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Hack Days as a Method to Increase Interdisciplinary Knowledge and Collaboration Skills of College Students in STEM Fields

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ABSTRACT

Providing college students with learning experiences that account for the interdisciplinary nature of most STEM professions has proven challenging. STEM educational practices typically follow a more scripted process designed to build important foundational skills. In contrast, most STEM professions are interdisciplinary and collaborative in nature. Thus, a gap in experience is created that needs to be addressed if we desire our students to be successful. One potential solution is to hold extra-curricular events, such as a hack day, to provide students with collaborative interdisciplinary learning experiences. We held two such hack day events and found that these events were a highly effective at increasing both the interest and interdisciplinary knowledge of undergraduates.

Keywords: active learning, cooperative learning, hack, hackathon, technology, engineering, drones

INTRODUCTION

Although most STEM professions require individuals with experience in science, technology, engineering and mathematics; these subject areas are still taught as classes contained within specific majors. Classroom practices are mainly instructor-centered and focus on building the discipline specific foundational knowledge of students. While this knowledge is a critical and necessary component of a student's training, it often does not address the complex problem-solving skills that are required of STEM professionals (Marra et al., 2016). Achieving long-term career success in STEM fields requires both field specific knowledge and a broader range of interdisciplinary knowledge and skills (Gao et al., 2020). The scientific and technological challenges ahead are complex and will most likely be solved through an interdisciplinary approach (Stokols et al., 2008). The task of STEM educators then becomes how to provide the basic field-specific content that students need while simultaneously expanding their knowledge of areas outside their chosen subject area.

In addition to the need to increase the interdisciplinary knowledge of STEM graduates, there is also a call to increase the intrepersonal skills of STEM students. It has become apparent that technical skills alone are no longer sufficient to compete in our fast-paced competitive global work environment. Specifically, the ability to work in a team has increasingly become acknowledged as a fundamental skill that yields better results across a wide array of settings (Kniffin & Hanks, 2018). Although these skills are critical to long-term success of STEM graduates, they are often neglected in traditional educational settings (Deepa & Seth, 2013). Indeed, the ability to work collaboratively in a team is one of the most important skills lacking in new professionals (Jang, 2016). Thus, a mixture of expertise and social skills is needed to produce the next generation of successful STEM professionals (Grugulis & Vincent, 2009). Although the ability to work collaboratively is a highly sought skill, providing students with opportunities to develop it have often only occurred through experiences outside the classroom such as internships or research. These opportunities are limited in number and often are not economically or logistically accessible for many students (Fifolt & Searby, 2010; Thiry et al., 2011). Specifically, lack of access to internships has been shown to disproportionately negatively impact unrepresented minorities and first-generation college students (Fournier et al., 2019). These students often have work or familial obligations that make it difficult for them to participate in long-term unpaid extracurricular activities. One possible method for increasing collaboration skills and interdisciplinary knowledge of college students in a more equitable manner is through the use of hack days.

A hack day, sometimes also called a hackathon, is an event that gathers individuals from different backgrounds to form multidisciplinary teams to tackle a problem in a dynamic and collaborative project environment.

Hack days typically last for 10 to 48 consecutive hours, during which time participants work in teams to design and develop innovative solutions to a specific problem. Hack days first originated in the software programming community; however, they have since evolved from a niche event for the computer science community to an event that crosses disciplines (Gama, 2019; Lapp et al., 2007; Ornes, 2016; Trainer et al., 2016). Hack days have been held with themes from science, technology, and art, and the 'hacks' designed and built at these events can be sewed, printed, constructed, and/or programmed. Most hack day events are organized in a similar format. Teams are formed and presented with a challenge. Once teams are formed, they develop an idea on how to address the challenge, assign roles and responsibilities, and finally start producing a prototype of their solution. The solution that they produce is typically called a 'hack' and is the basis of the name of these events. Typically, teams must also develop an effective and informative short presentation to communicate their project idea or prototype to a panel of judges in a pitch presentation that concludes the event.

Fundamentally, hack days provide an open low-stakes equitable environment in which people from diverse backgrounds can collaborate in a manner not possible in the classroom (Trainer et al., 2016). There are no prerequisites or prior knowledge necessary to attending a hack day, which should lead to a greater diversity of students participating. Specifically, we wanted to test if the short-term nature of the event (10 hours) would allow students who do not typically engage in extracurricular collegiate activities to participate. Further, we wanted to test if students who did participate in a hack day increased their interdisciplinary knowledge and collaboration skills. To test these hypotheses, we held a one-day hack day on the campus of California State University East Bay in both 2016 and 2017 and collected survey data prior to, and at the end of each event to assess the effectiveness of the events.

RESEARCH METHOD

The data collected is compiled from two hackathon events, each lasting 10 hours, that had the theme of 'drones and disease' and challenged students to use aerial and land-based drones to assist in the control and surveillance of mosquito-borne diseases.

Event Logistics

Attendees were composed of undergraduate students from California State University East Bay (CSUEB). The event was free, held on a Saturday from 10 am to 8 pm. Attendees were served free breakfast, lunch, and dinner, with snacks available during the entirety of the event. At check-in participants were given color-coordinated name tags which corresponded to their academic discipline (e.g. biology, engineering, computer science). This was done so a mixture of majors was created per group. The hack day commenced with a series of brief 15 minute ‘flash’ talks that covered the following topics: project management, aerial drone safety, programming sensors, drone controllers, mosquito surveillance, mosquito control, and mosquito borne diseases. Students then chose teams of 5-7 members and were required to have no more than two of any majors in order to compete. Thus, a team of all biology students or all engineering students could not occur. Creativity was encouraged and no strict guidelines were enforced in terms of design. Brief tutorials for beginners focused on the programming of the drones and the use of sensors were also provided. Space was provided for groups to test their land-based drones, and a large net enclosure was present for the safe testing of the aerial drones. At the end of the event, each group presented its idea and its prototype to a panel of judges, and the winning team received a monetary prize.

Event challenge

Diseases transmitted by mosquitoes are a major public health concern and are responsible for killing an average of 725,000 people around the world every year (Fernandes et al., 2018). As the geographical range of mosquitoes expands due to global warming so does the risk to humans of the diseases they transmit (Franklinos et al., 2019). Malaria is the deadliest mosquito-borne illness, with 80% of the world’s population at risk of infection and approximately half a million deaths each year. Most recently, the global spread of Zika, dengue, and chikungunya viruses by mosquitoes has become of concern due to their widespread epidemiological impacts (Jones et al., 2020). As insecticide resistance continues to increase in mosquito populations new strategies are necessary for the surveillance and control of mosquitoes.

Event solution: drone technology

The student teams could choose to work with either land-based or aerial drones. Detailed explanations of the drones used has been previously published (Tandon et al., 2017). The quadcopter aerial drones were remote controlled, while the land-based ‘car’ drones navigated autonomously. Basic tools were available at each table to assist groups in the assembly of their respective drone. Consumables such as tape, markers, cardboard, and other materials that could be fabricated to help create a drone solution were also available. Students were also provided with ten different sensor packages and extensive online tutorials for how to implement each sensor (Tandon et al., 2017). The tutorials were designed to allow novice students, with little to no experience, to integrate individual sensors and assemble their drone with ease. Indeed, by the end of the day all groups had built functional drones with at least one operable sensor (data not shown).

Data Collection & Analysis

Data about the student participants was collected at two distinct times during the event. Anonymous surveys were conducted during morning breakfast, at the start of the event, and during evening dinner, at the end of the event. Participants were provided an event ID that allowed data from pre and post event surveys to be matched but remain anonymous. These studies were approved by the CSUEB Institutional Review board office and informed consent was collected from all participants. A one-tail paired sample t-test was used to statistically analyze the pre- and post-event means concerning interest levels in the previously stated topics. One-tail test was used due to expectations there would be a rise in interest and knowledge. Not all data points collected were paired, with a few surveys returned with missing responses. Unpaired data points were removed prior to analysis.

Participants

Hack day participants were asked to identify by race/ethnicity, gender, and major prior to the event starting. The race/ethnicity and genders designations used in our survey were chosen to match the language used by CSUEB for the collection of their demographic data. Compared to the overall population at CSUEB, African American and Hispanic students were under-represented at the hackathon while Asian/Pacific Islander and white students were over-represented (Table 1). This corresponded to the largest group by academic major to attend the hack day, which was computer science/computer engineering (Figure 1A). In these fields Asian/pacific islander males and white males are typically vastly overrepresented, and the CSUEB campus is no exception (Trapani & Hale, 2019). The majority of participants had majors in computer science/computer engineering or a biology-related fields, which together comprised 78% of participants. The overall prominence of students in these fields of study is most likely related to the theme of the hack day event, 'Drones and Disease', and the active recruitment of students that occurred in biology and engineering classes.

RESULTS AND DISCUSSION

The gender of hack day participants skewed male, with female students being highly under-represented compared to the overall population at CSUEB (Table 1). This disparity occurred despite the second largest academic representation at the event being from the biological sciences and nursing (Figure 1), areas of study in which females are typically overrepresented.

One of the goals of this event was to attract a participant population representative of the overall student population at CSUEB, which was not met. However, the percentage of female participation at the CSUEB hack day was still higher than has been reported in other mixed gender STEM events (Trapani & Hale, 2019; Tsui, 2009). In subsequent years we plan to focus on greater female recruitment by working more closely with existing female-specific student organizations/clubs and offering child-care subsidies as studies have shown that female students are disproportionately impacted by childcare responsibilities (Wang & Degol, 2017).

Table 1. Demographics of hack day attendees (n=128).

Race/Ethnicity	CSUEB	Hack Day
African American/Black	11%	2%
American Indian/Alaskan Native	0%	0%
Asian/Pacific Islander	26%	49%
Hispanic	26%	16%
White	20%	28%
Multiple/Other/Unknown	7%	5%
Gender	**CSUEB**	**Hack Day**
Female	61%	36%
Male	39%	64%

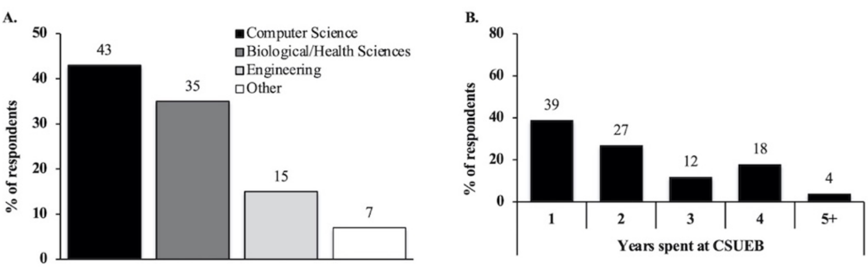

Figure 1. Self-reported academic profiles of 2016 and 2017 hack day attendees. (A) Academic majors of hack day attendees (n=124). (B) Number of years hack day participants had attended California State University East Bay (n=128)

CSUEB has a high rate of transfer students, thus rather than asking the academic standing of participants we asked the number of years the participants had spent at CSUEB. The majority of respondents (39%) had only spent one year at CSUEB (Figure 1B) and did not participate in any campus organizations or clubs (Figure 2A). Nearly half of hack day attendees were employed (Figure 2B) and on average these students worked 26 hours per week (Figure 2C). Together these data demonstrate that the event was highly effective at drawing in newer students and students who were not participating in other campus activities. Indeed, it was remarkable the number of students who attended that stated they worked more than 20 hours a week in addition to being full-time students. Historically, CSUEB is known as a commuter school with very low participation in school organizations and clubs. This one-day, weekend event appears to have reached students who do not typically participate in extracurricular campus activities. Without events such as hack day many of these students would not have an opportunity to develop interdisciplinary knowledge and collaboration skills.

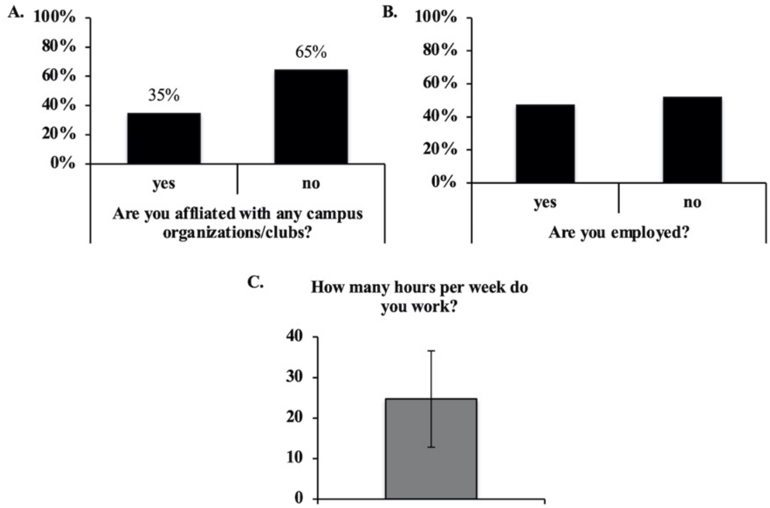

Figure 2. Self-reported extracurricular activities of 2016 and 2017 hack day participants. (A) Attendees affiliated with school organizations and/or clubs (n=128). (B) Attendees currently employed (n=130). (C) Average number of hours worked per week by students who were employed. (n=59, error bars = Standard Deviation.)

Students were provided with a scoring rubric at the beginning of the day to guide their hack building. The rubric specified four questions: (1) Was the challenge addressed? (2) How creative was the hack? (3) How well was the hack built/executed? and (4) How well was the hack presented? It is important to note that the goal of the day was not just to build a functioning drone but rather develop an idea that assisted with the surveillance and/or control of mosquitoes. Students came up with a variety of innovative ideas, from using aerial drones to map areas with stagnate water where mosquitoes are likely to breed to drones with a flame thrower for killing flying mosquitoes. Unlike most hack days, our event was not focused on producing a marketable product but rather was about exposing students to areas outside their major and building their collaborative skills. Not surprisingly then, the ‘hacks’ students came up with ranged from the highly feasible ‘mosquito-buster’ land drone that would help deliver insecticides to the more imaginative ‘mosq-harmony’ that would use the wing beat frequency of mosquitoes to shoot them out of the sky with lasers. Since neither aerial or land-based drone technology is taught on campus, students began the event with a low level of prior knowledge about drones (Figure 4), which led to a more equitable experience since no one was the “expert”.

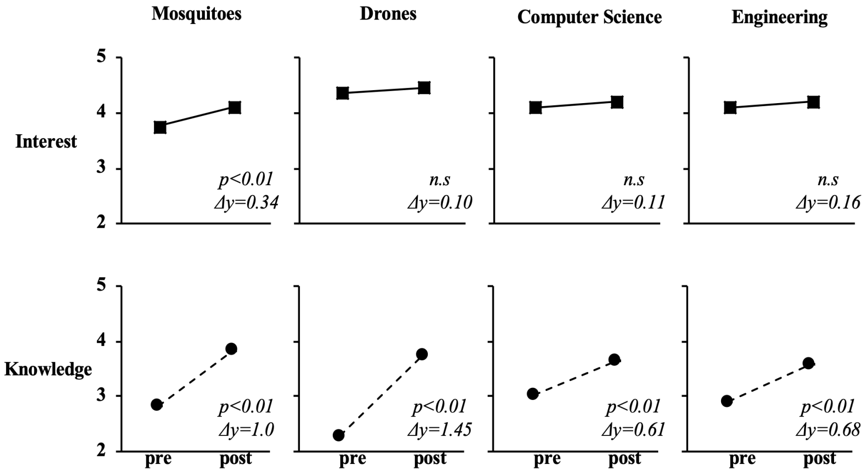

Figure 3. Participants interest and knowledge levels concerning mosquitoes, drones, computer science, and engineering. Likert values are defined as follows: Not at all interested or Not very knowledgeable = 1, Somewhat uninterested or Somewhat unknowledgeable = 2, Neutral = 3, Somewhat interested or Somewhat knowledgeable = 4, Very interested or Very knowledgeable = 5. Data is shown as avg ± sem, n = 106-110, Δy = change in Likert units, p-values are shown, N.S. = not significant.

Hack day participants entered the event with a fairly high interest level in drones, computer science, and engineering (Figure 3), which was not surprising given the focus of the event and the recruitment materials were very focused on drones. In contrast, interest in mosquitoes was the only content area surveyed that was below a 4 on the Likert scale prior to the event and was the only subject area to show a significant increase in interest levels post event (Figure 3). This is most likely a reflection of the fact that mosquitoes are not as prominent in mainstream media or in a broad range of classes taught on campus. It was encouraging to see that interest levels in mosquitoes did rise through participation in the event and raises the possibility of future follow up events that might build on this interest.

Participants self-reported low to moderate levels of knowledge in all four content areas surveyed, with drones scoring the lowest. This is most likely due to the fact that drones are not currently a part of any of the curriculum at CSUEB. At the conclusion of the event, statistically significant increases were observed in the knowledge gains of participants in all content areas, with the greatest gains being observed in drones (Figure 5). Students spent the majority of the day interacting, building, and testing drones and clearly these hands-on experiences made an impact. Indeed, the majority of students (91%) agreed or strongly agreed that they gained new skills and/or knowledge through their participation in the hack day event (Figure 4).

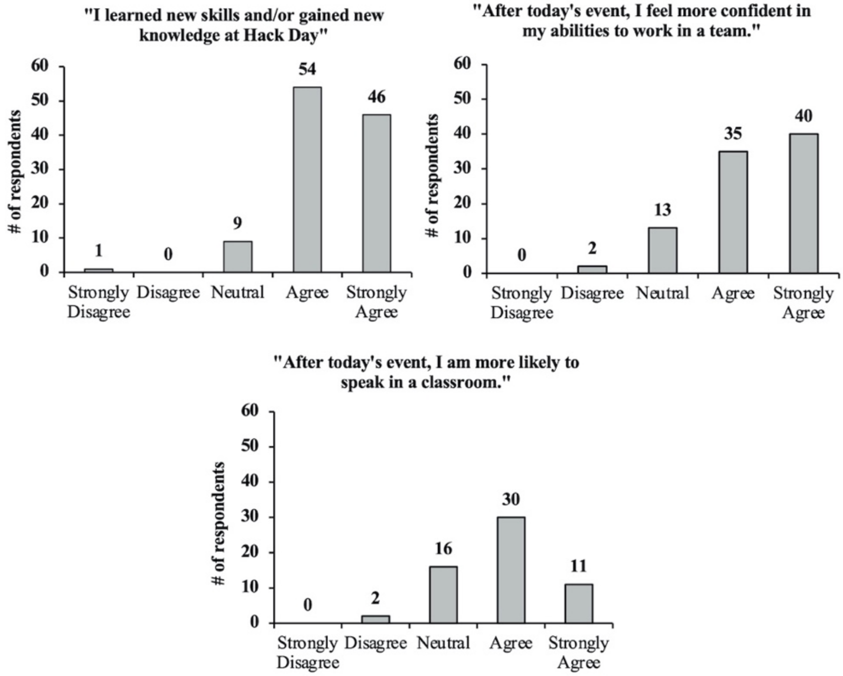

Figure 4. Impact of hack day on participants.

In addition to very specific academic skills and knowledge gained, students also self-reported increases in their abilities to work as team and communicate with peers (Figures 4 and 5). Specifically, 83% students reported feeling more confident at the conclusion of the event in their ability to work in a group (Figure 4). Participants in the 2017 Hack Day reported increased confidence in their public speaking abilities as well as their ability to learn new subject matters outside their chosen major (Figure 4). Students were also asked to reflect on how the hack day experience was valuable to them and similar to the Likert scale survey questions, the majority of student comments mentioned some form of knowledge gained from the event (Figure 5). However, students also valued their experiences communicating with others and working collaboratively (Figure 5). Finally, 97% of students who attended the full events in 2016 and 2017 stated that they would return for a future similar event (data not shown), a remarkable finding given that this was a 10-hour event held on a weekend. These students had just spent a Saturday working in teams with strangers building a very challenging project. The fact that so many would return demonstrates how positive an experience this was for them and the power of a one-day event to make an impact.

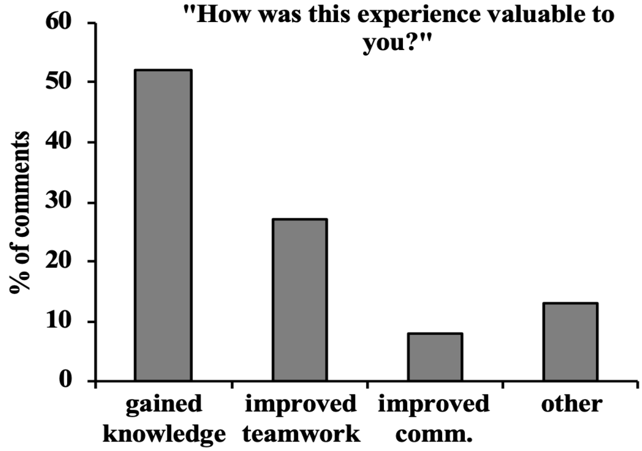

Figure 5. 2017 Hack day participants free responses on the value of hack day. Responses were coded based on language specific to knowledge gained, improved communication skills, or improved ability to work in a team. Comments that mentioned neither of these three topics were coded as 'other'. Sample comments can be found in Table 3, n=52.

Hack day provided students freedoms and creative liberties that are not traditionally present in academic classrooms. An event such as hack day assigns learning to a group-discovery process whereby participants collectively explore the creative space and determine the best way to find a solution. The success of the event is determined by participant gains and benefits to their academic development, not the product that is produced. The ethos of the event is defined by what occurs within the participant group between the times when the challenge is announced, and the group's 'hack' is presented. Exploring the creativity of participant groups, their methods of teamwork, and the collaboration between the interdisciplinary collection of budding academic minds, is the epicenter to cultivating interest and learning in STEM fields. These qualities are the seeds of innovation. In no way are they substitutes to the foundations built within a classroom, but they can provide context to the knowledge taught through textbooks and lectures, and support student interest and knowledge in STEM fields. Although the event was successful, further research will be conducted to help build a more robust profile of the CSUEB participant population and determine the effects of the hack day over time. Future longitudinal studies will focus on examining the long-term effects of the event on participant knowledge and skill gains. Ultimately, we hope that this event can be used as a model for others to hold similarly intensive short-term educational events in an effort to increase interest and knowledge in STEM fields.

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