

Universal Design for Learning (UDL) in the Academic Library: A Methodology for Mapping Multiple Means of Representation in Library Tutorials

Katy Kavanagh Webb and Jeanne Hoover

Librarians designed a biology tutorial not only to address an assignment, but also to make tutorials more accessible to students with various learning styles. The Science Librarian created the content by using aspects of the Information Literacy Standards for Science and Technology/Engineering, an informal survey of biology faculty, and assignments for the biology labs. The Instructional Design Librarian created multiple modules that engaged users through text, images, audio, and interactive tutorials. The researchers used Universal Design for Learning principles to address multiple learning styles, specifically multiple means of representation, and created a mapping technique for those principles that can be applied to any library tutorial. To assess the effectiveness, students with learning disabilities completed a usability test on the tutorial.



Librarians at East Carolina University (ECU) revised an existing biology LibGuide to incorporate Universal Design for Learning (UDL) elements and transform it into an online tutorial. UDL is an educational framework for creating instruction that allows for inclusion of many different types of learning preferences into the targeted curriculum. The Science Librarian at Joyner Library serves as a liaison to not only science-related fields, but also Project STEPP, an innovative grant-based college retention program for undergraduate students with multiple learning disabilities. This unique combination of duties became the basis for a project to improve a Biology 1051/1101 tutorial with the Instructional Design Librarian at Joyner Library to include UDL.

BIOL 1051/1101 is a lab course that counts as a required course for all students entering the science, technology, engineering, and mathematics (STEM) fields and a general education science credit for non-STEM majors. On average, BIOL 1051 has 15–20 sections per semester with 45–50 students per section. BIOL 1101 has 15–17 sections per semester with 45–48 students per section. Both lab classes

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require students to complete an assignment on locating primary and/or secondary resources in biology. Students in BIOL 1051 are required to find a primary and secondary source on the same topic. Typically, students choose news articles from CNN or *The New York Times* as their secondary sources and use library databases to locate primary sources. Students in BIOL 1101 need to find three primary sources on the same topic. This topic is related to a lab assignment and students use these primary sources in their lab reports. Historically, these courses caused many bewildered students to come into the library's reference desk in search of help and caused the Science Librarian to receive a large amount of one-on-one consultation requests. The instructors of the courses did not have time to bring students over to the library for instruction. The librarians felt that a comprehensive biology tutorial needed to be developed to help students with their assignments. The tutorial not only supplemented information provided by biology instructors but also helped reference librarians answer research questions consistently. Reference librarians used the tutorial when biology students came to the desk. This helped librarians who were not familiar with the science curriculum answer any questions related to the assignment. Over the course of the 2012/2013 school year, this tutorial was accessed 1,397 times: 892 times in the fall of 2012, 391 times in the spring of 2013, and 114 times in the summer of 2013. It is linked in the BIOL 1051 and 1101 Blackboard sites, listed on the assignment and in the syllabus, and verbally suggested to students by librarians at the reference desk.

The ADDIE Model for instructional design was used in the completion of new learning objects in the tutorial. The ADDIE Model, which stands for Analysis, Design, Development, Implementation, and Evaluation, is the generic instructional design framework that leads the tutorial creator through the process of devising learning objects in a step-by-step fashion.¹ The researchers defined learning objects as any piece of the tutorial that teaches an aspect of library research in the sciences. A few examples of learning objects used in the tutorial are screencast tutorials, instructional cartoons, and audio clips. This study will report on elements of research conducted by the librarians during four stages of ADDIE: Analysis, Design, Development, and Evaluation. During the Analysis phase, librarians surveyed biology instructors on the needs of the students. The Design phase included the creation of the tutorial based on UDL principles and findings from the Analysis phase. For the Development phase, the librarians used a mapping technique to identify the location and distribution of different learning strategies in the tutorial, including audio, visual, kinesthetic, and text. To judge the effectiveness of the tutorial, the Instructional Design Librarian conducted usability (user) tests with students with multiple learning disabilities from Project STEPP during the Evaluation phase. Usability is defined in the International Organization for Standardization's standard ISO 9241 as "the capability of the software product to enable specified users to achieve specified goals with effectiveness, productivity, safety and satisfaction in specified contexts of use."² Thus, the user tests focused on the ability of students to find information related to the assignment, as well as the navigability, ease of use, and overall satisfaction with the tutorial. The usability testing procedure used by the researchers was the speak-aloud protocol advocated by Nielsen in his seminal book, *Usability Engineering*.³ The researchers applied for an Institutional Review Board (IRB) Approval before conducting the tests. Each of these phases will be outlined in the paper with their own Methods and Results sections to accurately represent the process by which the tutorial was conceptualized, analyzed, created, and tested. By preserving this process, it will allow future librarians and instructional designers to follow similar steps for tutorial creation with UDL principles.

Literature Review

The concept of UDL originally came from the application of Universal Design in architecture developed by Ronald Mace of the Center for Universal Design at North Carolina State University.⁴ The philosophy of Universal Design revolves around the idea that environments need to be designed to be accessible or inclusive to everyone, regardless of whether or not they have a disability.⁵ The development of Universal Design, along with the passing of the American Disabilities Act, helped push the philosophy of Universal Design for not only architecture, but also educational settings.⁶ According to Kortering, McClannon, and Braziel, “UDL does not imply that one size fits all; rather, it recognizes the unique needs of every learner.”⁷ This framework is encouraged in special education curriculum as a way for students to be successful in school by giving students the opportunity to learn according to their strengths.⁸ By constructing curriculum with UDL in mind, educators cast a larger net that catches students regardless of disability or learning preference.

According to the National Center for Education Statistics, there are about 6.4 million students between the ages of 3 and 21 who qualify for assistance under the Individuals with Disabilities Education Act (IDEA) enacted in 1975.⁹ While there has been some statistical decline in the percentage of students who qualify for assistance, this still represents about 13 percent of the student population in public schools.¹⁰ IDEA recognizes disabilities ranging from specific learning disabilities to emotional disturbance to traumatic brain injuries. Currently, specified learning disabilities represent the highest percentage of students who qualify for free education under IDEA. Additionally, 80 percent of students with disabilities between the ages of 6 and 21 spent the majority of their day in general education classes in 2011–2012.¹¹ As these students move forward with their education, librarians should be aware that some students in their classroom may have a disability.

UDL can be divided into three main components: Multiple Means of Representation, Multiple Means of Engagement, and Multiple Means of Expression.¹² Ideally, educators apply these components to their lessons, which give students various ways to collect information, interact with it, and respond to it. Kortering, McClannon, and Braziel state that “UDL as a framework provides teachers with a context for focusing their instruction on how best to help students access . . . the course content by providing students with multiple means of representation, expression, and engagement.”¹³ Ying Zhong adds to this argument, saying “UDL anticipates diversity in learners and takes their needs into consideration from the very beginning of course planning.”¹⁴ Since UDL embraces multiple avenues for students to learn, students can use the formats that best suit their learning preferences.

The literature and theories on learning styles are extensive and vast. According to Lori Mestre, there are about 70 different approaches and theories discussing various learning styles.¹⁵ While there are various philosophies on learning styles, the researchers focused on a learning preferences approach where a student’s sensory learning may include auditory, tactile, and visual (verbal and nonverbal).¹⁶ A UDL approach to instruction asks educators to consider all learning preferences while developing a curriculum, since students can fall within multiple learning preferences.¹⁷

UDL is a relatively new framework in the library field. For decades, libraries have adapted physical space and services to allow users with disabilities to access resources. At its core, the first principle of UDL, multiple means of representation, has been addressed in library literature as using different approaches or frameworks. Zhong recently applied UDL principles to face-to-face library instruction, specifically focusing on Boolean logic.¹⁸ Her findings indicated that, while only a small portion of her students self-identified as having a disability, the majority of students indicated that

UDL principles enriched their library instruction session.¹⁹ Zhong's findings confirm the benefits of using UDL principles in library instruction. Ted Chodock and Elizabeth Dolinger applied Universal Design for Instruction, a parallel framework to UDL developed by the Center on Postsecondary Education and Disability at the University of Connecticut.²⁰ Chodock and Dolinger further explain that Universal Design removes the notion that only a portion of students will successfully learn from an instruction session. Instead, these principles create an effective lesson that can be digested by any student.²¹ Additionally, many researchers have reported the benefits of using multiple modalities in library instruction and online tutorials. In a survey conducted by Mestre et al. on librarians' use of learning objects for instruction, they found that librarians knew the importance of including multiple learning objects that incorporate different modes, like using text, audio, graphics, and video to address preferred learning styles.²² In a separate study, Mestre found that students better recalled information and successfully recreated the steps provided by static tutorials versus a screencast tutorial.²³ Specifically, 16 out of 21 participants favored static tutorials regardless of their learning styles for a number of reasons.²⁴ By using the static tutorials, students found that they could be active participants, easily navigate the tutorial, use images and listed steps for directions, and jump to different sections of the tutorial as needed.²⁵ Nancy Dewald analyzed pedagogy for online instruction and found that interactivity is essential for students to have motivation to complete the tutorial and to help them expand their research skills.²⁶ In another article, Mestre states that students need to have a variety of ways to interact with the materials because they often need multiple ways to process information before they can fully learn the material.²⁷ By giving students a variety of choices to interact with material, they can choose the formats that best suit them.

Over the past 20 years, there have been multiple studies on the effectiveness and usefulness of online tutorials for library research. In a study conducted on the comparison of online versus in-person instruction, Nichols, Shaffer, and Shockey found that online tutorials are just as effective as in-person instruction.²⁸ Additionally, there have been numerous studies on the effectiveness of science information literacy tutorials.²⁹ Dewald emphasizes the importance of online tutorials to be short and include summaries to help students learn new research skills.³⁰ A number of studies encourage designers to include learning outcomes for students.³¹ Tutorials, such as one designed by Ligaya Ganster and Tiffany Walsh at the University at Buffalo, have included learning objectives or a list of ways the tutorial can help students.³² Mestre et al. noted in their study that the majority of librarians recognize the importance of including learning outcomes in online tutorials.³³ Li Zhang suggests that "the librarian and the designer need to place text with caution and try not to fill a single webpage with a wall of text."³⁴ Zhang further explains that librarians need to consider color, graphics, navigation, interaction, audio, and visual pieces of a tutorial.³⁵ Mestre recommends that, for an online tutorial to be successful, the designers must include helpful multimedia, minimal text, navigation, and a feedback or assessment tool.³⁶ Additionally, her best practices include that the information should be relevant to the students and the tutorial should be adaptable based on student preferences and skills.³⁷ All of these pieces play a role in the success and effectiveness of an online tutorial. Mestre notes that tutorials "can facilitate a teachable moment at the point of need, and can be embedded within course sites."³⁸ Additionally, online tutorials do not take valuable time away from class lectures. Instead, students can complete tutorials at any time.

Assessing the effectiveness of tutorials can be completed using various measurements such as usability testing and surveys.³⁹ According to the best practices for online tutorials developed by Barbara Blummer and Olga Kritskaya, librarians need to have a way of assessing online modules.⁴⁰ Blummer and Kritskaya note that librarians are

using “usability tests, pilot studies, surveys, and anecdotal observations... pre-test and post-test scores as well as student and instructor feedback.”⁴¹ Katherine Stiwinter used usage statistics, a pre- and post-test, and a citation analysis to evaluate the effectiveness of her online tutorial.⁴² Zhang mentions that librarians can include feedback into an interactive quiz as a way to evaluate a tutorial too.⁴³ Sach et al. assessed their tutorials through a combination of focus groups, quizzes, and a faux research project.⁴⁴ What is clear in the literature is that librarians need to successfully evaluate their tutorials to ensure that they include options for students with different learning preferences along with meeting their goals and outcomes for the tutorial.

Analysis Phase: Informal Survey

Methods

Before the biology tutorial design began, the science librarian asked biology professors to complete a short three-question informal survey on the information literacy expectations for freshman or sophomore undergraduate students. The faculty rated the importance of specific research skills expected for a freshman or sophomore undergraduate student. The survey was created in Qualtrics and sent via e-mail to professors in the Biology department. Seven faculty members out of 47 from the Biology department responded to the survey.

Results

Most professors indicated that identifying primary versus secondary resources in the science literature is a key skill for undergraduates. Additionally, faculty felt that using scholarly literature, constructing search strategies, evaluating literature, selecting appropriate databases, and citing literature as also being important skills. Using this information along with information literacy standards and BIOL 1051 and 1101 assignments, the researchers developed the content of the tutorial. The researchers used information literacy standards that applied to the biology course; therefore, the tutorial does not apply every standard included in the *Information Literacy Standards for Science and Engineering/Technology*.⁴⁵ At the end of the Analysis phase, the learning outcomes were devised for the tutorial. The outcomes for the tutorial are listed below.

By the end of this tutorial, you should be able to:

1. Identify potential information resources on your topic;
2. Identify and locate primary and secondary sources in the biological sciences;
3. Construct a successful search strategy to locate primary and secondary sources;
4. Construct correct citations in CSE style.

Design Phase: Tutorial Creation

Methods

The BIOL 1051/1101 Tutorial (<http://libguides.ecu.edu/biol1101>) is a curated, web-based procession of learning objects. The tutorial is housed in a LibGuide, primarily because the library’s guides are a centralized location for students to seek help with research. Additionally, the ease for sharing, updating, and embedding the guides into the university’s course management system make LibGuides a great fit for tutorial creation. Unlike some LibGuides that consist mainly of text and links, this is a progressive step-by-step tutorial that endeavors to instruct students and meet certain learning outcomes.

Included in the tutorial are the following topics: primary vs. secondary sources, scholarly sources, finding articles, evaluating web pages, and CSE citation styles. The tutorial was divided into eight tabs: Home, Choose a Topic, Primary/Secondary, Scholarly Sources, Find Articles, Evaluate Webpages, CSE Citation, and Get Help. The following information literacy standards have been considered and applied during

the creation of the biology tutorial: Standard One, Standard Two, Standard Three, and Standard Four. Standard One states that an “information literate student determines the nature and extent of the information needed.”⁴⁶ The components of this standard included in the tutorial range from choosing a topic to understanding literature in the science field to identifying primary, secondary, and tertiary resources.⁴⁷ A student who successfully applies Standard Two will be able to find “information effectively and efficiently.”⁴⁸ The tutorial applied this standard through the explanation of creating successful search strategies found under the Get Articles tab. The tutorial also supported this standard by giving students multiple options to find materials such as a list of relevant databases and information on getting research assistance from librarians.⁴⁹ Additionally, Standard Two includes the need for students to correctly use citation styles in their research, and this section is covered under the CSE Citation tab. Standard Three states that an “information literate student critically evaluates the procured information and its sources, and as a result, decides whether or not to modify the initial query.”⁵⁰ In the biology tutorial, Standard Three is applied in the Evaluating Webpages tab where students can use tools to help them use online resources. Standard Four addresses the need for students to “understand the economic, ethical, legal, and social issues surrounding the use of information.”⁵¹ The CSE Citation section of the tutorial discusses plagiarism along with suggestions for students to avoid it. While plagiarism is just one small part of Standard Four, the tutorial helps the student be aware of the consequences.

Additionally, the creators of the tutorial aspired to differentiate the means of instruction in the tutorial according to UDL principles. Since a large number of students are enrolled in BIOL 1051 and 1101, the researchers felt a UDL approach for the tutorial was needed to ensure a comprehensive engagement. Students enrolled in these courses most likely vary in their learning preferences. Applying UDL principles, specifically multiple means of representation, allows students to learn according to their preferred learning method. The presentation of multiple means of representation can be as simple as including a piece of imagery to go along with a text. Due to the fact that the tutorial is completed on a student’s own time, the other two principles of UDL were not used.

Results

The tutorial included four main types of differentiation of methods of instruction: audio, visual, kinesthetic, and text. A description and examples of each of these instructional methods follows.

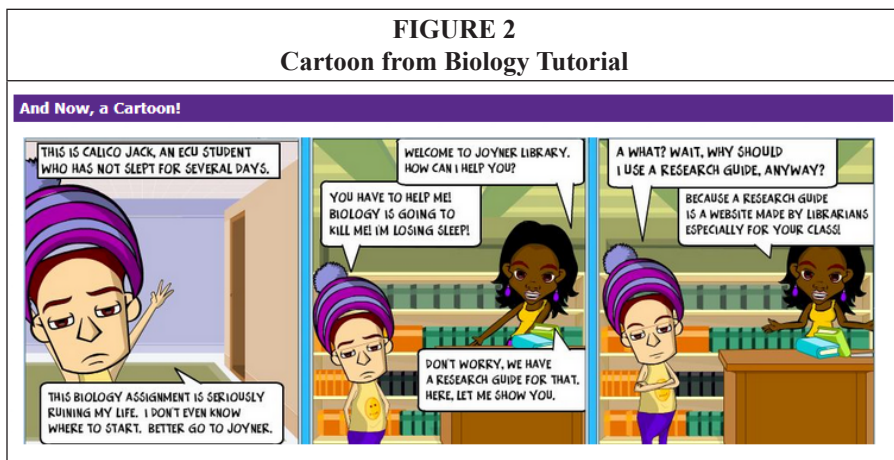
Audio

Audio was used in the tutorial to reinforce important concepts that were also expressed as text in the tutorial, such as learning outcomes and keyword generation. The for-

FIGURE 1
Sound Cloud Audio Player



mat that this took in the tutorial was a short recording of less than two minutes of a voice reading the text of that section. This was meant to help students with text-based learning disabilities, to assist those with blindness, and to benefit students who are audio learners. The technology used to create the audio portions of the tutorial was a microphone and audio recording program on a PC computer, and the audio files were embedded in the tutorial using the free Sound Cloud player (www.soundcloud.com).



Visual

Visual methods of instruction in the tutorial include videos, PowerPoints hosted on SlideShare, and cartoons. Two videos are included: one to teach students how to choose a topic, and the other to inform students of how to avoid plagiarism. The videos were a combination of live videos and screencasts. These were created using Camtasia, as well as other video editing software, such as Windows Movie Maker and Vegas. Cartoons were used on the first page to welcome students and inform them what they would find in the tutorial. A second, longer cartoon is on the Primary/Secondary page and includes nine frames that teach students about primary and secondary materials in the sciences. The cartoons were created using ToonDoo (www.toondoo.com), and include a cast of characters that can be found throughout ECU's Research Guides (LibGuides).

Kinesthetic

Various forms of interactivity were incorporated in the tutorial, including click-through Flash tutorials. The click-through tutorials were created using Flash Catalyst. Topics for these tutorials include the anatomy of a sciences article, as well as how to find certain elements of an article, book, or website needed to complete a citation.

The interactivity in the tutorial is best illustrated by the CSE Citation page. On it, students are asked to go through three click-through tutorials to learn where to locate citation information in three types of sources: articles, websites, and books. At the beginning of these tutorials, students are asked to write down specific information found in the initial part of the tutorial. In the second section, students are given the format for CSE style for articles, websites, and books. They are asked to try to create the citation on paper with the information gleaned from the first part of the tutorial. When they have completed their attempt at creating the citation, they can click "Reveal Answer" and watch an animated GIF of how to create the citation. This also allows students to check their answers against what they came up with in the second part of the tutorial.

Text

Although text is a visual format, the designers of the tutorial considered it as a separate entity. Every effort was made to reduce the amount of text in the tutorial to make it more engaging and easy to use for students with learning disabilities, as well as for students who do not prefer to read large blocks of text online. When it was not possible to completely remove text, the designers attempted to reformat the information in a more colorful and less linear format. In areas where text could not be avoided, key concepts were bolded or highlighted in a change of color to break up the text blocks. In addition to the updates to the tutorial to make it less text heavy, the librarians also added plain-text scripts of the video tutorials to make these accessible to individuals with sight impairments using screen readers. In most cases, where multiple means of representations are used, text is paired with a multimedia option for interacting with important information in the tutorial. This came in the form of audio recordings of the same information, as well as text paired with video tutorials.

FIGURE 3
“Home” Tutorial Page with Mapping

ECU Libraries > Research Guides > BIOL 1051/1101: Biology Information Literacy Tutorial

BIOL 1051/1101: Biology Information Literacy Tutorial

Last Updated: Sep 18, 2013 | URL: <http://libguides.ecu.edu/biol101> | [Print Guide](#) | [RSS Updates](#)

[Home](#) [Choose a Topic](#) [Primary/Secondary](#) [Scholarly Sources](#) [Find Articles](#) [Evaluate Webpages](#) [CSE Citation](#)

[Get Help](#) [Research Survey](#)

Home [Print Page](#) Search: [All Guides](#) [Search](#)

Table of Contents

- Home
- Choose a Topic
- Primary/Secondary
- Scholarly Sources
- Find Articles
- Evaluate Webpages
- CSE Citation
- Get Help
- Research Survey

Library 101

This guide is meant to assist BIOL students with a specific research assignment. For more general help with the research process, you might also go through [Library 101](#), which is an overview of the library and its resources.

Library 101

And Now, a Cartoon!

THIS IS CALICO JACK, AN ECU STUDENT WHO HAS NOT SLEPT FOR SEVERAL DAYS.

WELCOME TO JOYNER LIBRARY. HOW CAN I HELP YOU?

A WHAT? WAIT, WHY SHOULD I USE A RESEARCH GUIDE, ANYWAY?

BECAUSE A RESEARCH GUIDE IS A WEBSITE MADE BY LIBRARIANS ESPECIALLY FOR YOUR CLASS!

YOU HAVE TO HELP ME. BIOLOGY ASSIGNMENTS WILL MELT IN JESSIE'S GEL.

OH, OK. WE HAVE A RESEARCH GUIDE FOR THAT. HERE, LET ME GROW YOU.

THIS BIOLOGY ASSIGNMENT IS SERIOUSLY KILLING MY LIFE. I DON'T EVEN KNOW WHERE TO START. BETTER GO TO JOYNER.

We recommend completing this tutorial in order. You can use the tabs above or the buttons below to move forward.

Welcome to Joyner Library

Hello, and welcome to the Biology 1051/1101 Research Guide. My name is Jeanne Hoover and I'm the Science Librarian at Joyner Library. Please feel free to contact me with any questions you may have about this tutorial. My contact information is on the [Get Help](#) page.

By the end of this tutorial, you should be able to:

1. Identify potential information resources on your topic
2. Identify and locate primary and secondary sources in the biological sciences
3. Construct a successful search strategy to locate primary and secondary sources
4. Construct correct citations in CSE style

To listen to the outcomes as an audio recording, click the play button below.

1

KEY:

1. AUDIO
2. VISUAL
3. KINESTHETIC
4. TEXT
- N. NAVIGATION

Let's get started!

NEXT

Next Page

Development Phase: Mapping

Methods

During the Development phase, the researchers wished to determine the spread of multiple means of representation included in the tutorial. They decided to devise a mapping technique that would assist in looking for gaps in classifications. Each means of representation (for example: visual) was assigned a number. The researchers used a similar technique to Ping Li's past research with tutorial mapping, in which established library tutorials in the sciences were analyzed for their inclusion of information literacy standards.⁵² The librarians worked through the tutorial and sectioned it off according to the classifications listed above, including text, visual, audio, and kinesthetic. A number of individual modules within the tutorial received more than one classification. Typically, a module that had multiple classifications was a text and visually based tutorial. For any module that had more than one classification, the librarians marked them with both numbers. Each learning preference classification received a number 1–4 to ease

FIGURE 4
“CSE Citation” Page with UDL Mapping

The screenshot shows the 'CSE Citation' page from the ECU Libraries. The page is titled 'BIOL 1051/1101: Biology Information Literacy Tutorial' and includes a navigation menu with options like 'Home', 'Choose a Topic', 'Primary/Secondary', 'Scholarly Sources', 'Find Articles', 'Evaluate Webpages', and 'CSE Citation'. The main content area is divided into several sections, each with a UDL mapping number overlaid:

- Council of Science Editors' Style Guide:** A large number '2' is overlaid on the right side of the section.
- Locating Citation Information:** A large number '4' is overlaid on the right side of the section.
- Articles, Websites, Books:** A large number '3' is overlaid on the 'Websites' button.
- Constructing a Citation:** A large number '4' is overlaid on the right side of the section.
- Plagiarism:** A large number '2' is overlaid on the video player.
- Key:** A box at the bottom left lists the UDL mappings: 1. AUDIO, 2. VISUAL, 3. KINESTHETIC, 4. TEXT, N. NAVIGATION.

At the bottom of the page, there is a navigation bar with 'BACK' and 'NEXT' buttons, and a large 'N' in the center.

in the creation of the maps. Audio was 1, visual was 2, kinesthetic was 3, and text was assigned 4. The researchers also defined a navigation element demarcated with an N to take into account how the student would progress through the tutorial. The UDL map of the tutorial allowed the librarians to see where there were gaps of classifications.

Results

The following images are examples of maps that were created during the Development phase of the research project. Each map has one section of the LibGuide highlighted with a letter inside it. A key is provided at the bottom of the map. The total number of times each learning mode was employed in the tutorial is listed in table 1.

Audio	3
Visual	9
Kinesthetic	5
Text	7

Evaluation Phase: User Testing

Methods

After the tutorial was updated and mapped, it was made public and incorporated into classes. During the evaluation phase, in-person user tests using students with learning disabilities were conducted by the researchers in the library. The purpose of the user tests was to assess the effectiveness of the tutorial. The students were recruited through Project STEPP. The setting was a private study room with a single laptop computer attached wirelessly to the Internet. Four students were individually asked to interact with the tutorial online and complete a set of tasks, read by the Instructional Design Librarian. The tests lasted 35–40 minutes. The tasks took the test subject through the assignment that BIOL 1051/1101 students are asked to complete as a graded assignment in the course. Afterward, the test subject was asked a series of questions about his or her preferred learning and study preferences, as well as opinions about the usefulness, navigability, and layout of the tutorial. The script for the user test can be found in appendix A. During the user test, the Instructional Design Librarian took notes on paper as the students verbally explained their actions while using the tutorial. The students were additionally recorded using Camtasia software to capture their voices and movement within the tutorial during the user test. For privacy purposes, the students were not asked to identify their names or their specific learning disabilities. Users were assigned a letter A–D to ensure their anonymity.

Once the user tests were completed, the researcher watched the Camtasia recording of each of the user tests and filled out a matrix to review whether the users of the tutorials were able to complete each of the assigned tasks relatively quickly and without assistance. For each question, the researcher marked a Y or N on the matrix: Y indicates that the student was able to find the information and move on, and N indicates that the student had trouble completing the task. An analysis of the findings of the user tests follow.

Results

The following chart shows the diversity of the four participants in the user test in relation to the differentiation provided by Universal Design for Learning strategies.

The overall results of the user testing were extremely enlightening for the designers of the tutorial. Three out of the four students had taken the biology class in the past, and this proved to be a benefit for the user test, since they were familiar with the assignment but not with the tutorial. In fact, two of the students emphatically expressed that they wished that they had known about the tutorial when they took the class.

TABLE 2
Participants' Learning Preferences and Strategies

User	Learning Preferences	Preferred Learning Strategies	Best Time to Study
User A	Visual	alone	afternoon, late in the day
User B	Visual/ Kinesthetic	likes to review in a group, new stuff alone	late morning
User C	Visual	alone, with printed flashcards, repetition	morning
User D	Auditory Mainly	with 1 other person in a quiet study room	7–10 PM, at night

The four users tested invariably had no issues finding how to get help (Question 5), how to create a search strategy (Question 6), and how to avoid plagiarism (Question 8) in the tutorial. Three of the four test subjects easily located a database to search on the Find Articles tab. Even though User B successfully and quickly navigated to the Find Articles tab, she tried to search for articles in the search box that locates keywords in all ECU LibGuides, hoping that this would search all databases related to the assignment.

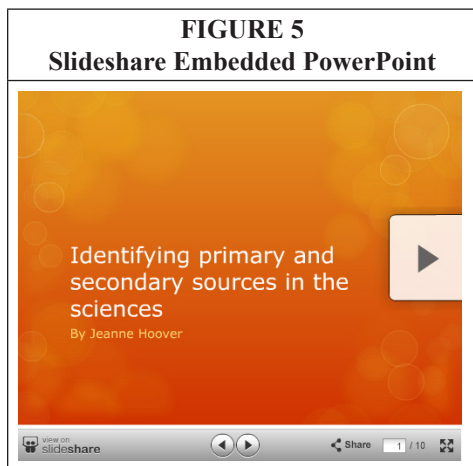
The question that made use of the embedded PowerPoint slideshow (Question 2) caused the most confusion for users. Three of the four users clicked on a link above the presentation and were taken to Slideshare's website, instead of clicking on the arrows in the embedded frame to advance the slide within the tutorial. Once they had navigated into the outside webpage, they then had to click the browser's back button to be taken back to the tutorial; this caused some confusion. In the case of two of the test subjects, the interviewer had to intervene at this point to get them back on track with the user test. In creating the tutorial, the librarians were unaware of this functionality, since they were familiar with the Slideshare product and had always clicked on the next and back buttons on the bottom of the frame around the presentation during initial testing.

Another question in the user test that caused confusion and required the investigator to intervene was the tab related to the instruction of Council of Science Editor's Style (Question 7). This citation format is normally not known by introductory biology students, and this course requires them to learn a completely new format. The users

tested simply wanted this page to be a citation generator without the expectation of learning the style. Thus, the underlying confusion about the page was that the students expected the button entitled *Article* to simply generate a citation in CSE style for an article. In fact, this button leads students to a Flash tutorial that assists them in finding elements of their article that will be needed for CSE style.

In the second part of the user test, students were asked about the navigation and usability of the tutorial. Each of the four students rated the tutorial either a 7 or 8 on a scale from 1 to 10 for engagement with teaching the subject

FIGURE 5
Slideshare Embedded PowerPoint



matter. All four of the test subjects agreed that the navigation around the tutorial was made easier by the inclusion of the top tabs, which validates the use of the LibGuides platform for the tutorials. One student commented, "Sometimes finding sources on the library website can be challenging, just because there is so much there. It's great because you can find so much, but it can be overwhelming, too. This was a good bit easier to navigate than the typical library website, which I am not bashing, but it gives you what you need to know."

Students were prompted to comment on the amount of text on the tutorial. When initially asked, all of the students responded that they felt that the amount of text in the tutorial was appropriate; however, two of the four students followed up by recommending reducing text even further, with one student commenting, "my eyes swim on text." User D summed up her expectations from library tutorials the best when she said, "Don't put any filler stuff on there. Just put only what you need. Because I feel like sometimes websites are about a topic, but you don't need all that information. Like in intro classes, you don't need all the same information you need in a pre-med biology class."

Students were additionally asked to state their preference for the different types of presentation of information. One student remarked, "I like slide shows that I can move through on my own, because then all of the information is not presented at once." Thus, it is not surprising that all of the four students tested invariably commented that they appreciated the inclusion of the embedded Slideshare presentation click-throughs; however, it has already been noted that the students also had trouble with this feature.

Discussion

Many changes were undertaken by the researchers based on the results of the user testing exercise that could be applied to tutorials more broadly. Due to the issues with the instruction of CSE style and the expectation that there would be a citation generator on this page, the tutorial creator has since found a CSE style generator online and plans to add it to the tutorial in a prominent location. The fact that students expect an option for an easier method to cite could be a reason to include the option of a citation generator in tutorials. A comment by User B was the suggestion that the tutorial design include a printable copy of the PowerPoint slides for the purpose of taking notes, which is a common exercise in the BIOL 1051/1101 course. This suggestion from the user test will be implemented in the tutorial for next semester. Based on the informal observation of students at ECU's reference desk, many students print PowerPoint slides. This common study method could apply to students with or without learning disabilities.

An unexpected outcome of the user test was the appearance of unrelated issues of usability with the website. One surprise was that scrolling on the pages was both expected and additionally not considered to be an issue by any of the test-takers, even though most web design principles caution against scrolling. Each of the four students taking the user test had trouble with the Share button on the top of LibGuides. The Share button allows people to e-mail, post to Facebook, or share the website on other social media sites. This button is located directly above the tabs for the final few sections of the tutorial. Each time the student hovered near one of these tabs, the Share button would expand and cover up the tabs. Although they did not verbally express their dislike for this, it seemed jarring and confusing for most of the test subjects. For this reason, the instructional librarians at ECU Libraries have decided to suppress the Share button in all LibGuides systemwide. This can be done easily in the administrative panel of LibGuides at any institution. It should be noted that the new version of LibGuides 2.0, set to come out soon, will not feature a Share button.

Study Limitations

In the Analysis phase, the informal Qualtrics survey sent to faculty had a low response rate of about 17 percent. In a future iteration of this study, the researchers will try to get a higher response rate. It should also be noted that Flash, which was used to author some of the tutorials, is not the most accessible format for individuals with disabilities. Flash does not allow for screen readers to be used by people with sight impairments; thus, HTML 5.0 is preferable to Flash because it allows for the use of screen readers. Some limitations of the user testing exercise were that the researcher conducting the test was also the tutorial designer, leading one student to ask, "Did you make this?" In a future user test, the tester could be a person outside the tutorial design team. Because the students were in Project STEPP, they are already aware of their learning preferences due to the strong emphasis on study skills; however, for the purposes of a larger study, it would be important to have each test subject conduct a learning style inventory before the user test. The results of the learning style inventory would be used to correlate preferences to how the students performed in regard to interactions with the different types of learning methods used in the tutorial. The small scale of the user testing portion is a further limitation. In the future, additional tests could include more students, as well as a similar number of students without learning disabilities. It could be interesting to conduct a user test of sorts to gain faculty viewpoints on the tutorial after the creation of the tutorial as well.

Conclusions

Employing a systematic approach to tutorial design that uses both the instructional design process of ADDIE and the design principles of UDL to differentiate means of representation of information will result in a positive educational experience for all students, not just those with learning disabilities. Students bring their own learning preferences and abilities to the library when seeking help. It is important to meet their information needs with tutorials that keep their attention and give them multiple ways to interact with the information presented. A UDL mapping technique can assist other librarians to ensure that their online tutorials will be inclusive to all users. Mapping can also be a helpful exercise when trying to look for places in tutorials where too much text has been used. User testing with even a small group of students helps inform tutorial design further and can be of great benefit when trying to improve systems in the library. Further research should be conducted to include user testing of UDL tutorial designs with students without learning disabilities. Technology is rapidly changing, and librarians need to be familiar with new software and methods that can assist with the creation of online learning tutorials. As each development in the field comes about, librarians can incorporate these evolutions to systematically design their tutorials; this includes ensuring that they have multiple means of representation of information literacy concepts for students.

Appendix A: Biology User Testing Questions/Script

The purpose of the tutorial is to help students taking BIOL 1051/1101 to complete their required literature search assignments. The tutorial leads students from choosing a topic to finding articles to doing citations.

Universal Design for Learning (UDL) is a framework used in developing educational classes and resources that allows all students to learn successfully through multiple representations of information. Everyone learns differently, and UDL helps ensure that every student in a classroom will succeed.

UDL uses three principles:

1. Multiple Means of Representation or multiple ways of providing information. An example of this is having an option to watch a movie or read a book with the same information.
2. Multiple Means of Action and Expression or multiple ways of expressing your knowledge. An example of this is having an option to do a class presentation, a paper, or a written exam for a class grade.
3. Multiple Means of Engagement or multiple ways of engaging with the information. An example of this is having an option to work alone or with a group.

The process that this user testing will take is that I will ask a series of 10 questions. The first set of questions will walk you through elements of the assignment, much like a scavenger hunt. There is no right or wrong answer. Instead, try to imagine that you are yourself, but that you've signed up for an introductory Biology class. You are trying to complete an assignment that you don't know much about. Try to speak out loud about why you are going to a particular area in the module, and what your rationale is for searching in particular areas. Even if you know the answer to a question, still try to find the item in the tutorial for me, and say why you went to that location. You are being timed, but don't worry about how long it takes. Are you ready? Let's begin.

1. What kinds of sources would you use to choose a topic? Where would you find them in the library?
2. Let's say that the assignment asks you to find something called a "secondary source." Look for a place in the tutorial where a definition or the attributes of a secondary source would be listed.
3. What is the typical layout of a sciences article?
4. If you chose the topic, "How does children's health in North Carolina compare to children's health in the rest of the United States?" where in the tutorial would you find the databases you need to complete the assignment?
5. Where would you go if you needed to chat with a librarian? What is the Joyner Library phone number?
6. Now you're in the database but you are having trouble finding an article. You aren't sure, but you think that maybe the reason your search is not working correctly because you are typing the whole research question into the search box. How would you break down your research question into a search that the database will recognize?
7. You find a source in the database, and you're sure it fits your topic and it is a secondary source. Now it is time to cite that source. The assignment says you need to learn something called Council of Science Editors' style. Where can you find the format of a citation for an article in this style?
8. Give one tip that you could use to avoid plagiarism.

The next set of questions is meant to show us about navigation and usability of the tutorial.

9. Was it always clear to you how you should move forward or back in the module to get where you wanted to go? If not, please elaborate.
10. Were the titles of the pages and the boxes in the module straightforward or confusing? If you found them confusing, please tell me why.
11. Do you think there was too much text in this module?
12. Did you find scrolling a problem or frustration point in this module? If so, please explain where.

The next set of questions has to do with the Universal Design for Learning aspects of the module.

13. When and how do you like to study? Do you know your preferred learning style? If so, what is it?
14. What learning style do you feel best describes you? Are you a visual, audio, kinesthetic or text-based learner?
15. Did you feel that people with different learning styles could use this module effectively and be engaged?
16. On a scale of 1 to 10, how engaging is the module to you?
17. We displayed information in a variety of ways, including in cartoons, in videos, in tutorials, and so on. Which one did you like the most? Which one did you like the least? What could be improved to differentiate instruction?

Appendix B: Matrix Showing User Testing Results

User	Q1. Topic	Q2. Secondary Source	Q3. Layout of Sciences Article	Q4. Topic: Databases	Q5. Get Help	Q6. Search Strategies	Q7. CSE Style	Q8. Avoid Plagiarism
User A	ND	N	ND	Y	ND	Y	N	ND
User B	Y	N	Y	N	Y	Y	N	Y
User C	N	Y	N	Y	Y	Y	N	Y
User D	Y	N	Y	Y	Y	Y	N	Y

Key:
Y—No issue finding this information.
N—Did not find the information, or tester intervened to help the subject find the information.
ND—No data recorded for this question (subject did not answer question).

Appendix C: Matrix Showing Navigational and Universal Design for Learning Questions during User Testing

User	Q9. Navigation	Q10. Title Boxes	Q11. Text Amount	Q12. Scrolling	Q13. Study Style	Q14. Learning Style	Q15. Engaged	Q16. Rating
User A	Y	N	Y	N	See Table 1	Visual	Y	7
User B	Y	N	N	N	See Table 1	Visual/ Kines.	Y	7
User C	Y	Y	N	N	See Table 1	Visual	Y	8
User D	Y	Y	N	N	See Table 1	Auditory	Y	8

Key:
Y—Yes
N—No

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