

Student Use of Librarian Expertise during Design Competitions: A Study of Efficacy and Resource Use

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abstract: Engineering librarians at Texas A&M University in College Station partnered with the university's College of Engineering to provide information assistance to students participating in Aggies Invent, a series of 48-hour design competitions conducted in the college's makerspace. To assess the impact of librarian-student consultations, the authors collected data on the questions asked and resources used, and they surveyed the participants after each competition. Results indicated that most questions were business-related, followed by engineering queries, and that participants used both business and engineering resources. Google products were also heavily used, although often in conjunction with other library resources and in an intentional manner. Overall, students found the librarian consultations useful in their designs and presentations.

Introduction

To support and enhance students' innovation, creativity, and design skills, colleges and universities create opportunities for students to engage in experiential and project-based learning. These learning activities can be incorporated into the curriculum, for example, of engineering design courses, or provided through academic enrichment programs, such as competitions.

The increased interest in entrepreneurship on campuses has contributed to the desire to enhance students' engineering design skills, resulting in "a growing need for facilities that allow students to develop their independent design projects and create prototypes of the products they are working to commercialize."¹ These facilities have



existed on college campuses in the form of machine shops for over 100 years.² More recently, makerspaces on campuses have emerged as centers for creating and innovation. More than machine shops, these spaces provide a sense of community where students can experiment, problem-solve, be creative and innovative, learn, and share equipment, skills, and knowledge.³

Competitions also contribute to the development of design skills.⁴ Daragh Byrne and Catherine Davidson report that such events provide a forum for maker activities and are considered a staple of “making” on campuses.⁵ When students engage in makerspaces and competitions, they are provided not only with the tools they need, but also with a support system in the form of experts and mentors.⁶ In fact, one of the maker competencies listed by Martin Wallace, Katie Musick Peery, Gretchen Trkay, Morgan Chivers,

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and Tara Radniecki is “solicits advice, knowledge and specific skills succinctly from experts.”⁷ Since making requires relevant and reliable information at all phases of the design process, librarians are uniquely qualified to serve as experts and provide information literacy instruction and reference services to the makerspace community and to students during design competitions.⁸ Indeed, Michael Fosmire and David Radcliffe advocate for the collaboration of librarians and engineering faculty to encourage an “informed approach” to engineering design projects that will enable students to produce “more grounded, practical, and higher quality solutions.”⁹ The purpose of

this paper is to assess the impact of librarian involvement in Aggies Invent, a series of 48-hour engineering design competitions hosted by Texas A&M University’s College of Engineering in its makerspace.

Background

Texas A&M University

Texas A&M University in College Station is a Carnegie R1 institution, a doctoral university with “very high research activity.”¹⁰ It is one of the largest public universities in the United States with over 69,000 students, of whom 19,286 (27.8 percent) are engineering students, more than twice the enrollment of the next largest college at the university.¹¹

Texas A&M also has Colleges of Medicine, Nursing, and Veterinary and Biomedical Sciences on its main campus, all of which cooperate extensively with the College of Engineering and Aggies Invent. The university recently launched an interdisciplinary School of Innovation (the “iSchool”) drawing faculty from all colleges to encourage innovation, collaboration, and entrepreneurship.¹²

College of Engineering

The College of Engineering is the largest college at Texas A&M University, both in terms of student enrollment and faculty employment. It offers 20 programs through its 14 departments. Student enrollment for fall 2018 was 15,490 undergraduate, 2,098 master’s,

and 1,698 doctoral.¹³ The college has recently renovated or constructed new facilities to expand its cutting-edge education and research, including the completely redesigned Zachry Engineering Education Complex, opened in 2018. The complex provides 525,000 square feet of active learning studios and interdisciplinary laboratories, including the SuSu and Mark A. Fischer '72 Engineering Design Center (EDC), where Aggies Invent takes place.¹⁴

Aggies Invent

Aggies Invent is a 48-hour “intensive innovation experience,” the goal of which is to develop engineers who are creative, innovative, and “entrepreneurial minded.”¹⁵ These competitions create a real-world environment where students practice their engineering design, teamwork, leadership, communication, and interpersonal skills. The events span engineering disciplines, but each is theme-based with problem statements or design problems developed and presented by industry or university sponsors. Many sponsors also serve as mentors and expert advisers during competitions. Aggies Invent began in 2014 with one event per semester.¹⁶ By 2015, it had grown to three competitions per semester. The competitions are open to both engineering and nonengineering majors. Each competition is composed of three phases. On Friday, students meet, form teams, select a problem statement, and begin to plan their design concepts. Teams are required to consider three concepts. On Saturday morning, the teams continue to work on their designs and build a prototype. On Sunday, the teams create a 90-second video that explains why they selected their final concept, technical aspects of their design, and where it fits into a market.

During this study, Aggies Invent took place in the Engineering Innovation Center (EIC), a 20,000-square-foot facility or makerspace that housed senior design students and engineering student enrichment programs, such as design competitions, equipment training, and pop-up instruction. The EIC also provided a design studio and fabrication center. Its facilities included a digital media center with computer support, machine shop, prototyping center, woodshop, welding center, paint room, laser cutter, and 3D printers.¹⁷ Design competitions have since moved to the new EDC, which opened in fall 2018.

Librarian Support

Faculty from Engineering Academic and Student Affairs (EASA) initially reached out to the university’s engineering librarians in the summer of 2015 to discuss developing a library makerspace for nonengineering students. After touring the EIC and learning about Aggies Invent, the engineering librarians proposed they join the expert staff available to students during the competitions, providing information literacy instruction and point-of-need reference. Librarians began assisting Aggies Invent teams during fall 2015, with two librarians available to students Friday night and two on Saturday morning into early afternoon. Since the competitions are theme-based (for example, veterinary medicine or STEM education), relevant subject librarians take part when possible so that each pair of librarians includes an engineering librarian and a theme subject librarian.

Figure 1 illustrates the relationships among the groups involved in Aggies Invent. Librarians primarily interact with students and EIC staff during the competitions, engaging little with individual Aggies Invent sponsors, advisers, or mentors. In the future, the authors plan to expand their engagement with the sponsors, advisers, and mentors.

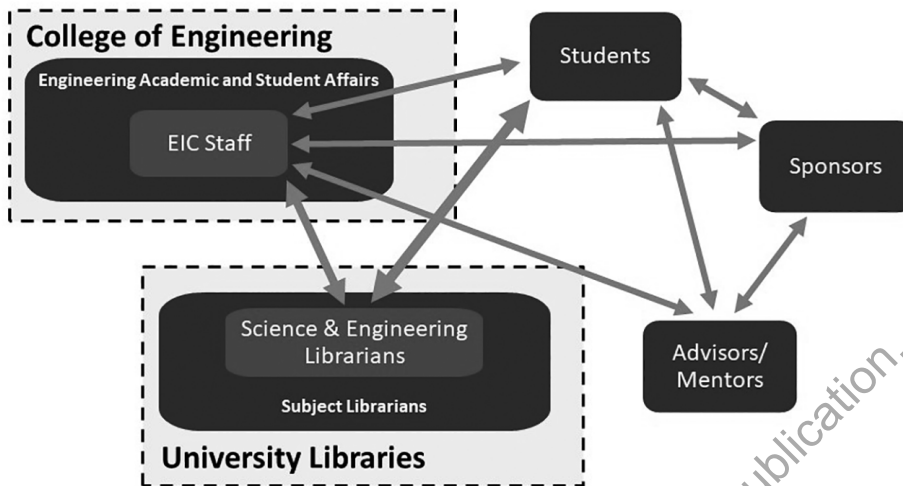


Figure 1. A visualization of the relationships among the groups involved in the Aggies Invent design competition at Texas A&M University in College Station.

Literature Review

The emergence of makerspaces is a trend on college campuses, although their locations, equipment, governance, management, and population served vary.¹⁸ These spaces provide a venue for a variety of design activities, such as coursework and enrichment programs, including competitions and entrepreneurial activities.¹⁹ Some authors provide guides to implementing makerspaces and thus focus on physical space, challenges, and such practical issues as funding, equipment, justification, workflow, and implementation.²⁰ Reports from academic libraries tend to provide descriptions, case studies, and commentaries.²¹ This latter group of papers, however, emphasizes the importance of integrating information resources and services into library makerspaces. This sentiment is echoed by Robert Curry, who maintains that academic librarians can provide makerspace support with the information literacy skills needed to find and evaluate information quickly.²²

Investigators have reported on how participation in makerspace activities²³ and competitions²⁴ impacts students' learning and growth. In general, studies show that these activities improve students' design and problem-solving skills, and also bolster what Marco Gadola and Daniel Chindamo refer to as "soft" skills—that is, time management, team building, and communication.²⁵ The Maker Literacy Task Force, associated with the University of Texas at Arlington Library's FabLab, sought to develop a set of "maker competencies" to assess the learning that takes place when such activities are incorporated into the curriculum. The competencies identified include project management, communication, collaboration, and critical and design thinking, and are used to measure "twenty-first century" or "soft" skills. They are "technology independent" and applicable across disciplines.²⁶ Maker competencies that relate to information literacy include analyzing and defining the problem, researching existing products, brainstorm-



ing and pursuing the most appropriate solutions, conducting market research, and consulting experts.²⁷

According to Karen Bursic and Cynthia Atman²⁸ and Michael Fosmire,²⁹ information is collected and used during the engineering design process. Based on the work of Karl Ulrich and Steven Eppinger,³⁰ Fosmire outlines the stages of the design process (planning, concept development, system design, detail design, testing, and production) and the respective types of information gathered during each phase (for example, marketing data, competitor products, patents, textbooks, standards, and retail data).³¹ Bursic and Atman specify that information is used to define a problem, devise potential solutions, and select the most appropriate solution to meet the customers' needs.³² Results of their study found that seniors collected more information of varying types than freshmen did and that a positive correlation existed between the quantity and type of information gathered and the quality of the final designs. They also noted that students may not use all the information they assemble.

Some studies of makerspaces and competitions have touched on the need for information during the design process. Cecilia La Place, Shawn Jordan, Micah Lande, and Steven Weiner found that, during competitions, students were motivated "to reach out to others, or to the Internet, or to find alternative solutions."³³ During the planning phase of a motorbike design competition, Marco Gadola and Daniel Chindamo report, students were required to develop a technical bibliography.³⁴ Cindy Harnett, Thomas Tretter, and Stephanie Philipp described the experience of nine engineering students at the University of Louisville in Kentucky with a locally hosted city makerspace where they completed self-proposed co-operative projects.³⁵ In addition to learning new engineering and social skills, the students needed to do more research when an initial idea failed and had to learn how to locate required information and resources both online and off-line. While finding information is in part library-related, the authors made no mention of library collections or librarians.

Three studies directly report on the need for information and librarian consultation during competitions. Librarians at the Bern Dibner Library of Science & Technology, New York University, developed a two-semester contest that invited students to solve the library's noise problem.³⁶ The librarians created a LibGuide, which contained reference sources and

links to subject databases, to function as the contest home page. Both librarians and teaching faculty served as mentors and presented relevant workshops to students at various stages. After the librarian workshop, the authors noted an increase in e-mails and

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requests for librarian consultations from participants. Post-contest focus groups provided evidence that the LibGuide and librarian workshops had increased student awareness of library resources and research consultation services, leading more students to ask a librarian for help. Heather Howard, David Zwicky, and Margaret Phillips described technical- and entrepreneurial-related librarian support at Purdue University in West Lafayette, Indiana, which included assistance for a soybean innovation competition.³⁷ Purdue librarians used a consultation-based instruction model for the event, providing a one-time research instruction session followed by in-depth team consultations that were encouraged by librarians and the competition director. Although most students were STEM majors, the entrepreneurial aspect of the competition required both engineering and business research and hence support from engineering and business librarians. The authors report (anecdotally) that winners of the 2017 and 2018 competitions consulted with librarians more than did the other teams. Jane Stephens, David Hubbard, Pauline Melgoza, Bruce Neville, Gary Wan, and Deva Reddy described a pilot project to provide librarian support for Aggies Invent competitions during fall 2015 to spring 2016.³⁸ The study provided a list of library resources used to answer questions, and as Howard, Zwicky, and Phillips did, the authors report that the winning and placing teams had generally consulted a librarian.³⁹

Makerspace communities and competitions provide a creative environment where students receive support from experts and mentors. Librarians, however, are seldom included as members of the expert support team, except in librarian-authored studies.⁴⁰ Additionally, the information needs of students in makerspace activities and competitions are not well described, even though recently developed maker competencies relate to information literacy.⁴¹ Therefore, the authors of this study sought to answer the following research questions:

1. What were the nature and number of the questions asked during Aggies Invent?
2. What information resources were used to answer questions?
3. Was librarian support effective, and did it result in a positive impact on the design projects or presentations?
4. How was the information used during the design process, and was it useful?

Methods

This study employed a mixed-methods approach, which included data collection during each competition, participant surveys afterward, and qualitative analysis of the responses provided by students. The study was submitted to the university's Human Research Protection Program for Institutional Review Board (IRB) approval and determined to be exempt [IRB2016-0653M].

From October 2016 to April 2018, librarians attended 10 Aggies Invent competitions and provided consultations. Forms completed for each librarian-student consultation collected information about participants and the resources used to answer their questions. The information consisted of year, semester, month, day, team name, topic number, problem statement title, librarian, questions, resources consulted, student name(s), and contact information. Apart from names and contact information, data from the forms



were transferred to spreadsheets for management and analysis. Student names and e-mail addresses were used for the online survey.

Early in the week following each competition, an anonymous Qualtrics XM online survey was e-mailed to the students who had consulted with librarians. The survey consisted of nine multiple-choice and three optional open-text questions (see the Appendix). It collected some demographic information but mainly focused on how students used the resources provided by librarians in their design and presentation, as well as their experience working with librarians. The students who had not completed their online survey were sent a reminder e-mail one week later, and the survey remained open for six weeks. The data from the survey were then downloaded into a spreadsheet for management and analysis. The students' reported use (or nonuse) of the resources provided by librarians was examined by class standing using Fisher's exact test, a test of statistical significance:

H_0 (the null hypothesis): There is no difference in the proportion of resource use by class standing.

H_1 (the alternate hypothesis): There is a difference in the proportion of resource use by class standing.

The questions asked during Aggies Invent were analyzed using content and textual analyses. During content analysis, questions were categorized into seven predetermined disciplinary categories: business, engineering, life sciences, social sciences, statistical data, physical sciences, and other. The business category included information associated with product marketing, whereas the statistical data category was limited to data not directly related to marketing (for example, how many lawsuits were filed charging Occupational Safety and Health Administration violations). The categorization was performed by two of the coauthors. Prior to classifying the questions, both coders categorized a random sample of 50 questions to determine the inter-rater reliability using Cohen's kappa. Returning to all the questions, the same two coders then classified half the questions each into the seven categories. They also conducted a word frequency analysis on the text of the questions. The text was analyzed using VOSviewer, a software tool for visualizing networks, which employed Apache OpenNLP™, a toolkit for natural language processing, to identify the most frequent nouns appearing in the questions.

Results

The themes, number of teams, librarian consultations, and questions asked in Aggies Invent are summarized in Table 1. Almost all teams that participated over the period of the study consulted with librarians at least once. A similar number of questions was asked on Friday and Saturday, though some competitions received more inquiries on one day versus the other. The questions asked per competition ranged from 12 to 50, with a mean of 24. A single consultation could and often did include multiple queries. Table 2 lists selected questions asked during each of the 10 events. Some questions were anticipated based on the problem statements provided to the students, but others were not. This will be addressed further in the "Discussion" section.

Table 1.
Teams, consultations, and questions during Aggies Invent

Month and year	Theme	Number of teams	Number of teams consulting a librarian	Number of consultations	Number of questions			Total
					Friday	Saturday	Total	
October 2016	Internet of things	7	6	9	14	23		
December 2016	Medical applications	10	4	6	5	11		
February 2017	Education	9	7	10	3	16		
March 2017	Construction science	11	9	16	11	26		
April 2017	Veterinary medicine	6	6	14	5	20		
September 2017	Bring your own idea	10	9	11	10	19		
October 2017	Special Operations Command	9	6	11	9	18		
November 2017	AR/VR [augmented reality / virtual reality]	10	9	18	14	50		
February 2018	Invent for the planet	8	8	15	29	42		
April 2018	Assistive technology	10	8	11	8	16		
Total		90	72	124	117	241		

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Table 2.
Selected questions from Aggie's Invent

Theme	Problem statement	Question
Internet of things	Friend of the future	How to monitor motion with language.
Medical applications	Infant care	What bio signals are most commonly monitored for infants?
Education	Fun with fractions	Learning fractions, math through body movement.
Construction science	Green asphalt	What is the cost of 1 mile of a road (asphalt aggregate)?
Veterinary medicine	Right pet food	How is Khan Academy funded?
Bring your own idea	Passive motion device	Bed rest as a prescription (statistics).
Special Operations Command	Blue Force Tracking*	How many soldiers injured per year by friendly fire?
AR/VR [augmented reality/virtual reality]	Showroom automotive	Vehicles damaged at dealership, showrooms, accidents, weather, etc. Cost? How many?
Invent for the planet	Rural medicine delivery systems	Statistics on data on transporting pharmaceuticals to rural or underdeveloped countries.
Assistive technology	Text-to-speech wearable technology	What is the recommended scanning resolution for OCR [optical character recognition]?

*Blue Force Tracking is a technology that uses Global Positioning System (GPS) data to reveal the location and movements of military forces.

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The 241 questions were categorized based on the seven categories outlined in the “Methods” section and were distributed as follows: business 41 percent (100), engineering 24 percent (58), life sciences 17 percent (41), social sciences 9 percent (21), statistical data 7 percent (17), physical sciences 1 percent (2), and other 1 percent (2). The inter-rater reliability, Cohen’s kappa, was 0.64 for a sample of 50 questions coded by two of the authors, indicating “substantial” agreement with respect to categorization.⁴² Surprisingly, most questions were not engineering inquiries, but business-related questions.

Table 3.

Word frequency of Aggies Invent questions

Word	Occurrences
cost	23
device	13
data	12
country	9
system	8
way	8
company	7
number	7
sensor	7
dog	6
food	6
market	6
owner	6
person	6
time	6
etc.	5
heart rate	5
money	5
question	5
use	5
waste	5

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A word frequency analysis provided additional insights into the nature of the questions (see Table 3). The word frequency analysis in Table 3 includes only nouns that appeared five or more times. Five main themes emerged. The terms *company*, *cost*, *money*, and *market* were often related to business questions about costs for components, comparable products, and market research. Engineering queries often focused on the “use” of a “device” or “system,” as well as how (or “the way”) the devices functioned. Questions also requested “data” or “numbers” not specifically related to market research. Some of the words in Table 3 are related to the themes (for example, *dog* and *owner* during the veterinary medicine competition). Other events included problem statements related to global and sustainability issues and can be seen in questions about “food,” “country,” and “waste.”

Table 4 lists the resources used to answer the questions during each competition, as well as overall. Many resources consulted for answers could be anticipated (for example, engineering e-book collections and databases) or seemed relevant to the theme (for example, PubMed/MEDLINE® or ERIC [Education Resources Information Center]), but the reliance on Google Search products by librarians was unexpected. Many business resources were consulted, including Business Source Ultimate, ABI/INFORM, IBISWorld, and BCC [Business Communications Company] Research.

One or more members from each of the 61 teams (129 students) who met with librarians were surveyed after each competition, and 34 responses were received, yielding a 26 percent response rate. Most of the respondents were engineering majors ($n = 22$, or 65 percent), with the other respondents majoring in business (2), economics (2), veterinary medicine (2), agricultural communication and journalism (1), computer science (1), landscape architecture (1), management information systems (1), and undeclared (2). Most respondents were undergraduates ($n = 24$, or 71 percent) and included all four undergraduate class ranks, with the remainder graduate students ($n = 10$, or 29 percent).

Of the 34 responses, 29 (or 85 percent) indicated that they used resources provided by librarians for product design, and 27 (or 79 percent) reported that they used the information for their presentation. Twenty-three (or 68 percent) described using the resources for both design and presentation. Only one respondent reported not using material provided by a librarian for the design or presentation.

Table 5 summarizes the students’ use (or nonuse) of librarian-provided resources for their designs and presentations by class standing. As indicated earlier, almost all used the resources in either the design or presentation. A two-way chi-square test of independence showed significant association between resource use by class standing for the design [$\chi^2(4, N = 34) = 13.246, p = .010$] but not for the presentation [$\chi^2(4, N = 34) = 4.214, p = .378$].

When the students were asked how they used the resources for their design and presentation, 12 and 14 responded, respectively. Table 6 lists selected answers as to how the resources and information helped with the design or presentation. In addition to responses about the design and presentation, nine general comments described the overall experience consulting with librarians, some of which are included in Table 6.

When asked if the librarian consultation was a worthwhile use of time, 32 of 34 indicated that it was. Of those who responded to the survey, the general opinion was that the librarian consultations improved the design and presentations. Furthermore,

Table 4.
Resources consulted during Aggies Invent by theme

Resource	Theme										Total
	Internet of things	Medical applications	Education	Construction science	Veterinary medicine	Bring your own idea	Special Operations Command	AR/VR [augmented reality/virtual reality]	Invent for the planet	Assistive technology	
Google	9	4	2	19	16	8	12	27	21	7	125
Google Scholar	9	4	8	6	8	3	5	28	14	5	90
Business Source Ultimate	5		2	8		2	2	5	4	3	31
Library catalog (LibCat)	2		9	1		1	2	10	3	2	30
Compendex	4	3				1	3	11	3	3	28
Google Books	1	2	1	2	2	4	4	8	3		27
PubMed/MEDLINE®	5	1			6	4		8		2	26
Discovery layer											
(EBSCO Discovery Service)	4		8					6		6	24
Knovel®	3	3		4	1	2	2	5	2		22
ABI/INFORM	1					1		10	4		16
Google Patents	3			2	2	3		2	2		14
ERIC (Education Resources Information Center)	1		11								12
IBISWorld	1				5	1		4		1	12

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Table 5.

Student use of resources provided by librarians for designs and presentations, by class standing

Class standing	Design		Presentation	
	Yes	No	Yes	No
Freshman	3	4	4	3
Sophomore	5	0	5	0
Junior	3	0	3	0
Senior	8	1	7	2
Graduate	10	0	8	2

Table 6.

Student comments regarding librarian consultations

Design

"Based on the information provided by the librarians, we were able to make smart decisions regarding the materials used, the efficiency of our design, and the liability of it."

"Helped generate a better understanding of the overall background and project requirements."

"We used information for defining prototype requirements, and presentation."

Presentation

"The research provided allowed us to create a more compelling argument for why a solution was needed to the problem we were addressing and helped us justify why ours was the best option."

"We used the ideas and resources given to us by the librarian to help us create a business plan for the product that we created."

"Wonderful background information to help 'sell' our product."

General comments

"[Named librarian] was awesome in understanding the problem, helping us better comprehend the problem, and provided wonderful articles to assist us even further. 10/10"

"Thank you to them for being there and helping guide our group's research!"

"The librarians were very nice and responsive."



when students were asked if they were more or less likely to consult a librarian in the future after working with one during Aggies Invent, 79 percent declared that they were more likely and 21 percent indicated neither more nor less likely.

Discussion

Initially, the authors thought the Aggies Invent competitions would be an opportunity to provide information literacy instruction within the context of individual consultations, as well as point-of-need reference. Instruction proved problematic given the time constraints and fast-paced nature of the competitions, and so the librarians often supplied point-of-need reference. In some cases, they educated students on search strategies and resources; at other times, they provided only the needed information. As may be evident from Table 1, the number of consultations during each competition varied in an unpredictable manner. Sometimes, more questions were asked on Friday, other times more were asked on Saturday.

Early in the librarians' participation in Aggies Invent, the authors decided that having two librarians on both days would be ideal, and overall that was the case, though on some days a third or even fourth librarian would have been helpful given the number of questions. At the time this study began, librarians had been involved in Aggies Invent for at least a year, and the teams were regularly directed to the consultations by EIC staff and others. Initially, librarians met with less than half of the teams, but during this study, librarians consulted with almost all teams.⁴³ Over 80 percent of students had one or two questions when they came to a consultation, but some arrived with a list of five or more queries. Librarians found themselves balancing consultations with a backlog of questions that they addressed during occasional lulls. The on-site consultations ended early Saturday afternoon, but the librarians sometimes finished answering question backlogs in their offices Saturday afternoon via e-mail.

While librarians prepared for each competition by reviewing the problem statements provided by the organizers and considering resources that might be useful, it was often difficult to anticipate and prepare for what the students asked. There were more problem statements than teams, and some problem statements were not selected, so librarians might prepare for a topic not pursued. Initially, the

authors were surprised by the number of business-related questions, expecting more engineering and technology queries, but the business inquiries made sense given that the students needed to understand their market and "sell" their solution. Comparing this to the information-seeking stages outlined by Fosmire⁴⁴ based on Ulrich and Eppinger's work,⁴⁵ librarians in this study provided support during the planning, concept development, and system design stages. The importance of market research in the planning stage⁴⁶ and as a maker competency has been previously noted.⁴⁷

While librarians prepared for each competition by reviewing the problem statements provided by the organizers and considering resources that might be useful, it was often difficult to anticipate and prepare for what the students asked.

Depending on the Aggies Invent theme, other subject librarians participated and lent their expertise. For example, during the education- and medical-themed competitions, the authors often invited subject librarians to participate along with an engineering librarian.

The interdisciplinary nature of the projects and the information skills of the librarians enabled them to provide resources across a variety of disciplines and to help locate information at every stage of the design process.

The need for business librarians during entrepreneurial competitions, such as Aggies Invent, had been noted earlier by Howard, Zwicky, and Phillips.⁴⁸ As evidenced by the many business inquiries, and based on the authors' experience, students asked more questions when an Aggies Invent theme and problem statement were outside their area of experience and knowledge. For example, the augmented reality/virtual reality-themed competition, which appeared at first to be engineering, included some problem statements that involved education, business, and environmental issues that may have been unfamiliar to the students. The interdisciplinary nature of the projects and the information skills of the librarians enabled them to provide resources across a variety of disciplines and to help locate information at every stage of the design process.⁴⁹

The librarians often used Google and related resources in an intentional or advanced manner to locate a known source or reach a specific webpage.

The authors viewed Aggies Invent as an opportunity for engineering undergraduate students to develop information literacy skills, especially those associated with engineering information sources, search strategies, and critical thinking skills. Based on previous experience working with engineering undergraduates on design projects and reports, the authors thought that the librarians would use mostly engineering information sources. They did not expect that the librarians would turn to Google products so often (Table 4), though they recognize that information literacy transcends specific tools and is contextual. The librarians often used Google and related resources in an intentional or advanced manner to locate a known source or reach a specific webpage. With respect to "advanced" Google searching, librarians might limit the domain to find certain government information or a specific file type (for example, images). It should also be noted that, in almost 80 percent of the questions for which a Google product was searched, a library resource was also consulted.

Business databases and reports are well represented—for example, Business Source Ultimate, ABI/INFORM, BCC Research, and IBISWorld—as are engineering resources—for example, the engineering bibliographic database Compendex, the online library Knovel®, IEEE [Institute of Electrical and Electronics Engineers] Xplore®, and ASCE [American Society of Civil Engineers] Library. Some resources reflect a given theme, such as ERIC for education or PubMed/MEDLINE® for biomedical-related competitions. A few resources reflect the preferences, familiarity, or expertise of individual librarians. Since Aggies Invent is held outside the physical library, only online resources are typically used, and there is little opportunity to consult other materials.



In the survey responses, students reported that their interaction with librarians and the assistance they received were overwhelmingly positive. Almost all students found the consultations with librarians helpful and used the resources suggested for their designs, presentations, or both. One exception was freshmen, who reported less use of the resources provided by librarians for their designs. Freshmen may not have seen the value in the resources or may not have known if the suggestions were followed because other members of the team handled the design phase. As noted by Bursic and Atman, seniors include more information and more types of sources in their design than freshmen do, which also might explain why freshmen reported lower use of resources.⁵⁰ However, Bursic and Atman also found that students did not use all information collected.⁵¹

Overall, the authors gained some insights into how the students used the information provided during Aggies Invent, but most of what they learned came from the students' comments on the survey. An additional approach, such as interviews or focus groups, may be needed to gain a deeper understanding of how the information helped students on the projects and why freshmen reported less use of the resources.

Various colleges on the Texas A&M University campus host other design, hacker, and entrepreneurial competitions. As noted by Howard, Zwicky, and Phillips, "Libraries, by virtue of their connections on campus and extant services, [are] well-positioned to take a stronger role in supporting entrepreneurship and technology commercialization on campus."⁵² When these activities are developed outside the library, librarians may not necessarily be identified as part of the expert support team.⁵³ Convincing organizers that librarians and library resources bring value and may even be essential during design competitions and other programs can be a challenge, as was the case for Aggies Invent. As discussed in the literature, makerspaces provide a venue for these activities, but they can be dispersed across campuses. In addition, not all enrichment programs take place in campus makerspaces. Therefore, librarians must be proactive and persistent in identifying and developing relationships with faculty and staff who organize and support enrichment programs or makerspaces. Given the interdisciplinary nature of many programs, collaboration and communication among subject librarians across disciplines are essential, particularly in large universities with complex organizational structures. In the case of Aggies Invent, engineering librarians met with Engineering Academic and Student Affairs (EASA) faculty during the summer of 2015. These meetings resulted from an invitation to tour the EIC and meet EASA staff, including the director of Aggies Invent and the EIC manager. During these meetings, librarians discussed library resources that

Almost all students found the consultations with librarians helpful and used the resources suggested for their designs, presentations, or both.

Convincing organizers that librarians and library resources bring value and may even be essential during design competitions and other programs can be a challenge ...

could be used during the design process and how their expertise could facilitate finding this information. Librarians also described their experiences with capstone design courses and sent links to engineering LibGuides. Part of the motivation for this study was to provide evidence of the need for library resources and librarian expertise during these activities. This evidence, and that from other studies, could help persuade program organizers to include librarians on expert support teams.

Demonstrating the value of librarians to student competitors is also a challenge. According to the survey, most students believed librarian consultations worthwhile, but a few were neutral when asked if they would consult a librarian again after Aggies Invent. Observations by the authors of this study provide some insight. Initially, librarians would roam through student work areas, talking to teams and soliciting questions. EIC staff began early on to advocate strongly for librarian consultations, telling students at the start of the competition and on Saturday morning that the winning teams had met with librarians. This tactic likely appealed to the students' competitive nature, and students began to approach librarians early on Friday and Saturday, making roaming unnecessary and frequently not possible. The authors also observed that some students

... students came to appreciate librarian expertise when they realized staff, mentors, and sponsors valued it.

requesting a consultation had been instructed by their sponsor to ask a librarian for specific information. While not direct evidence, the authors believe students came to appreciate librarian expertise when they realized staff, mentors, and sponsors valued it. Ultimately, success is the best advocate and can lead to other opportunities.

Conclusion

The engineering librarians at Texas A&M University proactively established a partnership with the faculty who coordinate Aggies Invent, a series of design competitions in the College of Engineering. Beginning in 2015, librarians assisted the teams in finding information during the planning, concept development, and system design phases of the competitions. While the authors expected these events to provide an opportunity for infusing information literacy into the College of Engineering, the fast-paced nature of the competition and intense pressure on students to deliver solutions often resulted in the librarians providing "information on demand."

The first two research questions concerned the nature and number of inquiries and the resources used to answer them, all of which varied. Librarians could not anticipate questions because they did not know which problem statements teams would select and what approach students would take. Initially, the authors expected the questions to be heavily engineering-related. Instead, 41 percent of the queries were business-related. The need for business information makes sense in hindsight, as the students need to understand the market and "sell" their solution. In addition to business resources, many standard engineering resources were consulted (Compendex, Knovel®, and the like), as were theme-related resources, such as ERIC and AccessMedicine, a collection of core medical reference and textbooks. The Google "family" of products was often used, though



librarians consulted these resources in a more expert and intentional manner. When possible, librarians used this as a “teachable moment” to illustrate advanced searching techniques and to emphasize the importance of evaluating the source of information obtained from the Internet. In almost 80 percent of the questions for which a Google product was searched, another library database was also consulted.

Addressing the third and fourth research questions, to determine the effectiveness of librarian support and whether the students used the information and resources, proved challenging and less conclusive given the details provided in the open-ended survey questions. Students who responded to the survey, however, indicated that the information was generally helpful and was used in the design, the presentation, or both. They found librarian consultations worthwhile and said they would be inclined to seek the help of a librarian in the future. Upper-level students reported using the information more than lower-level students did.

Whether within libraries or not, the design projects that take place within makerspaces require the skills to find and evaluate information. As such, librarians are uniquely qualified to serve as part of the expert support team and, when possible, to provide information literacy instruction to students engaged in these projects. Opportunities exist on campus for librarian involvement, but librarians must be proactive in seeking them out and in convincing program organizers that they belong on expert support teams.

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Appendix

Online Survey Questions

Information Sheet

Thank you for participating in this assessment of librarian impact at Aggies Invent. The purpose of this study is to assess the effectiveness and impact of librarian consultations during Aggies Invent. You were selected for this survey due to your participation in Aggies Invent and consultation with a librarian. The survey has nine multiple choice questions and three optional text questions. It is anticipated that the survey will only take 5–10 minutes to complete.

Risks and Benefits

There are no risks beyond those encountered in daily life. There is no direct benefit to you, but results of this survey will assist librarians with helping students during future Aggies Invent.

Confidentiality Protections

The records of this study will be kept private. No identifiers linking you to this study will be included in any sort of report that might be published. Research records will be stored securely, and only coprincipal investigators and coinvestigators will have access to the records. Information about you will be stored in a locked file cabinet and computer files protected with a password after the online survey is completed.

Information about you will be kept confidential to the extent permitted or required by law. People who have access to your information include the principal investigator and research study personnel. Representatives of regulatory agencies such as the Office of Human Research Protections (OHRP) and entities such as the Texas A&M University Human Research Protection Program may access your records to make sure the study is being run correctly and that information is collected properly.

Right to Decline or Withdraw at Any Time

Participation in this research study is voluntary, and you have the right to decline or withdraw from the survey at any time without penalty. Please contact the coprincipal



investigators, Jane Stephens [979-845-5382 | jstephens@tamu.edu] or David Hubbard [979-862-1902 | hubbardd@tamu.edu] if you have questions regarding this study.

For questions about your rights as a research participant, to provide input regarding research, or if you have questions, complaints, or concerns about the research, you may call the Texas A&M University Human Research Protection Program (HRPP) by phone at 1-979-458-4067, toll free at 1-855-795-8636, or by e-mail at irb@tamu.edu. The informed consent form and all study materials should include the IRB number, approval date, and expiration date. Please contact the HRPP if they do not.

By clicking "Agree," you are acknowledging the potential risks described above and giving your consent. Agree Disagree

1. What is your major?

[dropdown menu of academic majors]

2. What is your status?

Freshman Sophomore Junior Senior Graduate student

3. Have you participated in a previous Aggies Invent?

Yes No

4. Did your team use the resources provided or suggested by a librarian for your design project? [NOTE: There will be a similar question about the presentation later in the survey.]

Yes No

5. Do you feel that the assistance provided by the librarian improved your design project? [NOTE: There will be a similar question about the presentation later in the survey.]

Yes No

6. Describe how you used the information or resources suggested by the librarian for your design project? (optional question)

[Text box]

1. Did your team use the resources provided or suggested by a librarian for your presentation?

Yes No

2. Do you feel that the assistance provided by the librarian improved your presentation?

Yes No

3. Describe how you used the information or resources suggested by the librarian for your presentation? (optional question)

[Text box]



4. Was the time spent consulting with the librarian a worthwhile use of your time?
 - Yes
 - No

5. Are you more or less likely to consult a librarian for future research or writing projects after consulting with a librarian during Aggies Invent?
 - More likely
 - Neither more or less
 - Less likely

6. Any other comments you wish to share regarding your consultation?
(optional question)
[Text box]

Notes

1. Vincent Wilczynski, "Academic Maker Spaces and Engineering Design," paper presented at the 122nd ASEE (American Society for Engineering Education) Annual Conference and Exposition, Seattle, WA, June 14–17, 2015, 4, <https://peer.asee.org/23477>.
2. *Ibid.*, 1–19.
3. Cindy K. Harnett, Thomas R. Tretter, and Stephanie B. Philipp, "Hackerspaces and Engineering Education," paper presented at the 44th Annual Frontiers in Education Conference, Madrid, Spain, October 22–25, 2014, 1–8, <https://ieeexplore.ieee.org/document/7044395>.
4. Lindsay Anderberg, Matthew Frenkel, and Mikolaj Wilk, "Project Shhh! A Library Design Contest for Engineering Students," paper presented at the 125th ASEE Annual Conference and Exposition, Salt Lake City, UT, June 24–27, 2018, 1–14, <https://peer.asee.org/30900>; Rodney Boehm and Magdalini Z. Lagoudas, "Maker: 48-Hour Rapid Prototype Development," paper presented at the 122nd ASEE Annual Conference and Exposition, Seattle, WA, June 14–17, 2015, 1–6; Marco Gadola and Daniel Chindamo, "Experiential Learning in Engineering Education: The Role of Student Design Competitions and a Case Study," *International Journal of Mechanical Engineering Education* 47, 1 (2019): 3–22, <https://doi.org/10.1177/0306419017749580>; Heather A. Howard, David Zwicky, and Margaret Phillips, "Academic Libraries Support Cross-Disciplinary Innovation and Entrepreneurship," paper presented at the 39th IATUL (International Association of University Libraries) Annual Conference, Oslo, Norway, June 18–21, 2018, 1–9, <https://docs.lib.purdue.edu/iatul/2018/collaboration/3/>; Magdalini Z. Lagoudas, Rodney Boehm, and James L. Wilson, "Assessment of Innovative Skill Development in Weekend Challenges," paper presented at 122nd ASEE Annual Conference and Exposition, 1–14, <https://peer.asee.org/23600>.
5. Daragh Byrne and Catherine Davidson, eds., "State of Making Report," Carnegie Mellon University, 2015, 1–30, http://make.xsead.cmu.edu/week_of_making/report.
6. Boehm and Lagoudas, "Maker"; Byrne and Davidson, "State of Making Report"; Gadola and Chindamo, "Experiential Learning in Engineering Education"; Harnett, Tretter, and Philipp, "Hackerspaces and Engineering Education"; Edward Pines, Patricia A. Sullivan, and Luke Nogales, "Broadening Participation through Engagement in the Maker Space Movement," paper presented at the 122nd ASEE Annual Conference and Exposition, Seattle, WA, June 14–17, 2015, 1–15, <https://peer.asee.org/23634>; Martin K. Wallace, Gretchen Trkay, Katie Musick Peery, Morgan Chivers, and Tara Radniecki, "Maker Competencies and the Undergraduate Curriculum Final Performance Report," University of Texas at Arlington, 2019, 1–24, <https://rc.library.uta.edu/uta-ir/handle/10106/28332>.
7. Wallace, Trkay, Peery, Chivers, and Radniecki, "Maker Competencies and the Undergraduate Curriculum Final Performance Report," 15.

8. Anderberg, Frenkel, and Wilk, "Project Shhh!"; Karen M. Bursic and Cynthia J. Atman, "Information Gathering: A Critical Step for Quality in the Design Process," *Quality Management Journal* 5, 3 (1998): 60–75, <https://doi.org/10.1080/10686967.1998.11919148>; Michael Fosmire and David F. Radcliffe, *Integrating Information into the Engineering Design Process* (West Lafayette, IN: Purdue University Press, 2014); Howard, Zwicky, and Phillips, "Academic Libraries Support Cross-Disciplinary Innovation and Entrepreneurship"; Harnett, Tretter, and Philipp, "Hackerspaces and Engineering Education."
9. Fosmire and Radcliffe, *Integrating Information into the Engineering Design Process*, 3.
10. Indiana University Center for Postsecondary Research, "The Carnegie Classification of Institutions of Higher Education®," <http://carnegieclassifications.iu.edu/>.
11. Texas A&M University, "Student Metrics," <http://accountability.tamu.edu/Student-Metrics>.
12. Texas A&M University, "Colleges & Departments," Texas A&M University, <https://www.tamu.edu/about/departments.html>.
13. Texas A&M University, "Student Metrics."
14. Texas A&M University College of Engineering, "Engineering Buildings and Parking," <https://engineering.tamu.edu/about/buildings/index.html>.
15. Boehm and Lagoudas, "Maker."
16. Ibid.; Magdalini Z. Lagoudas, Jeffrey E. Froyd, James L. Wilson, Peter Seth Hamilton, Rodney Boehm, and Prasad N. Enjeti, "Assessing Impact of Maker Space on Student Learning," paper presented at the 123rd ASEE Annual Conference and Exposition, New Orleans, LA, June 26–29, 2016, 1–13, <https://peer.asee.org/26298>.
17. Ibid.
18. Thomas William Barrett, Matthew Cole Pizzico, Bryan Levy, Robert L. Nagel, Julie S. Linsey, Kimberly G. Talley, Craig R. Forest, and Wendy C. Newstetter, "A Review of University Maker Spaces," paper presented at the 122nd ASEE Annual Conference and Exposition, Seattle, WA, June 14–17, 2015, <https://peer.asee.org/23442>; John Burke, "Making Sense: Can Makerspaces Work in Academic Libraries?" paper presented at the 2015 Association of College and Research Libraries (ACRL) Conference, Portland, Oregon, March 25–28, 2015, 497–503, <http://www.ala.org/acrl/sites/ala.org/acrl/files/content/conferences/confsandpreconfs/2015/Burke.pdf>; Wilczynski, "Academic Maker Spaces and Engineering Design"; Anne Wong and Helen Partridge, "Making as Learning: Makerspaces in Universities," *Australian Academic & Research Libraries* 47, 3 (2016): 143–59, <https://doi.org/10.1080/00048623.2016.1228163>.
19. Lagoudas, Froyd, Wilson, Hamilton, Boehm, and Enjeti, "Assessing Impact of Maker Space on Student Learning"; Cecilia La Place, Shawn S. Jordan, Micah Lande, and Steven Weiner, "Engineering Students Rapidly Learning at Hackathon Events," paper presented at the 124th ASEE Annual Conference and Exposition, Columbus, OH, June 25–28, 2017, <https://peer.asee.org/28260>.
20. Barrett, Pizzico, Levy, Nagel, Linsey, Talley, Forest, and Newstetter, "A Review of University Maker Spaces"; Sylvia George-Williams, "If You Build It Will They Come? Building a FabLab in the University of Texas at Arlington Libraries and Building Faculty Partnerships for Its Use," paper presented at the 122nd ASEE Annual Conference and Exposition, Seattle, WA, June 14–17, 2015, <https://peer.asee.org/24219>; Heather Michele Moorefield-Lang, "Makers in the Library: Case Studies of 3D Printers and Maker Spaces in Library Settings," *Library Hi Tech* 32, 4 (2014): 583–93; Pines, Sullivan, and Nogales, "Broadening Participation through Engagement in the Maker Space Movement"; Adam Rogers, Ben Leduc-Mills, Brendan C. O'Connell, and Brian Huang, "Lending a Hand: Supporting the Maker Movement in Academic Libraries," paper presented at the 122nd ASEE Annual Conference and Exposition.
21. Tod Colegrove, "Editorial Board Thoughts: Libraries as Makerspace?" *Information Technology and Libraries* 32, 1 (2013): 2–5; Ina Fourie and Anika Meyer, "What to Make of Makerspaces: Tools and DIY Only or Is There an Interconnected Information Resources



- Space?" *Library Hi Tech* 33, 4 (2015): 519–25; Jane Lofton, "Students Are Makers! Building Information Literacy Skills through Makerspace Programs," *CSLA [California School Library Association] Journal* 40, 2 (2017): 18–20; Leah Mann, "Making a Place for Makerspaces in Information Literacy," *Reference & User Services Quarterly* 58, 2 (2018): 82–86.
22. Robert Curry, "Makerspaces: A Beneficial New Service for Academic Libraries?" *Library Review* 66, 4–5 (2017): 201–12.
 23. Ibid.; Craig R. Forest, Roxanne A. Moore, Amit S. Jariwala, Barbara Burks Fasse, Julie Linsey, Wendy Newstetter, Peter Ngo, and Christopher Quintero, "The Invention Studio: A University Maker Space and Culture," *Advances in Engineering Education* 4, 2 (2014): 1–32; Harnett, Tretter, and Philipp, "Hackerspaces and Engineering Education"; Lagoudas Froyd, Wilson, Hamilton, Boehm, and Enjeti, "Assessing Impact of Maker Space on Student Learning."
 24. Gadola and Chindamo, "Experiential Learning in Engineering Education"; La Place, Jordan, Lande, and Weiner, "Engineering Students Rapidly Learning at Hackathon Events"; Lagoudas, Boehm, and Wilson, "Assessment of Innovative Skill Development in Weekend Challenges."
 25. Gadola and Chindamo, "Experiential Learning in Engineering Education."
 26. Martin K. Wallace, Katie Musick Peery, Gretchen Trkay, Morgan Chivers, and Tara Radniecki, "List of Maker Competencies, including Preamble and Acknowledgments," University of Texas at Arlington Libraries, 2018, <https://rc.library.uta.edu/uta-ir/handle/10106/27634>.
 27. Wallace, Trkay, Peery, Chivers, and Radniecki, "Maker Competencies and the Undergraduate Curriculum Final Performance Report."
 28. Bursic and Atman, "Information Gathering."
 29. Michael Fosmire, "Ways That Engineers Use Design Information," chap. 3 in Fosmire and Radcliffe, *Integrating Information into the Engineering Design Process*, 35–44.
 30. Karl T. Ulrich and Steven D. Eppinger, *Product Design and Development*, 5th ed. (New York: McGraw-Hill, 2011), 14.
 31. Fosmire, "Ways That Engineers Use Design Information," 37.
 32. Bursic and Atman, "Information Gathering."
 33. La Place, Jordan, Lande, and Weiner, "Engineering Students Rapidly Learning at Hackathon Events," 11.
 34. Gadola and Chindamo, "Experiential Learning in Engineering Education."
 35. Harnett, Tretter, and Philipp, "Hackerspaces and Engineering Education."
 36. Anderberg, Frenkel, and Wilk, "Project Shhh!"
 37. Howard, Zwicky, and Phillips, "Academic Libraries Support Cross-Disciplinary Innovation and Entrepreneurship."
 38. Jane Stephens, David E. Hubbard, Pauline Melgoza, Bruce D. Neville, Gary Wan, and Deva E. Reddy, "Meeting Students in Their Makerspaces," poster presented at the American Library Association Annual Conference, Orlando, FL, June 23–28, 2016, <https://www.eventscribe.com/2016/posters/ala-annual/SplitViewer.asp?PID=Mzg1NjI4NTgwMQ>.
 39. Howard, Zwicky, and Phillips, "Academic Libraries Support Cross-Disciplinary Innovation and Entrepreneurship."
 40. Anderberg, Frenkel, and Wilk "Project Shhh!"; Howard, Zwicky, and Phillips, "Academic Libraries Support Cross-Disciplinary Innovation and Entrepreneurship."
 41. Wallace, Trkay, Peery, Chivers, and Radniecki, "Maker Competencies and the Undergraduate Curriculum Final Performance Report."
 42. J. Richard Landis and Gary G. Koch, "The Measurement of Observer Agreement for Categorical Data," *Biometrics* 33, 1 (1977): 159–74.
 43. Stephens, Hubbard, Melgoza, Neville, Wan, and Reddy, "Meeting Students in Their Makerspaces," 1
 44. Fosmire, "Ways That Engineers Use Design Information," 37.



45. Ulrich and Eppinger, *Product Design and Development*, 14.
46. Fosmire, "Ways That Engineers Use Design Information," 37.
47. Wallace, Trkay, Peery, Chivers, and Radniecki, "Maker Competencies and the Undergraduate Curriculum Final Performance Report."
48. Howard, Zwicky, and Phillips, "Academic Libraries Support Cross-Disciplinary Innovation and Entrepreneurship."
49. Curry, "Makerspaces"; Lofton, "Students Are Makers!"
50. Bursic and Atman, "Information Gathering."
51. Ibid.
52. Howard, Zwicky, and Phillips, "Academic Libraries Support Cross-Disciplinary Innovation and Entrepreneurship."
53. Gadola and Chindamo, "Experiential Learning in Engineering Education"; Harnett, Treffer, and Philipp, "Hackerspaces and Engineering Education."

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