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***Abstract*— This work in progress describes library research instruction and baseline assessment data in an undergraduate introductory-level mechanical engineering design course. We investigate whether librarian-led information literacy instruction enables students to develop confidence and more creative solutions to their engineering design challenges. Our study will be a multi-term examination of instruction and outcomes. We review student design reports for works cited and analyze them for quality and variety. In addition we use course end feedback responses to determine student engagement in information seeking, and gather opinions of the research instruction provided. Instruction will be iterated based on student feedback. Evidence from our first term of citation analysis indicates that students were successful in finding a wide variety of sources, such as technical reports, standards, peer-reviewed literature, patents, and trade literature. Feedback indicates that students understand the value of gathering a variety of sources of information, but that there are opportunities to enhance student engagement in the research process. Our future work is to gather more data to determine whether the quality and variety of information sources used by students, as well as their opinions of the research process can be correlated to their success in their design projects.**

Keywords— Engineering design; student engagement; information literacy; project based learning; outcomes assessment

I. INTRODUCTION

The information landscape in 2014 is complex; locating precise information at the moment of need has never been more intellectually challenging, particularly in technical disciplines. In addition to search skills, students need confidence and perseverance in order to effectively find the sources that they need for project based engineering course work and later success in the workplace. Information seeking skills are an important component of critical thinking and communications competencies that engineering programs in the United States and around the world must include within learning outcomes of their curricula in order to be in alignment with accreditation or quality standards. As a result, academic librarians can add value to engineering education programs through effective collaboration with classroom faculty. Our study examines a creative approach to a faculty librarian partnership in an introductory mechanical engineering design course in which undergraduate project teams design, construct and test a prototype device. Our work will build on existing literature by providing analysis of how references cited in student reports and attitudes toward research instruction are related to overall success of mechanical engineering student design projects.

II. EDUCATIONAL SETTING

The setting for our work is Worcester Polytechnic Institute (WPI), a university in Massachusetts, U.S.A, which is organized on a quarter system of four 7-week terms. WPI's innovative plan of project based learning throughout the undergraduate curriculum was established in the 1970s. The university has an undergraduate population of just over 4000 students from 49 U.S. states and 68 countries. The top major of choice for students entering WPI is mechanical engineering, with just under 200 declared mechanical engineering majors in the 2013 entering class. [1]

The subject of our work is the course ME 2300: Introduction to Engineering Design. It is a course designed for second year undergraduates, but third and fourth year students may also register for the course. During the first term of our study there were two sections of the course, with a total of 36 students combined. For over a decade, ME2300 has been an important place for students of mechanical engineering design to develop their research skills through working directly with WPI's research librarians. During the 7-week term in which the course is run, librarians serve as instructors for one 2-hour lab session in which they facilitate a directed search session. During the course, project teams must develop a device, which in many cases falls into the area of assistive technology for individuals with physical disabilities [2]. During the librarian-led lab session students learn to use citation management software (Endnote) and are challenged to locate technical handbooks, scientific research, market data, standards and laws, product and materials information, and popular and trade news. For second year students this may be one of the first times they have been required to locate such information, and the process can be intimidating. Through our work we seek

ways to engage students with the information seeking process so that they will not feel intimidated or frustrated by it, but will rather see it as a source of inspiration and creativity as they work through their design challenge. To this end, we employ a case study model of research instruction; during the lab students examine a children's toy and consider all the information needs use to design, construct, and market the toy.

III. Literature Review

Our methods of research instruction are informed by literature from library science as well as engineering education. Academic librarians have long investigated effective means of delivering information literacy instruction through collaboration with classroom instructors and evidence of the effectiveness of active learning embedded within the curriculum is clear [3,4]. Review of bibliographies (sometimes referred to as citation analysis) as an authentic method of assessing research effectiveness has been reported in the literature for over a decade; we employ this method here [5-7].

Assessment of our work in enhancing student engagement is built on foundations in both library science and engineering education. Kurbanoglu et al. in their article, "Developing the information literacy self-efficacy scale" recognize that measuring information literacy self-efficacy must include an evaluation of, "how well the final product resolved the information problem and how appropriate and efficient the steps taken to reach the desired outcome" [8]. Through citation analysis, student surveys, and report grading our work will address this expectation. However, it is not enough to only evaluate information literacy technical skills, there is a necessity to also measure student attitudes. Carberry's work, "Measuring Engineering Design Self-Efficacy" reveals that, "self-concept can influence how an individual learns, but is often overlooked when assessing student learning in engineering" and in particular, "for the domain of engineering, the effect of self-efficacy on learning can be more pronounced because of the frequent uses of design tasks as part of an engineering learning experience" [9]. Taking both of these works into consideration, it is clear that there is a need for measuring informational literacy skills in conjunction with assessing student attitudes particularly as applied to engineering design classes. Michael Fosmire's work, "Information literacy and engineering design: Developing an integrated conceptual model" addresses this concern with a new model of assessment. This model transforms the preconceived idea that information literacy curriculum is taught only as a professional skill competency to being understood as a "fundamental problem solving process for engineers" [10]. Relying on these foundations our work focuses on measuring two components of self-efficacy: enjoyment and engagement, and using student levels of self-efficacy to guide information literacy instruction.

IV. Methods of Research Instruction

The ME2300 design class has, for over ten years, included a lab in which a librarian has two hours to facilitate searching activities to find a variety of information sources to be put to use as students define their design parameters and work to develop effective device prototypes [2]. Because the lab is early in the term, at a time in which students are still exploring ideas for their prototype devices, we framed the research lab as a case study with search activities in which students investigated the information needs required to design a popular children's toy:

- What materials and parts could be used to create the toy?
- How do we know there is a market for the toy?
- What are some design flaws in similar toys?
- What standards and regulations must we comply with in our design?
- What evidence can we find to suggest that children in the intended market would enjoy this toy?

As we proceeded through the lab we discussed the types of information we may need to design the toy and where to find this information. To gather this information in one place that students could easily access after the lab, we developed an online research guide using the Libguides content management system. The research guide is available at http://libguides.wpi.edu/me2300 and includes examples of types of information sources related to the toy we were investigating, as well as links to specialized resources such as Engineering Village, IEEE Xplore, Business Source Premier, IBISWorld, ASTM Digital Library, and the U.S. Food and Drug Administration (FDA) Establishment Registration & Device Listing, that students could use to search for similar types of information related to their own chosen design. Over the course of the term the guide was viewed 1139 times and users clicked through to resources a total of 335 times. The ME 2300 Libguide was the most frequently used online research course-embedded guide used within the WPI Libguides system during the term, far exceeding the second most used course guide that had 360 views, with approximately the same number of registered students.

Figure 1. Library research lab session: WPI undergraduate David Quinn demonstrates how to use the children's toy that was part of an information-seeking case study in the lab. (photo credit: Jacquelyn Mushinsky)

After the lab session, students completed a graded lab report that required them to find information for their own

design, and also reflect on where and how they searched for information. Our next iteration of this assignment will include a requirement that students reflect on how their searches for scholarship, competing products, and technical information helped to ground their work in the current state of the art. As a part of this study, for the first time this year, the librarian instructor graded a portion of the lab report. In future terms this lab assignment will be redesigned to better align lab goals with final project report information goals.

V. Assessment of Outcomes and Attitudes

We use several indicators to determine student success in the information seeking process for their design reports:

- Number of information sources cited within the text of design reports.
- Number, variety, and quality of information sources included within reference lists/bibliographies.
- Responses to several end-of-course feedback questions regarding student research experiences during the class.

To assess student classroom engagement in the librarian-led lab, and student attitudes toward information seeking we review responses to an end-of-course feedback questionnaire.

VI. Results

This work in progress examines results and provides baseline data from one seven week term in a study that will span a minimum of 4 terms. Therefore results are preliminary and are being shown here mainly as a way to report our methods and to provide baseline data for future iterations of librarian-led instruction. Further analysis of the relationships between research skills demonstrated through sources used, classroom engagement and design project success will be possible once we have collected more data.

Table 1 provides initial citation and grade data for 7 final team project reports. Columns 1 and 2 are raw counts of the number of sources used within the text of the final design reports, and how many sources were cited in the reference list. Column 3 is the number of points out of five from the final project grading rubric that were specifically designated for review of quality and variety of student references. The final project was graded on a 100 point-scale. The point values for column 3 were determined by analyzing the variety and quality of sources, as well as the clarity of citation data (determined by the grader's ability to categorize the type of source used without requiring further searching). Column 4 is the final project report grade on a scale of 100.

TABLE I.

Team Number	***1.Total sources cited in text of report***	***2.Total sources in reference list***	***3.Points out of five on sources used and cited in final paper***	***4.Final report grade***
1	5	0	1	71.5
2	4	4	2	91
3	8	9	4	99
4	4	22	4	88
5	17	4	5	88
6	3	3	2	86
7	9	13	4	94

Course end library instruction feedback was completed by 27 of the 36 students registered for the course. Results are as follows:

- 23 students indicated that the information seeking process was important, and the same number found the librarian-led research lab helpful for finding information they needed for their design.
- 19 found the ME2300 online research guide (libguides.wpi.edu/me2300) helpful for finding information for their projects.
- 26 indicated they felt they had been successful in finding information for the projects.
- 12 students indicated that they enjoyed the information seeking process, while another 12 were neutral in this regard.

Open ended responses on the feedback survey provided further areas to explore that we will consider in future work, for example use and development of more online resources for the course.

Our future work is to iterate our instruction based on student feedback, collect and analyze more data across classes and instructors, and examine the relationship between student engagement in the classroom, information sources cited, and overall success in developing an effective prototype.

VII. Discussion

The preliminary results reported above provide a baseline of data for future work. We have learned that students were, in general, effective at finding many high quality and varied types of information sources, and that they viewed the information seeking process as important to the success of their projects. We will look to data from future project reports to determine if iterated instruction methods result in better student outcomes, both in the sources they use, and in their projects and prototypes at the broader level. While we gathered some information that provides us with a sense of student attitudes we need to examine the validity of our tool through iteration of questions and measured changes in pedagogy. Based on the feedback we received in this first assessment, we hope to improve instruction methods for information seeking that will encourage students to view the information gathering process as both engaging and important to the design process.

VIII. Conclusion and Future Work

The next phase of this project, currently in progress is to redesign the student lab report to better align its outcomes with the research needs that students have for their final project report and prototype. Librarian-led research instruction will be embedded in additional parts of the course

outside of the lab session. For example, during lectures in which the faculty instructor discusses topics such as intellectual property, or materials choice, the librarians will provide five minutes of information about where to find resources relevant to these topics. We plan to experiment with both live classroom visits by the librarians as well as online instruction modules.

Our assessment methods for both student success and student attitudes are being honed to include more opportunities for feedback from students. In particular we are designing a tool to capture students' attitudes about research, to be administered prior to the librarian's visit to the course lab session. This will include one open ended question as well as several Likert scale questions.

At the conclusion of this project our results will provide evidence and ideas to assist librarian practitioners and faculty instructors of engineering design courses in methods of successfully engaging students in an active-learning model of information seeking that will improve student design outcomes. We aspire for our work to add to the body of literature that supports information seeking as a critical, creative, and engaging piece of lifelong learning for design engineers and others.

Since engineering students, in general, enjoy engaging with hands on projects, we seek to instruct students in the research process through a hands-on, case based, and just-in-time approach. Our baseline data, reported here, in conjunction with future course iterations and data will clarify the question of how student engagement with the information seeking process, and ability to find excellent and diverse information sources can impact the development of innovative and effective design prototypes and overall design solutions.

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