Developing Elementary Students' Career Awareness of Advanced Manufacturing

Hengtao Tang, University of South Carolina

Hengtao Tang is an associate professor in Learning, Design and Technologies at the University of South Carolina. His research focuses on self-regulated learning in engineering education, especially using learning analytics and machine learning algorithms to understand the self-regulated learning process, profile self-regulated learners, and create AI-scaffolded interventions to support self-regulated learning.

Dr. Ramy Harik, University of South Carolina

Dr. Ramy Harik, a Fulbright Scholar, is a tenured Associate Professor in the Department of Mechanical Engineering at the University of South Carolina and a resident researcher at the McNAIR Center for Aerospace Innovation and Research. He is currently a v

Fostering elementary students' awareness and career interests in Advanced Manufacturing

Abstract

Broadening underserved students' participation in advanced manufacturing (AM) workforce at scale is critical. This exploratory study showcased outreach activities in a suburban elementary school serving primarily students from underserved communities. Given the age group of those elementary students, the goal of this series of outreach activities was to inspire their career awareness of engineering. Approximately sixty students all around the age of seven participated in this event. All of them had some STEM experience through their participation in math and science classes. Local students do not yet have solid career plans until the ninth grade, but most of the students involved in this outreach activity had an interest in engineering. There were six activities in the rotation: gum drop towers, popsicle stick structures, paper gliders, catapults, Legos, and homemade slime; each of these activities were associated with different tasks to accomplish. To ensure students' exposure to various aspects of AM projects and jobs, all the students had the opportunity to rotate through all the activities. Overall, elementary students involved in this outreach activities stayed engaged in those activities. The findings showed that students established awareness of the advanced manufacturing field and fostered excitement about pursuing such a career in the future. The experience assured the importance of hosting outreach events for students to hear it straight from people in the field who used to be in their same position.

Introduction

The rapid innovation driven by the Industries of the Future, such as artificial intelligence (AI) and the Internet of Things (IoT), has created opportunities for the manufacturing industry but also posed novel challenges of an increasing need for a qualified workforce. To date, the gap between the need for a qualified advanced manufacturing (AM) workforce and the current workforce development pipeline has been unfilled [1]. The National Strategic Plan on Advanced Manufacturing by the National Science and Technology Council in 2018 noted that by 2025, the manufacturing sector would create over 3.5 million new job opportunities, but 2 million of them will be unfilled. Preparing the next generation of AM workforce requires a commitment to educating younger generation [2]. Deloitte and The Manufacturing Institute's study [3] suggests American public opinions believe that formal and informal education programs on AM can help recruit and prepare the next generation of workforce to undertake a career in future manufacturing, which are positively perceived by a majority of Americans as innovative and technology-intensive. However, the pervasive disparities of underrepresented groups in the STEM workforce development pipeline remain an unsolved barrier gap [4]. Broadening participation for those students from underserved communities in AM at scale is thus critical.

This exploratory study showcased outreach activities in a suburban elementary school serving primarily students from underserved communities. Effective outreach and education advancements are essential to engage underserved student populations in AM education for two reasons. First, existing manufacturing courses in K-12 settings tend to focus on outdated topics and seldom specifically address the novel topics such as AI and IoT related to AM. Second, many

underserved students are not aware of the opportunities, benefits, and job security related to the AM field. Providing underserved students with access to relevant resources and activities may benefit them in fostering awareness of AM jobs and developing career interests in pursuing an AM career at their early ages.

Methodology

Needs assessment

To identify the specific gap in what needs to be taught and what has been taught in the current manufacturing curriculum, our team reviewed the curriculum for the cluster of manufacturing in local schools and school districts, Project Lead the Way (PLTW) courses on manufacturing (e.g., Principles of Engineering for Grades 11-12, Digital Electronics for Grades 11-12), and dual-enrollment courses offered to high school students. For this visit to the elementary school, we decided to follow STEM-WELM [5] to design outreach activities. STEM-WELM argues student action outcomes towards STEM careers or education are predicated on whether they can acquire dispositions (e.g., interests), knowledge (e.g., STEM domain knowledge), and skills (e.g., critical thinking) from learning experience. Considering the age of the participants and the existing curricular gap, our team decided to focus primarily on keeping elementary students engaged in outreach activities, providing them with an enjoyable learning experience, and raising their awareness of AM and AM-related careers. To this end, we aimed to motivate elementary students to steer towards engineering when they are older and can decide on their careers. To accomplish this goal, our team facilitated eight AM-themed activities interacted with the elementary students, triggered those students' excitement about this career field.

Participants and settings

The school was situated within a suburb area, primarily serving underserved communities. There was a STEM Coach in this school who oversaw STEM education initiatives. Given the age group of those students, their STEM topics are still quite simple. Our team gained contact with the STEM Coach who connected us with three teachers and their three classes. Approximately sixty students all around the age of seven participated in this event. All of which have some STEM experience through their participation in math and science classes. Local students do not yet have solid career plans until the ninth grade, but most of the students involved in this outreach activity had an interest in engineering.

Outreach activities

To ensure students' exposure to various aspects of AM projects and jobs, we aimed to develop multiple hands-on learning experience appropriate for this age group of students. Our team composed of engineering faculty and practitioners as well as educational researchers brainstormed and voted on a list of curated engineering education activities. Specifically, the alignment with our local state course standards and the appropriateness for this age group were installed as the main

criteria for voting. A debriefing session was held, resulting in a narrowed list of six activities and the confirmed logistics of the outreach activities.

Six activities in the rotation included gum drop towers, popsicle stick structures, paper gliders, catapults, Legos, and homemade slime. Each of these activities were associated with different AM tasks that students interested in this career may uptake in the future. The *gum drop towers* activity, aligned with the principles of structural engineering in advanced composites, asked students to build the highest tower possible by holding together puzzles with toothpicks. The *popsicle stick structure* activity allowed the students to practice their sense of accuracy and balance with the structure with the goal of balancing the highest number of sticks. This station allowed the students to begin experimenting with the importance of precision in manufacturing. *Paper gliders* were designed and decorated by the students, and there was a test launch station outside to test flight distance and accuracy. This station was designed to empower students with a preliminary exposure to aerodynamics in that well-designed gliders can fly farther. The *catapults* activity engaged students in a process of decorating, building, and testing catapults made of popsicle sticks and rubber bands. Their goal was to compete with peers to launch pompoms furthest down the hallway. The *Legos* station, focused on cultivating students' design skills and assembling processes, allowed the students to explore their creativity and design skills in a fun, hands-on activity. The *homemade slime* activity, related to material properties and viscosity, helped the students to practice their measurement understanding and skill.

The team facilitated six different STEM themed activities and got to interact with the students and get them excited about this career field. The focus for this outreach was to primarily keep their attention and share a fun memory, so that when they are older and deciding on their careers this may help to steer them towards engineering. Our team agreed that all the students should have the opportunity to rotate through all the activities. The team was split into different groups, and each was assigned an activity and a table, and the students rotated through all the stations. At the end of the outreach day, all the students joined our team in a bottle rocket launching activity outside the building to further reinforce their interests in AM related activities and careers.

Data Collection and Analysis

The STEM career interest survey (STEM-CIS) [6] was adapted to measures the degree to which elementary students were interested in pursuing advanced manufacturing careers. Our team revised the wording of those question items to make sure of their readability to students of the similar age (7-8). In the end, we curated a total of seven five-point Likert-type scale items in their career awareness and interests in advanced manufacturing. Descriptive statistics was used to analyze the data.

Results

A total of 23 students responded to the survey with a response rate of 43%. The reliability of the instrument for this study was assessed via Cronbach's alpha, which confirmed a high internal consistency (a = .96) among students' responses. On average, students indicated an agreement (*M* = 3.98, SD = 0.93) to those statements about their career interests in advanced manufacturing. Most students (n = 18) confirmed the impact of this outreach experience on their career aspiration towards STEM occupations and manufacturing domains. All the students (n = 23) who responded to the survey indicated that they have enjoyed and benefited from this outreach activity.

Findings

Overall, elementary students involved in this outreach activities stayed engaged in those activities. From preliminary observation, those students established awareness of the advanced manufacturing field and fostered excitement about pursuing such a career in the future. The outreach activity was just the beginning of our effort to broaden underserved student participation in AM education and workforce. The experience assured the importance of hosting outreach events for students to hear it straight from people in the field who used to be in their same position. Our next step is to continue to refine our curricular activities and plan the future integration of these topics into schools. Currently manufacturing curriculum is limited to outdated topics, but there is little to no mention of new advanced manufacturing techniques. Following an evidence-based approach, our goal is to development an age-appropriate, project-based AM curriculum that addresses young students' disposition, knowledge, and skills related to AM and facilitates their action outcomes towards pursuing AM education opportunities and career paths.

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