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Bridging Extracurricular Skill Needs in Bioengineering Capstone Design with Just-in-Time Workshops

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Introduction

Bioengineering undergraduate programs provide a foundation of didactic education for students to prepare them for a variety of post-graduate career paths including medicine, biotechnology, research, and entrepreneurship. Senior design (also called "capstone") courses serve a crucial role in helping to prepare bioengineering students for many career options. These courses also serve to directly address several ABET criteria for engineering programs such as general Criterion 5d: "a culminating major engineering design experience". Senior design courses also provide a rich platform to deliver many other ABET program criteria including functioning effectively in a collaborative team, conducting appropriate experimentation and analysis, and applying new knowledge with appropriate strategies [28]. Working on a relevant, topical problem also allows students to experience a more authentic form of work in their domain [25].

Faculty respondents in a 2019 bioengineering design education workshop reported that bioengineering departments have specific strengths in teaching interdisciplinary knowledge, communication, client needs, human anatomy and physiology, biological constraints, and interaction with clinicians [26]. The fact that bioengineering applications are broad and open-ended casts a wide net for the types of projects which end up being proposed and run through bioengineering senior design courses. This variety presents a challenge for faculty who deliver senior design courses in bioengineering to ensure consistent experiences for students when proposed projects in bioengineering may require knowledge ranging from robotics to materials science, to textiles, to software, and more.

In the past twenty years, several efforts have evaluated how student's past experience aligns to senior design course objectives. In recent work, Jaeger-Helton et al. highlight a disconnect between student and faculty perceptions of skills required for senior design, especially in the areas of design and experimentation [17]. They report that students often listed skills like data science and software as topics that had to be learned *"on the fly"* during their senior design projects. These findings reinforce what our team has experienced, which is that the broad range of topics covered in an undergraduate bioengineering curriculum requires students to rapidly acquire and apply more focused technical skills within the senior design course. Between the core curriculum, track electives, and extracurricular experiences, different students may have significantly different experience, perspectives, and preparedness for certain types of projects by the time they enroll in senior design [4,17]. While an argument can be made that acquiring new skills can be a valuable learning experience, there is also plenty of evidence to show that more meaningful learning happens when students are guided and given support when learning new skills [2,3,5,9,18].

Given the existing variety of coursework in the core curriculum for bioengineering, there is typically very likely little to no room to add coursework to cover additional topics, especially topics in niche areas like soft material molding and physical model making. Yet, many senior design projects require niche topic experience, to produce compelling designs, especially projects including medical task trainers and medical device validation. To address these types of gaps, we proposed a series of Just-In-Time Teaching (JiTT) [12] inspired workshop sessions to be delivered concurrently to our single-semester senior design course. The purpose of these workshops was to address what we see as skills which are common to many proposed projects in bioengineering, but scarcely or never covered explicitly in the core curriculum. Our goal was to deploy these workshops and assess their perceived utility to students and student projects.

Materials and Methods

At the University of Illinois at Urbana-Champaign, the bioengineering senior design projects are sourced from several places. Sponsors of projects typically include alumni, faculty, medical students, local healthcare workers, and representatives from various businesses in industry. Sponsors are invited to submit project ideas to the course directors, who screen ideas ahead of time for curricular alignment and scope to ensure they are appropriate for a team of senior undergraduates.

Throughout the undergraduate curriculum, students build from a foundation of mathematics through differential equations, physics mechanics and electricity & magnetism, general and organic chemistry, and introductory computing. The bioengineering core curriculum then focuses on topics including cell and tissue engineering, signals & systems, biomedical instrumentation, transport & flow, and human physiology. The core curriculum provides students with a strong foundation to understand many of the techniques and methodology applied in bioengineering research and development. Throughout each year, projects are present in core courses to facilitate teamwork and application of course principles [20]. Technical elective courses may provide discipline-specific, and senior design relevant hands-on design projects [10,15]. However, these are not required and not every student may choose to take these courses. Therefore, for most students, the senior design course in Year 4 constitutes the first time they will engage with engineering design principles.

The senior design course directors consider how each solicited project aligns to the topics taught in the core curriculum to ensure all students will have the opportunity to apply skills they have learned in their studies. Considerations for project alignment might include whether the project involves considerations for human physiology and whether the project requires application of common engineering governing equations such as can be found in biomechanics, thermodynamics, physiology, or control theory. Projects which are deemed to be a good fit for the program are pitched to students by the sponsors early in the semester, and students submit project and team member preferences to the course directors. Course directors assign project teams by reviewing student preferences for projects and team members and attempt to best accommodate all students.

Table 1. Project descriptions for the 2023-2024 academic year. Faculty perspective represents what workshop(s) course faculty would have predicted would be most relevant to each project. Project descriptions simplified to protect sponsor intellectual property.

Team	Project Description	Faculty Perspective
A	Drug delivery patch	CAD, Silicone
B	Back phantom	CAD, Silicone
C	Uterine phantom	CAD, Silicone
D	Intelligent surgical tourniquet	Arduino, Python
E	Compression garment	Silicone
F	Smart device holder	CAD, Arduino, Python
G	Needle driver feedback system	CAD, Arduino
H	Optical diagnostic tool	CAD, Arduino
I	Medication safety cabinet	CAD
J	Drainage valve	Arduino, Silicone, Python
K	Back support device	CAD, Python
L	Liquid handling robot	Arduino, Python

The didactic portions of the senior design course combines instruction to teach engineering design principles concurrently with student-led, team-based project work [14]. Topics covered in instruction include project management strategies, the Biodesign framework, patents & engineering standards, FDA & regulatory landscape, professional ethics [13], and a customer discovery series adapted from the NSF I-Corps program [30]. The semester consists roughly of three phases: background research, design, and implementation. In the background research phase, students research their project information and are directed to perform at least 3 stakeholder interviews. In the design phase, students work on ideation and requirement refinement as they plan out their solutions. In the implementation and testing phase, students focus on building and testing their solutions.

Over the first several years since migrating to a 1-semester course, instructors have noticed several patterns in the types of projects pitched from sponsors and for which of those projects, students tended to struggle more than others. Considering the semester schedule, course staff identified 4 opportunities in the calendar to host workshops to serve a similar role to JiTT learning modules; where students would refresh or acquire new skills and knowledge which they could immediately apply to their projects [12]. These workshop sessions have no strict assessment of learning but are intended to be interactive and hands-on so that students can receive guided instruction with the goal of providing students with models of expert level schema from the instructors [3,5,12]. While there are many potentially useful topics to choose from for our workshop sessions, we settled on the following four topics by way of observation of the prevalence of sponsored projects which required a skillset or knowledge, and whether those topics were covered at least in part in our core curriculum. A summary of the most recent projects run is listed in Table 1. Certain details about projects have been removed to protect our sponsors' intellectual property claims. Our selection justification and explanation of each workshop follows:

1) Computer- Aided Design (CAD)

The bioengineering curriculum does not have a dedicated, required Computer-Aided Design (CAD) course. Many projects submitted by sponsors are conceptual ideas and will require students to develop hardware or physical designs from scratch. CAD is particularly useful to projects requiring rapid prototyping (3D printing, laser cutting, other fabrication), but also serves an important role in documenting the project and communicating the design with course staff and project sponsors. The benefits of CAD to many design projects and the fact most students had little to no exposure to CAD before the senior design course made it an obvious choice for the course staff to include. The CAD workshop consisted of instructor-led walkthrough of creating a 3D object from scratch in Fusion 360 (version 18.0.0, Autodesk).

2) Arduino Microcontrollers and Circuits

Bioengineering students are required to take a “Biomedical Instrumentation” course with a lab component, where students build simple measurement systems and acquire data for analysis. However, the circuit designs and acquisition of data are heavily guided, and so many students will have had limited experience with designing their own circuits from scratch in areas such as motor control, data transmission, and multiple sensor integration. Given the prevalence of small device projects which require or would benefit from microcontroller functionality, this workshop was a clear choice to include. During the workshop, instructors led a session helping students create simple breadboard circuits using Arduino Uno microcontrollers with buttons and LEDs to turn on and off under certain logic conditions.

3) Silicone Molding

One of the criteria used to assess whether a project is a good fit for the bioengineering senior design course is whether the project involves human anatomy and physiology. Over the years, many sponsored projects involve some kind of human anatomy analog as part of the expected design and testing. Anatomical models used for medical testing and training are commonly called “phantoms” or “task trainers” in the medical education space. While there are many task trainers available online for purchase, many of the higher fidelity task trainers with extra functionality (such as fluid paths for arteries and veins, biorhythm production, accurate internal organs, etc.) can be quite expensive or inaccessible for a senior design team. A common material choice for medical task trainers are elastomers include silicone. These silicones have the benefit of being chemically inert and stable when cured, relatively easy to work with, commonly available and affordable, but techniques for working with these materials are not covered in our curriculum. The silicone workshop involved instructors offering students a choice between creating a simple alginate mold of their hand to cast out of resin, or to create a mold of an existing small object (figurines, fridge magnets, etc.).

4) Python Data Analysis

Many projects sponsored in senior design require students to write, test, and apply various kinds of software. This could include using software to analyze and plot data, software to control small robotics and sensors, or even development of custom user interfaces (UI/UX). The curricular prerequisites for computational coursework are delivered very early in the curriculum and typically teaches introductory Matlab or Python for engineers. Several courses in the bioengineering core curriculum build from this introductory programming prerequisite, such as “Signals and Systems”, “Modeling Human Physiology”, and “Bio Control Systems”. Many of the later coursework that requires the introductory computing prerequisite apply highly structured, domain-specific problems for students to work through as exercises. While these exercises in later courses provide students with a rich and interactive way to engage with the types of modeling and research techniques relevant to bioengineers, they do not always represent the type of software development required for senior design projects. A clear example of this disconnect was seen in project G, where motor control software driven by multiple human inputs was needed. This type of software involves very different code syntax and semantics compared to the statistical data analysis and physiological modeling delivered in the core curriculum. For the Python software workshop, the instructors led students through several common data loading techniques including loading images, tabular/text data, and numerical data. Students also learned how to calculate high level descriptive statistics from the datasets they loaded, and how to plot the results of their analysis. The focus of the workshop was intended to communicate the semantics, or ideas, about how the methods should be applied, as opposed to syntax or rote memorization of specific code patterns.

Because the design and prototyping which occurs in a senior design course is largely student driven and happens outside of the required course lectures, this presents a problem for implementing JiTT-style modules [21]. However, we find a compelling motivation to adapt many of the core ideas behind JiTT to reinforce specific design and prototyping skills which have high relevance to many senior design projects. Therefore, we chose to implement a series of workshops in sequence such that students might participate in the workshops and receive guided practice from instructors, then be immediately capable of applying those skills to their projects. In periodic check-ins and reports, this work would be evaluated by course staff, thus completing the feedback cycle. While these workshops are different from more traditional JiTT online modules, our approach was directly derived from the foundational ideas and their justifications in learning cognitive theory.

Implementation

We chose to implement our four JiTT-inspired workshops in the following order: CAD in week 6, Silicone Molding in week 7, Arduino and Microcontrollers in week 8, and Python data analysis in week 10 out of a typical 15-week semester. These workshops start well into the semester so that students will have had ample time to form teams, research the background of

Table 2. Post workshop survey format.

Question	Response Options
Rank your experience with [Topic] BEFORE this workshop	1. No experience 2. Little experience 3. Moderate experience 4. Extensive experience
Rank your experience with [Topic] AFTER this workshop	1. Would need additional training 2. Could apply on my own if needed 3. Extensive experience
Rank the relevance of this workshop to your project	1. (Not relevant to my project) 2. 3. 4. 5. (Very relevant to my project)
Rank the relevance of this workshop to your future career	1. (Not relevant to my future career) 2. 3. 4. 5. (Very relevant to my future career)
Please tell us one useful skill/lesson you gained in this workshop.	Open ended free response

their project, and derive initial design ideas. The order of workshops was also carefully considered. We began with CAD, under the assumption that those skills would be more widely used, and more useful in the early planning and design stages. The Arduino workshop was offered next, as teams which had circuit considerations would need ample time to build, test, and refine their designs. Silicone came third, which worked better later in the semester as the casting of specific components often requires a design and mold to be made beforehand. Several teams ended up attending the CAD workshop and learned how to design parts for 3D printing, and then used those 3D printed parts to mold during the workshop. Finally, data analysis in Python came last, as we hoped students would use these skills to help analyze their testing results at the end of the design course. At the conclusion of each workshop, students individually completed a brief survey which served both to evaluate student perceptions of the workshops and to track attendance for student credit. The surveys included 5 items (see Table 2). The survey data presented here are approved by the UIUC Institutional Review Board under NHSR designation [23380]. Workshops were offered during normal class times (~90-minute sessions). Students were required to attend one workshop but could attend more if desired.

The cost incurred to deliver each workshop varied, with around $600 of materials for the silicone workshop, around $350 of materials for the Arduino workshop, and the CAD and Python course incurred no consumable costs, as the software used was either open-source or free for students to access. A more detailed accounting of equipment and materials used can be found in Appendix A.

Data Analysis

At the conclusion of the semester, instructors reviewed the final reports submitted by each team and reviewed the content of the report to understand which workshop topics, if any, were applied to that project. We applied a deductive (top down) coding scheme derived from select vocabulary from the IEEE Taxonomy which we determined were the most relevant to the topics covered in our workshops [8,29]. Text definitions for IEEE terminology [29] in Table 3 were generated and summarized using ChatGPT 3.5 [6].

Table 3. IEEE taxonomy terms selected as coding scheme for analysis. Definitions provided by ChatGPT.

Term	Definition	Workshop
CAD/CAM	The use of computer technology in the design and manufacturing processes of products.	CAD
Design for manufacture	An approach in product design that focuses on optimizing the design of a product to make it more easily and cost-effectively manufacturable.	CAD
Breadboarding	Constructing and testing electronic circuits on a reusable device for prototyping and experimenting with electronic circuits without the need for soldering.	Arduino
Circuit testing	Process of evaluating the functionality and performance of an electronic circuit.	Arduino
Soldering	Process of joining two or more metal components together by melting and flowing a filler metal, known as solder, into the joint.	Arduino
Casting	Manufacturing process in which a liquid material, often a metal or an alloy, is poured into a mold to obtain a specific shape upon solidification.	Silicone
Curing	Process of allowing a material, such as a polymer, concrete, or coating, to set, harden, or reach its final state through chemical reactions, heat, or other means.	Silicone
Molding equipment	Machinery and tools used in the process of molding, which involves shaping a material into a specific form or shape.	Silicone
Data analysis	Process of inspecting, cleaning, transforming, and modeling data with the goal of discovering useful information, drawing conclusions, and supporting decision-making.	Python
Data preprocessing	Preparatory steps and techniques applied to raw data before it is used in data analysis or machine learning models.	Python
Text processing	Manipulation, analysis, and extraction of information from textual data.	Python

A set of custom codes were assigned to each teams' final reports on a discrete scale indicating the strength of evidence for inclusion of each topic (0=None, 1=Little/Tangential Usage, 2=High/Direct Usage). These codes were developed with the purpose of capturing how skills relevant to our workshops were applied to each project. A score of "1" indicated that while some concepts may have been referenced or used, there wasn't a clear demonstration that the project required that knowledge/skill to produce the result which was submitted. A score of "2" had direct evidence of skill or knowledge usage as was covered in a workshop. Table 3 contains all the terms as well as definitions which were mapped. The results of analyzing each report and assigning our numerical scale were then cross compared to team workshop attendance to explore how each workshop may have been received and applied to project work. Poor alignment between workshop attendance and skill usage in projects would suggest the need for faculty to make modifications to how workshops are presented. For example, if skills taught in one workshop were employed only by teams who did not attend, this would indicate students were preferring to apply those skills from other resources including past experience, making the presentation of that skill in a workshop unnecessary for student project completion.

Additionally, we calculated correlation matrices utilizing Pearson's R for the survey items to explore trends between response categories. We calculated an estimate of the standard error (SE) of each correlation as well, using the formulation SE = $\sqrt{((1 - R^2)/(n - 2))}$. Where R is Pearson's R and n is the number of observations/responses. Because our survey had different scales for the items asking about "before" and "after" experience levels, we chose to numerically encode responses such that the top/most experience response received the same numerical weight (4.0), the bottom/least experience would receive the same weight (1.0), and that the middle item in the "experience after" would receive a value in the middle of the "before" items (2.5).

Results

For the purposes of our analysis, a workshop was considered "attended" by a team if at least one student from that team attended and completed the workshop. In several cases, the teams would split up the workshop attendance. From past experience, student teams often distribute project work and delineate specific roles and responsibilities. In this effort, we did not assess individual contribution, instead focusing on the relationship between the workshops and the project work delivered. When comparing teams' attendance of workshops and the evidence of usage of those topics, we see that 64% of the topics we found in the final projects corresponded to attendance of a workshop for that topic. We also found that around 59% of teams that attended workshops used those skills for their project. Inversely, we could say that 36% of the skills we identified in the final project results were reported by teams who did not attend a workshop to learn or enhance that skill. We can also say that 41% of workshop material was apparently not used in the final deliverables for the course. Looking at Figure 3, we see that student responses indicate that they perceive workshops to be more relevant for their project (top) than for their career (bottom), with the exception of the Python workshop. This may have been a consequence of requiring attendance of at least one workshop. However, we note that all but two teams (E and I) attended multiple workshops. This comports with faculty expectations for skills assumed to be required for those projects, as seen in Table 1. In summary, we found that the majority of teams applied skills and knowledge covered in the workshops they attended,

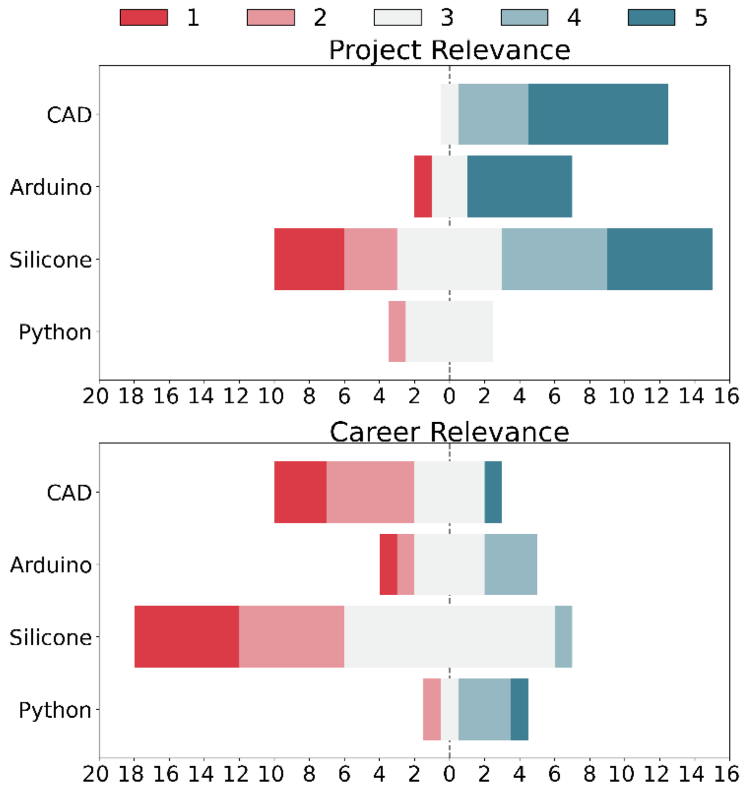

Figure 3. Student survey response counts to Likert-style questions, centered at neutral. Top: perceived project relevance (1=Low, 5=High) for each workshop. Bottom: perceived future career relevance (1=Low, 5=High) for each workshop, legend above.

Table 4. Selected student feedback from post-workshop survey question asking what students learned.

Workshop	Feedback	Exp. Before	Exp. After
CAD	"I've never used CAD before but now I know the basic fundamentals and could create an object on my own"	1 (None)	2 (Could apply on my own)
Arduino	"I learned how to combine different code to create a custom situation"	2 (Little)	2 (Could apply on my own)
Silicone	"I gained the knowledge of how to make molds and how to get more than one cut out of each mold."	1 (None)	2 (Could apply on my own)
Python	"Learned about using python for statistical analysis."	3 (Moderate)	2 (Could apply on my own)

but a smaller minority of students appear to have selected their workshop attendance for reasons not obviously connected to the course, given that they indicated they did not find the workshop relevant to their project and their group did not appear to apply the skills covered in that workshop.

Another interesting finding is shown in the correlation matrices calculated for the survey items in Figure 4. Several interesting items of note can be determined for each workshop. The comparison between self-reported experience level after the workshop ("Exp After") was always negatively correlated with perceived project relevance ("Proj Relev"). This may be due in part to the fact that each workshop was only 90 minutes, and it's intuitive to think that students would have had ample time to assess workshop relevance to their projects but not had time to

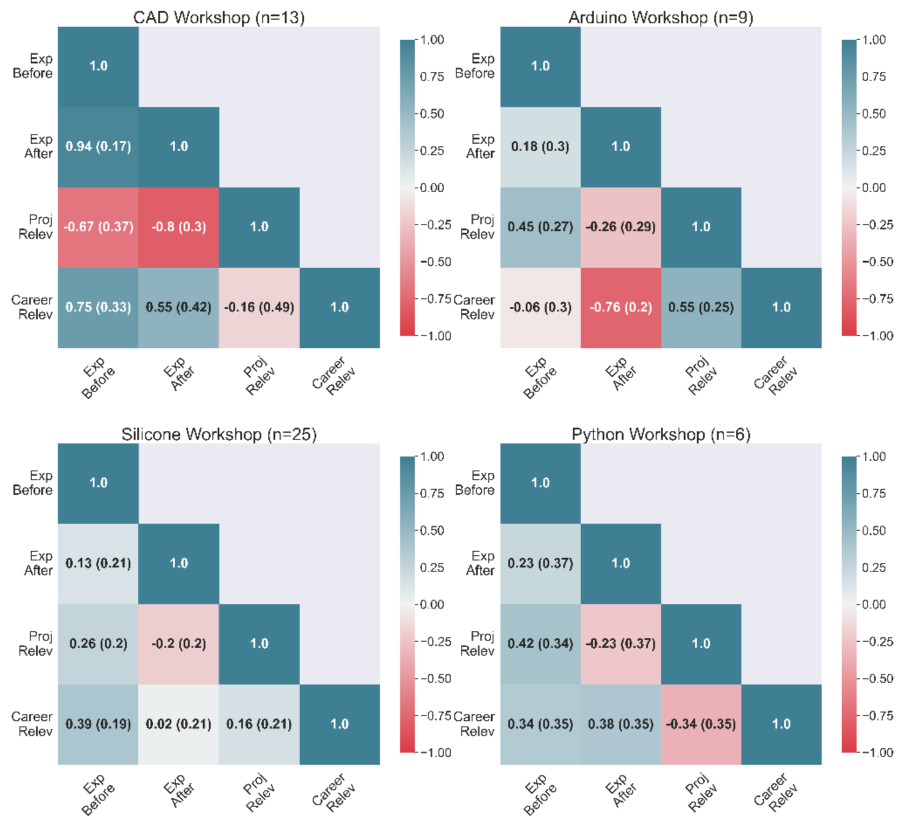

Figure 4. Correlation matrices using Pearson's R show relationships between survey response items for each workshop. The standard error for each estimate is shown in parentheses.

understand how their workshop experience may have positively impacted their skills and abilities. Some select feedback from students is provided in Table 4 which show how many topics covered were new to many students.

Table 4 is intended to highlight comments from students who felt they had improved and had provided meaningful comments. In several comments, student feedback gave less substantive or less positive indications. In the silicone workshop for example, one student responded to the question, 'What did you learn' simply with the one-word response: "Patience.". In the Arduino workshop, one student responded to the same question with, "I have done Arduino quite a bit before, so I don't know what to put here". These types of responses were

Figure 5. Qualitative scoring of workshop topic application in each Team's final project submission, where 0=None, 1=Little/Tangential, 2=High/Direct presence of that topic. Black boxes indicate at least one student from that team (row) attended the workshop (column). Each workshop is color coded along the top. Each topic scored was derived from IEEE taxonomy, and are referenced at the bottom.

uncommon. When we look back at Figure 3, it's clear that many students at each workshop thought there was high relevance to their project, except for Python. We were encouraged that every workshop had a slight but positive trend between experience before and experience after.

Most students (31/44) reported improving their perceived abilities from "Little/None" before the session to at least "Could apply this on my own" after the workshop (7/13, 5/9, 17/25, and 2/6 for CAD, Arduino, Silicone, and Python, respectively).

Discussion

Overall, our workshop series accomplished our goal of providing students with the opportunity to engage with our target knowledge and skills. We showed that most projects had evidence of applications of the topics covered in these workshops. However, a decent fraction of topics we looked at were present in student projects but without any team member having attended the corresponding workshop. We take this to mean students acquired or applied these skills utilizing other resources or past experience. This finding aligns with other work evaluating senior design outcomes where student preparedness for senior design work was found to be variable [4,17].

Looking at Figure 5, we can see that workshop attendance was a good predictor of project application of related skills for both the CAD and Arduino workshops given the overlap of attendance (black outline) and evidence of skill application (colored, 1's and 2's). While all teams who attended the Silicone workshop applied those skills, there were also many teams who attended the workshop but did not apply those skills to their project. Python had the least overlap between attendance and project skill application, which indicates the Python workshop may be a good candidate for review and refinement. Digging deeper into Figure 4, we see that the CAD workshop stands out as having a strong, negative relationship between student experience with CAD and project relevance, indicating that this workshop especially may have been important to offer, as that negative relationship is best described by students having very little CAD experience despite seeing the high relevance to their projects. This also aligns well to our understanding of our curriculum, where CAD is not taught in the required core curriculum but is available through certain technical electives. With all other workshops besides CAD, we see a slight positive relationship between prior experience and project relevance in Figure 4. We interpret this as hinting that some students may be attending workshops which they know are relevant to their project despite already having some familiarity with the topics covered. In the future, further exploration of student rationale for workshop selection may provide deeper insights to this trend. Given the limited number of students in attendance and thus higher standard errors, most of the weak correlations observed cannot be determined to be significant.

From Figure 4, we see strong negative correlation with experience and project relevance in the Python workshop, and high positive correlation between prior experience and career relevance. When we look closely at our attendance data, we find that most students attending the Python workshop had prior interest and experience with Python, which was unique to that workshop. The Python workshop was offered the latest (week 10/16), and had the lowest attendance (6 students, compared to 9, 13, and 25 for the other workshops), so we accept this evidence in that limited context. Of the topics covered in the Python workshop, data analysis was most prevalent in actual project usage (Figure 5, green columns), however, skills from the Python workshop were relatively scarce. In addition, it is possible students did not use the Python language to perform certain data analysis where we did find it being used. The intent of the Python workshop was to communicate ideas and semantics of data and text processing and focused less on specific syntax. In a future iteration of the course, we plan on adjusting the Python workshop by moving it earlier in the semester and will refine the topics addressed to focus on the kinds of data analysis skills we expect to see in relevant projects (see Table 1).

The course team was surprised to find that CAD had such a low perceived career importance, given the faculty's perspective that CAD and digital design in general were relevant to many industry positions. This was the strongest disconnect between faculty expectations and student reported perception. In a future version of our workshop survey, we plan to add an item asking about which career paths students are considering to investigate this disconnect and help place the results of our survey in a more specific context.

Several of our workshops had lower attendance, especially Arduino and Python. This complicated our ability to analyze our data using more robust methods, such as Chi-squared GOF and linear regression models. However, we feel the feedback from students and the evidence we see in their final projects shows that the majority of our students had to overcome a gap in knowledge and skill in order to deliver their final project results. Without an intervention to provide these skills and knowledge, students would be left on their own to experiment with higher effort, lower yield learning methods (trial and error, mimicking unrelated video tutorials, etc…) [2,3,18]. These workshops only took 6 hours in total contact time, with many students only attending a single, 90-minute workshop. We acknowledge there are non-trivial costs to deploying these types of workshops including the consumable materials, the equipment, the space, and also the instructor's time to prepare these types of learning experiences. However, we find this investment to be worth the effort to support students as they synthesize and apply skills to their senior design projects.

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Appendix A

SILICONE WORKSHOP							
Item No.	**Description**	**Manufacturer Part ID**	**Manufacturer**	**Consumable?**	**Price Each**	**Qty**	**Total Price**
1	Resin for casting	Smooth-Cast 65D 1 Gallon	Smooth-On	Yes	$ 114.64	1	$ 114.64
2	Silicone for casting	Dragon Skin FX Pro Gallon	Smooth-On	Yes	$ 219.22	1	$ 219.22
3	Mixing containers	16 oz case of 10	Smooth-On	No	$ 9.08	2	$ 18.16
4	Mixing containers	32oz case of 10	Smooth-On	No	$ 8.89	2	$ 17.78
5	Alginate for casting	Alja-Safe 20 lbs	Smooth-On	Yes	$ 194.28	1	$ 194.28
6	Stir sticks	Choice 4 1/2" Popsicle Stick 5(	Choice	Yes	$ 0.22	2	$ 0.44
7	100 Powder Free Gloves, M a	S-17150[M,L]	MAPA	Yes	$ 32.00	2	$ 64.00
						TOTAL:	$ 628.52
ARDUINO WORKSHOP							
Item No.	**Description**	**Manufacturer Part ID**	**Manufacturer**	**Consumable?**	**Price Each**	**Qty**	**Total Price**
1	Arduino Uno R3	A000066	Arduino	No	$ 27.60	10	$ 276.00
2	Switch	TL2230EEF140	E-Switch	No	$ 0.85	20	$ 17.00
3	LED Kit	KIT-20120	SparkFun	No	$ 6.95	1	$ 6.95
4	Resistor Kit	COM-10969	SparkFun	No	$ 8.95	1	$ 8.95
5	Hookup Wire Kit	DKS-WK1	DigiKey	No	$ 9.61	1	$ 9.61
6	USB A to B cable	3021001-03	Qualtek	No	$ 2.78	10	$ 27.80
						TOTAL:	$ 346.31