Students' Perception of a Method for Identifying Topics for Research Questions

line 1: 2nd Given Name Surname
line 2: *dept. name of organization (of Affiliation)*
line 3: *name of organization (of Affiliation)*
line 4: City, Country
line 5: email address or ORCID

line 1: 3rd Given Name Surname
line 2: *dept. name of organization (of Affiliation)*
line 3: *name of organization (of Affiliation)*
line 4: City, Country
line 5: email address or ORCID

***Abstract*—In this full research paper, the results of an approach for identifying research topics are presented. The initial step in developing research questions is identifying an interesting topic. The challenge is making the transition from an interest to a topic specific enough to support a research project. The purpose of this study is to assess students' perception of a method designed to help with identifying research topics. In this paper we examine, compare and present results from undergraduates who used the activity worksheet method to identify research topics for semester projects. The main research question is "How do students perceive the usability of the activity worksheet method for identifying topics?" A higher order thinking framework and elements of information literacy framework are used to address two key important aspects of identifying topics: 1) articulating what is known and 2) identifying lack of knowledge about a topic. The activity worksheet for identifying topics was completed by 45 students enrolled in two sections of an undergraduate data visualization course in a research-intensive university in the Midwest United States. After completing the worksheet students were asked to provide feedback on the usability of the worksheet. This feedback was provided as a Likert scale rating from 1-5, with 1 being strongly disagree and 5 being strongly agree. Results show 63.7% of responses were "agree" or "strongly agree" that the worksheet is helpful in identifying topics. This research is significant because it helps students to think critically about topic selections for research projects. As students understand what they know and need to know about topics they choose, their understanding will inform the types of questions they ask in the next stage of the developing research questions process: transforming topics into questions. The contribution of this work is a methodical approach to assist, in any discipline, in helping students to develop sound research questions. The implications of this work will help students to build skills in recognizing a need for information and data to answer a specific research question, a practice that is required in engineering and computing education**

Keywords—students' perception, identifying topics, research questions, Bloom's Taxonomy, information literacy, cognitivist pedagogy

I. Introduction

Developing good research questions is a skill that improves over time. The first step in developing research questions is identifying an interesting topic. The challenge is making the transition from an interest to a topic that is specific enough to support a research project. In this paper we examine, compare and present results from undergraduates who used an activity worksheet to help think through the process of identifying research topics for semester projects. The main research question for this work is "How do students perceive the usability of the activity worksheet method for identifying topics?" The first aim of the study is to introduce an activity worksheet approach for identifying topics for research questions. The second aim is to assess students' perception of the usability of the activity worksheet method in helping to articulate current knowledge on a topic. Engineers and computer scientists are routinely faced with solving open ended and multi-disciplinary problems, requiring higher-order learning in university education [1]. Rather than solving a specific problem, in this study, students are asked to identify topics of interests and exercise cognitive skills in determining how much they know about their topic (i.e., potential problems). This research is significant because it helps students to think critically about topic selections for research projects. As students understand what they know and need to know about topics they choose, their understanding will inform the types of questions they ask in the next stage of the developing research questions process: transforming topics into questions. The implications of this work will help students to build skills in recognizing a need for information and data to answer a specific research question, a practice that is required in engineering and computing education. The contribution of this work is a methodical approach to assist, in any discipline, in helping students to identify topics for sound research questions. Bloom's Taxonomy [2] of hierarchical learning and information literacy theory are the underlying frameworks that support this work.

II. Background

A. Bloom's Taxonomy

The hierarchy of Bloom's Taxonomy [2] and the revised model [3] are widely accepted frameworks used by many educators to guide their students through the cognitive learning process in disciplines such as math, biology, CS and engineering. Bloom's Taxonomy has been applied to the domain of computer science for course design and evaluation [4], structuring assessments [5] and comparing the cognitive difficulty level of computer science courses [6]. Abran [7] used Bloom's Taxonomy to classify typical programming and software engineering tasks. Shneider and Gladkakh [8] used the revised Bloom's Taxonomy for planning diagnostic assessments for programming, systems analysis and systems design. Thompson [9] provided an interpretation of the revised Bloom's taxonomy for computer science. Beginning with the simplest level and increasing in complexity, the cognitive levels are: Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation [1]. Action verbs for Bloom's Cognitive Levels include: Level 1 (Knowledge), Level 2 (Comprehension), Level 3 (Application), Level 4 (Analysis), Level 5 (Synthesis) and Level 6 (Evaluation). Levels 4 – 6 are considered to represent higher-level cognitive activities that require and develop mental faculties of creativity, critical thinking and innovative problem solving [1]. Fostering students' higher order thinking skills is considered an important educational goal [10]. Brookfield [11] defines three categories of higher-order thinking: (1) in terms of transfer, (2) those that define it in terms of critical thinking, and (3) those that define it in terms of problem solving. In this work, we adopt the definition of higher-order thinking in terms of critical thinking. Levels 4 - 6 of Bloom's Taxonomy are adapted in the worksheet method for identifying topics.

B. Pedagogical Theories and Frameworks

Three learning frameworks are mapped to the activity worksheet approach: behaviorist, cognitivist, humanist, and constructivism. The behaviorist model involves a teacher-centered approach in which the educator's role is to manipulate the environment for learners to elicit a specific response [12]. Behaviorism focuses on the mastery of prerequisite steps before moving to subsequent steps; this learning orientation is aimed at reinforcing what the teacher wants the learner to perform [13].

In this work, the behaviorist approach is used in the generation of research topics by motivating students to think of topics that interests them from a research perspective. The cognitivist framework is utilized in this work to facilitate cognitive processing by helping students "learn how to learn" [14]. The goal of the cognitivist approach is to develop the learner's capacity and skills for more effective self-directed learning [12]. Cognitivist theorist, [15] states meaningful learning results from relating new knowledge to what is already known. In the context of the activity worksheet method for identifying research topics, students are rarely asked to formally state what is known about a topic, and subsequently devote little reflective time to thinking deeply and logically about what is unknown about topics that interest them. Developing critical thinking through reflection is one of the most important components of the cognitivist orientation [11].

Information literacy is a way of thinking and reasoning about aspects of subject matter [16]. Orr [17] states to incorporate information literacy, courses should be structured in such a way that inquiry is the norm, problem solving becomes the focus, and critical thinking is part of the process. This multiplies the opportunities for students' self-directed learning as they become engaged in using a wide variety of information sources to expand their knowledge, ask informed questions, and sharpen students' critical thinking skills for further self-directed learning.

Elements of the Information Literacy Framework are used in this work to help students articulate what is known about their list of topics and to identify their lack of knowledge about a topic [18]. Mastery of generic information seeking skills is the precursor to, and lays the foundation for, the development of higher-level thinking and evaluative skills [17]. These skills are prerequisites for all analytic sciences.

The last framework associated with this work is the humanist framework [19]. In the humanist framework, the goal is for the learner to become autonomous and self-directed [12]. Learning that stems from this approach has several characteristic features, applicable in other learning situations regardless of the topic or context [12], including personal involvement of the learner, and learning that is self-initiated and is evaluated by the learner [20]. The role of the teacher in this framework is to facilitate the growth and development of the overall person [12]. In the context of this work, the identifying topics worksheet is a tool for teachers to use to facilitate the development of critical skills for identifying topics that are focused enough to support a substantial research project [21].

C. Implications for Engineering and Computer Science

Literature shows the pedagogical theories and frameworks utilized in this work are represented in engineering and computer science curriculums and pedagogy. A constructivist learning environment was the basis for supporting Question-based learning for first year students to learn design data flow diagrams [22]. Information literacy is essential to engineering [23] and computer science and has been shown to be a successful in integrating data science into computer and information literacy courses [24]. Critical thinking and higher order thinking are hallmarks of engineering and computer science. Sasidhar [25] describes enhancing critical thinking in engineering through an innovative e-assignment and peer review. In our work, critical thinking and higher order thinking are utilized in the identification of research topics as a mechanism for developing and refining of transferable skills that will serve students well throughout their educational and professional experiences.

We define higher-order thinking to be cognitive skills that allow students to function at the analysis, synthesis, and evaluation levels of Bloom's Taxonomy [26]. We define the following sub-research questions for this work:

1. Do students enrolled in an introductory data visualization course perceive the worksheet method to be useful in identifying research topics?
2. Do perceptions about the worksheet differ between sections?

These questions will be discussed with respect to the main research question, "How do students perceive the usability of the activity worksheet method for identifying topics?"

III. METHODOLOGY

A. Identifying Topics Worksheet

The first step of the methodology for this work aligns with the first aim of the project: to introduce an activity worksheet approach for identifying topics for research questions. For this work, a one-page worksheet was created to help students identify research topics, but more importantly, determine, through critically thinking, the viability of the topic to support a strong research focus. The goals of the worksheet are: (1) to identify topics of interest, (2) to think critically about what is known and what is not known about each topic, and (3) compare and rank the topics according to preference. The worksheet consists of two sections that map to Bloom’s Taxonomy of learning: generate and evaluate (Fig. 1). The generate section consist of five questions. The first four questions focus on creating/generating ideas. Question one asks students to list a minimum of three topics. Listing multiple topics of interest provides a short list to choose from in the event outcomes from future stages in the process of developing a research question necessitate a change in topic. Question two asks students to identify which of the three topics interest them the most and why. Elements of the information literacy framework are adopted in questions three and four to address two key important aspects of identifying topics: 1) articulating what is known and 2) identifying lack of knowledge about a topic. Question three asks students to articulate what they know about each topic. The fourth question, asks students to articulate what is not known about topic. The second section of the worksheet asks students

Topics

Goal: To generate research topics.
Objectives: Students will identify a list of topics of interest.
Outcomes: List of topics of interest (ranked and identifying who the audience is)

Generate

1) **List three topics that interests you (be as specific as possible)**
   a. *Replace this text with your First Topic*
   b. *Replace this text with your Second Topic*
   c. *Replace this text with your Third Topic*
2) **Which topic interests you the most? Why?**
   a. *Restate the topic using complete sentences*
3) **What do you know about each topic?**
   a. *Topic 1:*
   b. *Topic 2:*
   c. *Topic 3:*
4) **What do you not know about each topic?**
   a. *Topic 1:*
   b. *Topic 2:*
   c. *Topic 3:*

Evaluate

5) **Compare and rank topics**
   a. *In this space evaluate your topics, what you know what you do not know about them. Rank the topics according to your preference then answer the following questions about each: Is this the right challenge to tackle? Is there enough detail or is there too much?*

Fig. 1. Identifying topics worksheet.

to “evaluate” their topic choices by comparing and ranking the three topics based on their interests, what they know and what they do not know about each of the topics. Upon completing the evaluation, students are asked to articulate, based on their evaluation, if each topic is a viable topic for the research they are interested in and if the topics are too narrow or too broad in scope.

B. Participants

The research was implemented in an undergraduate data visualization course at a research-intensive university in the Midwest United States in Fall 2019. The 16-week course is an introductory course in data visualization. The course meets twice a week with a lecture/lab format. The learning objective for the course is to introduce the data visualization process. Upon completing the course, students are required to demonstrate their proficiency in applying the data visualization process by presenting results from a research topic of their choosing with data and visualizations to support their conclusions.

The activity worksheet for identifying topics was completed by 45 students enrolled in two sections of an undergraduate data visualization course in a research-intensive university in the Midwest United States in Fall 2019. The control group (Section A) was comprised of students, majoring in STEM related fields and in their second year or higher of the degree program. The comparison group (Section B) included students participating in a data science learning community (LC). Section B consisted of students from both STEM and non-STEM related majors. Section A consisted of 22 students, while Section B consisted of 23 students. The combined sections consisted of 2 freshmen, 24 sophomores, 14 juniors and 5 seniors. Students in both sections presented with little to no experience doing research and are typically unaware of a structured process for identifying topics to support a strong research focus.

C. Data Collection

The requirement of a semester project, based on research topics identified by students and approved by the professor, is discussed on the first day of class. Students were given the worksheet during the first week of classes and given one week to complete the worksheet.

Data for the project consists of completed worksheets (Fig. 1) and students’ self-assessment of the usability of the activity worksheet. Students were asked to provide feedback by completing a short assessment survey after completing and submitting the worksheet for review by the professor and teaching assistants.

After completing the worksheet, students were asked to provide feedback (Fig. 2) on their perception of the usability of the worksheet using a 5-point Likert scale. strongly disagree (1), disagree (2), neutral (3), agree (4), and strongly agree (5). The assessment survey consisted of three statements, shown in Fig. 2. If students responded strongly disagree or disagree, they were

Assessment

Using the Likert scale below indicate your level of agreement.

S1. I found the Topics Worksheet to be helpful in generating topics.

[ ] Strongly Disagree [ ] Disagree [ ] Neutral [ ] Agree [ ] Strongly Agree

S1a. If you answered strongly disagree, please provide a brief explanation.

S2. The worksheet helped me to understand the relevance of the task of choosing a topic.

[ ] Strongly Disagree [ ] Disagree [ ] Neutral [ ] Agree [ ] Strongly Agree

S2a. If you answered strongly disagree, please provide a brief explanation.

S3. I had a clear idea of topics before completing the Topics Worksheet.
The worksheet merely provided a mechanism for me to write topic ideas on paper.

[ ] Strongly Disagree [ ] Disagree [ ] Neutral [ ] Agree [ ] Strongly Agree

S3a. If you answered strongly disagree, please provide a brief explanation.

Fig. 2. Assessment questions.

asked to provide a brief a brief explanation. This data is collected to inform refinement of the worksheet. Analysis of this qualitative is not covered in this manuscript.

D. Data Analysis

Analysis of the data aligns with the second aim of the project: to assess students' perception of the usability of the activity worksheet method in helping to articulate current knowledge on a topic. For this work, only the student self-assessment data for the usability of worksheet are analyzed. Data analysis of Likert-scale data was performed. In this work multiple statements are used in the research survey instrument. The mean is used as the basic descriptive statistical indicator for each statement in the survey research instrument. T-tests are used to compare Likert scores by sections and by questions. Microsoft T.TEST function was used to calculate p-vale using two-tailed distribution, for two-sample unequal variance. An alpha level of .05 was used for all statistical tests.

IV. RESULTS

A. Comparing the overall mean score by sections

TABLE I. T-TEST RESULTS FOR COMPARISON BETWEEN SECTIONS

	Mean		***t-Test***
Overall (n=135)	Section A (n=66)	Section B (n=69)	p-value
3.57	3.53	3.61	0.52

B. Comparing usability statements by sections

TABLE II. T-TEST RESULTS FOR COMPARISON BETWEEN SECTIONS

	Mean		***t-Test***
Overall (n=45)	Section A (n=22)	Section B (n=23)	p-value
3.71	3.54	3.86	0.04

TABLE III. T-TEST RESULTS FOR S2: "THE WORKSHEET HELPED ME TO UNDERSTAND THE RELEVANCE OF THE TASK OF CHOOSING A TOPIC."

	Mean		***t-Test***
Overall (n=45)	Section A (n=22)	Section B (n=23)	p-value
3.73	3.72	3.73	0.94

TABLE IV. T-TEST RESULTS FOR S3: "I HAD A CLEAR IDEA OF TOPICS BEFORE COMPLETING THE TOPICS WORKSHEET."

	Mean		***t-Test***
Overall (n=45)	Section A (n=22)	Section B (n=23)	p-value
3.26	3.31	3.21	0.70

TABLE V. FREQUENCY RESPONSE COUNTS FOR S1, S2, AND S3

Likert Responses	All (n=45)	Section A (n=22)	Section B (n=23)
	Count (%)	Count (%)	Count (%)
Strongly disagree	1 (1%)	1 (2%)	0 (0%)
Disagree	11 (8%)	5 (8%)	6 (9%)
Neutral	37 (27%)	19 (29%)	18 (26%)
Agree	82 (61%)	40 (61%)	42 (61%)
Strongly Agree	4 (3%)	1 (2%)	3 (4%)
	135 (100%)	66 (100%)	69 (100%)

TABLE VI. FREQUENCY RESPONSE COUNTS FOR S1

Likert Responses	All (n=45)	Section A (n=22)	Section B (n=23)
	Count (%)	Count (%)	Count (%)
Strongly Disagree	0 (0%)	0 (0%)	0 (0%)
Disagree	1 (2%)	1 (5%)	0 (0%)
Neutral	12 (27%)	8 (36%)	4 (17%)
Agree	31 (69%)	13 (59%)	18 (78%)
Strongly Agree	1 (2%)	0 (0%)	1 (4%)

TABLE VII. FREQUENCY RESPONSE COUNTS FOR S2

Likert Responses	All (n=45)	Section A (n=22)	Section B (n=23)
	Count (%)	Count (%)	Count (%)
Strongly Disagree	0 (0%)	0 (0%)	0 (0%)
Disagree	2 (4%)	1 (5%)	1 (4%)
Neutral	9 (20%)	4 (18%)	5 (22%)
Agree	33 (73%)	17 (77%)	16 (70%)
Strongly Agree	1 (2%)	0 (0%)	1 (4%)

TABLE VIII. FREQUENCY RESPONSE COUNTS FOR S3

Likert Responses	All (n=45)	Section A (n=22)	Section B (n=23)
	Count (%)	Count (%)	Count (%)
Strongly Disagree	1 (2%)	1 (5%)	0 (0%)
Disagree	8 (18%)	3 (14%)	5 (22%)
Neutral	16 (36%)	7 (32%)	9 (39%)
Agree	18 (40%)	10 (45%)	8 (35%)
Strongly Agree	2 (4%)	1 (5%)	1 (4%)

V. Discussion

The main research question addressed by this work is "How do students perceive the usability of the activity worksheet method for identifying topics?" To answer this question, Likert-scales were used to capture students' perception of the usability of the worksheet. The mean is used as a statistical indicator of students' perception. For this work, a mean value greater than three is considered favorable (agree or strongly agree), and a mean value less than three is considered unfavorable (disagree or strongly disagree). As seen in Table V, a total of 135 responses (66 from Section A and 69 from Section B among all statements) were analyzed for the entire worksheet. Out of the 135 responses, 86 were positive (agree or strongly agree), equaling 63.7% of the total responses. Furthermore, 121 of the 135 responses, or 91.1%, were non-negative (neutral, agree, or strongly agree). Overall, all calculated means were a value of 3 or higher, indicating, on average, both sections found the worksheet to be helpful.

A comparison of Likert scores by sections using mean scores and t-test showed although the mean values suggest some differences between Section A and Section B, the t-test results indicate there is not sufficient evidence to make generalizations about the outcome to all students. In Table I, we obtained a p-value of 0.528 for the overall mean score for the worksheet, which means that the chance the section differences are due to random variation is 47.18 (p-value from 1) percent. The p-value is well above $P = 0.05$ and as such, we cannot be confident that our results are reflecting true differences between the two groups in how, overall, they perceive the usability of the worksheet as being helpful with identifying research topics. So, even though Section B had a higher overall average rating (3.61 versus 3.53), there is not sufficient evidence to think that this difference applies to all students.

No significant difference was indicated by examining all students' responses to the survey research instrument (assessment survey); however, an examination of students' responses to individual survey statements is used to address the sub-research questions:

> SRQ1: Do students enrolled in an introductory data visualization course perceive the worksheet method to be useful in identifying research topics?
>
> SRQ2: Do perceptions about the worksheet differ between sections?

A. *"Do students enrolled in an introductory data visualization course perceive the worksheet method to be useful in identifying research topics?*

To answer this question, the mean values were calculated and t-test applied to responses for each question and for each student section. Analysis of data for S1: "I found the Topics worksheet to be helpful in generating topics," resulted in a p-value < 0.05. A p-value < 0.05 is considered statistically significant. Table II shows we obtained a p-value of 0.0481 for the overall mean score for statement one, indicating there is a 95.2 percent chance the difference is not due to random variation. The p-value for statement one cleared the minimum significance level that is commonly used as a threshold for "significant results." Despite the contradiction to the previous results for students' overall perception of the worksheet (Table I), we conclude the difference we see, in statement 1 responses, is statistically significant.

Fig. 3 shows the frequency count for S1 and the color-coded distribution of Likert values between sections, revealing a possible cause for the skewed data: there was one disagree for section A and one strongly agree for Section B that may have slightly affected the data.

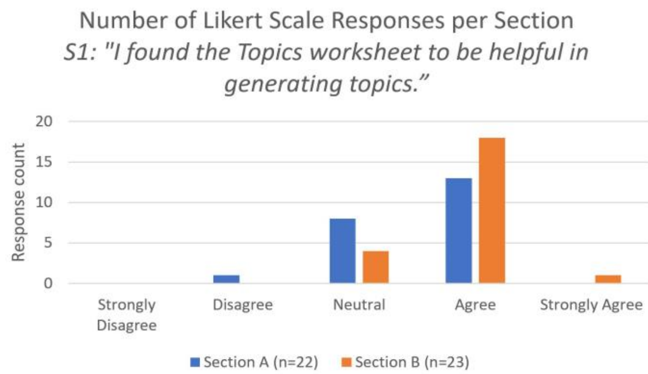

Fig. 3. Response count for S1.

P-values for statement 2 and statement 3, Table III and Table IV, respectively, are greater than 0.05. There is not sufficient evidence to conclude: 1) the worksheet helps students to understand the relevance of the task of choosing a topic, and 2) whether or not students have clear ideas of topics before completing the worksheet.

We were interested in understanding the inconsistency between lack of significant difference when examining the collective responses versus responses to the individual questions regarding the usability of the worksheet. A more granular look at responses for each statement by sections provided more insight for the second sub-research question (SRQ2).

B. *Do perceptions about the worksheet differ between majors and non-majors?*

We see from Tables I - IV, the overall averages for Section B, for each calculation, were consistently higher, than Section A, with one exception in statement 3. We find this to be interesting that the non-STEM section responses were more favorable towards finding the worksheet to be helpful in generating topics (S1) and the worksheet being viewed favorably towards helping to understand the relevance of the task of choosing a topic (S2). Section A had a slightly higher mean value for statement 3, suggesting students in Section A felt they had some clear ideas for research topics before completing the topics worksheet.

Frequency counts shown in Tables V – VII show the most common responses (in bold) for the worksheet (Table V) and across individual questions (Tables VI and VII) among respondents was "agree." The values in Table VIII shows the most frequent response for statement 3 for Section B was "neutral." As we look across the frequency tables, a pattern of a large number of "neutral" responses. It is unclear what "neutral" represents: indifference or a guess? For future offerings we will explore options for the "neutral" option to more accurately capture the neutral responses.

Although we are encouraged by the outcomes, we acknowledge the project is not without limitations. The first limitation is the relatively small sample size (number of participants). Fall 2019 was the first semester that offered two sections of the class in which the worksheet was used. The worksheet will be used in future offerings in the same class and other classes where students are required to develop research questions and or develop topic ideas for assignments and projects. That being said, the more students you sample, the better the chances that your results hold true for the entire 'population' of students you are trying to analyze [27].

Another limitation is the data itself, the Likert Scale data. Likert data are the most broadly used method for scaling responses in survey studies [28], but there has been a long standing debate over how to analyze these data [29]. The general question centers on whether to use a parametric or nonparametric test to analyze Likert data [28]-[29]. Results from [30] suggest that when you're looking at two sample analyses, such as for Section A and Section B for this work, it doesn't matter much as long as you have at least 10 observations per group. In this research there were over 20 participants in each group.

This paper only focused on Likert-scale data associated with the project. For a more in-depth analysis, data from the completed worksheets could be assessed and mapped to students' performance in the class. For each assessment question, if students' response was "disagree" or "strongly disagree" they were asked to briefly explain their disagreement. Qualitative analysis of open-ended feedback questions could identify issues and inform refinement of the worksheet.

VI. Conclusion

In this study, we assessed students' perception of the usability of the "Identifying Topics" worksheet in helping to identify topics for semester research projects. We define higher-order thinking to be cognitive skills that allow students to function at the analysis, synthesis, and evaluation levels of Bloom's Taxonomy [26] and provided an activity worksheet as vehicle to facilitate higher order thinking in the process of identifying research topic ideas.

We have presented results from the perception from two groups of students (Section A and Section B) of a worksheet method designed to assist in identifying research topics. Overall, both groups found the worksheet to be helpful, suggesting the worksheet could be a valuable tool. Future implementation of the worksheet will include content to help students focus more on what is not known about topics they identify. Understanding what is known and unknown about a topic helps students to transition from a broad topic to a focused one. Once they have a focused topic the next step is to formulate questions that point to data that is needed to answer them [21].

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