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Outreach and Recruitment with 3D Printing and CAD

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Abstract

Society has been changing faster every day to adapt to changes linked to economic, technological, environmental, and social shifts and uncertainties. In times of uncertainties, everything, including education, is affected negatively. To protect and support the education pipeline, educators, departments, and colleges should invest in recruitment and outreach activities more than ever before. For this purpose, at Southeastern Louisiana University, various off-campus, on-campus, and on-line day-long programs, summer camps, certification programs, and other activities for both K-12 students and school teachers are designed and delivered around the concepts of "3D printing and Computer-Aided Design (CAD)". In this study, the activities will be presented in detail. Students' and teachers' attitudes towards the concepts and activities will be discussed. Lastly, the challenges encountered will be shared with suggested solutions.

Introduction

Recruitment and retention of students are never-ending struggles of engineering and technology programs. Some of the recruitment activities target specific populations and groups to increase the inclusion of those groups in the engineering and technology fields[1,2]. For regional programs, the problem is more of an enrollment issue that is vital for the departments' survival[3]. In this study, various departmental and college level activities to recruit regional students into engineering technology and industrial technology programs are presented. Some of these activities were part of a bigger organization/program. For those bigger programs, only the 3D printing and design activities are included in this study. At the end, survey results and findings were shared.

Delivery of Activities

Summer Camp (on-campus)

In the summer of 2019, a two week long on-campus summer camp was organized to promote STEM fields among 9th and 10th grade high school students. Students were recruited from rural area schools with less opportunity to participate in STEM-related activities in and out of school time.

The camp was structured around eight STEM areas and the total number of participating students divided into eight small groups. The areas chosen were in different fields ranging from health to physics. For each subject area, a day-long module was created. Each student group attended one specific module every day and rotated to a different module the next day. The modules started with a short introduction and lecture, then the necessary hands-on skills were taught, and at the end of the day, a small hands-on project was completed. Every day the program started with breakfast at 8:00 a.m. and ended at 5:30 in the evening with dinner. Module specific activities started at 10:00 a.m. and ended at 3:30 p.m. During these two weeks, modules were held from Monday through Thursday. On Fridays, there were off-campus activities such as visits to local industry or research centers. In this summer camp, out of eight module subjects, one of the STEM subjects was “3D printing.”

On a typical day, the 3D printing module was starting with a Youtube video clip. A short Youtube clip about 3D printing and its application areas was presented. Afterward, a short lecture presentation was made to explain how engineering, science, and technology are related to each other. The emphasis was mostly on engineering, engineering design, and methodology of engineering problem-solving. After this introduction, hands-on activities were started. For each module, there were two undergraduate assistants helping instructors.

3D printing technology requires 3D CAD models as input. So, in the first hour, students were introduced to Tinkercad. Tinkercad is an entry-level CAD software. It was chosen for its simplicity, fast learnability, and easy accessibility. Tinkercad is cloud-based free software, and it can be used on most common browsers without downloading the program. More importantly, instructors can create classes and monitor students' projects in real-time. Although the modeling logic of Tinkercad is different from professional CADs, it is an ideal resource to teach high school level CAD background and work simultaneously with the students. Since Tinkercad is tailored towards younger students with no technical background, there are ample exercises and lessons available from simple to advanced levels.

For the 3D printing module, seven of the beginner level Tinkercad tutorials, which are available on tinkercad.com, were assigned to students. Most of the students were able to complete all seven tutorials in less than half an hour. Once the tutorials were completed, students were assigned a design and print project. The 3D printing process is slow because of the nature of the technology. So, the modeling and printing project had to be completed quickly in a short amount of time.

For this reason, "a key chain" design project was assigned to students. Students were instructed to design and print a key chain within a 2"X2"X.25" design envelope. With this size limitation, each key chain took less than thirty minutes to print. While waiting for parts to be printed, students were given a bicycle assembly project. The project required students to put together pre-printed pieces of a hand size bicycle model. With this activity, students could practice standard assembly methods for 3D printed parts, and they realized that the 3D printing technology could be used for bigger and more significant projects. After the assembly activity was completed, a quick tour of the labs was given to introduce various other printing technologies such as metal printing, composite printing, and stereolithography. At the end of the tour, the printing of the key chains was completed, and the key chains were ready for the students to pick them up.

Summer Camp (virtual)
In the summer of 2020, a second summer camp was done in the same structure with eight modules or subject areas using hands-on project-based learning activities for two weeks. However, this time the camp was delivered online because of the restrictions on gatherings related to the Covid-19 pandemic.

The preparation for the virtual camp was more complicated compared to the preparations for the on-campus camp. In the beginning, the goal was to prepare each module in such a way that the students could complete the module asynchronously without the instructors' assistance or supervision. For this reason, every instructional material, including video clips, handouts, and assignments, had to be recorded and saved to USB drives so that the students could follow the instructions on their own and complete the hands-on projects. However, because of the limited time of preparation and uncertainties related to the students' access to critical tools and technology, it was decided to do a synchronous online (virtual) camp.

The camp's main focus was increasing the students' interest in STEM fields by exposing them to various STEM-related hands-on activities, demonstrations, and presentations. For this reason, hands-on activity kits were designed to be shipped to students' homes. These kits included all necessary items and tools to complete each module without using any additional tools or accessories from the students' homes. The instructors and the undergraduate student assistants tested the activities and the kits to check if the activities can be completed by the materials included in the activity kits.

In the final preparation phase, a website was designed for each subject area to upload the teaching material and online communication. The websites are designed in the learning platform of "Moodle" because of instructors' and student assistants' familiarity with the system. Depending on the subject area, each website included short instructional video clips recorded by the instructors, presentation slides, web links to various websites, instructions for assignments, and necessary applications. For video communication purposes, the Google Meet application was used. On a typical virtual camp morning, students, instructors, and undergraduate assistants were logging into Google Meet and Moodle at the same time. Then, the instructor was leading the activities by instructions and demonstrations.

For the "3D Design and Printing" module, various hands-on and instructional activities were created around the theme of "designing a medical face shield." At the beginning of the day, a problem statement was given as follows: "design a piece of protective equipment that prevents the transmission of body fluids when the patient coughs or sneezes." After the problem was introduced, the engineering design process's typical steps were studied with the students. At every significant step of the engineering design process, an activity or assignment was performed.

In the first step of the engineering design process, the concept of "problem definition" was explained, and how engineers ask questions to define the problem and specifications were demonstrated. After that brief instruction, students were asked to create a list of questions that they would ask to understand or define the problem with details. Students submitted their responses as a written list to Moodle and then shared their responses and discussed them on Google Meet with other students, instructor and undergraduate assistants. In the next step, ideation was explained, and examples were presented. Students were asked to create a list of specifications and functions that their design will possess to solve the stated problem. Students submitted their responses to Moodle, and the discussion took place on Google Meet. In the third step, sketching and its relevance to product development were explained. Basic methods of creating orthographic views were also demonstrated, and students were asked to draw simple sketches of their "face shield" designs. After the sketching assignments were uploaded to Moodle, prototyping was introduced. For this activity, a kit was already sent to students. There were scissors, a stapler, vinyl sheets, a piece of sticky foam, and a 12" piece of rubber available in the kit. The students built their face shields with the provided materials. At the last educational component, 3D CAD was introduced. Different 3D modeling methods and software were presented, and students were directed to Tinkercad's website to complete the starter tutorials. Before the end of the day, students were asked to 3D model an object they wanted and submit the .stl file through Moodle. Students were given a 2"X2"X2" design envelop as the only restriction. After the camp was over, the models submitted by students were 3D printed and sent to students' homes.

Makerbot Certification

Makerbot, one of the leading 3D printer manufacturers in the US, has an online certification program. In the fall and spring 2020 semesters, two Makerbot certification programs were completed. The program is 20 hours long, consisting of video clips, reading materials, tests, and hands-on activities related to the engineering design process and Makerbot 3D printers. Upon completing the program, students earn an "operator" certificate and an "innovator" certificate. The program is completed under the supervision of an instructor. First, the instructor has to go through the certification process and earn the educator certificate. Certification program and materials are on a password-protected educational web portal. When the instructor earns the educator certificate, s/he becomes the administrator of the certification portal. An administrator can register the students and monitor the progress of the students on each course. The program is a self-paced program that can be completed by each student on their own. However, four-hour-long weekly meetings were arranged with students as a group, and program materials were studied and completed together in five weeks for better control and efficiency. For the meetings, the university provided Google Meet accounts were used. This way, the instructor was able to help or interfere when it was necessary. Six students participated in the fall semester, and twenty-eight students participated in the spring semester of 2020.

Science Fair Project Group

In the spring 2020 semester, a project group was recruited from the area high schools and mentored for six weekends. Students decided to design a toy panther (to represent their school mascot) that can be actuated with a model Stirling engine. The model Stirling engine was purchased from Amazon.com. In the first week, the students were trained on SolidWorks CAD program and Makerbot printers. Next, the Stirling engine was dismantled and 3D modeled with SolidWorks to adapt to the panther design. In the remaining weeks, the panther's 3D design and print were completed, and the Stirling engine was assembled into the panther's body. Students gained skills in 3D modeling, 3D printing, reverse engineering, precision measurement tools, and Stirling engines through this project. In March, students competed in the regional science fair and won third place with their project.

Teacher Professional Development

In the summer of 2020, a professional development program was initiated for the area high school teachers. The goal was to help the teachers with their professional development and create a bridge between high schools and the university through the teachers. The program was one week long with four themes, including "Teaching science with 3D printing." For this program, each theme created a dedicated Moodle website, and the communication was made through Google Meet. The participating teachers' fields were math, chemistry, biology, and physics and none of them had a background or previous knowledge in 3D CAD and 3D modeling. Thus, for teaching 3D CAD modeling, various software, tools, and websites were introduced to teachers. For traditional CAD, Tinkercad and OnShape were demonstrated, and simple assignments were completed with the instructor's help. Tinkercad codeblock, Turtleblocks, and Desmos were demonstrated and practiced together with the teachers for generating 3D models from mathematical formulations and computer codes. For general science, biology, chemistry, and medical fields, many other websites were presented with downloadable 3D models ready for 3D printing. (The list is provided in Appendix). Lastly, creating a course plan for a 3D printing project was explained using the course template available on Thingiverse.com.

Feedback on Activities

Summer camp (on-campus)
As a follow-up study, a specific survey for the 3D printing module was not conducted. However, a survey to measure the summer camp's overall success was conducted. Of 46 students, 26 of them completed the survey. 44% of the students reported an increase in their curiosity about STEM fields, 54% showed increased interest in technology, and 46% showed increased interest in engineering.

Summer camp (online)
At the end of the camp, student participation was calculated according to the percentage of projects completed by the students. Out of four assignments/project, for the “3D design and build” module, 1.43 projects were completed on average per student. After the camp, the students were asked to rate their experience from 1-5, with 1 being the lowest (it did not go as well as I expected) and 5 being the highest (it was better than expected). Fifteen out of twenty-nine respondents (52%) answered their experience was better than expected, while one (3%) rated their experience “it did not go as well as expected”.

Makerbot certification
In the spring 2020 semester, twenty-nine students registered for the MakerBot Certification Workshop and an additional 28 students registered on the waitlist for a total of 57 registrations from 26 schools. The 5-day curriculum consisted of five courses preparing participants for two certifications (Operator and Innovator Certificates). On average, participants completed 2.48 courses and earned one certification. Eighteen participants earned at least one certificate. Ten participants earned Operator certificates and 17 earned innovator certificates. Nine participants earned both certificates and nine earned one certificate. Nine students participated in the follow-up online survey. When the students were asked to rank the importance of each factor in the certification program, the highest score was for “Learning more about 3D printing” with 4.22 points out of 5 points. Other reasons and scores are as in Table 1.

When the students were asked if the certification program had changed their career goals, two students stated that the certification program “made me change my current college and career interest,” and one student stated that certification program “supported my current college and career interest.”

Item	Average*
Learning more about 3D Printing	4.22
Something to do while at home	4.11
It was free	4.11
Hands-on learning	4.11
It was online	4.00
It was offered by Louisiana GEAR UP	3.78
Earning a certificate	3.78
Working with Dr. Mehmet (Emre) Bahadir	3.56
Opportunities to get to know college instructors	3.56
Opportunities to meet other high school students	3.44
Opportunities to get to know college students	3.44
It was offered by Southeastern	3.33
*very important (5); somewhat important (4); neutral (3); somewhat not important (2); not important at all (1)	

Table 1. How important was each part of the MakerBot Certification Workshop

Teacher Professional Development
Fourteen teachers and administrators from nine schools registered for the virtual Summer Professional Development Program. A total of 8 participants attended at least one of six workshop days from 7 of the schools. At the end of the program, teachers showed great appreciation for what they have learned about 3D printing and its relevance to their area of teaching. Overall, the 3D Design and Printing was a successful workshop module that kept the participant active and engaged throughout the day. A follow-up survey was sent at the beginning of the fall semester. The follow-up survey showed the continuing interest in the subject and the demand for more advanced subjects on 3D printing. (5 out of 8 participants were "very interested" in learning advanced 3D printing subjects in the fall 2020 semester.) All 8 teachers registered for the next 3D printing course.

Summary and Conclusions

Overall, students and teachers show significant interest in 3D printing technologies and enjoy learning new skills in 3D printing, CAD, and the engineering design process. However, a follow-up study should be performed to measure how much of this interest translate into choosing engineering/technology majors at the college.

References

1. Darabi, H., & Nazempour, R., & Reckinger, S. M., & Nelson, P. C., & Revelo, R. A., & Abiade, J., & Ozevin, D., & Felder, A. E., & Bilgin, B., & Siow, Y. (2020, June), *An Integrated Program for Recruitment, Retention, and Graduation of Academically Talented Low-Income Engineering Students* Paper presented at 2020 ASEE Virtual Annual Conference Content Access, Virtual On line . 10.18260/1-2--34133
2. Osta, A., & Kadlowec, J., & Papernik, A., & Dias-Liebold, A. F. (2020, June), Work in Progress: Studying the Factors Affecting Women Recruitment and Retention in Engineering Paper presented at 2020 ASEE Virtual Annual Conference Content Access, Virtual On line . 10.18260/1-2--35687
3. Webster, R., & Turner, M. (2020, June), *Purdue Mission to Mars 2.0: A Learn-by-Doing Approach to Recruiting* Paper presented at 2020 ASEE Virtual Annual Conference Content Access, Virtual On line . 10.18260/1-2--35111

Appendix

List of websites with free 3D models for 3D printing

- Instructables.com
- weareteachers.com
- commonsense.org
- createeducation.com
- Chemical and biological models
    - Example from NIH
- amtekcompany.com
- NASA
- Smithsonian museum
- wpi.edu
- Thingiverse.com