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Information Use by Undergraduate STEM Teams Engaged in Global Project-Based Learning

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Information Use by Undergraduate STEM Teams Engaged in Global Project-Based Learning

Abstract

Our research examines information literacy education and resource use in significant and successful projects connecting technology with human need completed over a twelve year period between 2003 and 2014 by STEM undergraduates at a technical institute. We explain the evolution of collaborations between librarians, faculty project advisors, and research methods instructors during the preparation and completion of complex multidisciplinary projects completed mainly off-campus at project centers in the United States and around the globe. The projects we examine are completed as a mandatory graduation requirement for mainly third year undergraduates, 71% of whom will graduate with engineering degrees. We sought to understand not only how librarians teach students about information seeking and lifelong learning, but how faculty instructors and advisors approach teaching these critical professional skills. In addition we sought to understand what information sources students actually use by reviewing the works cited within five award winning project team reports per year of our study, for a total of 60 projects and almost 3000 works cited. We learned that student teams, despite year, project location, or discipline of study and faculty advisor use a broad range of sources, both peer-reviewed and not, and that these sources only partially correlate to the sources recommended by faculty. Most advisors depend on the support of librarians to help students achieve learning outcomes, and view personalized librarian consultations with project teams as the most critical piece of that support.

1. Introduction

The authors, both instruction librarians, completed this work as a baseline for understanding what questions and issues related to information seeking and use are most critical to faculty advisors and their student teams completing significant project work at project centers both in the U.S.A. and across the globe. This population has been the focus of library instruction at Worcester Polytechnic Institute (WPI) for over a decade since the information needs of the project teams are complex and extensive. The vast majority of team projects we examined were completed off-campus, and in most cases sponsored by government and non-governmental organizations in the U.S.A and abroad, with WPI faculty on-site at the project centers as advisors. These projects can be transformational learning experiences for the student teams and the learning outcomes achieved are critical to the undergraduate learning outcomes of the institution.^{1,2,3} As non-faculty instruction librarians we see ourselves as educators and we seek to understand how we can better support student learning, as well as understand which of our services are most impactful from the standpoint of faculty. This understanding is particularly

crucial as the student population at WPI increases and the number of students completing projects off-campus grows.

We are mindful of the broader issues facing higher education and the need to provide evidence of impact through assessment. Therefore, while some of the results of our study are not surprising, they provide data that shows the value of the educational experiences that non-faculty librarians can help to create, and also guide us in making those experiences as impactful, but also as efficiently administered as possible. We contribute to the literature of engineering librarianship and student outcomes assessment in that the type of projects we review are not widely assessed and reported.

Our research is framed in the understanding that project-based learning (PBL) is effective in providing transformational educational experiences for students, and that it is an excellent way to attract and retain diverse students to STEM disciplines. It is also one of the best places to embed information literacy education; PBL is an established method of bringing both disciplinary skills and lifelong learning skills together in ways that are engaging for students, and in the case of service learning, impactful to communities or individual stakeholders.^{4,5} WPI, as well as other institutions aiming to graduate future engineers across specializations, use student project outcomes to support professional as well as technical skills development for a wide variety of accreditation standards, including but not limited to those of ABET in the U.S.A.^{6,7,8,9}

Information literacy skills are critical to project-based learning outcomes, particularly in engineering disciplines. These skills can be seen holistically as well; they play a critical role in the development of lifelong learners who are effective users of information as students, professionals, and engaged community members. Within engineering design, Fosmire and Radcliffe demonstrate the value of information seeking and use in all stages of the engineering design process through their Information Rich Engineering Design (IRED) method.¹⁰ Informed learning, as described by Bruce, Hughes, and Somerville also provides a holistic view of how information relates to learning. They define informed learning as “the kind of learning made possible through evolving and transferable capacity to use information to learn.”¹¹

Information literacy and lifelong learning are well established within the academic librarian community as critical skills for students and professionals. Academic librarians in the U.S.A. have, since 2000 built information literacy programs on the competencies standardized by the Association of College and Research Libraries (ACRL).¹² In 2015 the ACRL’s *Framework for Information Literacy for Higher Education* has been published. The new framework places great emphasis on higher order thinking and situates information seeking and use to not only enhance knowledge creation across disciplines, but as an intellectual pursuit that can stand on its own.¹³

2. Literature Review

We examined research on assessment of information literacy using citation analysis and student artifact review, faculty-librarian collaborations in information literacy education, and

information literacy effectiveness within project-based learning. While significant work has been published in all of these areas, our work adds a dimension that has not been studied extensively: how multidisciplinary STEM undergraduate project teams learn about and use information in significant project-based learning experiences that are completed at global locations, using technology to meet a human need.

Reviewing student artefacts and analyzing works cited is an established method when understanding student information use. A number of science and engineering librarians have worked on detailed methods to review citations used by undergraduates. Mohler and Yu, Sullivan, and Woodall provided evidence of the usefulness of this method.^{14,15} In 2010 Denick, Bhatt, and Layton contributed further work to this method of analysis.¹⁶ In 2013 Wertz, Fosmire, Purzer, and Cardella made available their sophisticated *Information Seeking, Evaluation, Application, and Documentation (InfoSEAD) protocol*. *InfoSEAD* is extensive in detail and can be used to assess higher order thinking skills related to information seeking and use by engineering undergraduates.¹⁷

Significant research has been reported on embedded librarianship, and the effectiveness of faculty-librarian collaborations in teaching information literacy. David Shumaker's 2012 book *The Embedded Librarian: Innovative Strategies for Taking Knowledge Where It's Needed*, is in some ways a bridge from research to practice in this area.¹⁸ The work reviews significant examples of effective embedded librarianship within courses and curricula and provides suggestions on how to adapt these methods to a variety of educational settings. In their 2006 work, Arp, Woodard, Lindstrom, and Shonrock provided convincing arguments that faculty-librarian collaborations are critical in the teaching of information literacy within courses and curricula.¹⁹ Our work specifically builds upon the faculty-librarian collaboration reported by Drew and Vaz in 2008.²⁰

Research has shown that PBL is an opportune place to embed information literacy instruction across a variety of grade levels and disciplines, due to the variety and complexity of information needed for successful student outcomes. In their 2011 study, Chu, Tse, and Chow provide evidence that project-based learning is effective in teaching primary school children in Hong Kong the information literacy and information technology skills needed to be successful in a knowledge society.²¹ Fallon and Breen discuss the innovative ways that PBL can be used across disciplines at the college level to enhance information literacy outcomes.²² Diekema, Holliday, and Leary's 2011 work discusses the impact of problem-based learning on information literacy education at the college level. While problem-based learning differs from project-based learning, their approach and definition is similar enough to provide evidence to support project work as an effective vehicle for embedding information literacy instruction.²³

Riehle and Weiner's 2013 work calls attention to the value of two subsets of PBL, service learning and community based learning, as a vehicle in which to effectively embed information literacy skills.²⁴ Since many of the projects completed at WPI fall into one of these categories,

this study directly supports our work. However, few research studies examine closely the intersection of information literacy, project-based learning, and students completing projects off-campus and while studying abroad. In 2012 The CollegeBoard published its report, *Global Education: Connections, Concepts, and Careers* in which they specifically address information literacy and acknowledge its importance within global education: “Students are being confronted with an ever-expanding multitude of information that they must learn to navigate effectively. Global competency curricula need to include lessons that train students to do just that.”²⁵ Jiusto and Dibiasio discuss lifelong learning as it relates to experiential learning, and Drew and Vaz specifically address information literacy preparation for WPI students.^{4, 20} Our work contributes further to this area of information literacy and project-based learning, off-campus and abroad, which has not yet been studied widely.

3. Educational Context

WPI has long been a leader in project-based STEM education, since the establishment in the early 1970s of an innovative curriculum that is today called The WPI Plan. Students at WPI enroll in four seven-week terms during each academic year. The Plan allows students open choice in course work and requires them to complete three significant undergraduate requirements: the Inquiry Seminar which is a humanities and arts course with a significant writing requirement, typically completed in the second year, the Interactive Qualifying Project (IQP), which is the subject of our work here, typically completed in the third year, and the Major Qualifying Project (MQP) which is a project completed in the students’ major area(s) of study and completed in the final year of the undergraduate degree. The three projects may be completed off-campus at global projects centers, which accounts for WPI being recognized in the U.S.A. for sending more engineering undergraduates abroad than any other school. Most students who choose to go away do so for the IQP project, and complete projects sponsored mainly by governmental and non-governmental organizations, and advised by WPI faculty on-site at the project centers.

WPI has a population of 4100 undergraduates, 32% of whom are female. Students come from 47 states and 71 countries. Seventy-one percent of students major in a choice of more than ten engineering majors, including the U.S.A.’s first undergraduate major in robotics engineering.²⁶

Information literacy instruction has long been a component of the IQP project support, and is a required piece of the seven-week research methods course for students who intend to complete projects off-campus at project centers in the United States (Boston, Washington, Worcester, etc) or internationally (Cape Town, Bangkok, Melbourne, Windhoek, San Juan, etc.). In 2008 Drew and Vaz reported on library and faculty collaboration in project-based curricula at WPI. Their work examined how information literacy instruction was infused into the research methods course for all students completing an IQP at an off-campus project center. They reported that during the 2006-2007 academic year librarians consulted with 101 project teams in 50-minute research meetings. In that year 96% of the students agreed or strongly agreed that these

meetings helped them to complete better research.²⁰ Since that time the Interdisciplinary and Global Studies Division (IGSD) which administers off-campus project centers has slowly and steadily expanded the number of opportunities for students to go away. In 2014 librarians met with 136 project teams and led in-class lectures and workshops with all students completing the mandatory research methods course. Rating of student and faculty satisfaction with librarian research consultations and class visits is consistently high, and specific feedback often allows the instruction librarians to iterate and improve our educational offerings.

4. Reporting, Methods and Results

We report on faculty-librarian collaborations for information literacy instruction in support of projects completed for the twelve year period of 2003-2014. We also employ two data collection methods to understand faculty perspectives and student use of information: a faculty survey and a review of works cited by award winning project teams.

We surveyed the faculty advisors, and reviewed the works cited in projects that were winners of the President's IQP Award, with five winning projects chosen each year by independent faculty reviewers. We selected this group as a way to determine best practices and to try to understand trends of information use in projects that we could assume were successful in achieving expected student learning outcomes, and satisfying sponsors' needs. We hoped to understand 1) what, if anything was common among the works cited and 2) the faculty attitudes toward information use and information literacy instruction, in order to share best practices with future students, faculty advisors, and librarian collaborators.

4.1 Information Literacy Education and Faculty-Librarian Collaboration at WPI

Librarians at WPI have been working with IQP project teams since prior to 2003 to provide information literacy education; the learning outcomes of that education plan were mapped to the *ACRL Standards* beginning in 2004.¹² In 2010 a number of faculty instructors began inviting librarians to facilitate in-class workshops and provide guest lectures in the required 7-week research methods course for students going off-campus to complete their IQP. Faculty interest first arose from a desire to better educate students on citation methods and evaluation of source quality. These initial in-class visits focused on student teams learning fundamentals about the library website, and how to use RefWorks to manage and accurately cite resources. Librarians offered these instructional opportunities by request. At this time personal librarians assigned to specific project centers also met with teams in required research consultations. These team consultations required extensive preparation by the librarians so the addition of class visits forced a reconsideration of our model of education for scalability.

After gathering feedback and working closely with IGSD faculty, we were able to scale our efforts while retaining the personal touch that we knew was highly valued by students and faculty. In 2013 the model for librarians supporting IQP was redesigned with the intention of decreasing the preparation time for librarians meeting with project team, and placing more

responsibility for student learning on the teams themselves. The following table provides information about the educational opportunities provided by librarians between 2003 and the present and how the model of support has been redesigned over this period.

Table 1: History of WPI Librarian Support and Information Literacy Instruction for IQP Teams

Instruction/Support Type Provided by Librarians	2003-2005	2006-2012	2013-2015
Research Consultations With Teams	Yes, informal and by request from faculty and students teams.	Yes, 50 minute meetings with librarian required by most faculty.	Yes, 30-50 minute meetings with librarian required by most faculty.
Personal Librarians for Project Centers	No	Yes	Yes
Information Literacy Tutorials and Quizzes embedded in Course Websites	No	Yes	No
Information Literacy Research Guide embedded within Course Websites	No	Yes	Yes
Librarians embedded within BlackBoard Course Sites	No	Yes	Yes
Research Guide/Websites for Project Centers	No	Yes	Yes, but not for all sites
Information Skills Pre- and Post- Assessment	No	No	Yes, piloted in 2014-2015
Librarian Guest Workshops in Research Methods course.	No	By faculty request	Yes

4.2 The Faculty Survey: Results and Analysis of Project Advisor Perspectives

Oversight of the IQP is administered by IGSD, however, faculty across disciplines and staff across departments play a significant role in advising projects, and preparing students for their project experience. Most IGSD faculty are social scientists and they collaborate with humanities and arts, business, and STEM faculty to advise projects off-campus, typically in teams of two. We wanted to learn about what information literacy concepts they discussed with students beyond what the librarians covered, what they valued most about the instruction and guidance we provide to students, and what they saw as our primary areas of student support. We surveyed all faculty who advised the award winning projects that we reviewed for works cited below.

Of the 64 individual faculty advisors who were solicited for survey responses, we received 37 complete responses for a response rate of 58%. The breakdown of primary areas of research or teaching of faculty survey respondents is as follows:

- STEM: 35%
 - Engineering: 22%
 - Science and Technology: 13%
- Humanities and Arts: 30%
- Social Sciences: 22%
- Multidisciplinary/Other: 8%
- Business: 5%

With regard to IQP project advising experience, 68% of survey respondents have advised IQPs for 8 years or more, 24% for 2-7 years, and 8% for less than two years.

We asked faculty how important they considered the following library services in preparing IQP teams to find the information they need:

Table 2: Responses to Question: “How important are the following library instruction services in preparing IQP teams to find the information they need?”

	Very Important	Somewhat Important	Unimportant	No opinion
Librarian-led class visits to the preparatory research methods course.	24 (65%)	8 (22%)	0	4 (11%)
Team research consultations with a librarian.	33 (89%)	4 (11%)	0	0
Advisors' ability to contact a librarian for quick assistance.	14 (38%)	19 (52%)	2 (5%)	2 (5%)
Students' ability to contact their site librarian for quick research assistance.	25 (67%)	11 (30%)	1 (3%)	0

While all responses are positive, it is notable that 100% of faculty respondents considered the teams’ individual research consultations with librarian as important, with 33 of 37 indicating it is very important.

We asked faculty advisors the following question: Which of the following types of sources do you specifically encourage students to find and cite in IQP project reports? Choose all that apply.

Table 3: Responses to Question: Which of the following types of sources do you specifically encourage students to find and cite in IQP project reports? Choose all that apply.

Source type	Number of respondents	Percentage of respondents
Journal Articles	35	95%
Government Sources	31	84%
Books	28	76%
Non-Governmental and Association Sources	22	59%
Undergraduate Projects	22	59%
News (magazines, newspapers, news websites)	18	49%
Trade Magazines	17	46%
Standards and Regulations	16	43%
Technical Handbooks	13	35%
Academic Websites	13	35%
Theses and Dissertations	9	24%
Cases and Law Reviews	8	22%
Encyclopedic Sources (web or print)	6	16%
Other	5	14%
Blogs and Social Media	3	8%
Commercial Websites	2	5%

Encouragement to use journal articles, government sources, and books was not surprising. However, we were surprised that just 16% of faculty encouraged students to use encyclopedic sources, particularly since IQP teams are typically working in multidisciplinary areas that are new to them and often outside of their major area of study.

We asked faculty what they thought were the most important concepts or topics for librarians to address with the teams:

Table 4: Responses to Question: Rate the importance of the following topics that the librarians discuss with students.

Faculty:	Very Important	Somewhat Important	Unimportant	No opinion
Finding various types of sources (scholarship, academic books, data, news, etc.)	32 (86%)	5 (14%)	0	0
Choosing what databases to search for resources	27 (73%)	9 (24%)	0	0
Advanced web searching techniques (finding images,	24 (65%)	13 (35%)	0	0

finding domain specific sites - .gov, .edu, .na, etc.)				
Citing sources	21 (57%)	16 (43%)	0	0
Using sources to develop arguments	20 (54%)	15 (41%)	2 (5%)	0
Finding past IQPs	20 (54%)	13 (35%)	2 (5%)	1 (3%)
Understanding copyright	20 (54%)	17 (46%)	0	0
Understanding the importance of the literature review	16 (43%)	18 (49%)	2 (5%)	0
Using citation management software (Endnote, Refworks, etc.)	15 (41%)	16 (43%)	2 (5%)	3 (8%)
Using interlibrary loan	12 (32%)	23 (62%)	1 (3%)	1 (3%)

The responses above are overwhelmingly positive with regard to many concepts that we address with students. However, we can use these results to better understand where to focus efforts in creating online materials, tutorials, and instruction modules.

In order to understand what value that librarians can add to the learning outcomes of students completing the IQP, we asked faculty advisors how likely they would be to refer a team to a librarian if the team is struggling to meet the educational outcomes of the project.

Table 5: Responses to Question: Consider IQP Learning Outcomes (www.wpi.edu/academics/igsd/iqplea75.html). If a student is struggling in one of these areas how likely are you to direct them to a librarian for assistance?

Learning outcomes	Very Likely	Somewhat Likely	Unlikely	No Opinion
1. Demonstrate an understanding of the project's technical, social and humanistic context.	2 (5%)	12 (32%)	23 (62%)	0
2. Define clear, achievable goals and objectives for the project.	0	12 (32%)	24 (66%)	1 (3%)
3. Critically identify, utilize, and properly cite information sources, and integrate information from multiple sources to identify appropriate approaches to addressing the project goals.	30 (81%)	6 (16%)	1 (3%)	0
4. Select and implement a sound approach to solving an interdisciplinary problem.	1 (3%)	15 (41%)	19 (51%)	2 (5%)
5. Analyze and synthesize results from social, ethical, humanistic, technical or other perspectives, as appropriate.	2 (5%)	16 (43%)	18 (49%)	1 (3%)

6. Maintain effective working relationships within the project team and with the project advisor(s), recognizing and resolving problems that may arise.	0	3 (8%)	33 (89%)	1 (3%)
7. Demonstrate the ability to write clearly, critically and persuasively.	1 (3%)	5 (14%)	31(84%)	0
8. Demonstrate strong oral communication skills, using appropriate, effective visual aids.	2 (5%)	4 (11%)	31(84%)	0
9. Demonstrate an awareness of the ethical dimensions of their project work.	1 (3%)	12 (32%)	23 (62%)	1 (3%)

While it is not surprising that faculty would consider referring students to a librarian for outcome 3, with its direct reference to information sources, it is important to note that a significant percentage of faculty also indicated they would be somewhat likely to make a referral to a librarian for three of the remaining eight outcomes that also refer to higher order ways of thinking about and synthesizing information.

We provided a space in our survey for faculty to comment on the following prompt: Please provide any additional comments about how students find and use information while completing their IQP. There were 21 responses (57% of respondents). These open ended responses are rich and provide a basis for future focus groups or interviews. Faculty commented on the challenges that students face with regard to information seeking and the IQP, for example:

- Many IQP students struggle to understand the importance of the literature review.
- Most students don't search out a large diversity of sources on any one topic, and they don't seek out differing opinions and perspectives on topics. They usually don't know the extent of the range of sources that they can use, nor do they know the best key words to use when searching for sources of information.
- Students had very heavy use of websites and could not identify when they were reading a "published article" that was linked to a website and were not citing that correctly.

A number of responses indicated satisfaction with and the importance of the role that librarians play in this major project which is critical in student achievement of university-wide learning outcomes. For example:

- The integrated support of library staff is essential to students' learning experience and to their production of academically sound work that meets their projects' goals. [...] An IQP [team] that didn't need a librarian is an IQP that missed the boat!
- We would be sunk without strong library services to support our IQPs. It is a critical necessity and we have come to depend on it.
- I could not do it without the support of our research and instruction librarians.

- Our research librarians are vital contributors to student learning.

These open ended responses support the idea that instruction librarians can contribute significantly to the education of WPI students, and that faculty acknowledge this value.

4.3 Students, Projects, and the Works They Cited

We reviewed the works cited in 60 project reports completed over the twelve year period of 2003 and 2014. The five projects selected per year were each years' winners of WPI's President's IQP Award. Between 2003 and 2014, IQP teams completed between 229 and 303 projects but in most years there were fewer than 50 teams that self-nominated for the award. Our sample is not intended to be generalizable but has the benefit of being a list of projects for which we can make an assumption that they were considered successful by the student authors, faculty advisors, sponsors, and the independent faculty reviewers who determined the five winners each year.

Our purpose in reviewing the citations was to look for similarities or differences among the projects. We wanted to know if there were outstanding qualities of student reference lists that could help us to better understand student information needs in projects that we knew to be successful. We also sought to find any evidence of information use changing over the ten year period.

The sixty projects were completed at project centers around the globe, with the exception of five that were completed on the WPI campus. Project winners completed projects at the following global locations: Australia, Costa Rica, Denmark, Hong Kong, India, Italy, Namibia, New Zealand, Puerto Rico, South Africa, Thailand, the United Kingdom, and the U.S.A. To get a sense of the topics examined by students we provide a small selection of titles:

- Development and Initiation of Sustainable Wastewater Management in Nakhon Si Thammarat, Thailand (2014)
- Supporting Urban Beekeeping Livelihood Strategies in Cape Town (South Africa, 2012)
- Analysis of Privacy and Interoperability Issues Affecting Danish Consumers of Health IT Systems (Denmark, 2010)
- Energy Profiling for Off-Grid Energization Solutions in Namibia (2007)
- Optimizing Parking Regulations Enforcement and Revenue Collection in the City of Cambridge (U.S.A., 2003)

Most projects completed after 2007 are available in full text through the WPI library website (www.wpi.edu/+library); they are also indexed by Google Scholar.

4.3.1 Characteristics of Project Winning Student Teams

Team size and disciplinary make-up of student teams are determined by faculty advisors and IGSD faculty.

With regard to team size, four-student project teams were the most common (35 teams), with a high number of three-student teams (24 teams), and one five-student team. Projects completed in Thailand and India also included local students who are not included in these team counts.

Of the 217 students who completed the award winning projects, the breakdown of primary disciplines is as follows, and teams were mixes of students from various disciplines:

Table 6: Breakdown of primary disciplines of award winning student team members

Disciplines	Total Students on Winning Teams
Mechanical, Manufacturing, or Aerospace Engineering	54
Biology, Biotechnology, or Biochemistry	31
Civil, Environmental, or Architectural Engineering	29
Electrical and Computer Engineering	23
Chemistry and Chemical Engineering	18
Biomedical Engineering	17
Computer Science	13
Other or Unknown	32
TOTAL	217 Students

4.3.2 Analysis of the Works Cited

The 60 projects that we reviewed contained a total of 2906 citations. Our method of reviewing the citations was not based on whether the citation was completely accurate. Even in the case of citations that were missing elements, if we were able to determine what the source was and track it down, we categorized it. There were a number of citations that required further investigation based on poorly formatted citations, however both authors reviewed any citations that were not clear and we came to consensus on the identity of the sources in every case.

The breakdown of sources over the twelve year period and across all projects, for a total of 2906 works cited is as follows:

Table 7: Number of sources by type for the 60 project reports reviewed

Source type	Number of citations of this type in the complete data set	Number of projects out of 60 that cite this type of source	Range of times this source type is used in project where it is present
Journal Articles	645	57	1-63
Non-Governmental and Association Websites	643	59	1-57
Government Websites	383	55	1-25
Books	333	55	1-27

Commercial Websites	327	49	1-25
News Sources	148	42	1-15
Educational Websites	137	45	1-11
Previous WPI Undergraduate Projects	67	34	1-8
Conference Papers	64	22	1-10
Trade Literature	54	23	1-7
Other	105	n/a	n/a

The types of sources that comprise the category of “Other” were those that were cited fewer than 50 times in all the projects: reference works, standards, laws, blogs, personal interviews, data sets, graduate theses, and videos.

We also examined how many types of sources teams were citing per project to better understand the role that diverse source types play in these projects.

Table 8: About the number of source types cited within each project

Average number of source types used per project	8
Most common number of source types used per project	7
Number of projects citing between 6 and 11 source types	57 (95%)

Of the remaining 3 projects (5%), one cited 4 types, and 2 cited 12 types. Emphasis on using a wide variety of source types, both peer-reviewed and not, both available through the library and through free or open access websites is important to note as librarians and faculty teach concepts related to information use.

We investigated patterns of sources across time and project centers and found no patterns. This is an area that could be explored more effectively through completing a generalizable sample of projects completed in a particular year or completed at a particular project center over a number of years.

5. Conclusions

Our analysis of citations revealed that the sources used by award winning projects over a twelve year period did not change significantly. Use of journal articles, organization websites, books, commercial websites, and government resources are the most important resources in all years and across project centers, based on how many times these types of sources were used over our entire data set. These do not, however, correlate with the top five sources that faculty report recommending to students: journal articles, government sources, books, non-governmental and association sources, and undergraduate projects. Further information from students, and interviews with faculty would be needed in order to better understand why source choices were

made, and what factors most influenced those decisions. Use of blogs and social media, multimedia, datasets, and white papers do not play a significant role in the completion of these successful IQP projects to date. However, it is not surprising that a large percentage of sources were most likely from potentially free or open access websites. The prevalence of free web sources is a reality, and a good one, as long as students are making choices based on sound quality criteria. Creating educational environments and experiences that allow students to explore information in all its varieties is critical to the value that instruction librarians add to learning outcomes in academic settings.

Faculty place high value on the instruction that librarians provide and acknowledge the role that the librarians play in student learning outcomes with regard to information literacy and the IQP project. Their responses remind us that highly personalized educational experiences made available through instruction librarians are of great value and should be retained even in the face of arguments of efficiency. It is possible to provide highly personalized service that is effective; in fact this is the constant challenge of all instruction librarian and educators in our time. Luckily librarians and educators can and do thrive on creativity and a passion for student learning, making the challenge of efficiency one through which we can create and iterate effective and engaging information literacy opportunities for students.

6. Future Work

There are a number of ways to build upon this preliminary study in order to gain greater understanding of some of the data we have collected and analyzed here. A broader survey of faculty, as well as faculty interviews or focus groups would enhance our understanding of what faculty value in off-campus or international student projects as related to information use. Student feedback has not been considered in the work, however work is underway to examine student opinion and understanding with regard to the importance and use of information within their IQP projects. Faculty and students are solicited for feedback on library IQP support regularly so as instruction methods are iterated, further assessment could be done. Another interesting possibility for future work would be to review a broader sample of projects completed for individual project centers in order to do a comparison of information needs based on where project results are intended to be implemented around the globe.

References

1. Elmes, M., and E.T. Loiacono. 2009. Project-based service-learning for an unscripted world: the WPI IQP experience. *International Journal of Organizational Analysis*. 17(1): 23-39.
2. Demetry, C., and R. F. Vaz. 2002. International project experiences: assessing impact on students' educational and personal development. In *Frontiers in Education, 2002. FIE 2002. 32nd Annual*. 2: F4B-13. IEEE.
3. Worcester Polytechnic Institute. 2013. WPI Undergraduate Learning Outcomes. <https://www.wpi.edu/academics/catalogs/ugrad/outcomes.html>.
4. Jiusto, S. and D. DiBiasio. 2006. Experiential learning environments: do they prepare our students to be self-directed, life-long learners? *Journal of Engineering Education* 95(3): 195-204.
5. Daniels, M., Å. Cajander, A. Pears and T. Clear. 2010. Engineering education research in practice: Evolving use of open ended group projects as a pedagogical strategy for developing skills in global collaboration. *International Journal of Engineering Education* 26(4): 795.
6. Mello, N., D. DiBiasio, D., and R. Vaz R. 2007. Fulfilling ABET outcomes by sending students away. In *Proceedings of the 2007 American Society for Engineering Education Annual Conference & Exposition*.
7. Kulturel-Konak, S., A. Konak, I.E. Esparragoza, and G.E.O. Kremer. 2003. Assessing professional skills in STEM disciplines. In *IEEE Integrated STEM Education Conference (ISEC)*, 2013 IEEE: 1-4.
8. Mills, J. E., and D.F. Treagust. 2003. Engineering education—Is problem-based or project-based learning the answer? *Australasian Journal of Engineering Education*. 3(2).
9. Zhou, C. (2012). Fostering creative engineers: a key to face the complexity of engineering practice. *European Journal of Engineering Education*, 37(4): 343-353.
10. Fosmire, M. and D. Radcliffe, Eds. 2013. *Integrating Information into the Engineering Design Process*. Purdue University Press.
11. Bruce, C., H. Hughes, and M.M. Somerville. 2012. Supporting informed learners in the twenty-first century. *Library Trends* 60(3): 522-545.
12. Association of College and Research Libraries. (2000). *Information Literacy Competency Standards for Higher Education*.
13. Association of College and Research Libraries. (2015) *Framework for Information Literacy for Higher Education*.
14. Mohler, B.A. 2005. Citation analysis as an assessment tool. *Science & Technology Libraries*. 25: 57-64.
15. Yu, F., J. Sullivan, and L. Woodall. 2006. What can students' bibliographies tell us? Evidence based information skills teaching for engineering students. *Evidence Based Library and Information Practice* 1: 12-22.
16. Denick, D., J. Bhatt, and B. E. Layton. 2010. Citation analysis of engineering design reports for information literacy assessment. In *Proceedings of the 2010 American Society for Engineering Education Annual Conference & Exposition*.
17. Wertz, R., M. Fosmire, S. Purzer, and M. Cardella. 2013. *InfoSEAD protocol and sample memo*. Purdue University Research Repository. doi:10.4231/D3WW7702P
18. Shumaker, D. 2012. *The embedded librarian: Innovative strategies for taking knowledge where it's needed*. Information Today.
19. Arp, L., B.S. Woodard, J. Lindstrom, and D.D. Shonrock. 2006. Faculty-librarian collaboration to achieve integration of information literacy. *Reference & User Services Quarterly* 46(1): 18-23.
20. Drew, C. and R. Vaz, R. 2008. Global project preparation: infusing information literacy into project-based curricula. *American Society of Engineering Education Annual Conference 2008*, Session AC-2008-1220.
21. Chu, S. K. W., S. K. Tse, and K. Chow. 2011. Using collaborative teaching and inquiry project-based learning to help primary school students develop information literacy and information skills. *Library and Information Science Research*, 33(2): 132-143. doi:10.1016/j.lisr.2010.07.017
22. Fallon, H., and E. Breen. 2005. Developing student information literacy skills to support project and problem-based learning. In *Handbook of Enquiry and Problem-based Learning*. The Ireland Society for Higher Education. 179-188.

23. Diekema, A. R., W. Holliday, and H. Leary. 2011. Re-framing information literacy: Problem-based learning as informed learning. *Library & Information Science Research* 33(4): 261-268.
24. Riehle, C. F., and S. A. Weiner. 2013. High-impact educational practices: An exploration of the role of information literacy. *College & Undergraduate Libraries* 20(2): 127-143.
25. Balistreri, S, F. T. Di Giacomo, I. Noisette, and T. Ptak. 2012. *Global Education: Connections, Concepts, and Careers*. CollegeBoard, Research In Review 2012-4.
26. WPI 2014. 2014 Student Factbook. <https://www.wpi.edu/offices/ir/enrollment-data.html>.