Analysis of Student Utilization and Activities in a Campus Innovation Center

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The Branam Innovation Center (BIC) has served our campus for six years providing support for competition teams, capstone and class projects, a maker space, and other campus activities. The 16,000 sq. ft. center provides project space, supervision, and access to fabrication and prototyping resources. It has been a popular and increasingly utilized resource with student entries to the building increasing 1.35 times in the last two years.

Several aspects of maker and innovation centers have been reported on including a classification system, operating policies, training programs, and assessment approaches. This paper will report on student utilization of our innovation center through the analysis of activity records. Over the years of operation of the center, multiple measures of student activity and utilization have been collected including lock logs, team rosters, and training completions. This paper will analyze these sources of data and report on several aspects of growth and utilization of the center including: (a) overall level of student activity over the last three years; (b) student activity broken down by time of year, quarter, and day; (c) student gender and class standing; and (d) student participation in training classes. The paper will also report on assessment approaches that have been used and general student feedback on the center and activities. It is believed that these results are useful in a variety of situations including prioritizing center activities, marketing the program to students, allocating space, scheduling staff, and determining overall resource needs.

Background on University Innovation and Maker Centers

Innovation centers and maker spaces have appeared on university campuses within the last 20 years to nurture creativity, design, self-learning, and hands-on fabrication skills in undergraduate students. While maker spaces often support a student community of makers and their co-curricular projects, our innovation center houses competition teams, capstone projects, class projects, and a maker space.

Several maker programs have been described in the literature. The ‘BucknellMakers’ program makes tools widely available, offers training and skill development, and encourages curricular and co-curricular experiences¹. The Georgia Tech ‘Invention Studio’ is managed by students and supports over 1000 students per month engaged in both class and personal projects. The cultural benefits of the studio for both students and the university are noted².

Results from the development and operation of maker spaces and centers have been reported. The acronym ‘SPACE’ has been suggested as providing important direction – Student involvement, Pick a high traffic space, Adaptability, Culture, and Equipment should be unintimidating³. The Invention Studio has reported on their approaches to staffing, equipment, safety, IP, funding, and outreach². More detailed operational practices are summarized including a smart badging system⁴ and approaches for equipment utilization⁵.

As various types of maker and innovation centers have emerged, a classification system has been proposed which includes scope, accessibility, users, footprint, and staffing as classification

attributes⁶. Reviews of maker spaces have reported including: (a) ratios of users to space and supervision to users⁷, and (b) location, use policies, and equipment availability^{8,9}.

Assessment studies of maker and innovation centers, are appearing and while still preliminary, suggest that in addition to improving innovation and hands-on building skills, innovation and maker centers could increase student confidence, increase retention, and create a sense of belonging^{10,11}.

Vision and Operation of the Center

The Branam Innovation Center (BIC) opened in the fall of 2011. Constructed in a simple open-concept style with reused/recycled furnishings, the 16,000 sq. ft. building houses competition teams, capstone projects, class projects, and a maker space. The center provides working space, tools, materials, training, and supervision for students working in the building. Special fabrication areas include a machine shop, welding shop, paint booth, wood/dust shop, and rapid prototyping/maker equipment. The center is staffed for 90 hours of operation per week by staff and student workers.

Students gain access to working in the center through membership in one of the supported groups and by completing a series of online and face-to-face training sessions. Students may join one of the competition teams at any point during the year and capstone students work in the center when enrolled in their courses. The MakerLab club is the easy entry point for students who want to work on their own projects in the center.

Entry to the center during supervised hours requires completing two online training modules in environmental, health, and safety and 5S. The center has one main entry door which is locked 24/7. Campus IDs are scanned at the front door to provide entry. Additional face-to-face (F2F) training is required to enter the machine and welding shops.

Environmental, Health, and Safety (EHS) and risk management policies have been developed in cooperation with the relevant campus offices. The policies span a range of operating rules, supervision, training requirements, shop access, and student travel. Of note is that the machine and welding shops are open only during supervised hours while the main areas of the center with no hazardous equipment are open 24/7 to students with additional training.

The 5S approach has recently been introduced to help set a standard for housekeeping and neatness in project areas. 5S is a workplace organization method that focuses on organizing a work space for effectiveness and reducing waste. The name comes from the five Japanese words that help define the phases of the approach. 5S audits of workspaces are conducted multiple times each quarter with scores and rankings tallied and posted.

Competition teams and clubs are assigned dedicated workbays ranging from 300 to 900 square feet. Capstone teams in ME, ECE, and BE are assigned either workbench space or shared floor space depending on the nature of the project.

With a focus on creating a collaborative and innovative culture, the center provides easy access to tools, materials, and consumables. Students are prohibited from bringing their own tools into the center and materials/supplies for competition teams are provided. A variety of training classes are offered to students to develop safety, skill, and professional competencies.

The center connects and provides value to several other campus offices including admissions, career services, and institutional advancement. The BIC is a regular and popular stop for admissions campus visitors. We communicate regularly with admissions staff and student tour guides so they are able to provide a detailed and exciting introduction to the center. The center is also a connection point for corporate partners and these relationships are cultivated through the career services and institutional advancement offices.

Analysis of Team Memberships

Table 1 and Figure 1 summarize team and group memberships for the center from inception to the current year. At the current time, the center is reaching about 30% of the campus student population in some way. These data come from Moodle groups and rosters.

Membership	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18*
Competition Teams	151	163	224	314	356	365	313
Maker Club				42	53	75	56
Classes/Events						121	183
Capstone			16	101	146	133	171
Other		40	40				
	151	203	280	457	555	694	723

Table 1 – Student Membership in BIC Groups

Figure 1 – Student Membership in BIC Groups

In the first two years, the center housed only competition teams. In the later years, additional competition teams, capstone projects, classes, and events are using the center. Current competition teams include Formula SAE, Human Powered Vehicle, Concrete Canoe, Rose Efficient Vehicle, First Robotics, Chemical Car, Autonomous Vehicle, and Robotics (with four sub-teams).

The table and figure show that competition team memberships have increased due to more teams and increased interest. In the current year, team memberships have declined slightly as two teams are in a period of transition with changing student leadership.

The center began housing capstone project workspaces in 2013 and now supports 171 capstone students in ME, BE, and ECE. Use by classes and events has also increased to over 150 students. Class use varies during the year but has included freshman design, design for manufacturing, and sustainable technologies classes. Use by shorter duration campus events has included diversity related design competitions and outreach maker events for middle and high school students. All activities coexist relatively harmoniously with class/event use occurring during the day and team activity concentrated in the evening hours. Opportunities for additional utilization will focus on class/event use as these activities are typically low cost and occur during the day when center utilization is lower.

Analysis of Training Completions

Table 2 and Figures 2 and 3 summarize training classes and completions for the center from inception to the current year. In the early years of the center, an annual environmental, health, and safety (EHS) class was required for all students. Many students on competition teams arrived with fabrication skills and training for other students could be provided on an as-needed basis by these skilled students or staff members.

Training Classes	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18*
Total Class Offerings	0	2	2	5	99	135	72
Total Student Enrollments		80	100	325	1065	1309	1748
Required for Entry		80	100	150	582	641	1374
Required for Shops				175	375	405	257
Optional Enrollments					108	263	117

Table 2 – Summary of BIC Training Class History (2017-18 is partial year)

With the addition of capstone design projects and increasing student numbers in general, the need for more formal and comprehensive training in safety or skill became critical. Table 3 summarizes the classes offered to center students. All classes are offered in the late afternoon and evening time, usually last for two hours, and they are not for academic credit. The training necessary to enter the center is being offered as online modules to support the increasing number of students using the center. The data in Table 3 depict the typical four classes per week that were offered in 2016-17 with an average class size of 9.7. The shop classes are capped at six students.

Figure 2 – Summary of BIC Class Offerings (2017-18 is partial year)

Figure 3 – Summary of BIC Training Class Enrollments
(a. 2017-18 is partial year and b. many students enroll in multiple classes)

Training Class	Duration (Hour)	F2F	Online	Entry to Center	Entry to Shops	Optional
Intro to EHS	1		X	X		
Intro to 5S	1		X	X		
Shop Safety	1	X			X	
Shop Safety Refresh	1	X			X	
Intro to Shop Practices	2	X			X	
Shop Practices – Lathe	2	X				X
Shop Practices – Mill	2	X				X
Shop Practices – Bench	2	X				X
Intro to Welding	2	X			X	
Intro to Welding Refresh	1	X			X	
Welding 1	2	X			X	
Welding 2	2	X				X
Welding 3	2	X				X
TIG	2	X				X
Precision Measurements	2	X				X
Maker - Copper Jewelry	2	X				X
Maker – Birdhouse	2	X				X

Table 3 – Summary of Training Classes Offered at the BIC

Analysis of Center Utilization

Examination of the access/lock log data provides insight into the utilization of the BIC throughout the years. With the center being locked 24/7, students present their campus ID cards at the electronic lock at the front door to gain entry. The card-entry system has captured student entry records into the center since the winter quarter of 2014-15. Our analysis includes only student entry records. Faculty/staff entries, duplicate student attempts, and middle/high school visitor entries were removed prior to aggregating access records by academic year, quarter, week, day, and hour. Our campus is on a three-quarter system rather than two semesters. We believe that the lock data are a conservative estimate of the number of student entries due to the situation where one student may scan their ID while additional students may enter on this one log entry.

As discussed earlier, the overall level of student activity, thus the utilization of the center, has increased over the last three years. For instance, the access log data summarized in Table 4 reveals there were over 21,000 student entries in the 2016-17 academic year with a 37% increase in access between academic years 2015-16 and 2016-17. In addition, the winter quarters of both years have the most frequent access by students.

Quarter	AY 1415		AY 1516		AY 1617	
Fall	NA		3985	25%	6437	29%
Winter	3763	45%	6192	39%	7875	36%
Spring	3925	47%	5150	32%	6798	31%
Summer	714	8%	601	4%	771	4%
Total	8402		15928		21881	

Table 4 – Student entries to the BIC by Quarter (data for a partial year in 2014-15)

The following analyses include data for fall, winter, spring, and summer periods. Even though activity is much lower in the summer, the data are included to maintain consistency. It is also noted that the 2014-15 year represents a partial year data for winter through the summer periods. Analyzing by the ten weeks of academic instruction in an academic quarter, Table 5 shows that during 2015-16 and 2016-17 the center has a relatively even number of visits in weeks 1 to 10 with the most visits by students during Week 8 of the 12-week quarterly schedule. The number of visits drops during week 11, which is finals week, and during quarter break.

Week of Quarter	AY 14-15		AY 15-16		AY 16-17	
Week 1	370	4%	1491	9%	1875	9%
Week 2	811	10%	1369	9%	1964	9%
Week 3	883	11%	943	6%	2020	9%
Week 4	741	9%	1474	9%	1697	8%
Week 5	810	10%	1293	8%	1753	8%
Week 6	827	10%	1487	9%	2055	9%
Week 7	812	10%	1409	9%	2101	10%
Week 8	777	9%	1657	10%	2353	11%
Week 9	740	9%	1478	9%	2256	10%
Week 10	803	10%	1494	9%	2181	10%
Week 11	425	5%	733	5%	620	3%
Break	403	5%	1100	7%	1006	5%
Total	8402		15928		21881	

Table 5 – Student entries to the BIC by Week of Quarter

Analyzing by day of week, Table 6 shows that for the three years studied, Wednesdays consistently have the most number of visits from students followed by Tuesdays and Thursdays. These results reflect that some capstone design classes meet and work at the center on Wednesdays. Tuesdays and Thursdays are often workdays for competition teams. These results also show the importance of weekend hours with 20% of visits occurring on Saturdays and Sundays.

Day of Week	AY 2014-15		AY 2015-16		AY 2016-17	
Mon	1166	14%	2021	13%	2984	14%
Tue	1445	17%	2944	18%	3583	16%
Wed	1752	21%	3434	22%	5286	24%
Thu	1332	16%	2638	17%	3187	15%
Fri	1017	12%	1964	12%	2476	11%
Sat	1014	12%	1572	10%	2302	11%
Sun	676	8%	1355	9%	2063	9%
Total	8402	100%	15928	100%	21881	100%

Table 6 – Student entries to the BIC by Day of Week

Analyzing by class hour of the day, Table 7 shows entries to the center increase during the day with the busiest time of the day being the 10th hour for academic years 2014-15 and 2015-16; however, it was during the 6th hour for academic year 2016-17. The center opens at 10 a.m. for supervised hours so entries during 1st and 2nd hours represent students with 24/7 independent access to the center.

Time of Day		AY 2014-15		AY 2015-16		AY 2016-17	
AM	Midnight to 8:05 am	222	3%	479	3%	909	4%
1st	8:05 to 8:55	201	2%	241	2%	497	2%
2nd	9:00 to 9:50	220	3%	483	3%	611	3%
3rd	9:55 to 10:45	461	5%	912	6%	1074	5%
4th	10:50 to 11:40	444	5%	874	5%	1000	5%
5th	11:45 to 12:35	669	8%	1214	8%	1590	7%
6th	12:40 to 1:30	715	9%	1336	8%	1970	9%
7th	1:35 to 2:25	516	6%	1205	8%	1525	7%
8th	2:30 to 3:20	658	8%	1008	6%	1435	7%
9th	3:25 to 4:15	802	10%	1182	7%	1672	8%
10th	4:20 to 5:10	858	10%	1454	9%	1633	7%
PM	5:10 pm to Midnight	2636	31%	5540	35%	7965	36%
Total		8402		15928		21881	

Table 7 – Student entries to the BIC by Time of Day

By partitioning a typical day into morning hours (12:00 – 8:04 a.m.), class hours (8:05 a.m. – 5:10 p.m.), and evening hours (5:11 – 11:59 p.m.), Table 8 shows the busiest time for the center for the past three years was consistently during class hours followed by evening hours, then by morning hours. Over half of the annual student visits to the center were during the class hours. However, these results also show the importance of evening hours with 40% of visits occurring outside of the 8 a.m. to 5 p.m. day.

Time of Day		AY 2014-15		AY 2015-16		AY 2016-17	
AM	Midnight to 8:04 am	479	3%	888	4%	909	4%
CH	8:05 to 5:10	9909	62%	12490	59%	13007	59%
PM	5:11 to 11:59 pm	5540	35%	7732	37%	7965	36%
Total		15928		21110		21881	

Table 8 – Student entries to the BIC by AM, Class Hours, and PM

Analyzing the data by the unique student visits to the center, Table 9 shows that there were 725 different students visiting the center in 2016-17. The gender profile for these students is also shown in Table 9 with the percentages of female students aligning with overall campus figures of 22% and 25% for the full-year in 2015-16 and 2016-17 respectively.

Gender	AY 2014-15		AY 2015-16		AY 2016-17	
Female	80	21%	115	20%	189	26%
Male	294	79%	471	80%	536	74%
Total	374		586		725	

Table 9 – Student visitors to the BIC by Gender

With the majority of students visiting the center are undergraduate STEM students, analyzing the racial and ethnic profile of the undergraduate student visitors in 2016-17 as shown in Table 10 reveals a similar pattern to the general undergraduate student population in the STEM fields.

Racial/Ethnic Group	UG Visitors (AY 2016-17)	UG CS/ENG (Fall 2016)
American Indian or Alaska Native	0.3%	0.1%
Asian	5.8%	4.6%
Black or African American	2.1%	2.4%
Hispanics of any race	4.4%	4.3%
Native Hawaiian or Other Pacific Islander	0.3%	0.1%
Nonresident Alien	11.2%	12.5%
Two or more races	3.6%	3.9%
Unknown	0.6%	0.2%
White	71.7%	71.9%
Total	704	2054

Table 10 – UG visitors to the BIC and UG STEM Enrollment by Race/Ethnicity in 2016-17

Analyzing the unique student visits by class standing, Table 11 shows a shift from heavy senior participation in 2014-15 to a more balanced representation in 2016-17. Reasons for this shift are not clear, but this may be the result of marketing the center programs to prospective students during their visits to campus.

Class Standing	AY 2014-15		AY 2015-16		AY 2016-17	
FR	5	1%	9	2%	27	4%
SO	14	4%	25	4%	172	24%
JR	25	7%	133	23%	151	21%
SR	301	80%	393	67%	354	49%
GRAD	29	8%	26	4%	21	3%
Total	374		586		725	

Table 11 – Student visitors to the BIC by Class Standing

Analyzing the unique student visits by the number of time a student visited the center in the 2016-17 year, Table 12 shows that over half of students entered the center less than 10 times and only 7% visited more than 100 times. Over four quarters, 100 visits correspond to two visits per week for all four quarters.

Visits to Center per Student	AY 2016-17	
1 to 10	401	55%
11 to 100	272	38%
> 101	52	7%
	725	

Table 12 – Number of visits to the BIC per student in 2016-17

Analysis of Student Assessment Data

Student assessment studies have been administered each spring to students who have worked in the BIC during the year. These were initially satisfaction and suggestion surveys but have evolved into more comprehensive studies exploring student roles played, ABET related outcomes, and impacts on class and career readiness.

In the spring of 2017 (from May 2 to May 14, 2017), a confidential online survey was administered to students involved in an activity at the BIC. In total, 52 students provided responses to the survey. The majority of these students were involved with a competition team/club (73%, N=38). About a quarter of students either used the BIC for their capstone projects (15%, N=8) or were involved in other activities (12%, N=6). The results from this survey are reported with appropriate IRB approvals.

Students were asked to indicate how much their BIC experience(s) contributed to their ability to engage in various behaviors. The response options ranged from Not at All (1) to Very Much (5). Figure 4 below highlights the percentage of respondents who indicated either Quite a Bit (4) or Very Much (5). Affirmation of establishing safety as a top priority for the center is noted with ‘awareness of safety protocols’ at the top of the list. Other top ranked items include manage projects, solve engineering problems, and work on multidisciplinary teams.

Figure 4 – Student Ability to Engage in Behaviors

Using the same set of items, students were also asked to indicate the skills they gained at the BIC that they felt would be the most useful in the upcoming year. Over half of students indicated the following skills they gained will be the most useful: (a) design a product or process to meet desired needs (52%, N=27); (b) work on multidisciplinary teams (52%, N=27); and (c) solve engineering problems (69%, N=36). More information can be seen in Table 5 below. One of the lower rated skills is exhibit 5S awareness and skills. Training in 5S was offered through an optional online training module and only a few students completed it. In the current year, completing the 5S module is a requirement for all students working in the center and an increase in awareness in this skill could be reflected in this year's survey.

Figure 5 – Student Skills Gained Most Useful in Upcoming Year

Students were asked to indicate how often they fulfilled various roles during their BIC experience(s). These roles have been identified by Davis, et al. as defining the ‘profile of an engineer performing well in professional practice¹².’ Further, ‘the profile presents technical, interpersonal, and professional skills or behaviors that align with key roles performed by the engineer.’ The response options ranged from Never (1) to Very Often (5). Table 13 below highlights the means, standard deviations, and percentage of respondents who indicated either Often (4) or Very Often (5).

The role student fulfilled least often was Communicator (56%, $M=3.58$, $SD=1.11$) and the role fulfilled most often was Self-Grower (79%, $M=4.12$, $SD=0.94$). Self-Growers proactively learn and use resources. This favorable finding aligns with one of the new ABET learning outcomes with students possessing ‘an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.’

	<i>M</i>	<i>SD</i>	<i>N (Often/Very Often)</i>	% (Often/Very Often)
Leader (take initiative in guiding the project)	3.83	1.18	34	65%
Designer (produce work products on time and within budget)	3.83	1.00	39	75%
Collaborator (contribute constructively to team performance)	3.88	0.96	36	69%
Communicator (communicate effectively with key stakeholders)	3.58	1.11	29	56%
Self-Grower (proactively learning and using resources)	4.12	0.94	41	79%

Table 13 – How Often Engineer Professional Practice Roles Fulfilled

Finally, students were asked to indicate the extent to which they agreed/disagreed with different statements about the BIC. The response options ranged from Strongly Disagree (1) to Strongly Agree (5) with results summarized in Table 14.

	<i>M</i>	<i>SD</i>	<i>N (Agree/Strongly Agree)</i>	% (Agree/Strongly Agree)
I performed better in my classes because of my involvement at the BIC	3.58	1.09	25	48%
Because of my BIC experience(s), I was better informed on career options	3.85	1.19	35	67%
Because of my BIC experience(s), I was better informed on what classes to take	3.35	1.19	22	42%
Overall, I am satisfied with my BIC experience(s)	4.46	0.67	49	94%

Table 14 – Student Satisfaction and Being Informed on Class and Career Options

Findings suggest students were satisfied with their BIC experience(s) with 94% ($N=49$) either agreeing or strongly agreeing to the statement, “Overall, I am satisfied with my BIC experience(s).” However, findings suggest a need to better connect the BIC experience with students’ classroom experiences. Less than half of respondents agreed or strongly agreed that because of their BIC experience(s), they were better informed on what classes to take (42%, $M=3.35$, $SD=1.19$) and performed better in their classes (48%, $M=3.58$, $SD=1.09$).

Lessons Learned

The following lessons learned are offered as a result of six years of operation of the BIC.

1. Build the right culture – the center has established a collaborative, professional, and safety-aware culture. With few walls and locks, we rely on the good judgment of students to make appropriate use of equipment and resources.
2. Student experiences are a key measure of success – high quality experiences are a result of engaging culture and the right mix of facility, equipment, programming, and technical support resources.
3. Things change, build few walls – while the center has walls to restrict access to shops with hazardous equipment, the majority of the project workspace is open and reconfigurable. As activities in the center have grown, work areas are regularly reconfigured.
4. Train early and often – a comprehensive training program focused on safety, shop skills, and professional skills is essential for preparing students to work effectively in the center. Training records are kept from year to year and the records show certain students completing all of the available classes during their time on campus.
5. Space is the most precious and contentious resource – of the resources of time, money, and space, space has been the most contentious. This is perhaps comes from the perception that there is never enough and that once assigned, space assignments may be perceived to be more permanent. It has been noted that the 5S training increases the ability of teams and students to use space more effectively.
6. Storage space is wasted space – in the original configuration of the center space, a large area for storage was created. Over the years, we have noted that much of what students, teams, and even staff think we need to store should be recycled or discarded. We have worked to cut in half the storage space in the center itself and have secured additional storage space on campus.

Conclusions

This paper has reported on multiple measures of activity and utilization for the Branam Innovation Center including lock logs, team rosters, training completions, and assessment results. This paper has analyzed these sources of data and has highlighted the overall growth and utilization of the center. In addition, more detailed analysis illustrates: (a) overall level of student activity over the last three years; (b) student activity broken down by time of year, quarter, and day; (c) student gender and class standing; and (d) student participation in training classes. The center has increased participation by freshman and sophomore students and has found that PM and weekend hours are desired and utilized by students.

Assessment results indicate that students are satisfied with their overall experience at the center and report that the experience contributed to their ability to engage in various behaviors with the

top ranked items being awareness of safety protocols, manage projects, solve engineering problems, and work on multidisciplinary teams.

It is believed that these results are useful in a variety of situations including prioritizing center activities, determining operating policies, allocating space, scheduling of staff, marketing the program to students, and determining overall resource needs.

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