face lectures, and adding features such as instructor review videos.

I developed a digital book sourced from various open educational resources, such as OpenStax, LibreTexts, and content authored by Rebecca Sansom.

The book's chapters were arranged based on the corresponding day of class. We prototyped other organizations and found this was the best organization for both Dr. Sansom and her students. This organization simplified the placement of the embedded content for the face-to-face lectures. This organization was also desirable because the client did not want the additional difficulty of integrating the textbook into a learning management system, so the clarity of the alignment of reading assignment to class day needed to be as clear in the textbook as possible.

Throughout the chapters, I incorporated YouTube videos and PhET simulations. To enhance the learning experience, the answers to chapter examples were hidden and could be revealed by clicking on them. Each chapter also provided links to supplementary practice problems, allowing students to practice further. At the end of each chapter, Dr. Sansom's lecture slides, group participation worksheets, and additional materials for in-class use were embedded.

To summarize, the final product consisted of the open textbook designed for the first semester of general chemistry course, featuring organized chapters based on class days, embedded videos and simulations, interactive example answers, links to supplementary practice problems, and resources for in-class activities.

I incorporated Universal Design for Learning (UDL) strategies into my instructional design to address specific learner needs and achieve project goals. The implementation drew upon two core UDL principles: engagement and representation.

To cater to the principle of providing multiple means of representation, the textbook was designed so that each chapter offered an audio option and each image included descriptive alternative text for all images. These features not only enhance the overall student experience but also benefit students with dyslexia, hearing loss, or visual impairments.

For the principle of multiple means of engagement, the textbook design incorporated video content, PhET simulations, and ensured that the book was mobile-friendly. Additionally, each chapter section began with clearly defined learning goals, and the organization of the chapters facilitated students' understanding of what they needed to read for each day of class.

By drawing on UDL strategies, the design addressed learner needs, achieved project goals, and considered relevant theories and research to enhance the learning experience.

I successfully accomplished the goal of creating a usable resource for Dr. Sansom by the start of the Fall semester. This was achieved through early prototyping, prioritizing the development of a minimum viable product, and subsequently adding features based on their relevance and development time. The project also provided a useful exploration of collaboration between a graduate student and university faculty to create OER.

I took into account constraints imposed by the Chemistry department by collaborating with Dr. Sansom to create a resource within those parameters.

To address the time constraints faced by Dr. Sansom, her involvement was focused on essential Subject Matter Expert (SME) tasks, while routine quality checks were assigned to her Teaching Assistants (TAs). All necessary components requiring input from content experts were completed, allowing sufficient time for feedback consideration and implementation.

Furthermore, recognizing the necessity of having a usable product by the Fall semester, I employed rapid prototyping techniques to obtain approval on a foundational design from all stakeholders. Subsequently, I developed a minimum viable product and, when feasible, added optional features. As a result, the textbook was ready for use by the Fall semester of 2022.

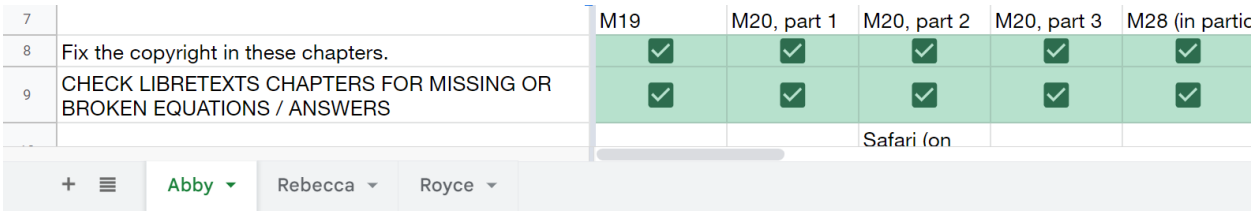
I referred to comparable digital textbooks, such as the BIO 365 OER textbook from BYU-Idaho, which demonstrated the effectiveness of consolidating lecture topic information on a single page instead of dividing it across multiple pages. Similarly, the BIO-265 textbook from BYU-Idaho showcased the benefits of organizing topics into multiple sub-pages. Drawing from these examples, I made the decision to group the General College Chemistry chapters into course Units.

Unit I. Atoms

1. Introduction
2. Matter
3. Measurement
4. The Atom
5. Periodic Table
6. Moles & Mass
7. Light
8. Blackbody Radiation, Photoelectric Effect
9. Atomic Spectra, Bohr Model
10. Orbitals & Quantum Numbers
11. Electron Configurations
12. Periodic Trends

Unit II. Molecules

I have previously outlined the digital product. Now, I will focus on the structural and operational aspects of my design. I established and managed a workflow for the book's production, ensuring a systematic and efficient process. Additionally, I implemented a review and feedback mechanism involving the professor and her Teaching Assistants (TAs) to maintain quality and gather valuable SME insights.



7		M19	M20, part 1	M20, part 2	M20, part 3	M28 (in partic
8	Fix the copyright in these chapters.	☑	☑	☑	☑	☑
9	CHECK LIBRETEXTS CHAPTERS FOR MISSING OR BROKEN EQUATIONS / ANSWERS	☑	☑	☑	☑	☑
				Safari (on		

Abby Rebecca Royce

Screenshot of module fixes to be implemented.

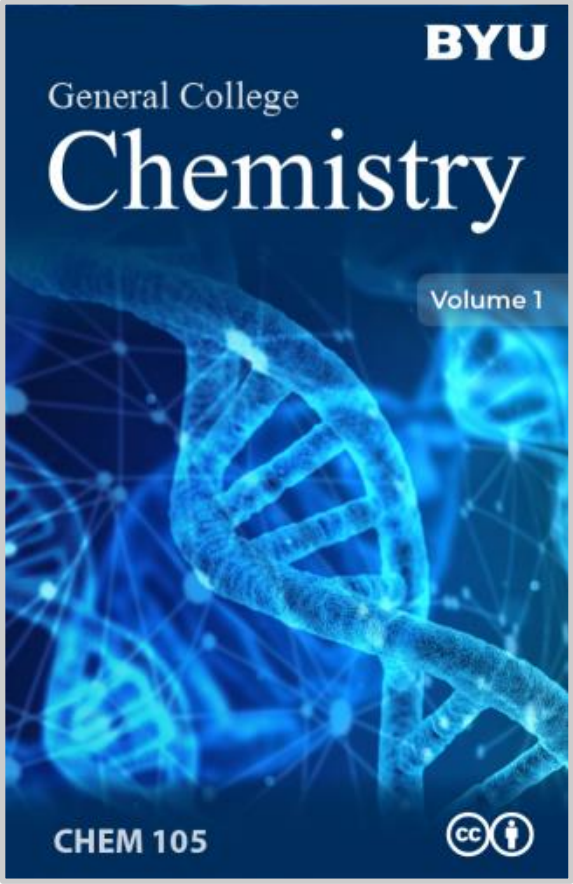
Module-Level Checks	Checked?	Reviewer Notes	Fixed?	Abby's notes
Links have descriptive text. No plain URLs or links text like "here," "site," or "link."	☑			
Module has a copyright attribution	☑			
The footnotes are formatted consistently across modules	☑			
The supplemental exercises are formatted as a callout box.	☑			
Each callout box is consistent in capitalizing the titles	☑			
Any link that takes you outside of the module should open in a new window/tab. Note any links that are broken or that do not open in a new window/tab.	☑	Broken links: Figure 38.1 just under the subtitle "Bond Strength: Covalent Bonds," Figure 38.2 under Table 38.2	☑	Fixed.

Mod 36 | Mod 37 | Mod 38 | Mod 39 | Mod 40 | Mod 41

Screenshot of SME review sheet.

Actual Product

Here is a link to the General College Chemistry textbook. Here are several screenshots that illustrate the contents available in the textbook.:



Book cover

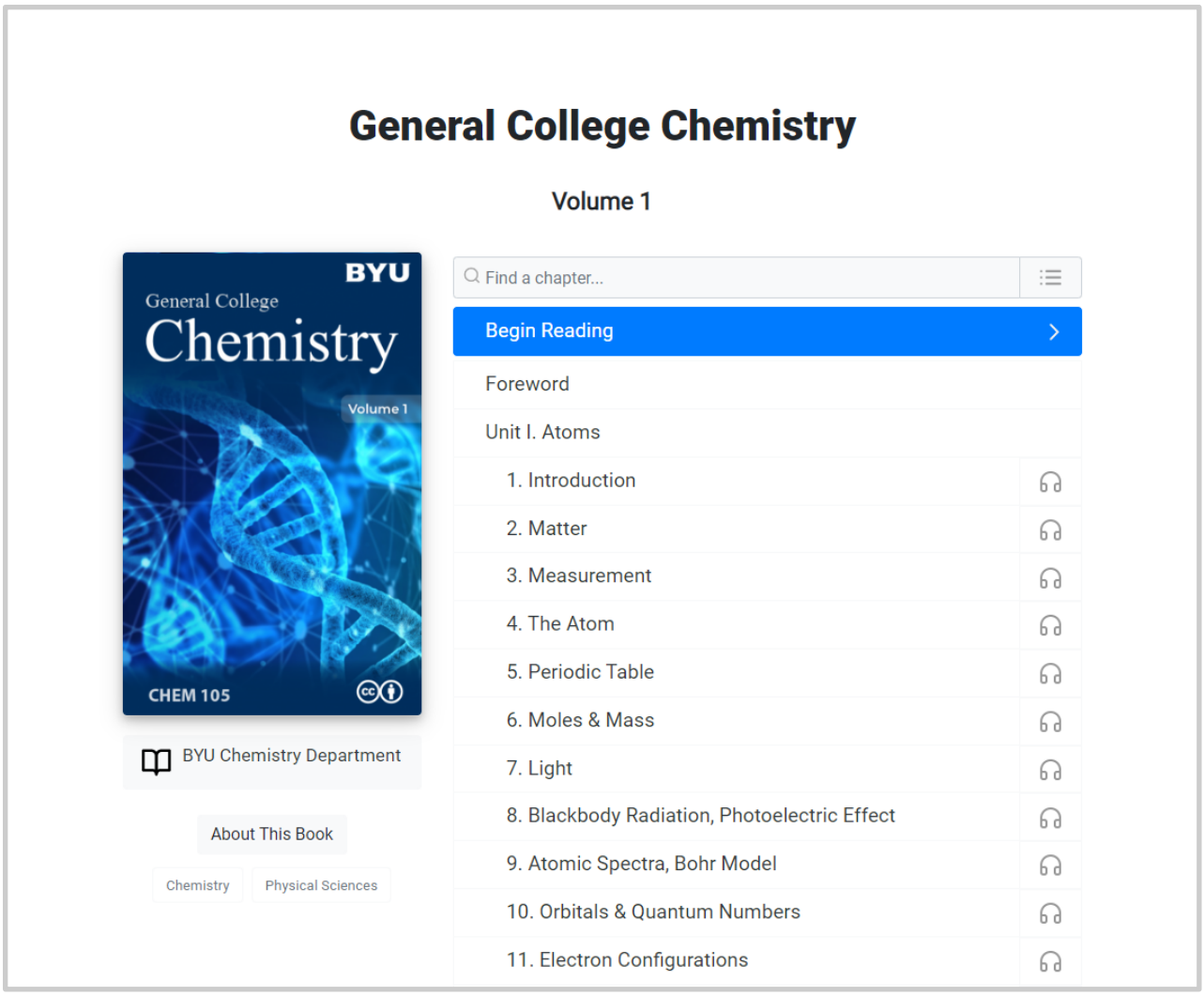
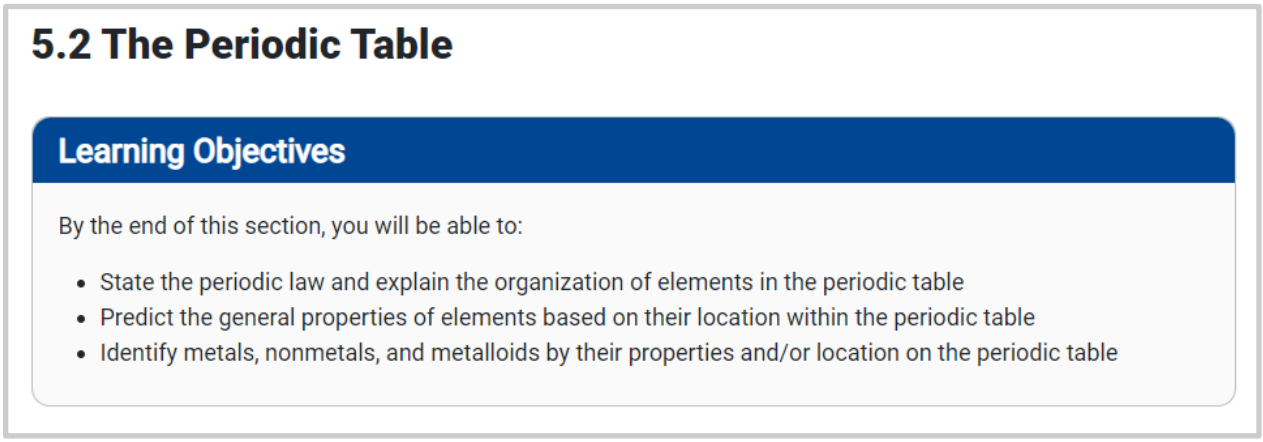


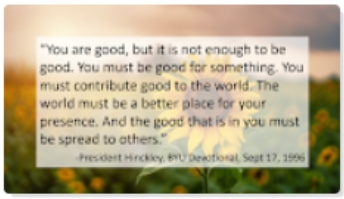
Table of Contents



Learning Outcomes

Embedded Files

Files



05 Periodic Table.pdf

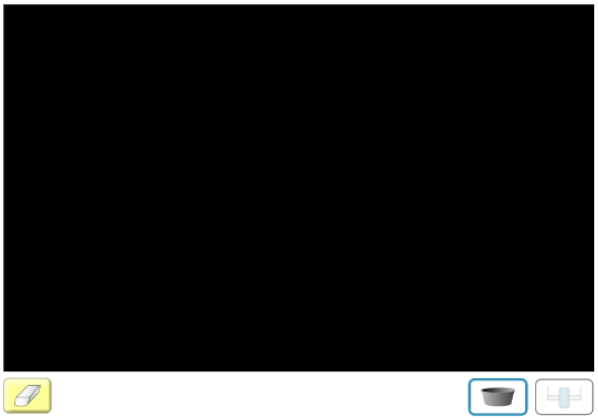
Participation 05-Peri…

PS05-Periodic Table…

Open in Google Drive

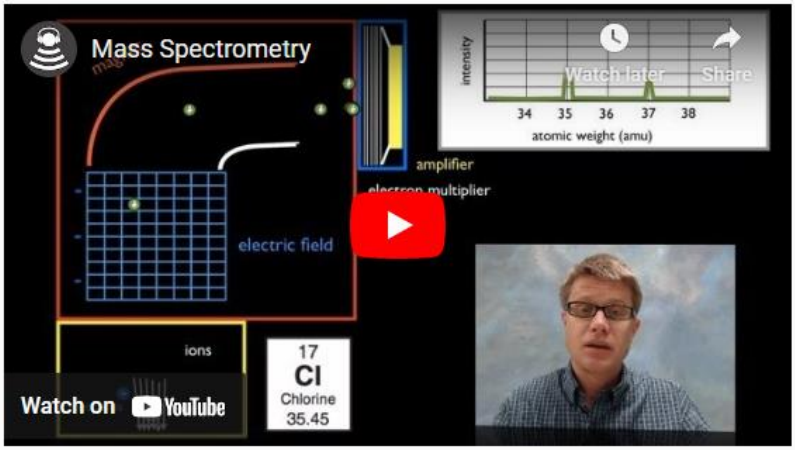
Link to Learning

Use this simulation to make mixtures of the main isotopes of the first 18 elements, gain experience with average atomic mass, and check naturally occurring isotope ratios using the Isotopes and Atomic Mass simulation.

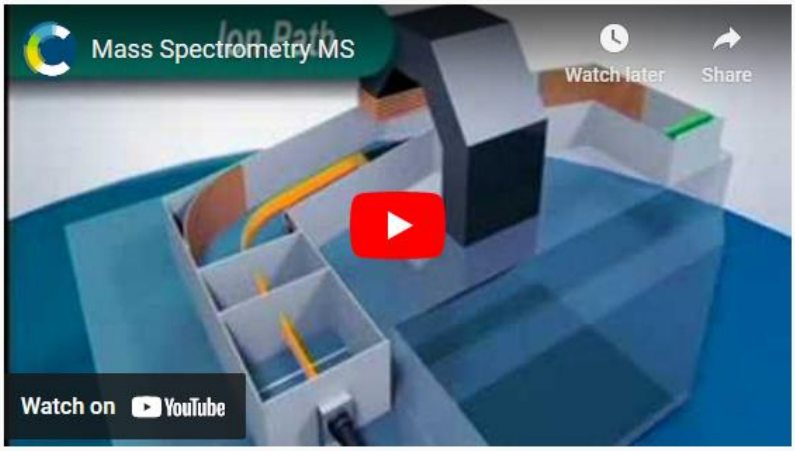


Embedded PhET simulation

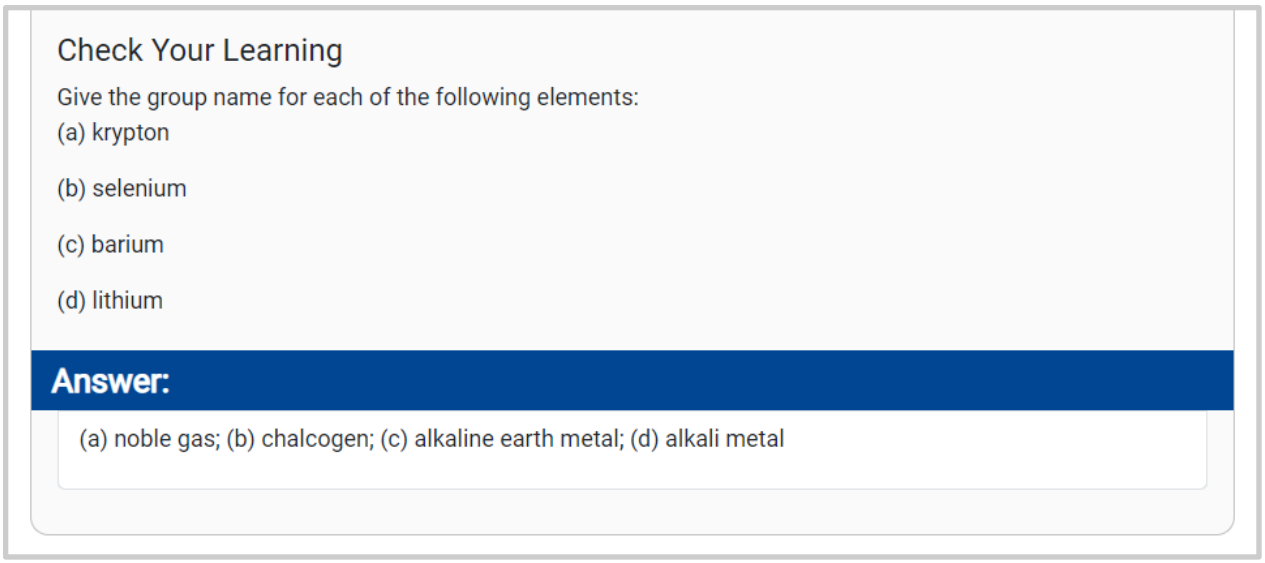
Watch this explanation of of mass spectrometry.



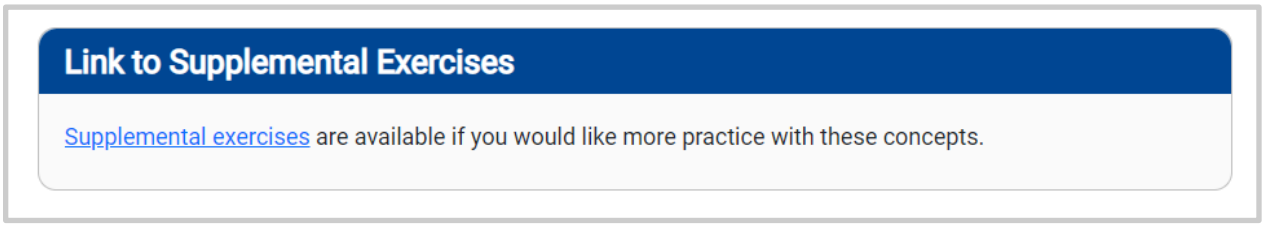
Watch this video from the Royal Society for Chemistry for a brief description of the rudiments of mass spectrometry.



Embedded Videos



Question and Answers



Link to Supplemental Exercises

Video Walkthrough

Here is a video walkthrough of some of the instructional strategies and features for the textbook.

Design Process and Evolution

The design process comprised several key phases:

1. Initial phase: This involved establishing needs, schedule, and expectations, along with conducting reviews with former Chemistry students. Additionally, it included exploring available tools and acquiring proficiency in their usage.
2. Reading creation phase: This phase began rapid prototyping for a textbook chapter to secure stakeholder approval for a foundational design. It culminated in the creation of all of the textbook chapters. This involved remixing selected OER readings to add customizations and align them with Dr. Sansom's topic map. It also entailed addressing new feature requests, accommodating changes in the design process, and conducting usability testing.
3. Review and refinement phase: A comprehensive review process was implemented to evaluate the book material, ensuring necessary fixes were made to enhance its quality and usability.
4. Post-interview phase: This phase involved conducting post-interviews to gather feedback and insights.

Overall, the design process encompassed stages of initial assessment and expectation setting, reading creation with responsiveness to feedback, review and refinement, and post-interview analysis.

Throughout the project, my work involved the following major interactions:

1. Communication and Planning:
    a. Met with Sansom and Kimmons to establish a communication plan and determine the key aspects of a minimum viable product.
    b. Conducted interviews with former Chemistry students to gather insights about their experiences with the textbook.
    c. Created a prototype chapter for evaluation and received valuable feedback.
2. Reading Formatting and Tool Development:
    a. Received a list of collated readings from Dr. Sansom and formatted them within the textbook website.
    b. Collaborated with Dr. Kimmons to develop any necessary new scripts or tools required for the project.
3. Chapter Review Process:
    a. Identified common issues within textbook chapters and established a systematic chapter-by-chapter review process.
    b. Noted issues I identified, such as the need for abstracts, and assigned them to the Teaching Assistants (TAs) for resolution.
    c. Addressed issues found by TAs, such as runoff equations, missing headings, or broken PhET simulations.
4. Usability Testing:
    a. Recruited participants for usability testing and conducted guided interviews to assess the user-friendliness and effectiveness of the textbook.

These interactions encompassed activities related to communication and planning, formatting and development, chapter reviews and revisions, as well as usability testing through guided interviews.

Product Implementation

One of the features of this project is that the implementation was extremely easy. All that was needed was for students to be given the URL for the online book. Dr. Sansom reported that there were no issues with textbook access for any of her students over several months. Dr. Sansom reported that in the first semester of the OER textbook's use, the self-report data from students indicated that near the end of the semester forty to fifty percent of students were still reading the textbook. This was an encouraging uptick from the ten percent of students that typically were still reading the text by the end of the semester.

Evaluation

In the final phase of the project, I conducted interviews to assess the overall success of the project. My evaluation primarily focused on determining whether the project goals had been accomplished, specifically with regards to enhancing accessibility and streamlining organization. Additionally, I conducted interviews to evaluate the extent to which the client's or sponsor's objectives were met. In this section, I will provide a concise summary of the key findings derived from these interviews.

Project Goals

Information from this section comes from UX interviews with students, information provided by Dr. Sansom in an interview, and students' anonymous end-of-course feedback.

UX Interviews to Determine Navigability

The goal was for students to easily access and navigate the textbook. I assessed whether this outcome was achieved by doing guided usability interviews. Here's what I asked:

Questions

- Have you used a digital textbook before?
    - positive or negative, generally
- What are the pain points of using this book?
- What are the good/best parts of using this book?
- What devices do you use to read the book? Laptop, phone, tablet, printed, etc.
- Do you do the readings?
    - Why or why not?
- When and where do you typically read?
    - Why or why not?

Scenarios

- Pull up the textbook. [How many clicks does it take them?]
- Find and read module 20.
- How do you check the answer to the example?
- [Prompt to jump to 21.3 title Do they use the side nav?]

- [start from the beginning] You're preparing for a test, and you forgot what Henry's Law means. Could you find that? [can be found through chapter search]
- [start from the beginning] Your assignment requires you to remember what noble gas is. Could you find that? [Can be found with hamburger menu search of book]
- [start from the beginning] You hear a word [chirality] and you don't know what it means. Can you find it in the book?

Streamlined Organization

Comparing the new textbook to the traditional textbook, Dr. Sansom said "one of the things I think was different was that because it was organized by the day of class--and [students] did comment on the organization of it: it was very organized, it was easy to follow--was that we only put things in the chapter that were things that we were going to talk about that day in class. So, normally in a regular textbook, they'll have a reading assignment and there will be some extraneous nonsense that's not part of [the class discussion] but it's too hard to be like 'read until the second paragraph and then stop and skip that one and go to the next one,' you know? You don't do that when you give a reading assignment in a regular textbook." Because of the nature of the creative commons licenses, we were able to remix content to remove all extraneous material and supplement readings in order to align the reading with Dr. Sansom's lectures.

Also on textbook organization, she reported "I do think that [students] appreciated the organization. Having it be organized by the day of the class. And having the slides and the worksheets and whatever that they needed for that day contained in the same place."

Here are comments from student interviews and feedback:

- A student reported that the course was "super organized. We had an accurate textbook as well as a textbook that followed the lectures super well."
- "I was often confused in class. But when paired with the online textbook and homework, it was a bit better."
- One student commented that navigating the textbook "seems pretty intuitive."
- A student commented: "I haven't had trouble finding what I need yet. The title of the lecture in class matches, so it's easy."

Though students took different paths to finding certain content, all were able to navigate to what they were instructed to find. Dr. Sansom also published her map aligning the lectures to the book chapters, which was helpful to students navigating.

In summary, there is evidence that the new textbook made it easy for students to navigate to and in assigned readings. Students appreciated the accuracy and alignment of the textbook with the lectures, as well as the intuitive navigation and the ability to easily locate specific content within the textbook.

Improved Access

Dr. Sansom reported that students were able to easily find the textbook and that there were no problems with textbook access.

A student commented "easy access to textbook and helpful materials including review videos." In user experience interviews with students, one student said "at first, the book was kind of hard to find because [Dr. Sansom] put the link in a content page on LearningSuite but I just bookmarked it and now it's just right there [easy to find]."

One student said "I like that [the chapter] tells you how much time it thinks you'll take." She plans her readings based on these time estimates. "That's a good indicator of how long it will take. I feel like I'm somewhere in the average of the time it will take to read and the time to listen." She also said "the audio recording, too, is nice. [...] Sometimes I know I just need that."

These interviews suggested that the new textbook gave students easy and convenient access to the textbook. And because the textbook is free, each student has equal access to this resource rather than some students opting out because of cost (Sansom et. al, 2021). Thus, this project improved access to the textbook.

Client/Stakeholder Goals

In an interview with Dr. Sansom, she reported that she did not have the time and capacity to do this project by herself and that "this just would never have happened if you hadn't done all of that work. You did so much work." As noted in the environmental analysis, one of the greatest obstacles to instructors adopting OER is the time cost of design and development. Ultimately, the project successfully achieved Dr. Sansom's objective of providing her general college chemistry students with an OER general chemistry textbook.

This project also achieved other stakeholder goals by providing a real-life example of graduate student work with faculty to create OER for a course. Furthermore, the project's implementation directly contributed to enhancing and introducing content creation tools on the open.byu.edu platform. For instance, the manual re-numbering of images and figures from existing OER content in the current textbook prompted the development of an automated tool to streamline this process.

Lastly, I'll mention the cost savings to students. In various sections of the CHEM-105 course, the price range for the required commercial textbook typically spans from $123 to $180 when purchasing a new copy. However, if students opt to rent or acquire a used version, they can potentially bring down the cost to as little as $40.00. Considering an approximate enrollment of 200 students in Dr. Sansom's CHEM-105 lectures for the Fall semester of 2022, the OER textbook developed for this project presents an opportunity for students to save anywhere between $8,000 and $36,000 for one semester. Furthermore, the OER book eliminates the need for students to search for a more affordable used book, delay studies as they wait for mail delivery, share their book with another student, or worry about returning a rented book before completing their final exam preparations. Thus, this project achieved the goal of savings money for students.

Other Findings

Another encouraging finding was that during Fall semester, students' textbook use increased. Dr. Sansom reported that "[throughout Fall semester] I asked students who used the book. And I'll remind them to read before we get to something hard. I asked them who was reading. I asked them regularly, several times throughout the semester and by the end of the semester we were still like 40 or 50% of people who were reading, which is way higher than normal. Normally it might be like 10%. And I was really encouraged by that."

Testaments to the overall quality of the book, here are a couple more comments from students' end-of-course reviews:

- "Even the book [...] is great."
- "I really liked the textbook."

A student reported her use of the lecture slides: "Sometimes I'll pull of the readings and skim them and compare them to the lecture slides to see if there's anything I don't recognize." If there is, she'll read more in-depth. Thus, the embedded lecture slides are a useful feature for students even outside of their intended in-class use.

Possible Places for Improvement

The interviews did reveal some places for possible improvements. On the process of updating materials, Dr. Sansom reported "It's a little bit hard and tedious because there were so many places to update things." In order to lock in the formatting for special characters (including math and chemical equations), embedded documents were given to students as PDFs. And to ensure both that any updates to face-to-face materials were reflected in the embedded documents but that students did *not* have access to answer keys, we created designated "for students" folders. This clarified where to put final updates after working documents were updated. However, it did create another place where files would need to be updated every time an update was made.

While the majority of students assumed that the click-to-reveal answers for the examples were clickable, two students did not at first realize that they could click to reveal the answers.

Two of the students commented that while they liked the organization of the textbook in terms of being able to find readings, they got bored of scrolling through the very long chapters. In more detail: "There are pros and cons [of the book], I feel like. It's nice that you can access it almost any time. That's pretty good. But I have a hard time with any digital format. This chapter is so massive, I just keep scrolling. I think it makes sense, though, since I'm supposed to read the whole thing for class. It can be harder to skim, though. I guess I could just use control F and find things. I'm not the biggest fan of digital, though. I think they're convenient and I'll use them and if they're free it's even better because then you don't have to pay for a textbook and carry it around. But the chapter can feel longer than it actually is just because there is so much scrolling." There is tension between the intuitive navigation (that allows students to easily align reading assignments with lecture days) and an organization that breaks up their substantial reading assignments into smaller chunks.

Conclusion

The design project involved creating an open textbook for general college chemistry that offered students a user-friendly reading schedule and easy access to textbook and in-class materials. Additionally, a collaborative system was established to support a faculty member in the design and development process. The textbook incorporated various open educational resources and was organized based on class days for clarity. It included embedded videos, simulations, interactive example answers, and links to supplementary practice problems. The design implemented Universal Design for Learning (UDL) strategies, focusing on engagement and representation to address learner needs and achieve project goals.

The evaluation of project goals revealed that the new textbook successfully addressed the objective of providing students with easy access to course materials. Feedback from students indicated that the textbook's navigability was intuitive and that they were able to find the content they needed. The organization of the textbook, which aligned with Dr. Sansom's lectures, received positive feedback, with students appreciating the concise and focused approach. Furthermore, the project improved access to the textbook, as reported in students feedback and confirmed by Dr. Sansom. Students praised the easy accessibility and the inclusion of helpful materials such as review videos. The availability of multiple modes of access, along with the free nature of the textbook, ensured that all students could equally benefit from the resource.

The project successfully achieved client and stakeholder goals, providing a usable product by Fall semester and providing a real-life example of a graduate student collaborating with faculty to create OER for a course. Additionally, the project was completed ahead of schedule, allowing for the incorporation of optional features such as click-to-reveal answers and instructor review videos. The project also contributed to the enhancement of content creation tools on the open.byu.edu platform, streamlining the process for future content updates.

While the findings were largely positive, there were some areas identified for possible improvement. These included ameliorating the tedious nature of PDF updates and clarifying instructions regarding clickable elements within the textbook. Students also expressed occasional difficulties with the lengthier chapters.

In conclusion, the project achieved its goals of enhancing accessibility and organization, as evidenced by positive student feedback and the successful alignment of the textbook with Dr. Sansom's lectures. The project also fulfilled client and stakeholder objectives. The identified areas for improvement will serve as valuable insights for further enhancements in future iterations of the project. Overall, the design and development of this product meaningfully contributed to the elimination of obstacles that hinder student success.

Annotated Bibliography

The objective of this section is to synthesize the relevant literature pertaining to my project. Each reference will be summarized concisely, capturing the key aspects that make it valuable and useful for my project. I will group related references together and synthesize their annotations to present a comprehensive understanding of the topic at hand.

OER Efficacy

The effectiveness of OER serves as a motivating factor and is crucial for the success of this project. Consequently, studying the efficacy of OER was essential not only to provide justification for the project but also to gain insights into the benefits and advantages associated with OER.

1. **Hilton III, J., Fischer, L., Wiley, D., & Williams, L. (2016, December). Maintaining Momentum Toward Graduation: OER and the Course Throughput Rate. International Review of Research in Open and Distributed Learning, 17(6), Volume 17, Number 6.** This article explores the potential of OER to replace traditional, commercial textbooks in higher education courses. It presents a case study comparing the performance of students who used traditional textbooks against the performance of students who used replacement OER. The study revealed that students who used OER exhibited significantly better course throughput rates. These results suggest that OER can not only reduce the financial burden on students in higher education, it can also enhance student success.
2. **Hilton, J. Open educational resources, student efficacy, and user perceptions: a synthesis of research published between 2015 and 2018. *Education Tech Research Dev* 68, 853–876 (2020). https://doi.org/10.1007/s11423-019-09700-4** This article examines four years of research related to OER. The author synthesizes this research to reveal that "95% of published research indicates OER does not lead to lower student learning outcomes" and that students and faculty perceive that OER is of equal or higher quality compared to traditional textbooks.
3. **Fischer, L., Hilton, J., Robinson, T.J. et al. A multi-institutional study of the impact of open textbook adoption on the learning outcomes of post-secondary students. J Comput High Educ 27, 159–172 (2015). https://doi.org/10.1007/s12528-015-9101-x** This is another study that examines differences in outcomes between students who used OER and those who did not. This study was conducted across 10 institutions, comparing about 5,000 students using OER to over 11,000 students using commercial texts. The student found that "students whose faculty chose OER generally performed as well or better than students whose faculty assigned commercial textbooks."
4. **Feldstein, A., Martin, M., Hudson, A., Warren, K., Hilton, J., & Wiley, D. (2012). Open Textbooks and Increased Student Access and Outcomes. European Journal of Open, Distance and E-Learning.** Feldstein et al. conducted a study at the Virginia State University School of Business, revealing that the replacement of traditional textbooks with openly licensed books resulted in improved access and outcomes for students. The study indicated that students in courses utilizing OER textbooks exhibited higher grades and lower rates of failing and withdrawal compared to those in courses without openly licensed texts. Interestingly, these researchers emphasized the significance of allowing flexibility in the mode of content delivery to enhance accessibility for students. This finding is particularly relevant to my own project as we aimed to provide students with multiple avenues for accessing the content.

These articles offered compelling rationale for the creation of an OER textbook as a solution that would simultaneously enhance student success while operating within the departmental requirements for course content.

Additional Research for Environmental Analysis

1. **Rebecca L. Sansom, Virginia Clinton-Lisell, and Lane Fischer. (2021). Let Students Choose: Examining the Impact of Open Educational Resources on Performance in General Chemistry. Journal of Chemical Education 2021 98 (3), 745-755. DOI: 10.1021/acs.jchemed.0c00595.** This article serves as additional research for my environmental analysis and focuses on the reasons why many students opt for general chemistry courses. It delves into the challenges faced by instructors when considering the adoption of Open Educational Resources (OER) materials. Specifically, it explores the barriers and the effort required for instructors to implement OER materials into their teaching practices, with a particular emphasis on textbooks. The article sheds light on factors influencing students' decision to purchase or forgo purchasing textbooks, as well as the impact of textbook usage on success rates in general college chemistry courses. Several key reference points highlight the significance of this source. First, it emphasizes that the cost of commercial textbooks is a significant source of stress for students (p. 745). Additionally, it highlights the time and effort burden placed on instructors when accommodating OER materials (p. 745). Lastly, it underscores the potential benefits to students, such as reducing the financial burden of college and alleviating stress, as well as enabling greater investment in education (p. 746). These findings align with the research presented in the "OER Efficacy" section of this annotated bibliography, further reinforcing their importance.

Additional Research Related to Precedent Product

1. **Palmiotto, A. (2018, March 30). How OpenStax books are made. https://openstax.org/blog/how-openstax-books-are-made.** This article provides a comprehensive overview of the book creation process employed by OpenStax. This information is relevant for my project given that a significant portion of Dr. Sansom's selected readings are sourced from OpenStax content. Of particular significance is the assurance that OpenStax materials align with the quality standards set by the BYU chemistry department, as evidenced by the meticulous quality control measures in place. These measures involve extensive chapter reviews and revisions conducted by numerous faculty members from various colleges, followed by additional reviews prior to publication.

Additional Persona Research

1. **Ward, Lee, et al. First-Generation College Students : Understanding and Improving the Experience from Recruitment to Commencement, John Wiley & Sons, Incorporated, 2012. ProQuest Ebook Central, https://ebookcentral.proquest.com/lib/byu/detail.action?docID=832570.** This book provides valuable insights into the experiences of first-generation college students, offering a unique perspective that I was not able to obtain through student interviews. It sheds light on various aspects of the first-generation student experience. Specifically relevant to my persona research, the authors explore how first-generation students may have limited understanding of available curricular offerings. Additionally, the book highlights the financial challenges often faced by first-generation students.

Note on Copyediting

The author used GPT-3, OpenAI's large-scale language-generation model, to copyedit this report, using prompts such as "copyedit this passage and suggest edits." Upon generating copyedited versions of passages, the author reviewed and revised the edits and takes ultimate responsibility for the content of this report.