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Topic Development in the Freshman Engineering Paper: Finding a Focus

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Short Title: Finding a Focus

Abstract:

Topic development and focus are relatively neglected areas of the student research process. This study examined how students in a freshman engineering writing class developed initial research paper topics into focused thesis statements. A mixed methods approach was used, incorporating online surveys, qualitative interviews, and a rubric to track topic development and assess thesis statement focus. The survey results and student comments indicated that participants were more competent at the mechanics of finding sources and writing than at developing appropriately scoped thesis statements. Closer collaboration between writing instructors and librarians is urged to more effectively support and scaffold topic development.

Keywords: topic development, focus formulation, novice researchers, engineering education

Introduction

According to a longitudinal study of college students' information seeking practices conducted by Head and Eisenberg (2010), 84% of college students find the most difficult stage of research to be just getting started (p.25). For experienced writers, coming up with a focus to write about may be a relatively straightforward task, but for many undergraduate students, this can be a snag (Brostoff and Beyer 1980; Fister 1992; Head and Eisenberg 2010).

It is safe to say that college and university freshmen are novices within their chosen majors in that they have not yet developed an essential grounding in their disciplines. This grounding includes a facility with the terminology and major concepts, the problems and 'big questions' within the discipline, as well as a sense of what questions are worth asking. Students who are required to come up with a research paper topic in a field that they know very little about may have no idea where to begin, what questions would be fruitful to ask and explore, or even where to look for guidance.

It does not help that the consequences of failing with a topic are dire. If a student fails to come up with a nicely-summarized topic, or takes too long to finalize her topic or focus, she can fail the writing assignment (Head and Eisenberg 2010, 31–32). Outside the library, the pedagogy of research and writing at the college level, especially in an applied science field such as engineering, can sometimes seem to oversimplify the process of knowledge creation as "finding answers" rather than "identifying questions" (Fister 1992, 168). Furthermore, by providing a summative grade mainly for the end product, instructors may implicitly privilege the successful focus (Lundstrom and Shrode 2013) rather than the exploration and discovery of potential questions and problems.

Western Michigan University in Kalamazoo Michigan is a doctoral level university with “Higher Research Activity” in the Carnegie Classification (Indiana University Center for Postsecondary Research n.d.). The College of Engineering and Applied Sciences (CEAS) at Western had 3,179 students in Fall 2017 (Western Michigan University 2018), of whom 487 were freshmen (Western Michigan University - Institutional Research 2018).

Incoming students at CEAS are required to take a freshman-level engineering writing seminar called IEE1020 Technical Communication. The culminating assignment is a 12-14 page research paper (IEE Technical Communication Staff 2015, 24) that requires students to select a topic related to their majors, gather background information, and develop what is called a purpose statement. The purpose statement describes a technical problem and the proposed solution for that problem (IEE Technical Communication Staff, 2015, p. 13). Over a decade of working with students in this course, the researcher has noticed student struggles in choosing and refining research paper topics, with many students often choosing topics that are ultimately too broad for them to write effective papers on. The motivation for this study is to determine whether the researcher’s day-to-day perception of student difficulty was an accurate reflection of the experience of students in this course, or is simply a result of the librarian having interacted more with the students having trouble. Furthermore, these student struggles guided the development of the research questions for this study

The researcher draws on students’ perspectives and lived experiences to gain a sense of their metacognitive processes as they conceptualized and researched their paper topics. In addition, the researcher examines final purpose statements submitted by students in their research papers. Such a qualitative look at students' thought processes may illuminate ways that the librarian and the instructors in IEE1020 can identify and better address the "stuck places"

(Ellsworth 1997, 71) of student research, leading to better pedagogical interventions and well-thought out research papers.

Research Questions

The purpose of this study is to examine how students in a freshman engineering writing class come up with research paper topics and develop those initial ideas into workable thesis or purpose statements for their research papers. The research questions that guided this study were: RQ1: How do freshman engineering students generate or select topics for research papers? RQ2: What difficulties do students have developing selected topics into researchable questions or purpose statements? RQ3: What resources do students use to help them develop their purpose statements? RQ4: Have students achieved appropriately focused topics (as articulated by their purpose statements) by the time they have written and submitted their final paper drafts?

Literature Review

A number of studies have probed what happens in the information seeking process as academic writers attempt to select and focus a topic. McMullin and Taylor (1984) discuss what they call the "focus continuum" (p.100), which refers to how well a researcher can articulate her question or problem. As a result of several studies of library users in school, college, and public libraries (1988b, 1988a, 1989, 1990, 1991), Kuhlthau developed a model of information seeking that described how students move through these different levels of focus. A person who seeks information begins in a state of uncertainty and even anxiety (Kuhlthau 1991, 365) as she struggles to articulate her information need – a hindrance even for experienced researchers (Belkin 1980; Taylor 1969) but particularly difficult for novices (Brostoff and Beyer 1980; Sommers and Saltz 2004). Starting with an initial inchoate idea or even no idea at all, a researcher engages in “prefocus exploration” (Kennedy, Cole, and Carter 1997, 1999; Kuhlthau

2004, 47) to build a cognitive and intellectual context for a potential topic. More experienced researchers may have already laid this foundation down through their extensive experiences in graduate school, the workplace, and in previous projects, and so can skip or speed through this step; unless, of course, they are undertaking research into a new or untried domain, in which case, they too must build a new framework.

Topic ideas may originate from personal interests (Fister, 1992; Kuhlthau, 2004; Lund and Schrode, 2013), assignment requirements (Kuhlthau, 2004; Lundstrom and Schrode, 2013), faculty suggestions (Fister, 1992), the student's major (Fister, 1992), the ready availability of resources on the topic (Kuhlthau, 2004; Lundstom and Schrode, 2013), and serendipitous exploration of books and other resources (Fister, 1992). To further develop or winnow their ideas, students often find it useful to talk to other students (Swain 1996; Whitmire 2003), their parents or family members (Swain, 1996), or to engage in a classroom discussion around the subject matter (Zamel 1982).

Once a user has read enough background information, her thoughts can begin to coalesce around a more focused topic – a "semi-focus" (Kennedy, Cole, and Carter 1997, 564) or "connecting" idea (McMullin and Taylor 1984, 95). With this provisional focus in hand, she can begin the process of searching for specific sources to address and refine that focus. At this stage, the specificity of the topic parallels the specificity of the sources sought.

There is some evidence that certain aspects of the search process are extra challenging for the "domain novice user" (Cole, Mandelblatt, and Stevenson 2002) or non-expert, such as the typical undergraduate. Rinto, Bowles-Terry and Santos (2016) examined initial research topics and thesis statements submitted by students in a required freshman writing course to see how well focused the topics were in terms of breadth and feasibility, their use of appropriate

disciplinary language, and their inclusion of an arguable thesis. Freshmen in their study struggled to come up with manageable topics and theses that contained clearly defined arguments rather than being merely informative or talking about the topic. It should be pointed out that Rinto et al. (2016) looked at topics and theses submitted before students engaged in the research and writing of their papers. It is quite possible that the final thesis statements drafted by students after further research would have been much more developed than the initial ones submitted as part of their study. But that said, their study provides some tentative support for the hypothesis that focusing a topic is something that novice researchers have difficulty with.

While the studies discussed above have pinpointed some of the ways that student writers develop research foci, no studies have looked at how freshman engineering students navigate this process and how unique their needs may be. This study attempts to verify what Rinto et al. (2016) discovered regarding the freshman topic selection process, as well as provide some detail on potential problems that may underlie freshman engineering topic selection. To do this, the researcher resolved to closely examine the experience of novice engineering students as they prepare to research an applied science topic for a writing project.

Method

Participants

Participants in the study were students enrolled in the freshman engineering writing course IEE1020 at CEAS during the 2016/17 academic year. Approval to conduct the study over a one-year time period was obtained from the WMU Human Subjects Institutional Review Board (HSIRB# 16-04-36). Participants were recruited from sections taught by the same instructor in both the spring and the fall semesters. Participants in the study received a $30 research incentive ($10 total for the biweekly surveys and a $20 one-time incentive for the end-of-semester

interview). Six students in Fall 2016 and twenty-eight students in Spring 2017 agreed to participate in the study. Of the students who participated in the end-of-semester interviews, twenty-two were freshmen, two were sophomores, and two were juniors (one of whom admitted being a transfer student).

Prospective participants met with the researcher in the researcher's office (or at students' request, in the IEE1020 classroom) to read and sign consent forms. Each participant received a random-generated participant number which was used for the duration of the research project to anonymize the study results, and yet allow the matching of survey and interview responses, as well as to the problem statements, over the course of the study.

For reasons of time limitations, the investigator had originally envisioned recruiting a maximum of 25 study participants from each of the Fall 2016 and Spring 2017 sections of the IEE1020 classes for a total of 50. However, only six participants enrolled in the study in Fall 2016. Due to the small number of participants in that research cohort, this phase was treated as a pilot phase for testing the surveys and for the assessment of the student problem statements. However, the interview transcripts from both semesters' cohorts were analyzed to identify themes.

Design

This study utilized a mixed methods approach, incorporating both quantitative and qualitative methods. The instruments and procedures are detailed below. Data from the methods was then examined using a grounded theory approach (Strauss and Corbin 1994), to inductively uncover patterns and themes from student responses. In grounded theory methodology, the theory that one develops arises from (is 'grounded' in) the data itself (Kuckartz 2014; Strauss and Corbin 1994). Three separate data collection instruments were used: online surveys, a rubric to

assess student-submitted problem statements, and qualitative interviews. These instruments and procedures are discussed below.

Instrument 1 – Online surveys

To track topic and thesis development over the course of researching their papers, student participants completed four biweekly online surveys over the seven weeks of the study. The first survey probed students' initial topic ideas and where they came from. The second survey tracked changes in student topics since the first survey (two weeks earlier). In addition, both of the first two surveys asked students how difficult or easy the process of developing their topic was at that stage. The third survey (given in week five) gathered data about topic development up to that point, as well as where students were in the process of writing their papers. A final survey in week seven asked participants to share their finalized purpose statements OR alternately the paragraphs from their papers that best described the overall purpose (problem and proposed solutions) of their papers. During the 2016/17 academic year, 33 students completed the online surveys. Only the Spring 2017 survey results were used in this study. 28 respondents completed survey one, 25 completed survey two, 24 completed survey three, and finally, 23 respondents submitted thesis statements for evaluation. See Appendix I. for Spring 2017 survey questions.

Instrument 2 – Rubric

Purpose statements submitted by study participants in the final online survey were assessed using a rubric modified from one developed by Rinto et al. (2016, 755) to measure their level of focus. The purpose of this evaluation was to ascertain how skilled the participants were at writing a properly focused research paper topic. The original rubric by Rinto et al. (2016) rubric evaluated proposed student topics (before they wrote their papers) on four criteria (p.755):

• Researchability (given library resources);

• Appropriate breadth;

• Language context; and

• Presence of an arguable topic.

"Researchability" refers to how feasible the students' initial topic ideas were, given library resources and limitations. "Appropriate breadth" refers to how broad or focused student topics were, based on how well they defined a specific research question and provided supporting details. "Language context" refers to how well the students used appropriate disciplinary language to show disciplinary context. Use of disciplinary language would demonstrate that students understood how their proposed topics fit into the large conceptual context of the disciplines. The final category refers to whether the topic statements were thesis or argument-driven, or were merely descriptive or expository. The rubric is designed to assess skills at three levels: Beginning (one point), Developing (two points) and Exemplary (three points).

Permission was requested and granted from the original authors to revise the Rinto et al. rubric to better reflect the nature of the assignment in this study. The "Researchability" category was removed, since the Rinto et al. study looked at student topics *before* the papers were researched and written, not *after*, as in this study. The reviewer criteria for the other three categories were significantly revised to better reflect the types of papers students in IEE1020 were required to write in terms of length and subject matter. The final revised rubric can be seen in Appendix II.

In addition, a page of sample language for each category and skill level was developed to assist the raters, three of whom had not routinely worked with engineering students and so were not familiar with the topics. The sample language is not included here because it uses some quotations from student papers as examples.

Three librarian colleagues from the WMU Libraries agreed to assist the researcher with the rubric assessment. A norming or calibration session was held at the end of the spring semester, to train the raters on using the rubric. The training utilized the problem statements from the Fall 2016 group for practice. The rubric was subsequently revised at this point and the new rubric used for final assessments of Spring 2017 statements. In addition, one rater dropped out due to time constraints. Hence, three raters were involved in the final assessment. The Parity method was used to resolve score differences (Johnson et al. 2005; Kim 2011). In this method, when the two original scores were the same, the final operational score became that score. When the scores diverged, the investigator (the third rater) averaged his scores with the two original scores to achieve a final operational score.

Inter-rater reliability, the measure of how much reliability exists between scores on the same artifacts given by different scorers (Moskal and Leydens 2000, 6), was estimated using Krippendorff's Alpha test. Krippendorff's Alpha (Hayes and Krippendorff 2007) is a reliability test currently used when evaluating inter-rater reliability when more than two scorers or raters are involved and the scoring scale is ordinal. The α values are reported in the results section.

Instrument 3 – Interviews

A short semi-structured interview with individual research subjects was held at the end of each study semester, after research papers had been turned in. The purpose of the interviews was to get a qualitative sense of the research process students went through over the course of the semester in their own words. The interviews provided a chance for students to articulate the experience of developing an engineering topic into a final paper, with all the intellectual and emotional work that is involved in that process. A total of 27 students participated in the qualitative interviews in the fall 2016 and spring 2017 study semesters.

The interviews were recorded using a digital voice recorder (with participants' permission) and transcribed by hired student assistants. Handwritten notes were taken as well, partly to aid in checking the accuracy of the transcripts. The interview transcripts were imported into the ATLAS.ti 7 software for analysis. Themes or categories in the students' research process were then labeled using code words. Both Friese (2012) and Kuckartz (2014) were helpful in providing a clear process for coding themes within the transcripts. The final code list contained about 55 codes. Once the transcripts had been read through and coded the first time, the researcher read through them all again to compare and contrast codes, identify larger patterns, combine redundant codes when necessary, and also see what was missing from the data. Transcript quotes in this article were edited for clarity and to remove repetitious language ("like", "uh", "you know").

Results

A. How do freshman engineering students generate or select topics for research papers (RQ1)

Table 1 summarizes student responses from the initial Spring 2017 survey regarding why they chose their topics. Participants indicated that their topic ideas were based mostly on personal interest, with much smaller numbers indicating that friends, instructors, or even a librarian had some influence.

Table 1: Topic Selection Reason (Spring 2017)*

Reason	Number
Personal interest	23
Friend suggestion	3
Instructor suggestion	2
Librarian suggestion	2
Other - "I have a class on this topic. Didn't know what else to research."	1
No response	1

* Could select more than one option

In the first survey, a Likert scale was used to measure students' familiarity with their topics, as follows: "Not at All Familiar"; "Slightly Familiar"; "Somewhat Familiar"; "Moderately Familiar"; "Extremely Familiar." As can be seen in Table 2, most students were at the low end of familiarity with their potential topics. 41% of respondents were Slightly Familiar with their topics and 38% stated that they were Somewhat to Moderately Familiar with their topics. No one was Extremely Familiar with her topic and only one person was Not at All Familiar with her topic. (Due to an unforeseen error in the survey development, students were able to select more than one option to this question, hence the inclusion of the "Slightly/Somewhat Familiar" and "Somewhat/Moderately Familiar" options.)

Table 2: Familiarity with Topic (Spring 2017) *

Level of Familiarity	Number	%
Not at All Familiar	1	4
Slightly Familiar	11	41
Slightly/Somewhat Familiar	1	4
Somewhat Familiar	8	30
Somewhat/Moderately Familiar	1	4
Moderately Familiar	5	19
Extremely Familiar	0	0

*27 respondents

In the interviews, twelve students mentioned web/internet surfing as a way that they found their topic ideas. Eight students said that they had a prior interest in their topics (something observed also by Fister 1992, Kuhlthau 2004 and Lundstrom and Schrode 2013) – of these, six said that their interests were deep personal ones. Six students stated that their topic ideas developed as a result of conversations with friends or classmates. It is important to point out here that the course instructor emphasizes that he would prefer that students select topics that relate to their majors. Despite this requirement, only five of the interviewed students actually mentioned selecting topics that related to their majors.

One student mentioned that his passion or interest in the topic only became strong after he'd developed the topic to the point where he engaged with it and added his own ideas to it.

> "I wasn't as interested...When I specified and started adding my own ideas to what's already there, then it got interesting, it got more of a, you know, passionate thing than work. Actually what happened is when I really connected with the [topic]…then I really got into it…something I can relate to. It became more for fun." – Participant 32

While the investigator tried to get students to open up about how they discovered the problems they decided to work on, and how their perspective on those problems and their solutions changed over the course of researching them, few students were able to speak articulately about this process. One student mentioned that she did not develop an actual problem until rather late in her research process. Even then, the problem was extremely basic:

> "Well, at first I didn't even really think about a problem, I was just sorta looking into exoskeletons, but… halfway through it, I knew I needed one, so I just thought about how exoskeletons could help people: medical field, industry, and military." – Participant 46

Table 3 shows how respondents described their topics changing between surveys one and two (weeks one and three), and surveys two and three (weeks three and five). Between surveys one and two, topic choices were somewhat fluid, with four students' topics having changed

completely, while five narrowed and two broadened their topics. Ten student topics (nearly half) remained the same. By Survey Three, topics appear to have stabilized to a certain extent, with only six out of eighteen respondents mentioning any changes at all, and twelve students' topics (two-thirds) staying the same between surveys two and three.

Table 3: Change in Topic from Survey One to Three (Number of respondents)

	Survey One to Two	Survey Two to Three
Same	10	12
Complete change	4	0
Slight Change	1	2
Narrowed	5	3
Broadened	2	1
Total	22	18

Similarly, in the interviews, six students claimed that their topics did not change at all in the process of research and writing. See for example:

> "It didn't change too much. It was pretty much just autopilot versus human pilot. It kind of just stayed the same the whole time." – Participant 36

This was borne out by students' responses to the surveys regarding topic development. It appears that many students' topics stayed at a very general expository level, with little actual development of an argument or problem. However, for other students, the topic or thesis can evolve over the course of the research process:

> "[A]t first I was gonna focus on improving employee efficiency. Then I thought that was too broad, so I narrowed it down to health care, the health care industry, and then I was doing research on that, and then found the idea of the electronic health records, and the health information systems." – Participant 13

One student had a very pragmatic reason for sticking with his original paper topic idea:

> "So I was thinking solar panels, and then I was thinking renewable energy in general but then I thought it was too broad…There's so many different aspects. So I narrowed it down to electric vehicles. I did some research, and I found a lot of topics about battery development so then I was thinking, maybe I could just

> talk about new battery developments, my whole paper could be about that. About maybe half way, maybe more towards the due date, and I already had a lot of research done on electric vehicles. So, it just seemed logical to stick with that." – Participant 49

Six students stated that the availability or non-availability of sources affected the topic or problem they eventually chose for their paper. There were several different reasons stated for this. One of the requirements for the IEE1020 research paper is that five sources (out of the total sources utilized in the paper) must have been published in the previous two years. This can be a difficult requirement to meet for some topics. It is especially concerning that many students interpret this requirement as being that *all sources* in the paper must be from the previous two years. Other students became stymied in their keyword searches in databases, where the limited set of search terms they used brought up the same articles over and over again. In a related vein, some students just could not find enough sources on their initial topic, and so switched to a more easily researched topic. This makes sense and is a factor in student topic selection and development that is mentioned by Lundstrom and Schrode (2013).

B. Challenges in developing topics into purpose statements (RQ2)

In surveys one and two, participants were asked about the ease of researching and developing their topics. In each survey, a Likert scale was used to measure perceived level of difficulty, as follows: “Very Easy (No effort required)”; “Easy (Some effort required)”; “Neutral (I can handle this, with moderate effort)”; “Difficult (Taking a lot of work)”; “Very Difficult (I’m struggling).” Table 4 shows the responses to that question for both surveys.

Table 4: Perceived Level of Difficulty – Surveys One and Two (Number of respondents)

Process	Survey One	Survey Two
Neutral (I can handle this, with moderate effort.)	18	15
Difficult (Taking a lot of work.)	5	4
Easy (Some effort required.)	3	5
Neutral/Difficult (Taking a lot of work.)	1	0
NR	1	4
Total	28	28

In both surveys, students were asked to explain their answer to this question, with most students indicating that they really were not having much trouble. Some issues mentioned in Survey 1 include time pressure for searching; finding relevant sources; finding "current" sources (published within the past two years); sifting through irrelevant sources; and having a complicated topic. One student stated:

> "The biggest thing is that my searches haven't come up with very straight forward or solid answers. I would just like to see more solid answers." – Participant 71

Of all the various troubles that students mentioned in the surveys and interviews, no one issue stood out. The main hurdle that students mentioned in Survey 2 was finding enough sources to support their chosen topics. In the interviews, four students mentioned that they did not have enough information or details on their initial topics, which forced them have to search for additional information, keep their topics very broad in focus, or change their topics entirely. Surprisingly, only two students mentioned that synthesizing all the information they had gathered was challenging. One of those students described talking to the course instructor to get help with synthesizing the information he had gathered into something cohesive and focused.

> "So it was about a week before the outline was due. I kinda came up with something, just because I was really struggling with where should I take all the information I have and put it towards the research paper.

> What I should discard out of the 30 or so articles that I had generated originally. And he helped a lot with kind of cutting back some things and directing my focus." – Participant 54

Three students mentioned not finding enough information for their initial focus and having to change direction. Other obstacles mentioned by students included struggling with English as a Second Language, getting sidetracked or procrastinating, underestimating the amount of work required, wishing they could have reworked the topic and paper structure after the paper was submitted, and suffering writer's block. Each of these were mentioned once.

While comparatively few students mentioned any difficulties in defining the problems they wished to tackle, the following quote does illustrate how this can be more challenging when one lacks background knowledge, which is the case for most engineering freshmen:

> "[It] was just kinda hard to, I don't know, find a solution for biofuels. I mean the problem clearly was that biofuels are the future and we can't rely on fossil fuels forever. But it was hard to find a problem. I couldn't find anything specific, or a solution for it since I'm not really that well versed in that kinda stuff." – Participant 57

A related issue mentioned by a few students (but peripheral to topic development) was difficulties in reading and understanding the sources found. While only three students mentioned this issue, their comments highlight how challenging the scholarly engineering literature can be for freshman students who have not had previous exposure.

> "I would say it's kind of hard to read all these scholarly journals. You kinda get used to reading them. I wasn't that, I guess, familiar with it at first. So I guess [laughs] being familiar… familiarity with what you're even talking about." – Participant 5

> "And as far as the research, I think it wasn't that I had a hard time finding research. I had a hard time finding research that was easy to comprehend. 'Cause it was very technical. I had to learn a bunch of terms about engines to understand what they were talking about." – Participant 35

> "I had to read things over four times, and really take a slow process it. And then on the side, google stuff. So I could connect to these articles. I got it done and everything but that was probably one of the more

> harder things, interpreting these articles because they're written in such a way that's just meant for people who are experienced in the field, and so being someone who has little or no experience, going to that it was a little tough at first. But with some effort, I was able to do it." – Participant 76

A couple of students also mentioned the instructor's requirement that student topics be related to their majors as an issue. This requirement may have caused some students to avoid topics they would have been more passionate about. See the following comment from a paper and printing engineering major:

> "I wanted to do something car related, because it's easy for me to write on 'cause I'm interested in the topic but my professor noted that I couldn't just do a paper simply on something that wasn't directly related to my major. So he recommended the use of printed electronics in automobiles." – Participant 34

The overall sense that one gets from the surveys and the interview transcripts is that students' approaches to the research paper process are eminently pragmatic: get the assignment done as efficiently as possible. The fact that no obstacle to topic development or problem definition was mentioned by a significant proportion of students indicates that they do not seem to be overly concerned with these issues. A topic, problem or thesis works for them (i.e. is 'successful') if they are able to find enough sources to write about it for the required page length, the topic is acceptable to the instructor (and relates to the student's major), and is relatively interesting enough for them to stick with for seven weeks.

C. Resources used to help develop purpose statements (RQ3)

Table 5 shows resources that students mentioned in surveys one and two that were helpful in researching and developing their topics up to those points in time. Students indicated a general awareness of library databases in survey one, but there were slightly more mentions of specific library resources as useful in survey two, including more mentions of ProQuest (a database linked to in the IEE1020 class guide), books, the Library, journals, technical

journals/trade magazines, and the ScienceDirect database. Engineering Village, a database taught in the IEE1020 library instruction sessions, was mentioned by the same number of students in both surveys.

Table 5: Resources Used to Research Topic – Surveys One and Two (Number of respondents)

Resources Mentioned*	Survey One	Survey Two
Databases	15	11
Websites	8	6
Articles	6	4
ProQuest	6	8
Engineering Village	6	6
Magazines	3	1
Google	3	0
Books	2	4
GoogleScholar	2	1
Library	2	5
Journals	2	4
Library Search (Discovery engine)	1	0
EBSCO	1	0
Engineering department material	1	0
Technical/Trade magazines	1	6
ScienceDirect	1	3
Online information	1	1
Conference papers	0	1
YouTube Videos	0	1

* Students could mention more than one resource.

Students seemed to need minimal help from other people in developing their topic ideas. Predictably, the IEE1020 instructor was the most frequently mentioned support. He encouraged them to pick topics they would be interested in, recommended the further tightening of focus, and insisted topics be related to majors. In addition, he supplied sample papers and a general outline for students to follow as part of the course materials. This provided much appreciated scaffolding for students' writing.

> "Professor had it set up so it was a pretty streamlined process from just the original gathering of printed sources and stuff to come up with the topic, to getting better sources and getting the bibliography done. You know all the steps were pretty much laid out. All we needed to do [was] to put the pieces together enough to write the final edition and then turn it in." – Participant 47

Students' research and writing process seemed to move between focusing on their own work and occasionally talking with other IEE1020 students. Students discussions with each other consisted mainly of talking over their papers in general or bouncing ideas off each other. It appears that few students seemed to get or request any real help with the development of their topics from anyone else beyond just basic back-and-forth brainstorming of ideas. Only three students even mentioned getting proofreading assistance from their peers.

Given the broad range of topics students were working on, it may simply have been too difficult to bring a fellow student up to speed on one's ideas in any productive way. For example:

> "Just because of where I was in the research paper, and the amount of detail that I was into it, I kinda felt it almost counterintuitive to start a conversation, as far as building them up to the level of what I needed, to the technical level to which I needed to be speaking at for the research paper." - Participant 54

Finally, another complication in attempting to understand student topic development was that study participants seemed very circumspect about discussing any collaboration or idea-sharing with other students. Six students, in particular, insisted that they received no help at all from fellow classmates. In hindsight, they might have been worried that the investigator was probing for evidence of plagiarism or cheating. Given this possibility, it would have been prudent to reassure students at the outset of the interviews that the study was not investigating plagiarism or academic dishonesty.

D. How focused are student purpose statements? (RQ4)

Table 6 shows the results of the assessment of student research paper purpose statements submitted in week seven of Spring 2017, based on the three-point scale used in the modified Rinto et al. 2016 rubric.

Table 6: Assessment of Problem Statements (Final Survey)

	Breadth	Vocabulary	Arguable Thesis
Rounded Mean:	1.5	1.6	1.5
Median:	1	1	2
SD:	0.49572845	0.6478115	0.576804311
Krippendorff α:	0.0473	0.4852	0.0996

Beginning 1 point; Developing 2 points; Exemplary 3 points

On average, study participants scored between the beginning and developing levels on all three criteria: breadth of topic, use of disciplinary vocabulary, and the presence of an arguable thesis. While the mean score for the disciplinary vocabulary category was slightly higher than the means for the breadth and arguable thesis categories, this difference is insignificant, given the Standard Deviation which is at least a half point in each category. In addition, the Krippendorff's alpha scores show that inter-rater reliability was extremely low in each category, below the minimum standard of 0.8. So, one cannot conclude that the rubric used in this study would yield reliable scores.

That said, the overall mean scores are understandable, given that, with the exception of transfer students, the study participants were new to both college-level academic and technical writing. In the interviews, the researcher asked students about their prior experience in writing papers of any sort. The majority of interviewees reported that they had written three or fewer research papers in their previous high school education. Six transfer students reported writing some research papers at their previous institutions. The papers students had written in the past

were overwhelmingly from high school English literature or composition classes. Only three students remembered writing any papers that were related to science or technology topics. Students are also asked in the interviews how satisfied they were with the final purpose or problem statements they submitted to the researcher. Of 27 interviewees, 24 stated that they were satisfied, and three were unsatisfied. The participants were asked to clarify their answers. Student comments indicated that they were satisfied that they covered their topics well, demonstrated some effort, and that their purpose statements "pretty much sum[med] up [their] paper[s]" (participant 59). Participant 8 doubted his topic at the beginning but felt it had "turned out better than I thought." Few students otherwise admitted to having any misgivings about their purpose statements. These responses support Pianko's 1979 finding that undergraduate students are satisfied with their college-level writing when they have "met the requirements of school-sponsored writing" (p.12).

It is possible that some students interpreted this question as "How satisfied are you with your *paper overall*?" rather than "Are you satisfied with your *thesis or purpose statement*?" Oddly enough, even though the "statement of purpose" or thesis statement was a requirement for the paper, students seemed to have trouble understanding what the interviewer meant by these terms. In the study guide for the course, the "purpose statement" idea is referred to in several different ways: "Statement of Problem"; thesis statement; and statement of purpose. Perhaps the lack of consistency in the study guide terminology contributed to student misunderstanding during the interviews.

The three students who admitted to being unsatisfied with their purpose statements had interesting observations about why. One student felt his statement was inadequate because he did

not have enough sources (due to the assignment requirement to have five sources published in the past two years) to cover his original focus:

> "It felt sometimes kind of clumsy to talk about the F35 [airplane]. It almost seemed like an afterthought. I wish that even if the sources that I had to use were three or four years old instead of just two years old then I would've had enough to not have to talk about anything but the A10 [airplane]. And that would've been best, I think. It would've flowed a lot better." – Participant 37

Another student attempted to explain her dissatisfaction:

> "[My purpose statement] was lacking. It wasn't super strong, it was kind of bland. It probably didn't strike you, like, oh, I want to read this. I think because it was a bit more broad. I kind of wrote about a lot of things. I felt like if it was more focused and pinpoint, it might've been a bit more developed, I guess." – Participant 45

Finally, participant 48:

> "I mean, I wish it could've been a little more of what I wanted. I kinda felt like I was, you know, a little bit forced by the topic lines to go more into the stuff I didn't care as much about in the field." – Participant 48

These statements illustrate the tension students feel between meeting the instructor's assignment requirements while maintaining some control over the direction of their papers.

Discussion

Currency of sources versus topic narrowing

The survey results and in-person interviews show that some students clearly struggle with balancing topic focus with the requirement to find "current" sources (published within the past two years). If they properly focus their topics, they run the attendant risk of not finding any relevant or usable articles in the previous two years. Faced with a paucity of current sources, some students appear to broaden their foci until they retrieve an 'adequate' number of current sources, 'adequate' in this case meaning at least five (according to the assignment requirements).

However, this strategy is problematic because it privileges source currency over topic development. While it is important to encourage students to consider currency of sources as one of many factors in source selection, this criterion should not override the need for students to learn to focus and narrow their topics to an appropriate scale for a 12-14 page paper.

Topic scope

Appropriate topic scope was also an issue for students in this study. Many of the purpose statements in this study were not of an appropriate scope for the type of research paper being written. Some statements proposed simplistic solutions (waste management practices, electric vehicles, alternative jet fuels) to very messy real-world problems such as climate change. Other students investigated vaguely-framed or incompletely thought-out comparisons such as whether aviation is more climate-friendly than driving, or whether automated flight control is safer than flight by human pilots (missing the fact that most commercial aviation flight is a combination of both modes). Other students seemed unable to articulate their focus, becoming so lost in trying to define their topics, that the topics effectively disappeared in verbiage. A thesis that began talking about how manufacturers "aren't all bad" turned out to be about the value of printed electronics in the automotive industry.

A related factor may be how the research process is framed by the assignment instructions. The process of research in the IEE1020 course is framed as pick a problem, find (not create or synthesize or explore) a solution(s), and write up the results. The main body of the IEE1020 paper, where the bulk of the content lies, is even called the "Collected Data" section. Framing information seeking as merely "data collection" unavoidably presents it as a cut-and-dried process, simple and direct, not as exploration or open-ended inquiry. There are two unstated and problematic assumptions that students pick up in this framework. The first is that

the problems students select will automatically be well-structured and solvable. The second is that the solutions to these chosen problems will already exist and all students need do is to find them rather than construct or design them. While this way of framing the research process may understandably make “doing the research paper” easier for freshmen on a practical level, it presents a problem for these new engineering undergraduates. Real world problems such as engineering solutions for climate change can be very messy and ill-structured, even "wicked" because they might have no definitive solutions (Crismond and Adams 2012; Dringenberg and Purzer 2018; Rittel and Webber 1973).

What can be done to help students learn to deal with the messy real-world problems they may face once they graduate and enter the work force? Crismond and Adams (2012) discuss the use of an “informed design pedagogy” (p.742) to give budding designers and engineers a sense of how novices differ from expert designers. This pedagogy involves training students in the characteristic behaviors of expert designers: problem framing, paying attention to problem complications, iterating while designing, and brainstorming potential solutions rather than immediately jumping to the most obvious solution.

Topic development process is invisible to students

In both the surveys and the interviews, the students were much more articulate about the mechanics of searching and finding sources than about their topic development process. This study supports Kracker and Wang’s (2002) and Lundstrom and Schrode’s (2013) contention that topic development is not very salient to undergraduates. Perhaps it would be useful to include a “research journal” or “design diary” (Crismond and Adams 2012) portion within the paper assignment, in which students could reflect upon the process of developing their topics, so that they become more aware of this aspect of the research process.

Implications for Library Practice

One clear recommendation that comes out of this study is for more communication and collaboration between instructors of freshman writing courses in the STEM disciplines and the librarians who serve them. Many of the issues identified in this study could be avoided with different or better assignment instructions. First of all, topic development and focus are relatively neglected areas of the student research process. Librarians tend to be more focused on helping students find sources, than on topic development, but given the difficulty of topic development, students should be getting more support from librarians on this. Both Kennedy, Cole and Carter (1999) and Kuhlthau (2004) stress that, to provide effective assistance, librarians must take into account a student researcher's stage in the "focus continuum" (McMullin and Taylor (1984) when they attempt to assist or instruct her. Kennedy et al. (1997) recommend that librarians use a "connecting strategy" to help the undergraduate connect her information need to her online search strategy, and in so doing, help the student "identify [her] own degree of focus" (p.567). The focus is not just one of a series of steps toward the final paper, it is the core of the whole process and should be treated as such. It is arguably more important than the actual paper itself.

For example, the "Research as Inquiry" Frame of the ACRL *Information Literacy Framework* (2016) may provide some insight into developing students' understanding of topic scope. According to this Frame, an information user who is developing increasing skill in information literacy learns to break down complex problems into more manageable ones, thereby framing the problems and potential solutions appropriately (p.7). Addressing this learning objective more explicitly in the IEE1020 research assignment could involve encouraging students to think about and *explicitly address* this aspect by having them attempt to articulate the problem and solution scopes either within their papers or within a separate "design diary"

(Crismond and Adams 2012, 749). They may still struggle with developing appropriately focused problems but at least they have been given an opportunity to become mindful of problem and solution scales.

Also, STEM librarians should encourage instructors to set less stringent limits for source currency. At the very least, it is essential to communicate promptly about topic areas that require more flexibility in this criterion. Even allowing a five to ten-year time frame for "current sources" would make finding sources for some STEM topics so much easier. This would thereby provide students more "wiggle room" for topic development.

Part of effectively searching a provisional topic is being able to select appropriate and useful search terms. Freshmen engineering students have not had enough coursework to develop a sense of appropriate disciplinary terminology. This was shown by the low scores in the results of the "Vocabulary" portion of the assessment of student problem statements. Lack of effective search terms hampers student online searching and retrieval. One recommendation would be to have students submit search terms and initial search results to the librarian (either via email or through a specially-designed Google form) for critique and advice (Crismond and Adams 2012, 753). This would provide valuable feedback to students, and perhaps save student information search time.

Finally, the Rinto rubric or the modified version used in this study provides a useful method for assessing paper topic focus. Encouraging instructors to make use of a tool like this would potentially open up valuable conversations on this relatively neglected area of the student research process. The resulting conversations could lead to more effective interventions to support and scaffold topic development.

Study Limitations

Writing a rubric that could be effectively and reliably used by multiple scorers was an unanticipated challenge in this project. Despite an attempt to rewrite the original Rinto rubric to make it better fit this project, and to make the rating system clearer, the scores given by the three raters diverged enough to raise questions about the validity of any final ratings. The different experiences of the raters with regards to engineering topics potentially created different approaches to using the rubric. It is recommended that future studies take more time to calibrate the use of the rubric among the scorers, and even consider resolving divergent scores through discussion and consensus.

In addition, this study focuses on one group of engineering students at one institution. Ideally, a multi-institutional sample would provide a more generalized vision of freshman engineering student topic development.

Conclusion

While freshman engineering students demonstrate competence at the basic search, retrieval and writing aspects of the research process, the rubric evaluation of their problem statements tentatively indicates that they are less skilled at focusing their topics in terms of breadth, use of disciplinary vocabulary, and framing their purpose in terms of an argument. It would be worthwhile to push these students to develop these skills as they are valuable adjuncts to the real-world design and problem-solving aspects of the engineering discipline. Toward this goal, the revised version of the Rinto rubric used in this study would be useful as an assessment tool in engineering writing courses to get a sense of how well students are able to develop or focus their thesis statements. Measuring these skills is the first step to making sure students develop them.

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Appendix I. Biweekly Survey Questions (Spring 2017)

Survey One (Week One):

1. Please input your Research Study participant number: [This is the number given to you by the Primary Investigator.]
2. At this point, have you selected a topic for your IEE1020 research paper? [Yes/No]
3. If you have selected a topic, what is that topic? (Please include as much detail as possible here, including any alternate ideas or directions that you have in mind.) [Open text box]
4. How did you select your topic? Select all that apply. (Select at least 1.)
    a. Personal interest
    b. Instructor suggestion
    c. Friend suggestion
    d. Librarian suggestion
    e. Other, please specify [Open text box]
5. How familiar are you with your topic at this point? Choose one.
    a. Not at all familiar
    b. Slightly familiar
    c. Somewhat familiar
    d. Moderately familiar
    e. Extremely familiar
6. What resources have you used to research this topic so far? (e.g. Book, website, article, library database.) [Open text box]
7. How has the process of researching and developing this topic been for you so far? Choose one.
    a. Very Easy (No effort required.)
    b. Easy (Some effort required.)
    c. Neutral (I can handle this, with moderate effort.)
    d. Difficult (Taking a lot of work.)
    e. Very Difficult (I'm struggling.)
8. Briefly explain your answer to Question 7. [Open text box]

Survey Two (Week Three):

1. Please input your Research Study participant number: [This is the number given to you by the Primary Investigator.]
2. What is your IEE1020 paper topic? (Please include as much detail as you can here.)
3. What resources have you used to research this topic since the first survey? (e.g. Book, website, article, library database.) Please be specific!
4. Since the first survey, how has your topic changed or developed?
5. How has the process of developing or focusing this topic been for you so far? Choose one.
    a. Very Easy (No effort required.)
    b. Easy (Some effort required.)
    c. Neutral (I can handle this, with moderate effort.)
    d. Difficult (Taking a lot of work.)

    e. Very Difficult (I'm struggling.)
6. Please briefly explain your answer to Question 4. (What has made it easy, neutral, or challenging?) [Open text box]

Survey Three (Week Five):

1. Please input your Research Study participant number: [This is the number given to you by the Primary Investigator.]
2. Have you started writing your IEE1020 paper yet? [Yes/No]
3. If you answered yes, what stage are you at in the writing process?
4. Since the last survey, how has your topic changed or developed? (Please provide as much detail as possible.) [Open text box]

Final Survey (Week Seven):

1. Please input your Research Study participant number: [This is the number given to you by the Primary Investigator.]
2. Please paste in the box below the main paragraph from the "Purpose and Audience" section of your research paper that describes what you researched (your final thesis/problem statement or research question). [If this is a question and a solution, please paste here both the question AND the proposed solution(s).]

Appendix II. Rubric for Analyzing Student Thesis Statements – IEE1020 (Based on Rinto et al. 2016)

	Exemplary – 3 points	**Developing – 2 points**	**Beginning – 1 point**
Appropriate Breadth (12-14 pages)	The thesis statement is focused on a specific problem and/or question, and specific solutions or answers are proposed for solving or addressing that problem/question. Supporting details are supplied.	Topic is still overly broad for a 12-14 page research paper, but the student has defined some areas of their subject in any "two of the following areas (who, what, when, where, how, why)."	Thesis statement is so broadly or vaguely written that it is not manageable for a 12-14 page research paper; "the student does not specify various aspects of their subject (who, what, when, where, why)."
Discipline-Related Vocabulary and Language Context	Student uses more than 4 discipline-specific vocabulary terms to provide language context for the thesis. It is **apparent from the terminology used that the student understands the disciplinary context** of his/her thesis.	Thesis statement is written using 3 or fewer discipline-specific terms. However, **most terms used are non-specialized**. Hence, it is not entirely clear that the student understands where his/her thesis stands within the larger discipline.	Thesis statement is written **using entirely non-specialized, generic terminology**, rather than discipline-specific terminology. It is clear that the student does not understand the disciplinary context of his/her thesis.
End Result as Arguable Thesis	Thesis statement contains a **clearly defined argument**. **Language is present that indicates** that student **is taking a stand** on an issue or question, and will support that stand with evidence from sources.	Thesis statement "asks a "how" or "why" question that could lead to analysis or the development of an argument" but beyond asking a question, **no argument is readily apparent from the thesis as written**.	Thesis statement is **entirely informative or expository, not argument-driven**. It "asks a yes/no or "factual" question", or simply summarizes an issue. Thesis "does not facilitate analysis or argument."

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