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ENGage LSU 2.0: Transitioning a Field Trip Experience to a Virtual Format and Its Impact on Middle School Students (Evaluation)

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Abstract

ENGage LSU is a yearly event designed to expose middle school students to different fields and research areas of engineering to spark an interest in possible future careers. This single-day field trip experience invited students to tour several labs and facilities in the College of Engineering and to participate in hands-on activities conducted by university faculty, graduate students, and undergraduates. Students were split into groups of 10-20 and rotated through five different demonstrations and activities with a heavy focus on basic and applied research associated with biomedical, chemical, and environmental engineering, such as designing a scale model of microscale technologies to capture cancer cells, examining the properties of polymers, and observing water filtration methods. There were three iterations of this event starting in 2017 with an average participation of 100 middle school students per year. Results from pre- and post-surveys showed that 22% of participating students increased their interest in engineering and over half increased confidence in their ability to become engineers and their desire to pursue a career in engineering. The 2020 offering was slated to be the largest ENGage LSU event up to then, but unfortunately, the event had to be canceled due to the COVID-19 pandemic. Not wanting to lose momentum and knowing that ENGage LSU was having a positive impact on local students, the authors decided to host a virtual event in 2021 due to continued limitations on in-person gatherings and began planning how to make this transition. Sixteen faculty members volunteered to participate—half of them opted to develop and lead a hands-on activity and the other half performed a demonstration live or asynchronously. 308 students were registered to participate from seven middle schools in four different school districts. Classroom sets of materials for the hands-on activities were distributed to the participating schools prior to the event so that the students could perform the activities while following along virtually. Pre- and post-survey analyses revealed that 19% of these students increased their interest in engineering, 27% increased their confidence in becoming an engineer, and 28% increased their desire to pursue an engineering career. While these trends matched what was observed in the previous in-person events, the amount of increase in some categories was lower. Lessons learned from this virtual transition included the need for better communication between the university and middle schools regarding technology/software availability and the need for more teacher oversight in some of the classrooms during the event. Even with the return to traditional in-person gatherings, the authors were inspired by the success of the event to potentially offer future virtual experiences. Applying the lessons learned, a virtual event would broaden the impact and accessibility, allowing middle schools with limited transportation options and from a wider geographic area to participate.

Introduction

There is an ever-increasing need for STEM professionals in the United States, so it is imperative to encourage more students, especially those from underrepresented groups, to pursue college degrees in STEM fields [1]. While 50.5% of the U.S. population is female, 13.6% is

African American, and 18.9% is Hispanic [2], the number of engineering graduates in 2019 from these populations was only 22.5%, 4.3%, and 11.9% in these populations respectively [3]. To increase these numbers, academic preparation of K-12 students is essential, but students must also be aware of and interested in pursuing STEM degrees and careers [4]. A young person will not choose to pursue a STEM career if they are not aware of the career possibilities in those fields, they do not know anyone who works in STEM, or they do not understand what professionals in those careers do [5], [6]. Furthermore, many K-12 students have few to no experiences with engineering, which could partially explain why there are not more students pursuing engineering degrees [7].

Along with museums and science centers, institutions of higher education should take an active role in helping to expose students to engineering concepts and career options [8]. These interventions should be offered to students before they start high school, as it is widely known that students consider their future career path in middle school or earlier and most start losing interest in STEM in middle school [9]. It has been reported that more than 75% of STEM professionals were interested in pursuing a STEM career before they entered high school and that although two-thirds of girls were interested in STEM at ages 6-12, their interest decreased by half at ages 13-17 and dropped to only 4% by the time they entered college [10]. Results of a longitudinal study found that half of surveyed middle school students who aspired to work in STEM ended up earning a STEM baccalaureate degree, and these students were 3.4 times more likely to have earned a degree in physics or engineering than students who were not interested in a STEM career [11]. These findings illustrate how the career aspirations of young students can greatly impact their choice of college major and future career.

Although some programs targeting middle school students outside of the classroom have not been shown to make large leaps in student interest in STEM [12], many other university-sponsored middle activities including a 90-minute engineering week program and an after-school robotics program have reported impressive successes in increasing middle school interest in engineering [13], [14]. This research led the authors to design an event to introduce middle school students to the myriad of career choices in engineering, ENGage LSU. This single-day field trip experience invited students to tour several labs and facilities in the College of Engineering and to participate in hands-on activities conducted by university faculty, graduate students, and undergraduate peer mentors. Students were split into groups of 10-20 and rotated through five different demonstrations and hands-on activities heavily focused on biomedical, chemical, and environmental engineering, such as designing a scale model of microscale technologies to capture cancer cells, examining the properties of polymers, and observing water filtration methods. Local public schools with high enrollment of students from underrepresented groups were invited to participate. ENGage LSU was offered during the university’s spring break when faculty do not have teaching duties, and which does not coincide with most of the local public school’s holiday. There were three iterations of this event starting in 2017 with an average participation of 100 middle school students per year; over 80% were African American and about 50% were female. Results from pre- and post-surveys showed that 22% of participating students increased their interest in engineering and over half increased confidence in their ability to become engineers and their desire to pursue a career in engineering [15].

The COVID-19 pandemic forced the authors to cancel the 2020 offering of ENGage LSU, which had 286 students registered to attend with a waitlist of 175. The past successes of ENGage LSU and the increased interest from schools, along with the continued restrictions of in-person gatherings, were the impetus for creation of a virtual event in 2021.

Virtual Event Description

The authors met early in the fall semester of 2020 to discuss options for a virtual ENGage LSU event with the hope that students would be able to not just watch engineering demonstrations but to also follow along with faculty giving instructions for hands-on activities. To solidify the details of how the event would work, we polled schools and faculty members to gather preliminary information. Teachers who participated with their students in past years and those that were registered for the previous spring's event were sent a survey to ascertain which videoconferencing platforms were used by their schools, how many students would participate and if those students could be split into small groups for hands-on activities, what percentage of students were attending school in person at that time, and how much time they could allocate to ENGage LSU—a full day like the past in-person events (4-5 hours) or a half day in the morning or afternoon (2-3 hours). Ten teachers completed this interest survey. 19 faculty also completed a survey to ascertain their interest in a virtual event and whether they could facilitate a synchronous or asynchronous hands-on activity or demonstration. Due to the overwhelming interest of schools and faculty, plans began quickly for a virtual offering in spring 2021.

Teachers registered 308 students to participate from seven middle schools in four different school districts. Sixteen faculty members volunteered, and half of them opted to develop and lead a hands-on activity while the other half performed a demonstration; one professor had a scheduling conflict and prerecorded instructions for his hands-on activity, while the others participated synchronously. The demonstrations included hydrogen fuel cell vehicles as renewable energy, near-infrared imaging systems to detect tumors, 3D printing of organs, microfluidics, electromagnets and magnetic liquids, resonance in buildings under winds and earthquakes, DNA coding and gene expression, and mud houses inspired by dirt daubers' nests. The hands-on activities included building tiny bug-like robots, testing models of a new bridge verses an aging one, observing salinity gradient energy using hydrogel beads, decoding messages from healthy and cancer cells, learning about biomedical applications of drug delivery using superabsorbent polymers, measuring contaminates in a density tower to simulate water treatment, laying composite materials to affect mechanical properties, and testing hydrophobicity in plant leaves to inspire stain-resistant clothing.

Each faculty member leading a hands-on activity provided instructions for the teachers and a list of needed materials. The event facilitator modified instructions as needed and collected the supplies. Classroom sets of materials were assembled and distributed to the participating schools the week prior to the event, and teachers were instructed to share some of the materials with students attending school virtually, if possible. Copies of the pre- and post-survey were also included in the kits sent to each school with instructions to give the pre-survey to students before the day of the event.

Based on feedback from teachers, the virtual offering of ENGage LSU was a two-hour event, held either in the morning or afternoon based on their preference and availability. The schedule was made so that each participating school was able to participate in two different hands-on activities and two demonstrations, each lasting about 30 minutes. The schools were instructed to split their class into two smaller groups, and each group was given their own Google or Teams link. Each faculty planned to perform their activity or demonstration four times, rotating through four different Microsoft Teams or Google Meet rooms. Volunteers were recruited from a university student organization, Society of Peer Mentors, so that each room had a moderator to ensure that the technology was functioning and to communicate with the event facilitator and professors. Schools were assigned to one of four session blocks by videoconferencing platform to make it easier to the faculty to switch between rooms. Each peer mentor began the event in their room by showing a short introductory video put together by the event organizers, then they introduced their first professor once they were logged in and ready. The schedule is detailed in Appendix A.

Methods

Participants

Eight teachers from seven public schools signed up their classes to participate in this virtual program. Three schools were in the East Baton Rouge Parish School System, and the other four were from schools in surrounding districts: Baker, Iberville, and St. John the Baptist Parishes. A total of 308 students were registered to attend, but only 198 fully participated in ENGage LSU. The demographics of the participating students were 82% from ethnic minorities (mostly African American) and 48% were young women. These school districts each serve a high proportion of students from low socioeconomic households.

Data Collection

Each school was sent copies of the pre- and post-survey and a pre-stamped envelope with return address along with their activity supplies; 190 copies of each survey was received after the event. Survey questions were the same as the previous three years of the program, so that results could be compared between years and delivery format [15]. The purpose of the survey was to evaluate how the program affected students' knowledge of engineering and their interest in engineering. It was designed to (i) measure their interest, confidence, and desire in being an engineer and (ii) identify how much they knew about the different engineering disciplines and what engineers do. These questions were crafted as the authors had previously observed that middle school students abandoned the idea of becoming an engineer either because of lack of self-confidence in succeeding as an engineer or lack of understanding of what engineers do (e.g., more than build bridges, make cars, and work at chemical plants). The survey began with a set of Likert-type statements to determine students' interest and self-efficacy in engineering with the choices: yes, a lot; yes, a little bit; not sure; probably not; and no way (see Appendix B). The next question was open-ended and directed students to list as many types of engineering as they could. The last question consisted of a list of 14 things and instructed students to answer the question, "what do engineers do?" by selecting items from the list. These items included things that tend to be more widely associated with engineering and items that may not be as widely known but that students should have experienced through some of the activities and demonstrations. The post-survey contained all the same questions as the pre-survey with two additional open-ended questions on the back—explain at least one thing you learned about engineering, and what was your favorite part. These additional questions were helpful in identifying which aspect of the program piqued the highest student interest.

Analysis

The survey responses were entered into a spreadsheet for analysis. The surveys were marked by the participating students so that their pre-survey responses could be matched with their post-survey responses; each student's surveys were assigned a number from 1 to 190. The Likert-type responses were input as ranked factors with 5 for "yes, a lot" and 1 for "no way" to simplify comparisons between pre- and post-responses. For question two, a student worker first counted the number of correct answers. Answers considered correct included mechanical, electrical, computer, robotics, nuclear, and chemical engineering. Some answers counted as incorrect were technical, design, ocean, and farming engineering. A second person was consulted when a response was unclear. This second person also randomly checked a few surveys to test for interrater reliability. Additionally, the number of students who mentioned each field were tallied and included in the spreadsheet for comparison between pre- and post-survey. The number of statements selected for question three was also recorded for each student, and an overall count of the number of students who chose each response was also documented.

Results

Individual differences in survey responses revealed that 19% of participating students increased their interest in engineering, 27% increased their confidence in becoming an engineer, and 28% increased their desire to pursue an engineering career. While these trends matched what was observed in the previous in-person events, the level of increase in some categories was lower (the percent increases for in-person events were 22%, 54%, and 56%, respectively; see Table 1 for comparisons) [15].

Table 1. A comparison of survey responses between two years of in-person events and the virtual offering in 2021.

	% increased interest in engineering	% increased confidence in engineering	% increased desire to pursue an engineering career	Difference in number of engineering fields named	Difference in number of items that engineers do
2021: Virtual (n = 190)	19%	27%	28%	0.42	1.76
2017-2018: In-person (n = 211)	22%	54%	56%	0.79	4.29

For the second question, students were asked to name as many types of engineering as they could. Each student's correct answers were tallied and compared between pre- and post-survey. The average number of engineering fields named on the pre-survey was 1.69 and increased slightly to 2.11 on the post-survey, a difference of 0.42. The greatest increase in engineering fields was in environmental engineering; four times more students named that field on the post-survey than on the pre-survey. The last question asked students to check off items on a list that they thought engineers do. The correct answer was 14, as every item on the list was valid. Students checked an average of 7.22 items on the pre-survey and 8.97 items on the post-survey for a difference of 1.76. Table 1 shows the comparison between the survey results between the prior in-person events and the virtual event for all three question categories. The changes in pre- and post-survey responses for each statement from question 3 is provided in Table 2. The statement selected most frequently on the pre-survey was "design cars, airplanes, and robots" (94%). The largest increase in responses was "discover how cells talk to each other in the body" with nearly six times as many students selecting that statement on the post-survey compared with the pre-survey.

Table 2. Percent of participating students who selected each statement below in response to the question, what do engineers do. The fold increase illustrates the change between students' responses from pre- to post-survey.

What do engineers do?	Pre	Post	Fold Increase
Design Cars, airplanes, and robots	94%	87%	0.93
Help doctors diagnose and treat patients with cancer and deliver medications	65%	69%	1.06
Determine how buildings and bridges are damaged	64%	78%	1.20
Develop new ways to make our energy sources "greener"	61%	72%	1.18
Drill for oil underground	51%	58%	1.15
Study the properties of materials to make new things	49%	81%	1.64
Perform chemical tests on small pieces of paper	83%	68%	0.83
Invent machines to do things in new ways	69%	93%	1.33
Design systems to make water safe to drink	44%	66%	1.50
Study the properties of DNA and create organs for plants and animals	57%	70%	1.22
Learn how to use different materials to make better houses	74%	69%	0.93
Work in chemical plants	48%	81%	1.68
Study the properties of plants to develop new ideas	35%	64%	1.83
Discover how cells talk to each other in the body	11%	62%	5.90

Conclusions

The increase in students' interest in engineering after the virtual ENGage LSU event was almost the same as from the in-person event. This finding shows promise that while the experience of touring engineering labs and performing hands-on activities in a university setting was impactful for middle school students, they could also benefit from seeing it on a computer screen. However, students showed only slight increases in self-efficacy and interest in pursuing an engineering career; the in-person event seemed to have a larger impact on students in these areas. We hypothesize two reasons for this discrepancy. Firstly, students were more engaged in some classrooms than others depending on the level of interaction from the teacher. (The next section describes this aspect in more detail.) Secondly, the experience of visiting a college campus cannot be replicated virtually. The building that houses the College of Engineering at Louisiana State University was completely renovated and expanded in 2017 with state-of-the-art laboratories and classroom spaces. Many participants from past years indicated informally that this was their first visit to a college campus, so this novel experience in a modern facility could serve to amplify the students' interest in pursuing a STEM career.

Students generally increased their awareness of the field of environmental engineering, and they improved their knowledge of biomedical engineering, as only 11% thought that engineers discover how cells talk to each other in the body before participating in this event. The authors plan to examine data from the two post-COVID years (2022 and 2023) where the event returned to an in-person format to compare with prior in-person offerings and with this virtual event.

Lessons Learned

Other engineering programs that transitioned to a virtual format reported successes during the COVID-19 pandemic and provided helpful lessons learned. Having a functional, accessible online platform and being able to troubleshoot software issues, providing kits of materials with a plan for replacement parts, and employing a team of staff and/or mentors were all shown to be necessary for success [16], [17]. The distribution of materials kits to schools and the training of a team of peer mentors were especially essential for the delivery of ENGage LSU in a virtual setting. While the students did not have the ability to physically step into a researcher's lab, they were able to follow along with hands-on activities and to ask questions to engineering researchers while getting a sneak peek into their lab environments through the camera. The undergraduate peer mentors were able to monitor each virtual room, moderate questions, assist professors to use videoconferencing platforms that were new to them, and provide inspiration to these students to pursue engineering degrees. These peer mentors were instrumental in the program's success.

The biggest lesson learned from this event was the need for better communication between the middle school teachers and university staff. There were a multitude of connectivity issues at the outset of the event with many teachers not able to use the links provided to them. Teachers were asked ahead of time if it was possible to divide their class into smaller groups to easier facilitate the activities. Although all agreed to do so, three of the eight teachers did not follow these instructions, which caused gaps in the schedule. Additionally, during the activities, several teachers left their classrooms or used this time to perform other tasks, leaving their students essentially unsupervised while faculty were giving hands-on activity instructions from afar. This led to issues with keeping students' attention and engagement in the demonstrations and activities. For future virtual events, the authors plan to conduct a brief training for participating teachers and to require a contract for participation that elaborates on the teacher's role as on-site facilitator of the activities.

Many educators at all levels have struggled to transition successful in-person programs to a virtual format, but it is imperative that we continue to do what we can to inspire the future generation of STEM professionals. The results of the virtual ENGage LSU event showed that although the results may not be as strong with virtual programs as with in-person ones, there is still learning occurring and interests sparked.

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Appendix A: 2021 Virtual ENGage LSU Schedule

This table illustrates the ENGage LSU 2021 schedule showing four rotation blocks with two schools and four faculty in each session block (except Session A, which had four groups from the same school).

Morning Session A	**Volunteer**	**Platform**	**8:30am**	**8:40am**	**9:10am**	**9:40am**	**10:10am**
School 1: Group a	Peer Mentor 1	Google	video	Dr. SK	Dr. JX	Dr. CB	Dr. CA
School 1: Group b	Peer Mentor 2	Google	video	Dr. CA	Dr. SK	Dr. JX	Dr. CB
School 1: Group c	Peer Mentor 3	Google	video	Dr. CB	Dr. CA	Dr. SK	Dr. JX
School 1: Group d	Peer Mentor 4	Google	video	Dr. JX	Dr. CB	Dr. CA	Dr. SK
Morning Session B	**Volunteer**	**Platform**	**8:30am**	**8:40am**	**9:10am**	**9:40am**	**10:10am**
School 2: Group a	Peer Mentor 5	Google	video	Dr. AM	Dr. PJ	Dr. XZ	Dr. MG
School 2: Group b	Peer Mentor 6	Google	video	Dr. MG	Dr. AM	Dr. PJ	Dr. XZ
School 3: Group a	Peer Mentor 7	Google	video	Dr. XZ	Dr. MG	Dr. AM	Dr. PJ
School 3: Group b	Peer Mentor 8	Google	video	Dr. PJ	Dr. XZ	Dr. MG	Dr. AM
Morning Session C	**Volunteer**	**Platform**	**8:30am**	**8:40am**	**9:10am**	**9:40am**	**10:10am**
School 4: Group a	Peer Mentor 9	Teams	video	Dr. SS[a]	Dr. BB	Mr. NT	Dr. CS
School 4: Group b	Peer Mentor 10	Teams	video	Dr. CS	Dr. SS[a]	Dr. BB	Mr. NT
School 5: Group a	Peer Mentor 11	Teams	video	Mr. NT	Dr. CS	Dr. SSa	Dr. BB
School 5: Group b	Peer Mentor 12	Teams	video	Dr. BB	Mr. NT	Dr. CS	Dr. SS[a]
Afternoon Session D	**Volunteer**	**Platform**	**12:10pm**	**12:20pm**	**12:50pm**	**1:20pm**	**1:50pm**
School 6: Group a	Peer Mentor 13	Google	video	Dr. JD	Dr. TL	Dr. GP	Dr. XT
School 6: Group b	Peer Mentor 14	Google	video	Dr. XT	Dr. JD	Dr. TL	Dr. GP
School 7: Group a	Peer Mentor 15	Google	video	Dr. GP	Dr. XT	Dr. JD	Dr. TL
School 7: Group b	Peer Mentor 16	Google	video	Dr. TL	Dr. GP	Dr. XT	Dr. JD

[a]One professor recorded instructions for his hands-on activity, and the volunteer played the video at the assigned time, making sure the students were ready and pausing when there were questions.

Appendix B: ENGage LSU Pre-survey

1. Check one box for each statement below:

	Yes, a lot!	Yes, a little bit	Not sure	Probably Not	No way!
I want to learn more about engineering.					
I think I have what it takes to be an engineer.					
I know someone who is an engineer.					
I am planning to go to college.					
I want to work as an engineer or scientist.					

2. List as many different types of engineering as you can.

3. What do engineers do? (select all that apply)

_____ Design cars, airplanes, and robots
_____ Help doctors diagnose and treat patients with cancer and deliver medications
_____ Determine how buildings and bridges are damaged
_____ Develop new ways to make our energy sources "greener"
_____ Drill for oil underground
_____ Study the properties of materials to make new things
_____ Perform chemical tests on small pieces of paper
_____ Invent machines to do things in new ways
_____ Design systems to make water safe to drink
_____ Study the properties of DNA and create organs for plants and animals
_____ Learn how to use different materials to make better houses
_____ Work in chemical plants
_____ Study the properties of plants to develop new ideas
_____ Discover how cells talk to each other in the body