

# Visualizing Student Research through a Multi-Conditional Branching “Choose Your Own Adventure”-Style Tutorial

Maggie Faber

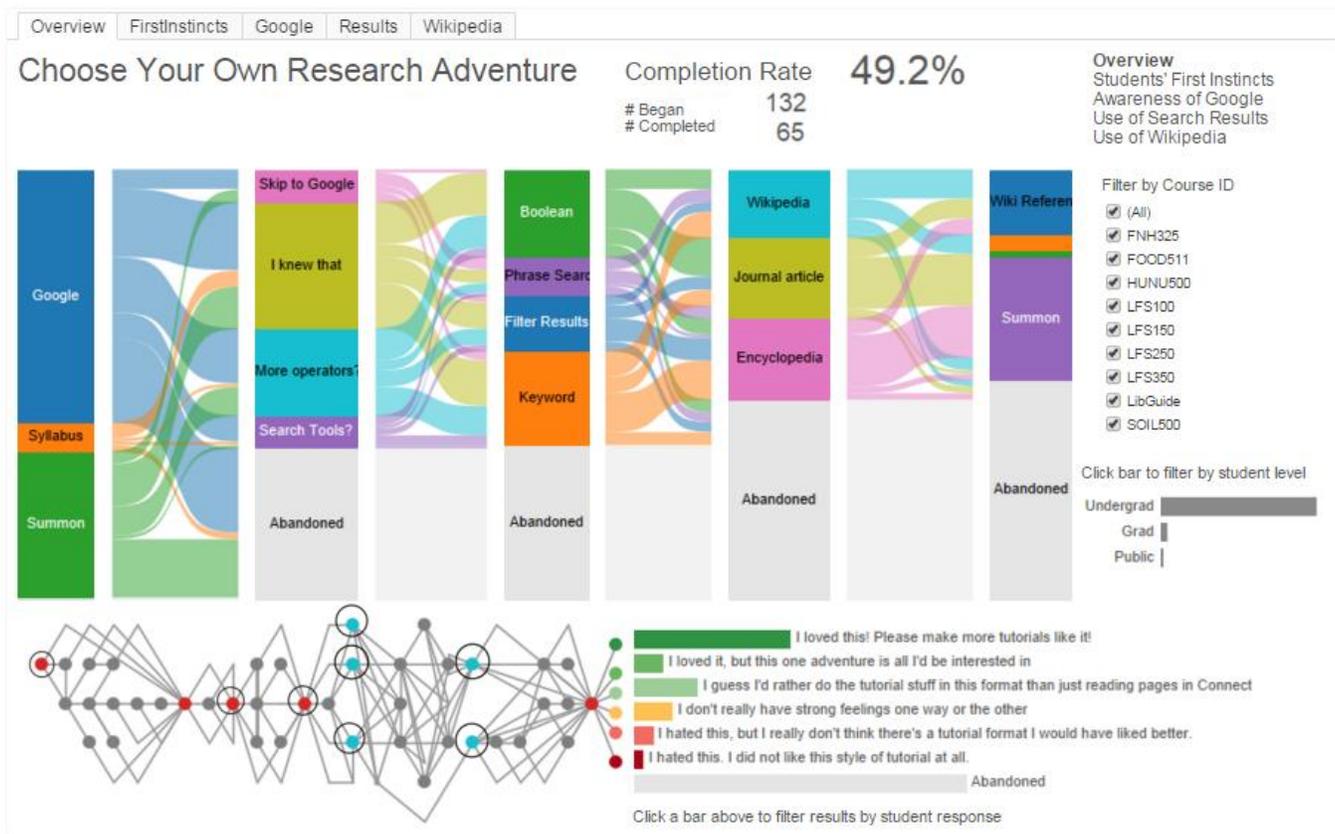


Fig. 1. Overview page of the Tableau dashboard. The Sankey diagram (middle left) shows student responses to each question as flows between the possible branches of the tutorial. Users can orient themselves with the node-link tree structure (lower left) showing the branching paths through the tutorial content and the specific nodes being visualized in the Sankey diagram. Students' final response to the tutorial has been displayed as a bar chart (lower right) which also acts as a filter to display patterns of use by a selected response. The user can also filter by the individual course codes to which the content was distributed (middle right) and level of course, which has been supplemented with a scented widget showing the number of respondents in each category. The exact number of users and the overall completion rate is show (upper middle) as well as a table of contents showing which dashboard the user is viewing (upper right).

**Abstract**— Flipped classrooms, asynchronous learning, gamification, and multimodality are familiar concepts in education, and *Choose Your Own Adventure*-style instruction brings together these ideas by allowing the student to direct their own path through more traditional learning materials. But while nonlinear structure offers significant opportunities to reinforce learning objectives, model behavior, and increase student engagement, developing and assessing this content poses some significant challenges. In this paper, I explore the use of established visualization idioms and visual analytics tools to produce a conventional dashboard layout that will aid analysis of student behavior through *Choose Your Own Adventure*-style instructional materials.

**Index Terms**—Sankey Diagram, Node and Link Graph, Tableau Software, Education, Dashboard, “Choose Your Own Adventure”

## 1 INTRODUCTION

In the 80s, *Choose Your Own Adventure* books were experiments in storytelling that put the power to direct the narrative into the hands of the reader. Now, instructors and librarians are starting to adopt this style of content for educational purposes [1-2]. Flipped classrooms, asynchronous learning, gamification, and multimodality are familiar

concepts in education, and *Choose Your Own Adventure*-style instruction brings together these ideas by allowing students to direct their own path through more traditional learning materials. But while nonlinear structure offers significant opportunities to reinforce learning objectives, model behavior, and increase student engagement, developing and assessing this content poses some significant challenges.

• Maggie Faber is with the University of British Columbia. E-mail: [jaberm@gmail.com](mailto:jaberm@gmail.com)

*Choose Your Own Adventure*-style content is inherently nonlinear. Participants expect the information they see to reflect the choices they made earlier, meaning there is often content that is never shown and that they have no way of accessing. A “branch and bottleneck” structure, where several choices can lead to the same constriction point, reduces the development impact of this [3-6], but different choices leading to the same place means the choice as well as the result is essential analytics information. And while *Choose Your Own Adventure* books have been a popular visualization subject for hobbyists, their analyses typically focus on narrative endings rather than use. Without usage information, each possible path is as likely and important as any other, whereas to an instructor, stumbling blocks and “best of” choices are crucial, and identifying unused content can indicate a need for restructuring the material or changing the emphasis of their instruction.

Any data extracted from a *Choose Your Own Adventure*-style platform will reflect this complexity and can be expected to have significant gaps from any unchosen paths and selections. Without an established framework of analysis or easy model for visualization, instructors rely on poor reporting tools or tables of numbers to make sense of complex usage patterns. In this paper, I explore the use of established visualization idioms and visual analytics tools to produce a conventional dashboard layout that will aid analysis of student behavior through *Choose Your Own Adventure*-style instructional materials.

At UBC, the Faculty of Land and Food Systems (LFS) is restructuring their curriculum to support distance learners, increase student engagement, and assess and improve the research skills of their students. In order to reflect students’ modes of thinking and model research behavior, a *Choose Your Own Adventure*-style module has been added to the LFS Library Research Skills tutorial, which is a requirement in most classes. This module allows students to choose their path through basic research tools such as Google, Wikipedia, and the library catalogue, positively reinforces student choices even when redirecting them toward a more productive path, and reiterates the concepts covered in the previous, more traditional, tutorial modules.

The “Choose Your Own Research Adventure” tutorial module [20], created with FluidSurvey and embedded in Connect, is currently the best tool the library and the LFS faculty have to see aggregate information literacy data across classes. Because the Connect platform is so restrictive, the embedded survey is the first step toward identifying how—and if—students are using the content, how they feel about the tutorial, and what the rate of attrition is within the tutorial. While a single module can’t answer these questions completely, it has the potential to be an important analytics tool for the library and the LFS faculty.

## 2 PREVIOUS WORK

*One of the challenges for applying metrics to the design and analysis of interactive storytelling is developing appropriate visualizations to facilitate designers in developing insights about player experience—Sali [10]*

Although rarely the subject of academic research, visualizations for *Choose Your Own Adventure* books are popular among hobbyists. Swineheart’s “One Book Many Readings” visualizations [7] are the most widely cited and recognized in this community, but his work focuses primarily on the possible story endings. While he does some work on the nonlinear structure of the books, using arc diagrams to show where the narratives send you forward or backward in the sequence, because they are based on paper material objects, he focuses on the structure of the story as opposed to patterns of use. However, Swineheart does provide a roadmap for identifying patterns and standardizing visual encoding. His visualization techniques include chronological story maps, color lines, trees, arc diagrams, and node-link graphs. He also broadly classifies stories based on the number and type of endings, the number of decisions the reader can make, and “story” pages with no choices or endings.

Ashwell builds on Swineheart’s classification work by identifying standard patterns in choice-based games, and describes the “branch and bottleneck” structure used in the LFS tutorial as one that is used most often “to reflect the growth of the player-character” [3]. Fabulich and Strong-Morse, co-founders of the Choice Of games, call this pattern delayed branching, where “at the end of Chapter 1, you always go on to Chapter 2, no matter what choices you made in Chapter 1. But your choices in Chapter 1 can affect Chapter 2” [4-6]. While both authors use illustrations to convey their concepts, they focus exclusively on the structure of the underlying content rather than usage patterns, and both of them use simplified models to convey the concept rather than a detailed structure of an existing narrative.

None of the work in Interactive Fiction/Interactive Narrative/Interactive Storytelling has approached the concept of delayed branching in their assessments. In “Visualizing interactive narrative” Andrews says “One of the recognized problems of evaluating interactive stories is that the conclusions may not be applicable beyond the texts being analyzed,” [8] and in “Measuring user responses to interactive stories: Toward a standardized assessment tool,” Vermeulen says “quantitative measures of user responses to [Interactive Storytelling] systems are thus an important yet missing tool for generating more empirical and conceptual knowledge on audience reactions and preferences” [9]. However, neither of these papers offers vis techniques to begin the analytical process—they attempt to identify preconditions of meaningful user responses and validate their results and identify patterns heightened reader comprehension within a narrative [8-9]. “Using Information Visualization to Understand Interactive Narrative” adds squarified treemaps to the vis solutions offered, as a “compact and concise representation of many different possible player actions,” [10] but this, like Swineheart’s initial work, fails to distinguish between categories of users or user choice through the narrative.

Game analytics, however, offers detailed information about player use and experience. Much of the visualization focus in game analytics is on geospatial analysis (players moving through videogame environments), which is not a concern in a text-based game. However, designing a system that “enables comparisons of behaviors across different play styles, allowing analysts to see how their game fairs to different tastes and styles” [11] is essential in both domains. The DataCracker team provide a template for collaboration between vis designers and game designers, and offer detailed reflection on the “live team” dynamic, the “portion of the development team that supports a game after it is released” [12]. The need for the analysis tool to stand alone and support additional development that may change the type of data being collected (by changes to the game environment or tutorial structure) is a huge priority for the LFS team. The DataCracker group provides a branded dashboard using simple but effective visualizations as part of their effort to make data analysis in gaming more accessible. They recommend developing the analytical tool with the game designers and alongside the development of the game itself, a process we have adopted by ensuring the LFS team is comfortable interpreting the proposed visualizations at each step of the project and walking them through sample analyses when faced with unfamiliar idioms.

Although the library team does not have access to student grades and class performance, which is the standard data in learning analytics, some analogous visualization techniques surrounding MOOC data was still relevant. Stephens-Martinez *et al.* identified key metrics in educational dashboards, particularly where grading rubrics are deprioritized, to support future curriculum development [14]. Individual student performance, per-student performance compared to the class as a whole, common misconceptions shared by many students, and activity patterns, such as the material students actually look at, were key measurements to the surveyed instructors. Kizilceç says the goal with instructional dashboards is “to provided educators, instructional designers, and platform developers with insights for designing effective, and potentially adaptive, learning environments that best meet the needs of...participants,” a benchmark shared by

researchers in the game analytics and interactive storytelling domains as well [15].

### 3 DATA

The “Choose Your Own Research Adventure” tutorial module was developed using the FluidSurvey platform and all usage data was collected by their system. The tutorial itself has 42 questions, 115 possible selections, and 59 branching rules controlling the appearance the content and the users’ path through the tutorial. Each question has 1-5 possible responses, though 3 is the most common. The native reporting tools offered by FluidSurvey are not functional for our non-traditional use of the program, as they present each question as a bar chart of response rates, with no visible overview of the entire structure, no way to view paths through the content, and no logical connection between questions.

The usage information can be extracted as a cross tabulated dataset, but minimal—if any—data transformation was essential for the ongoing sustainability of the project. The workflow needs to be as simple as an export of the data from FluidSurvey, adding the new responses to the existing table, and refreshing the workbook. Because FluidSurvey does not capture the custom URL of the content, the course code to which the tutorial was populated does need to be manually added by the user.

The crosstab report assigns a unique ID for each user and encodes question in the tutorial as a different attribute. The exact response the user selected is recorded in the cell as categorical information, and gaps in the data could either indicate a question that the user wasn’t shown or indicate that the tutorial had been abandoned altogether, see Fig. 2.

ID	Status	Created At	Location	Completion Ti	(begin)	(summon)	(syllabus1)
aa7	Incomplete	10/15/2015 11:47	South Carolina		UBC Library's Syllabus	The assignmen	
a77	Incomplete	10/25/2015 21:37	British Columbia		Your course s	The assignmen	
if05	Complete	9/25/2015 17:06	British Columbia	0:04:21	UBC Library's Syllabus	I think we read	
521	Incomplete	10/6/2015 4:57			Google		
aa4	Complete	10/11/2015 5:46	British Columbia	0:02:21	UBC Library's Google		
558	Complete	10/12/2015 23:44	British Columbia	0:01:56	Google		
b5c	Incomplete	10/14/2015 1:10		0:00:36	Google		
047	Incomplete	10/16/2015 23:05	British Columbia	0:04:35	Google		
99f	Complete	10/17/2015 2:02		0:14:41	Your course syllabus	I think we read	
1ai	Incomplete	10/17/2015 3:24		0:00:23	UBC Library's Google		
ac5	Complete	10/23/2015 16:32	British Columbia	0:01:21	Google		
223	Complete	10/23/2015 23:09	British Columbia	0:00:46	UBC Library's Syllabus	The assignmen	

Fig. 2. A sample selection of the exported data. A selection of "Google" in this part of the tutorial means the user is jumped ahead to the next constriction node. In the red box, note that a response of “Google” in the first or second column is followed by empty cells as the content is hidden from the user, but has no bearing on whether or not the tutorial was completed. In the yellow box, note that different responses in the first column still leads to the same content in the third, as the content in the middle column allows the user to jump on to a different path.

Although Tableau is built for visualizations using normalized data, the system is able to join sheets contained in a single Excel workbook. This feature allowed me to link the individual responses in a format that can be added to and updated over time to a model that supports the necessary visualizations. Two models were built, one using Catherin and Shaffer’s structure for Sankey diagrams in Tableau [16-17], and another based on Martin’s network graphing in Tableau [18].

The network graph model had to be hand coded to reflect the tutorial content. Each question was recorded as a node with a single location on an XY axis and each possible response as a link that started at one node and ended at another. Those three entries were then assigned a unique relationship ID. While time consuming, the node and link tree layout was necessary for understanding the structure of the tutorial, and did allow me to record the actual text of the questions in a way that would be explorable within the Tableau environment. However, the time and labor to produce the necessary

data for this visualization is likely to be prohibitive for general application, or for content of more substantial length.

The tutorial was distributed to 8 LFS classes, 3 graduate and 5 undergraduate, and was embedded in several UBC LibGuides accessible to students and the public. From this pilot run, we received responses from 132 unique students, 65 of which completed the entire module. I used the complete dataset to construct the visualization system, but as the content only reached a relatively small user group, this initial pilot did not generate enough data to make meaningful comparisons between student categories or classes. The data did support broad calculations, such as response rates and number of respondents by category, but for more fine-grained analysis, the tutorial would need to be widely distributed to ensure significant quantities of each group of students was represented.

### 4 TASK

Stephens-Martinez identifies key metrics instructors are interested in when evaluating asynchronous distance learners; in particular, individual student performance, per-student performance compared to the class as a whole, common misconceptions shared by many students, and activity patterns, such as the material students actually look at [15]. These needs do not change when the content is nonlinear—indeed, most students experience MOOC content in a nonlinear order, jumping ahead to sections of interest and or reviewing material later in the term. But while educational dashboards are a useful guideline for tutorial assessment, the LFS team had specific questions grounded in their own practice that they felt far more acutely. Some of these questions were:

- Are students using the tutorial? How many? In which classes?
- Is the information we received worth the development effort put in?
- Should we continue offering individual class surveys or should we combine them into a single survey?
- Do students like this type of tutorial? Should we invest in additional development, leave it as is, or remove it entirely?
- Where do students tend to lose interest and drop out? What is the global attrition rate for this module? Are any sections better or worse than the others?
- Are there choices and paths in the tutorial that are not being used? Where is there potential to streamline the content?
- Are students reporting differences in research strategies between undergraduate and graduate degrees? If so, are they different enough to require separate instructional content?
- Are students reporting good research habits? Do we need to emphasize certain skills more – or deemphasize ideas they’ve already mastered? Where are the information gaps for students?
- How can we make the analysis of the results sustainable for the future?

This tutorial was primarily of interest as a tool to see aggregate performance of students across course and course level, as the Connect platform provides instructors with information about individual student performance in the more traditional tutorial modules, and the professors obviously have access to individual student work in their course. The team also needed to assess the effectiveness of the tutorial itself. The *Choose Your Own Adventure*-style module was a gamification experiment that took a lot of development work and customization, and the team was looking for clear indications of success before continuing down this path. On a much broader scale, they are also interested in evaluating whether the

success of the tutorial is due to novelty or if the branching pathways are actually an effective tool to reflect student thinking. The decisions for which the project team looked for support fell into 5 broad categories:

1. Student use of tutorial content
2. Student opinion on tutorial format
3. Reach and retention rate
4. Patterns of use by different classes of students
5. Understanding of student research methods

These categories are reflected in the questions asked throughout the development cycle. In the abstract, the team wants to discover trends in the data and to identify and compare patterns of use. The specific tasks this dashboard supports are:

- Identify high and low-use paths, which have implication on tutorial development and instruction content
- Compare patterns of use across categories of students
- Discover trends and anomalies in the reported research habits
- Identify module sections with high and low rates of retention

## 5 SOLUTION

The solution I have developed supports instructor analysis of student’s research skills with an “overview first, details on demand”-style dashboard, where the user can get a broad overview of the entire tutorial and then drill down to look at individual sections in more detail. I use Sankey flow diagrams to convey patterns of student use through the various branches of the tutorial. These diagrams are paired with a node and link tree structure to give an overview of all possible branching paths, which displays the full text of the questions and responses on hover. The tree also acts as a navigational tool, showing the user the exact nodes being displayed in the Sankey diagram in each view. The interactive dashboard supports filtering by student response, class level, and course code, and displays the exact number of users as well as the overall completion rate for each section.

### 5.1 Sankey diagram

Sankey diagrams are traditionally used to represent energy flows through complex systems. However, interactive Sankey diagrams have been presented for use as a planning tool, allowing for the exploration of possible scenarios “by interactively manipulating different parameters in the energy flow network” [13]. Because these diagrams show flow from and between different categories, with the size of the flow indicating the quantitative measurement of that section, they offer a resonance with the pattern of use information through the complex paths of a *Choose Your Own Adventure*-style environment.

The Sankey diagrams in this system encode student responses to each question as flows between the possible branches of the tutorial. The questions have been aggregated into bar charts based on the depth into the tutorial that content appears. The length of each bar indicates the proportion of students who selected that response, with the exact count available on hover. The number of respondents who were sent to the same node is shown along the bars, while the number of respondents who selected the exact path from one node to another is shown in the flows between the bars. The exact count of respondents

taking a specific path is also available on hover. Categorical color has been used to distinguish between responses in and out of each node.

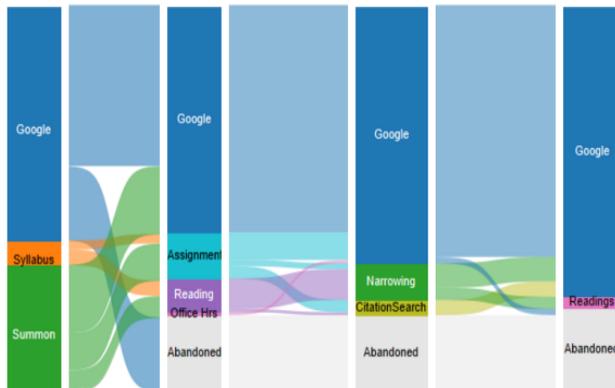


Fig. 3. Sankey Diagram from the "First Instincts" view. Note that the “Google” section gets larger as more and more users take that pathway to the next constriction node while, after an initial spike, the rate of abandonment stays relatively low. Most of the attrition in this section occurs between the first and second questions—people who initially select “Google” and don’t continue exploring the tutorial.

The Sankey diagram does not support comparison of individual respondents to the class total, as the paths are aggregated into flows, and the flows are aggregated into nodes once they reach the bars. As the diagram is so space-intensive, there is only room for a single Sankey in each view, so comparisons between student categories rely on manual toggling back and forth between views, rather than comparing them side by side. While linked highlighting can be programmed into Tableau Sankey diagrams using dashboard actions, this functionality was ultimately removed because the dimmed content was barely legible after the first step away from the selected node, and identification of the path down the line was important to users’ understanding of the overall use of that section as well as the orienting the user within the tutorial content.

### 5.2 Node and Link Tree Structure

Similar to the visualizations of the *Choose Your Own Adventure* books, the node and link tree structure shows an overview of the tutorial content rather than responses and use of the content. Originally, the structure was going to encode number of users on a path as line width, but the wide variance in the number of responses between central paths and low-use branches made grouping in distinguishable bins nearly impossible, and occlusion became a big problem in some of the more completed sections later in the tutorial.

In this view, questions are encoded as nodes, with links as the number of possible responses. As respondents are sometimes able to skip ahead to later sections of the tutorial, nodes are only drawn when respondents are shown new content. As indicated in Fig. 5, the lines better convey the path to the next node where students jump ahead to the next constriction point.

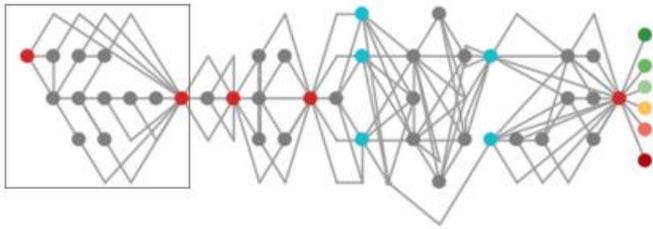


Fig. 4. Node and link tree structure. The square enclosure on the left indicates the section of the tutorial being visualized in the current view. Hovering over any node or link will show the exact text the user sees in the tutorial. Red nodes are constrictions points where every user will see the same content, while the teal nodes indicate constrictions points where the text is customized based on choices in previous sections—one of three options in the first branch, and one of two in the second.

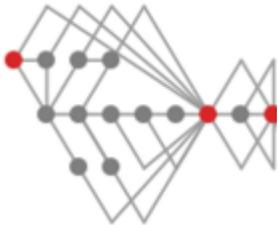


Fig. 5. Detail view of node and link tree structure showing two places users are able to skip ahead to later content in the red constriction nodes. Because users are not shown content in between their selection and the next displayed question, the default node has been removed from that intersection of the graph.

The tree layout is optimized for depth into the tutorial and navigational clarity, not visual attractiveness or lack of occlusion. Each step forward along the X-axis corresponds with an additional question answered by the respondent. Although loops in the content make an exact count in this way difficult, the linear progression approximates the minimum number of questions answered by a respondent who sees a given question within a given section, resetting at each constriction node. Although slight modifications to the structure have been made to reflect the design principles established by HOLA [19], early attempts to use a force-directed algorithm were resisted by the LFS team, as the users preferred the implied linear progression from left to right, which reflected the way students progressed through the content.

The use of color in this view reflects the kind of content at that juncture in the tutorial. Optional content is encoded as grey nodes and links. Red nodes are constrictions points where every user still taking the tutorial will see the same content, and the teal nodes indicate constrictions points where the text is customized based on choices in previous sections. Participants will see one of the options available at that step, but never more than one.

The tree acts as a navigational tool, showing the user the exact nodes being displayed in the Sankey diagram in each view, and shows the full text of the questions and responses on hover. The dashboard uses enclosure to show the user which nodes are shown in the Sankey diagram in the selected dashboard view.

### 5.3 Additional Features

#### 5.3.1 Scented widgets

In order to maximize information density, filters for the Sankey diagram were added as scented widgets that conveyed the number of respondents in each category. Clicking one category will filter the information in all other views on that dashboard, and comparisons can be made by toggling between different categories. The default selection reduces the data shown to a single category of user, but users can create their own category using by holding down control as they select more than one grouping.

To capture student response to the module, the final question asked student to leave feedback on their experience. As the precise wording of the possible responses was labored over in the tutorial design, the team wanted to be able to distinguish between the exact categories of response. A bar chart of each category, redundantly encoded with a traffic light color pattern for assessment at a glance, shows the number of respondents in each category, as well as the number of people who failed to leave a response due to leaving the module early.

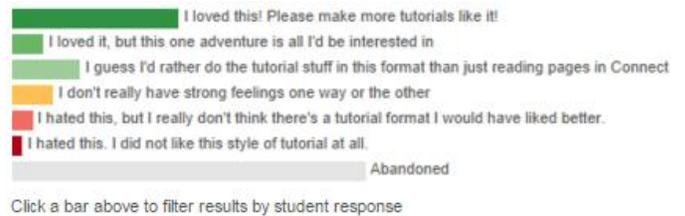


Fig. 6. Scented widget showing categories of response. Clicking on a bar will filter the information in all other views on the dashboard to just that category of user. Comparisons can be made between groups by toggling between categories.

Because the number of respondents for an individual course was as low as 1 or 2 students, subdividing by student type made any conclusions drawn much more reliable. As above, clicking on any bar will filter the results to just that category, and the exact number of respondents in that category is available on hover. Unlike the student responses, however, the student level widget is also linked to the overall completion rate in order to compare retention by category and class. As everyone who saw the overall response node completed the tutorial, the response rate would stay at 100% for every category and is thus not providing any additional information. Student level, however, captures complete and incomplete responses, so an adjustment to the calculation can be meaningful.

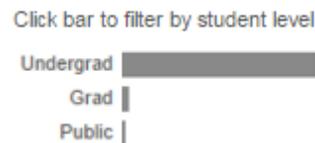


Fig. 7. Scented widget showing categories of student type. Clicking on a bar will filter the information in all other views on the dashboard to just that category of user. Comparisons can be made between groups by toggling between categories.

#### 5.3.2 Completion rate

The derived calculations at the top of the screen shows the exact number of users who experienced that part of the tutorial well as the overall completion rate for that section.

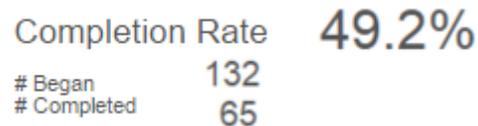


Fig. 8. The calculated completion rate for each section of the tutorial, as well as the exact number of users, are shown at the top of each dashboard.

### 5.3.3 Navigation

The tutorial content was too long to display in a single Sankey diagram, so I followed the guideline of “Overview first, details on demand” to show a manageable amount of content in each view. The initial dashboard page shows an overview of the entire tutorial by visualizing just the primary constriction nodes. Individual sections of the tutorial are shown in order and briefly described at the top of each dashboard view. Users navigate to the detailed layers by clicking the desired tab.



Fig. 9. Navigation to other dashboard views. (a) shows the tabs of each dashboard view, while (b) shows a brief description of each view in the table of contents.

### 5.3.4 Color

Color use throughout the dashboard is exclusively categorical. I tried to distinguish the flows throughout the tutorial content by assigning each node a color that was not used in the previous or subsequent step, unless the node indicated the choice to skip ahead, as in Fig. 3. Unfortunately, because there are so many questions, the color use in the Sankey diagrams is relatively chaotic. While it allows for the user to distinguish the originating node and trace the path to the next node, I believe a more appealing scheme could be found. I tried to minimize the use of red, green and yellow as categorical colors in the Sankey diagram to ensure the traffic light scheme for student responses, which the LFS team strongly preferred, remained visually distinct. However, when nodes had a higher number of possible responses, I was not always able to do so.

## 6 IMPLEMENTATION

The LFS team explicitly asked for the visualization to be developed in Tableau, in part because UBC Library has made significant effort to familiarize staff with the program and ensure users are comfortable reading and interacting with Tableau as a reporting solution. As the tutorial visualization is intended to be a tool that can stand alone after I leave the project, using a system the primary user group is comfortable with is essential to ensure its ongoing use. The substantial development knowledge throughout the library system also means that glitches in the system and small changes to the underlying data can be resolved without starting from scratch.

While the bar charts, filters, and calculations are easy to create in Tableau, building the Sankey diagrams and the tree hierarchy depended on tutorials created by the user community. The Sankey diagrams, which are essentially stacked bar charts between single step routing reports, are based on Catherin and Shaffer’s work on dynamically generated polygons [16-17]. The visualization uses their model, with significantly modified aggregation calculations in order to condense the number of required steps in the final visualization. Fig. 10B, for example, shows the necessary calculation to group together the results in a diverging constriction node and the results of that aggregation.

Martin’s Tableau network graph tutorial [18] was necessary to construct the node and link tree structure that provides an overview of the content. His data structure was modified to reflect an ordered, if nonlinear, progression through the content and to remove nodes from all intersection points to better convey when students jump ahead to the next branch, as in Fig. 10.

The data exported from FluidSurvey recorded the categorical choices of the students rather than any quantitative measurements of their results. Tableau offers a default “number of records” measure, but linking the responses and the data model duplicates each response for every data point in the model. While the proportion of responses would have been the same, the exact count would be misleadingly

high. To depict the number of students following the various paths through the module, I relied on a Count Distinct of unique IDs. For response rates to a given question, which has one of only 5 possible input values, I relied on a count of responses, as in Fig. 11.

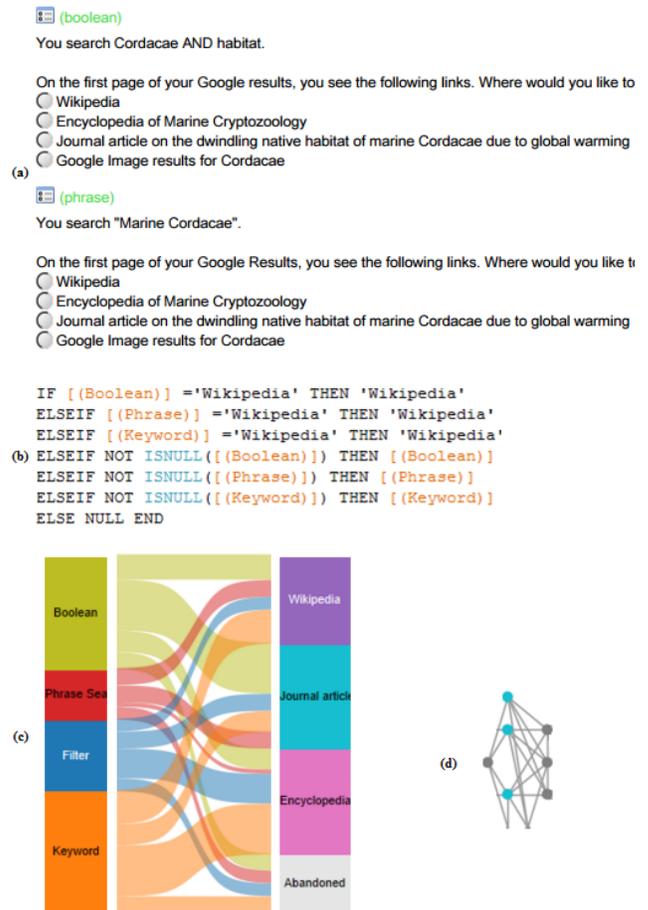


Fig. 10. Underlying data and visualization of a diverging constriction node. In this section of the tutorial, the user can give a response that leads to one of three nodes: Boolean, Phrase, or Keyword. The content of each question is customized, but the possible responses to the customized content are identical (a). The previous step showed the choices that led to one of these three nodes, so this calculation aggregates the responses and allows instructors to compare results across each selection. (b) shows the calculation in Tableau that determines the shape of the Sankey diagram and bar chart, (c). Note in the Sankey diagram that though the first step is slightly weighted toward “Boolean” and “keyword” searching, the choice in the second step is almost even between use of Wikipedia, journals, and encyclopedias. (d) shows the tree hierarchy for this question. A single question on the left has four possible responses that lead to one of 3 possible results. Each result can then lead to one of four results in the second step, one of which has not been selected by any users in our dataset and is thus not shown in the Sankey diagram.

$$\text{count}([(\text{Summon}) 2]) / \text{count}([(\text{Begin})])$$

Fig. 11. Calculation for the overall response rate to the tutorial.

## 7 RESULTS AND DISCUSSION

This system is the first to combine usage information with *Choose Your Own Adventure*-style branching content. Pairing the traditional node and link tree hierarchy with Sankey diagrams encoding student responses to possible paths orients the analyst within the module and allows them to identify patterns and trends in the usage data. Scented widgets act as filters to support comparison between groups of users,

and response rate calculations allow the analyst to compare the use of key pieces of the module to the content as a whole.

While a custom-designed system could support much more flexible analysis and added interactivity, using a publicly available analytics dashboard tool acts as a template for future assessment work on this kind of nontraditional narrative and educational content.

## 7.1 Evaluation

The LFS team was involved at most points in the development process. They provided feedback on test visualizations, strongly preferring the linear tree structure to a forced directed layout or a flowchart, and explained the interpretations they were able to form based on the visual idiom before them. This iterative development ensured that they were comfortable using and interpreting the visual encodings and navigating within the Tableau environment.

Although the team was initially hesitant about the complexity of the Sankey diagrams, once the layout was complete, they responded positively to the kinds of analysis it supported. They appreciated the clarity of the flows rather than the line width on the tree, and even commented that the chaotic color scheme was somewhat reassuring, as the content it reflects is actually complex. They believed that the system answered basic questions about each part of the tutorial, and supported the analysis they would like to perform on student research methods.

The team interacted with the dashboard as it was built and was very present in the development cycle, but they have only had access to the final dashboard for a few days—and at the end of term, nobody was really focused on this analysis. After a presentation of the system and a walkthrough of the features available in the final version, initial responses were positive, but slightly more focused on the effort I had put in than the analysis it supported. Two specific comments on the utility of the system were “it looked amazing! The visuals really helped to understand the pathways students are taking through the tutorial” and “attractive and effective in communicating the message.” The ongoing sustainability of the system is still an open question—although my own test scenario of uploading different data was successful, I do expect some troubleshooting and additional refinement to be necessary once the team is uploading and analyzing the information on their own.

## 7.2 Scenario of Use

Alice is the subject librarian for the LFS faculty at UBC. She is passionate about student learning and wants to make sure her students are confident in their research skills and comfortable using the library’s resources. When the term is over, she exports the data from the “Choose Your Own Research Adventure” module to see what students are reporting about their research methods. She copies the exported data into the template file and refreshes the data connection in Tableau. The visualization automatically updates the flows and usage statistics to reflect the current terms’ use. She also opens the archived report from the previous year for comparison. On the overview page, she can see that the overall response rate is lower than last year, but the number of students they reached was much higher. She suspects the wider deployment of the tutorial to courses outside the LFS department is responsible, so she filters out the courses outside her area to compare more precisely. She notices that the number is still a bit higher, and that the proportion of graduate students using the tutorial has greatly increased from the previous year. She remembers that the tutorial was a new requirement for the intro graduate seminar. This is the first year they’ve had sufficient numbers of graduate students responding, so she selects the bar to filter for just graduate students to see view the paths they took and their overall response. While the undergraduate responses run the gamut of “love it” to “hate it”, the graduate responses are more measured—some find it useful, others less so. But more importantly, she finds that most of their first instincts are to turn to the library search rather than Google. She checks the “Google” tab and the “Results” tab and finds that most of the graduate students select

citation searching and source triangulation paths early on, even when forced outside the library search environment. Since the ideal research behavior is already being modeled by the students, maybe they can relax the mandatory course requirement going forward.

Turning to the undergraduates, Alice is pleased to discover that the 4 classes she taught the Library Skills workshop to retained some of that information and are choosing to use Boolean search operators at a higher rate than the classes that relied solely on the online content. She makes a note to clarify the use of those operators in the traditional tutorial materials, and sends an email to the department reporting these results and offering to teach another workshop in the fall.

Alice then turns to the tutorial content itself, noting that one branch of the module has only been used once—by a user who didn’t even finish the survey. Other branches saw increased use from the previous term, and a lot of those users chose to request additional development at the embedded feedback points. She makes a note to review that material and see if there are any new tools or research strategies she should discuss. Highlighting the low-use branch, she finds that the abandoned path was about using Google images. Although that content was originally included for levity, she notes that this path also saw no use in the previous year, and it might be worth eliminating for ongoing simplicity.

Finally, she compares the overall satisfaction of the users to the previous year, finding that students are still enjoying this type of module, despite some of them having seen it in their previous courses. While she still needs more information to determine whether or not this kind of material is just a fad, for now, she is pleased that students are enjoying the tutorial and reporting good research habits.

## 7.3 Limitations

As is characteristic of other interactive storytelling assessments, this system is definitely based on one particular tutorial instance. While I believe I have created a template for other analysis of this style of content, they would still need to build an entire dashboard from scratch, aggregating their own question nodes and coding their own node and link tree overview.

The dashboard could also use additional integration of the tutorial survey content. Using the dashboard still requires extensive familiarity with source material, and even where the exact text is available, the user must be familiar enough with the survey to know what that means. Many *Choose Your Own Adventure* visualizations are for enjoyment and exploration, but this system does not offer an exciting point of entry into new content. The final dashboard also does not convey information about the time students spent taking the tutorial.

### 7.3.1 Implementation

Some of the limitations are based on the program used to implement this system. Network graphs and Sankey diagrams are not natively-supported visualizations in Tableau, and a change in the platform would mean relatively easy enhancements to the user experience.

One of the biggest concerns is the ambiguity of link direct when the content doubles back on itself. Small arrows instead of lines would be an easy solution, but there is no way to indicate directionality in the available node link networks. In this module, there are only two places where the user can experience such a loop, and as they are relatively small branches, the team decided the ambiguity was an acceptable compromise for a more familiar system.

One other concern is the fixed ordering imposed by Tableau. While I am able to sort the responses manually, when the user filters out information, there is no way to impose a “best of” layout on the new data. In some cases, as in Fig. 12, this leads to cases where each flow runs parallel to the next flow, obscuring the number of users and the different paths that are possible.

Although the scale axis in Tableau can be fixed at a certain range, in order to support different distribution scaling going forward, we left the axis to be scaled automatically by the program. However, with very low use categories, such as public users, the program scales the Sankey flows and the stacked bars differently. The ordering and

proportions are the same, but the alignment becomes skewed. While analysis is still possible, the inconsistency would be irritating if sustained investigation of low-use paths are of interest.



Fig. 12. Filtered view showing the information loss when the user only sees parallel flows. In this view, “Extra Search” leads to three different choices, but the path between the second nodes are parallel and unable to be distinguished from each other.

It would have been nice to be able to build in more organic navigation between dashboards. If the user could select a view from the table of contents, select a node from the tree to view that detail view, or drill down into a given node in the overview to see that section in detail, I believe the analysis process would be a lot more intuitive. While Tableau does support links to other URLs, the tabs of a single dashboard do not have unique identifiers that can be used for navigation between views.

Finally, I must acknowledge that coding to create each step of the Sankey is currently inelegant. An ideal system would reuse the calculation between each step of the Sankey, so the steps progress in order from Step 1 to Step 2 and Step 2 to Step 3. However, I began coding each diagram individually, from Step A1 to Step A2 and Step B1 to Step B2, because I wasn’t sure which nodes I would want to include and wanted to be sure I could remove an unnecessary step without starting from scratch. While this did allow me more flexibility in developing the final layout, I would have liked to go back and pare down the redundant calculations.

#### 7.4 Future Work

As discussed above, one of the concerns of the “live team” dynamic is that the data collected will be used to support additional development on the product that may change the type of data being collected. If questions in the original survey are added or removed, the system should be able to reflect these changes. The current system can reflect modifications to the responses, but adding new content currently necessitates manual revisions to the visualization system and the coding of the data model.

I also believe additional interactivity and flexibility would help assessments of *Choose Your Own Adventure*-style content. The ability to dynamically select the nodes for comparison to build a custom Sankey diagram would allow for the drill down and “details on demand” views to be much more organic and intuitive. Comparing multiple Sankey diagrams side by side would add a lot of support to comparisons between user groups and categories, and would even allow for the comparison of an individual respondent to the class

average. And the ability to trace the user’s final response to the content through the paths through the tutorial would allow for much easier identification of patterns of strong like or dislike of the content.

## 8 CONCLUSION

I developed an analytics dashboard to support instructor analysis of student’s research skills through a *Choose Your Own Adventure*-style tutorial module. This dashboard is the first to combine branching, interactive narrative content with analysis of responses and patterns of use, and provides a model for applying standard visualization idioms to assessment of similar content. The tool is an “overview first, details on demand”-style dashboard, allowing the user to get a broad overview of the entire tutorial by first visualizing key constriction nodes and then drilling down to look at individual sections of the tutorial in more detail. I use Sankey flow diagrams to convey patterns of use through the various branches of the tutorial. These diagrams are paired with a node and link tree structure to give an overview of the possible paths through the content, which display the full text of the questions and responses on hover. The tree also acts as a navigational tool, showing the user the exact nodes being displayed in the Sankey diagram in each view. The interactive dashboard supports filtering by student response, class level, and course code, and displays the exact number of users as well as the overall completion rate for each section.

## ACKNOWLEDGMENTS

The author wishes to thank Katherine Miller, Jeremy Buhler, and Tamara Munzner for their support and assistance. This work was supported in part by a grant from TLEF.

## REFERENCES

- [1] Algar, R. & Maxwell, J. (2015). I Hate Textbook Questions: Developing Software to Help Teach Students in Large Classes Think Critically About Chemical Analysis. CSC2015, Ottawa.
- [2] Fraser, I. (2015). Introduction to the library: A day in the city. Presentation at Univ. Winnipeg.
- [3] Ashwell, S. K. (2015). Standard Patterns in Choice-Based Games. *These Heterogenous Tasks*. Blog post. Accessed from: <https://heterogenous-tasks.wordpress.com/2015/01/26/standard-patterns-in-choice-based-games/>
- [4] Fabulich, D. (2010). 5 Rules for writing interesting choices in multiple choice games. *Choice Of Games*. Blog post. <https://www.choiceofgames.com/2010/03/5-rules-for-writing-interesting-choices-in-multiple-choice-games/>
- [5] Fabulich, D. (2011). By the Numbers: How to Write a Long Interactive Novel that Doesn’t Suck. *Choice Of Games*. Blog post. Accessed from: <https://www.choiceofgames.com/2011/07/by-the-numbers-how-to-write-a-long-interactive-novel-that-doesnt-suck/>
- [6] Strong-Morse, A. (2010). Vignette Structure as a Means of Controlling Branching. *Choice Of Games*. Blog Post. Accessed from: <https://www.choiceofgames.com/2010/01/vignette-structure-as-a-means-of-controlling-branching/>
- [7] Swinehart, C. (2009). One Book Many Readings. *Samizdat Drafting Co*. Blog post. Accessed from: <http://samizdat.cc/cyoa/>
- [8] Andrews, D., & Baber, C. (2014). Visualizing interactive narratives: Employing a branching comic to tell a story and show its readings. *Proc. of the SIGCHI Conference on Human Factors in Computing Systems*. p1895-1904. doi:10.1145/2556288.2557296
- [9] Vermeulen, I. E., Vorderer, P. A., Roth, C., & Klimmt, C. (2010). Measuring user responses to interactive stories: Towards a standardized assessment tool. *Lecture Notes in Computer Science*, V. 6432, 38-43. doi:10.1007/978-3-642-16638-9\_7
- [10] Sali, S., & Mateas, M. (2011). Using information visualization to understand interactive narrative: A case study on façade. (pp. 284-289). Berlin, Heidelberg: Springer Berlin Heidelberg. doi:10.1007/978-3-642-25289-1\_31

- [11] Seif El-Nasr, M., Drachen, A., & Canossa, A. (2013). Visual Analytics Tools – A Lens into Player’s Temporal Progression and Behavior. *Game analytics maximizing the value of player data*. London: Springer London. P 435-470. doi:10.1007/978-1-4471-4769-5
- [12] Medler, B., John, M., & Lane, J. (2011). Data cracker: Developing a visual game analytic tool for analyzing online gameplay. Paper presented at the SIGCHI Conference on human factors in computing systems, doi:10.1145/1978942.1979288
- [13] Riehmman, P., Hanfler, M., & Froehlich, B. (2005). Interactive sankey diagrams. Paper presented at the IEEE Symposium on Information Visualization. doi:10.1109/INFVIS.2005.1532152
- [14] Stephens-Martinez, K., Hearst, M., & Fox, A. (2014). Monitoring MOOCs: Which information sources do instructors value? Proc. of the ACM conference on learning. doi:10.1145/2556325.2566246
- [15] Kizilcec, R., Piech, C., & Schneider, E. (2013). Deconstructing disengagement: Analyzing learner subpopulations in massive open online courses. Proceedings of the Third International Conference on learning analytics and knowledge. doi:10.1145/2460296.2460330
- [16] Catherin, O. (2014). Building a Dynamic Sankey Diagram made of Polygons in Tableau. *Data + Science*. Blog post. Accessed from: <http://www.dataplusscience.com/SankeyPolygon.html>
- [17] Shaffer, J. A. (2014). Using Improved Data Connectivity in Tableau 8.2 to Build Sankey Diagrams. *Data + Science*. Blog post. Accessed from: <http://www.dataplusscience.com/SankeyinTableau82.html> :
- [18] Martin, M. (2012). Build Network Graphs in Tableau. *Clearly and Simply*. Blog post. Accessed from: [http://www.clearlyandsimply.com/clearly\\_and\\_simply/2012/12/build-network-graphs-in-tableau.html](http://www.clearlyandsimply.com/clearly_and_simply/2012/12/build-network-graphs-in-tableau.html)
- [19] Kieffer, S., Dwyer, T., Marriott, K., & Wybrow, M. (2015). HOLA: Human-like orthogonal network layout. *IEEE Trans. on Visualization and Computer Graphics*, 22(1), 349-358. doi:10.1109/TVCG.2015.2467451
- [20] Faber, M. (2015) Choose your own research adventure. University of British Columbia Woodward Library. <https://survey.ubc.ca/s/LFS/>