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Online Distribution

The online EDGJ is a reality as a result of support provided by **East Carolina University** and **Biwu Yang**, Research & Development, ECU Academic Outreach.

EDGD Calendar of Events

Future ASEE Engineering Design Graphics Division Midyear Conferences

EDGD Midyear Conference – To be discussed at the ASEE Annual Conference

Future ASEE Annual Conferences

Year	Dates	Location	Program Chair	
2023	June 25 - 28	Baltimore, Maryland	Shaobo Huang	shaobo.huang@usask.ca
			Golnaz Mirfenderesgi	mirfenderesgi.1@osu.edu
2024	June 23 - 26	Portland Oregon		

If you're interested in serving as the Division's program chair for any of the future ASEE annual conferences, please contact the Director of Programs, Brooke Morin (morin.29@osu.edu).

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Message from the Editor

Nancy E. Study, *EDGJ* Editor
Penn State Behrend

Over the past several years, the *Journal* staff and I have tried many things to increase submissions—sending out notices to listservs, recruiting submissions in person (but that was stifled by the pandemic when in-person conferences were cancelled), and reaching out to colleagues in other ways to encourage them to submit their work to the Journal. Success has been limited. We feel engineering design graphics is still an important part of the engineering and engineering technology curriculum and sharing our research and classroom experience is important to EDG educators.

Since the pandemic, participation in Division activities has declined due to research interruptions, reduced travel funding, and time limitations due to increased teaching responsibilities. Hopefully, this year we can start fresh and renew interest in the Division and the *Journal*.

Many institutions have eliminated, or combined graphics departments with other departments. The number of course offerings that are specifically graphics-related have declined. The field of engineering design graphics has changed and we need to consider what we can do to expand our active membership base and encourage participation in the Division. We need your input and suggestions for how you would like to see the Division move forward.

So this brings me to the questions I have for the readers… where do we go from here? Are we still relevant? Should the *Journal*, and the Division expand their scope? How should we actively recruit now that things are returning to normal? I am hoping that with the 2023 Annual Conference being in-person, and with a record number of submissions and attendees, according to ASEE data, there will be a better attended business meeting, well attended Division sessions, and a chance of recruiting more *Journal* submissions, and more active members.

As always, I thank Judy Birchman for her able assistance in doing the copyediting, Bob Chin, even though he is retired, for the ongoing technical support, and all of my reviewers for their timely feedback. Hope to see you all in Baltimore.

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Increasing Underserved Students' 3-D Modeling Skills and Self-Efficacy using Distance Mentoring

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Abstract

Formal learning environments have struggled to introduce STEM content and STEM careers to students from underrepresented populations. This problem is exacerbated when dealing with students who live in rural areas where access to quality materials and instruction is limited. The eMentorship project is an innovative approach to mentoring that utilizes the latest in communication technology to help support a formal mentoring program. This study investigates the impact of a virtual mentorship program on underrepresented students living in rural North Carolina. The project was an eight-week mentoring program that matched underrepresented student teams with graduate student mentors from a local university. In addition to the mentoring experience student participants were also taught three-dimensional (3-D) modeling skills using a "flipped" classroom approach to instruction. The paper presents the curriculum developed to guide the program, student examples of 3-D models, self-efficacy scores and qualitative interviews conducted with the student participants. Results of the study provide evidence that students found great value in the mentoring experience and were able to learn 3-D modeling skills in a virtual learning environment.

Introduction and Literature Review

Formal learning environments have traditionally struggled to successfully introduce underrepresented student populations to STEM content and careers (Denson, Austin & Hailey, 2012). With this noted, it is imperative that educators at all levels provide learning opportunities outside of formal classroom environments, where students spend 87 % of their time (Gerber, 2001). This issue is even more pressing for underrepresented student populations who live in rural areas, where access to institutions of higher learning and other resources is limited. Turning to informal learning environments as a means of introducing students to STEM content may help provided some answers for educators. As an informal learning environment, mentoring has shown promise as a strategy for the recruitment of underserved students to STEM fields (Denson & Hill, 2010) and there is even evidence of mentoring's' impact on learning (Maughan, 2006).

Research has provided evidence of the benefit formal mentoring programs have for women and minorities in regards to assimilation to the workplace (Hansman, 2002), with mentorship programs having been used as a tool of affirmative action since the 1970's Van Collie (1998). Furthermore, mentorship programs have displayed an ability to positively impact students' academic success particularly for at-risk students (Hall, 2006; Campbell-Whatley, 1997). While the evidence of mentoring's' impact on recruitment and retention is intriguing, Maughan (2006) extends mentoring's capacity even further by asserting that mentoring has repeatedly shown an ability to enrich the process of learning. For underserved students who have an interest in STEM careers, mentoring may offer not only a viable means of introducing them to STEM careers but may offer a way of enhancing their learning experience.

Underserved students who live in rural areas where access to institutions of higher education

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and other resources is limited, face increased challenges of accessing high quality tools and instruction (Denson et al., 2015). For students in these areas, the Internet provides a medium through which students can receive access to high quality tools and virtual instruction. Brown and Adler contend that the Internet can provide students with access to high-powered software and tools, such as telescopes, and supercomputer simulation models (2008). Recently, advances in educational and instructional technology have allowed for the merging of the Internet-based virtual world and the physical world thus allowing for the extension of traditional learning (Education n.d.). Utilizing the power of the Internet with the theoretical underpinnings of a formal mentorship program may provide learning experiences that extend beyond the traditional classroom.

Federal legislation distinctly mentions that one purpose for mentoring is (to) "encourage students from underrepresented groups to pursue scientific and technical careers" (Act, 2006). As a tool of recruitment, mentorship programs have shown the ability to recruit and retain minorities in the workplace (Allen, 2006). Research provides indication that mentorship programs have a positive effect on students' academic success, especially for at-risk students (Hall, 2006). To effectively meet challenges of access and opportunity for underserved students in rural areas, there is a need to develop innovative interventions that are informed by the extant literature, speak directly to students' unique challenges, and employ creative use of technology and other media sources to engage students in STEM. Distance mentoring or *eMentoring* may meet these needs and offer an alternative to the traditional face-to-face mentoring relationships to which we're accustomed (Single & Single, 2005; Wilburn, Amer & Kilpatrick, 2009).

The ability of *eMentoring* to overcome issues of geographic centrality and mitigate the requirements of synchronicity makes it an ideal platform for forging a relationship between STEM majors who have a demanding workload and underrepresented students who live in rural areas (Stoeger et al., 2013). Moreover, Ghods & Boyce (2013) contend that *eMentoring* is uniquely suited for addressing social inequities by providing mentoring opportunities to those who would not otherwise receive them due to geography, costs, and/or physical limitations. With this noted, there is still a lack of empirical research documenting effective models for mentoring students for STEM careers.

The framework guiding this innovation is based on Kram's (1983) theory of mentoring. Kram (1983) proffers that mentoring is a relationship between an experienced member of an organization and an understudy whereby the experienced role model provides support and direction. To build upon this theory the social learning theory was employed to help explain the mentoring experience (Merriam, 1999). According to Merriam and Carafarella (1999) "social learning theories contribute to adult learning by highlighting the importance of social context and explicating the process of modeling and mentoring" (p. 139). This theory states that people learn from one another and it includes the concepts of observational learning, imitation, and modeling.

Purpose

The following paper reports on an innovative approach to mentoring using a "flipped" classroom approach to instruction to enhance the mentorship experience. The curriculum developed for the program, methods of communication, media used to facilitate the program, products developed and assessment are presented. Over an eight week-period, graduate students from a research one university in North Carolina mentored underrepresented student groups from rural counties in the participants' respective state. In addition to the mentoring experience,

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students were introduced to three-dimensional (3-D) modeling software and techniques. At the conclusion of the program researchers evaluated participants' self-efficacy as it related to 3-D modeling and their perceptions of the *eMentorship* program. Outcomes of the project include 3-D models of the participants' products, a 3-D self-efficacy scale and the curriculum that guided the program.

Description of the Innovation

In the *eMentor* program researchers partnered with a pre-college outreach program to develop a virtual mentoring experience that targeted underrepresented students who had not had exposure to STEM careers. Participants for the program were selected from two districts in rural counties and comprised of approximately 18 students. The *eMentorship* program provided mentorship training for the mentors, which was required for assignment. Although the project provided students with mentorship training, qualified mentors had to demonstrate a working knowledge of graphic communications and more specifically Solidworks modeling software. The principal investigator (PI) for the project assigned between three to five student participants per *eMentor*.

The *eMentors* followed a four-point protocol developed by the PI, based on formal mentorship "best practices". This four-point protocol included (a) video representation that is representative of a career in STEM, (b) field experience that offers the student exposure to a STEM profession, (c) a design challenge to be solved using graphics software, and (d) advising sessions where students are advised on college preparatory and other related topics (Denson & Hill, 2010). *eMentors* were responsible for keeping a weekly log that must be submitted each week in order to receive compensation.

Virtual "Flipped Classroom"

A flipped classroom is a process of inverting the classroom whereby events that traditionally take place in the classroom would take place outside of the classroom and vice versa (Lage, Platt, & Treglia, 2000). This method of instruction puts the onus on the learner to review lecture material on their own. Students in these settings are expected to come to class prepared to discuss relevant material. Ideally in this setting more time would be allocated for one-on-one time with the learners. This project piloted an emerging instructional technology by creating a virtual flipped classroom setting where students received instruction via prerecorded tutorials describing tasks for the week. During the weekly meetings with their mentors, students had an opportunity to ask questions and/or address any challenges they may have encountered. The flipped classroom model allowed the students to receive quality instruction without overburdening mentors for the project who were comprised of graduate students. To facilitate the virtual mentoring for the program, student mentors used Google Hangouts™, text messaging, email and phone calls to communicate. To facilitate the 3-D modeling, student groups received a temporary license for Solidworks™ software which was installed at each of the participants' school. *eMentors* committed to one hour a week of synchronous advising during which time students could address any issues. To scaffold the program, student participants met with the PI for this project bi-weekly to reinforce concepts learned throughout the week.

eMentor Curriculum

To help provide structure and a framework for the *eMentorship* program a website was developed for the student participants (Figure 1). The site was hosted on the PI's university's server and temporary IDs were developed for the mentees, which provided them with access to the site for the duration of the program. Working with the *eMentors* the researchers for the project developed an eight-week curriculum that acted as a guide for the *eMentors*. Bi-weekly face-to-face meetings were also enacted as a part of the program providing the mentees with a field expe-

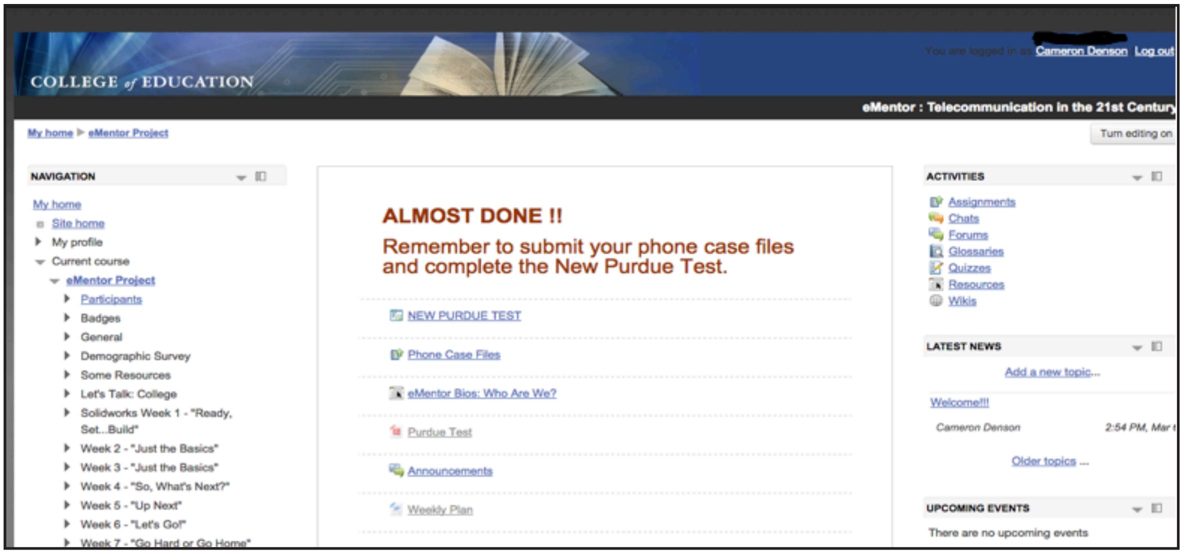

Figure 1. *eMentor* Project Page — Learning Management System containing course content.

rience and opportunity to refine skills learned virtually.

The theme of the *eMentorship* was *Telecomunications in the 21st Century*, which was indicative of the media used to facilitate the program as well as content covered in the program. As an introduction to the engineering design process mentees were prompted to participate in the *Build a Cellphone* (Figure 2) activity developed by The Ohio State University engineering program http://www.edheads.org/activities/eng_cell/swf/index.htm. The animated web source walks students through the designing of a cell phone for elderly clients. The design teams work with a client in order to determine the desired goals of the project. Students have to make decisions on button size, screen brightness, features, shape, etc. all while working under a budgetary constraint of $200. Once the students submit their design they were notified as to if they had achieved the sales goals of the client. Successful groups printed out their results and submitted them to the PI during the field experience.

Students built upon this experience by learning and developing 3-D modeling skills using Solidworks™ software. As an introduction to solid modeling, each design team's first challenge was to model an Apple iPhone. This phone was chosen due to students' familiarity with the model and the relative unsophistication of the phone's outward features. The design features a basic sketch (rectangle), and extrusion (to provide depth), one feature (fillets to round the corners) and the addition of slots to represent the buttons of the iPhone.

The design challenge faced by the design teams was that of modeling a cell phone case. Student groups were allowed to design a cell phone case of their choice as long as they were able to locate specifications for the design. Students also had the choice of using calipers to identify the dimensions of the phone case however this was not a requirement of the *eMentorship* program. Once a design was agreed upon student groups worked with their *eMentors* to model their cases in Solidworks. A student example of a modeled phone case is featured in Figure 3. Student groups who successfully modeled their phone cases had their designs fabricated using rapid prototyping machines.

Methods

Prior to the launching of the *eMentorship* program prospective mentors participated in a two-day training session, which was a requirement for the program. During the training sessions the PI discussed in detail the 4-point protocol that the *eMentors* were responsible for implementing. The *eMentors* also collaborated with the principal investigators to help develop the curriculum for the program. *eMentors* were subsequently assigned weeks within the program that they were responsible for developing and/or locating content for the respective week.

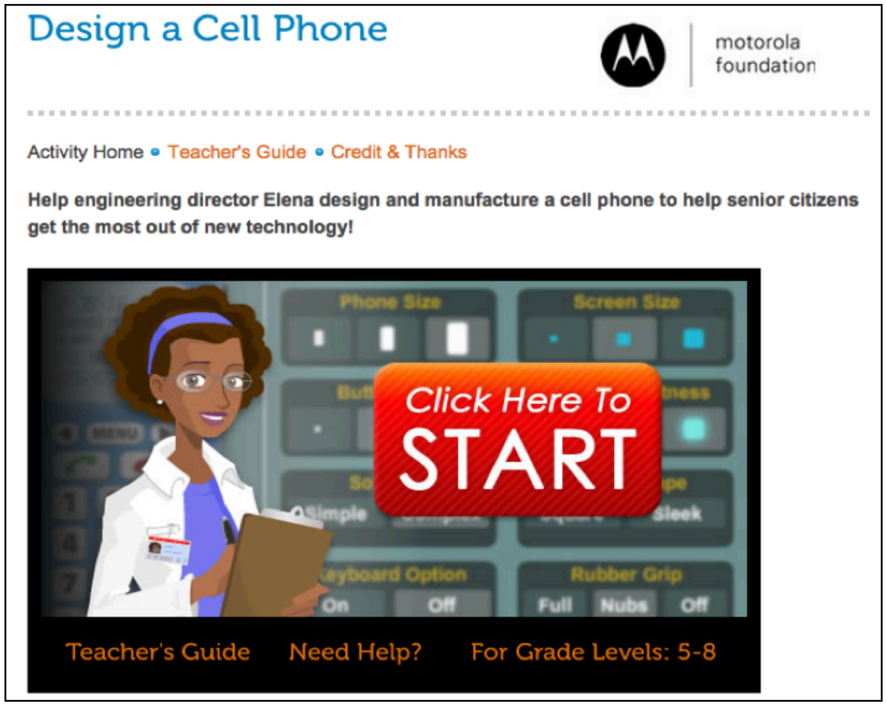

Figure 2. Edheads Landing Page.

The program only ensued after ensuring that all student groups had access to the Solidworks™ software and establishing meeting times with their respective schools. *eMentors* used a variety of communication methods to facilitate the virtual mentorship in addition to the *eMentor* website. *eMentors* were responsible for providing weekly logs through the program detailing topics covered for that week, contact made with protégés, and any difficulties encountered for that week. *eMentors* were committed to a one-hour synchronous meeting with their design teams.

The *eMentorship* program was able to sign up 18 students from five different high schools in two rural counties in North Carolina. The students were assigned to five different *eMentors* with design team 1 consisting of 4 participants, design team 2 consisted of 5 participants, design team 3 consisted of 3 participants, design team 4 consisted of 4 participants and design team 5 consisted of 2 participants. The groups consisted of 14 boys and 4 girls who all identified as African-American or Black.

Participants in the *eMentorship* program were provided instruction using a flipped classroom approach. A total of five (5) *eMentors* were assigned to students in 5 different high schools in various districts represented throughout rural eastern NC. Prior to the launch of the program, *eMentors* uploaded videos and resourceful content to the designated workspace in the learning management system. After *eMentors* uploaded materials, mentors contacted students via e-mail, social media, or text message throughout the program. Throughout the duration of the program, students worked independently of their mentors. Each school allowed students a designated time and place to work on the assigned projects at their school site. The students would collaborate with one another to produce the assigned tasks. Upon completion each week, mentors attempted to connect with students to

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review concepts or talk through any issues. However, there were breaches in communication at times, yet most mentors found success in communicating with the students. The flipped classroom worked well for this project due to distance and space issues.

Most of the content populated within the site was purposed for college freshmen with an interest in engineering or technology, however, mentors provided tutorials, videos and diluted the content in such a way that could be comprehended by the participants. Participants worked within a popular graphic design software to produce shapes, extrusions, and cuts in coherence with basic engineering principles such as linear and circular relationships. The end goal was presented so that students would produce a cell phone case, which would be printed using a rapid prototyping machine after which time they would be distributed to student participants. Each week, assignments would build upon previous weeks' lessons to prepare students to construct their personal cases for their group. [See Appendix].

All student groups met with the PI every other Saturday. This was part of the field experience that was facilitated by the cooperating outreach program. The bi-weekly sessions allowed students to visit labs at the host institution, meet faculty and have some face-to-face with their *eMentor*. This part of the program provided reinforcement for the lessons learned throughout the week. This field experience was also key in helping the mentees develop their STEM self-efficacy and STEM identity. For many underserved students who will be first generation college attendees, visiting a university and working in its labs was helpful in allowing students to "see themselves" within their respective STEM major.

Assessment

In order to assess the impact of the mentorship program students participated in self-efficacy surveys. To measure students' self-efficacy as it relates to modeling 3-D objects using computer software it was imperative that the researchers had an effective instrument. After consulting with experts in the area of technical and graphics communication the researchers developed a 9-item scale to measure students' self-efficacy [See Appendix]. Using a 7-point Likert-type scale researchers piloted the instrument with 101 student participants in the Math, Science, Education, Network (MSEN) program. This also included the treatment group of the 10 students who completed the *eMentorship* program. Results from reliability tests yielded CronBach's Alpha ratings of .7 or above for all nine (9) items in the self-efficacy survey and an overall all rating of .815. The results are provided in Table 1 below.

Researchers investigated students' self-efficacy to determine if there was a statistically significant difference between self-efficacy for the MSEN students (control) and the *eMentor* participants (treatment). Due to the low number (n) for the treatment group, this comparison did not yield a high effect rate. This study did not find a statistical difference between the *eMentor* participants self-efficacy (4.69) and the control group of MSEN students (4.66), $t(18) = .065$, $p = .949$.

Table 1
Reliability Test.

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.815	.816	9

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Of the five design teams that participated in the program only two groups and a total of 10 students were able to successfully complete the program which included designing their own phone case (Figure 3) and taking a 3-D modeling self-efficacy survey. Groups who were able to submit a completed design had their designs printed out using a rapid prototyping machine. To better understand why certain groups were not able to complete the final design exit interviews were conducted with each design team. Results of the semi-structured interviews have been provided in the qualitative research section.

Qualitative research

Value of the eMentorship program

For the qualitative portion of this study researchers sought to answer the following question; What is the value of the *eMentorship* program for underrepresented students? Semi-structured interviews were conducted with each student design team. Student groups were asked two questions (1) What do you feel that you are gaining by participating in the *eMentorship* program? (2) What aspect of the program were you particularly excited about? Researchers asked additional probing questions based on participants responses.

Career, College and Modeling

Student responses below illustrate what they felt that were gaining by participating in the program. This included gaining knowledge specifically in the area of careers, college, and 3-D modeling. The following quotes illustrate students' thoughts.

"I feel like I'm gaining uh knowledge, against, towards a profession I want to go towards." (Design team 1)

"Getting to learn more about 3-D modeling and getting designing on computers and stuff" (Design team 5)

"…like an elder like to help you out during your high school years. To be prepared for when you go to college."(Design team 2)

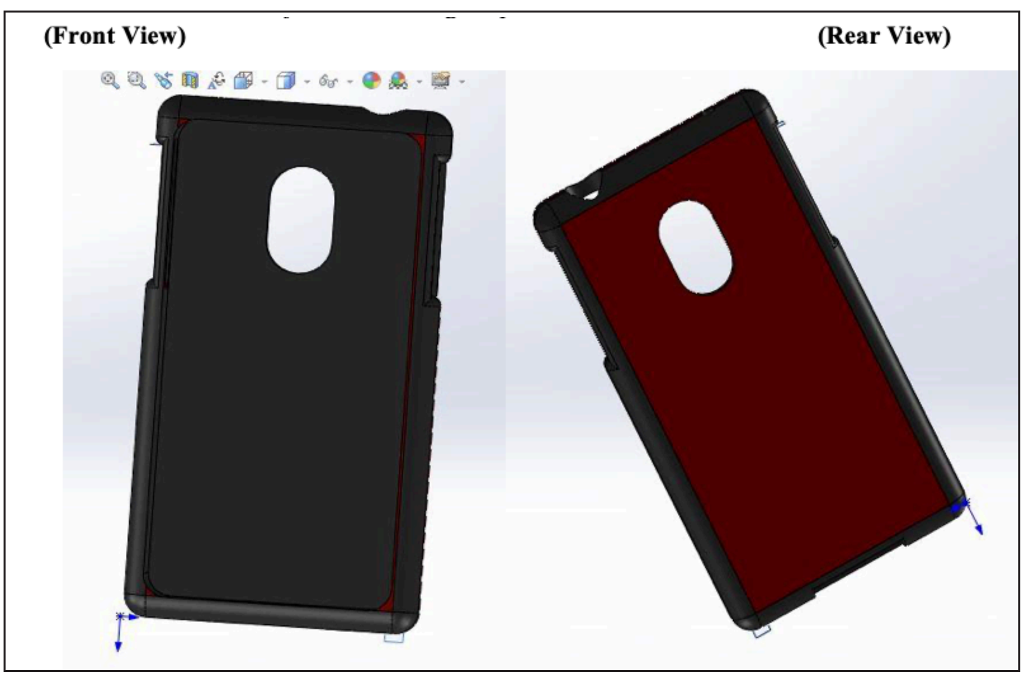

Figure 3. *Front and Back views of a student-designed phone case.*

Phone cases, phone cases and the program

When asked about an aspect of the *eMentorship* program that students were particularly excited about, participants overwhelming expressed their excitement about creating their own phone case although one group was excited about the program itself. The following quotes offer insight into students' thoughts.

"Really the program itself...The fact that I get to do it (3-D modeling) and learn how to use it, that means a lot." (Design team 1)

"Building a phone case" (Design team 2)

"I was excited about making the phone case. Yeah" (Design team 3)

"It's just the idea of like being able to create your own case and to, um, print it out and have that" (Design team 4)

Communication is Key

When asked what they would like to see done differently the design teams all expressed a want for more time in the program and better communication between faculty and staff and their respective schools. Many student participants complained of their teachers not allowing them to participate in the program during school hours.

" I would want like my school to be more aware of like what is going on because, like. The way it is set up, I only have like three, three periods a week and like I try to do some of the stuff then, but it like never works out with the software." (Design team 2)

" Like if we had like more time up here to work on it rather than at school. Cus it's kinda hard to do that." (Design team 4)

"Yeah, they didn't know. Miss, Ms. H### was like, only person that really knew and I don't think she working over there no more. " (Design team 3)

Sustainability

The principal investigator and the co-principal investigator for this project will use the preliminary results from this pilot study to inform proposal development for an NSF grant. Results from this study include a model for virtual mentoring, curriculum for teaching 3-D modeling in a flipped classroom setting, and a valid and reliable measure for students' self-efficacy as it relates to modeling 3-D objects. It is the researchers' intention to scale up the program to feature more student participants and increase the number of *eMentors*. The scale-up would include extending the mentoring program to last for 4 months in lieu of the eight-weeks that framed this program. In addition, the researchers would like to secure more resources in an effort to build the infrastructure for the program, recruit more schools and *eMentors*, and improve the technology supporting the project.

Conclusion/Summary

Students from underserved populations lack the common resources, opportunities and exposure needed to build their self-efficacy and knowledge structure for STEM content. Due to a decline in underserved populations in the economic pipeline and an increase in STEM related careers, faculty members and graduate students at a research one university in the North Carolina developed the *eMentorship* program. The focus of the program was to engage students, who were selected from an engineering outreach program, build knowledge structure, and introduce new concepts through utilization of the flipped classroom method. The program concluded after eight weeks however students provided evidence that this was sufficient time to complete assigned projects and gain a new perspective. Qualitative research provided evidence that student participants obtained positive experiences and valuable knowledge acquisition that will assist them as they persist in their educational and professional pursuit.

Several instruments were used to record participant data such as a demographic survey and a qualitative survey at the completion of the pro-

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gram to ascertain pertinent information that could have possibly affected the outcome of students' perception regarding the program. Data collected from the distributed survey showed a wide range of interests and diverse soci-economic status, however, all students resided in a rural area, with all of the students identifying as African American. Prior to the *eMentorship* program, students professed having had some STEM exposure, albeit very little. The *eMentorship* program provides evidence that students valued the mentoring experience. Further development of the *eMentorship* program will provide a platform to help develop 21st Century skills for underserved students and provide them with opportunities that will enable them to compete in a global society.

Implications

Data collected during the *eMentorship* program indicated levels of success for engaging student participants, assisting them in building knowledge structure, as well as introducing them to concepts they would have otherwise not had experienced in their current setting. Generally, participants reported that the authentic learning experiences provided through the *eMentorship* program facilitated the ability for them to associate the experiences with professional careers in a desirable way. The success of this preliminary study gives credence for the need to further develop the program and accompanying curriculum. Psychometric instruments need further development including methods for assessing *eMentors* and measuring students' spatial visualization ability after completing the program. While researchers measured participants' spatial visualization ability prior to the program they did not follow with a post-test assessment. Spatial visualization ability is recognized as an important skill for those entering engineering and technology fields and furthermore is seen as the most important indicator for success in working with computer-aided design (Katsioloudis et al., 2014). Metrics for evaluating student engagement, knowledge structure development, and concept attainment through a "flipped classroom" need to be reviewed and enhanced to collect adequate data to inform from a larger participation sample.

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Appendix

3-D Modeling
Self-Efficacy Instrument

Please indicate your level of agreement with the following statements by writing down a number between 1 and 7 next to the respective statement with 1 indicating the lowest level of agreement and 7 indicating the highest level of agreement.

1. I feel that I am good at visualizing/manipulating 3-D objects in space. _____
2. I have confidence in my ability to model 3-D objects using computers. _____
3. I am confident enough in my 3-D modeling to help others model 3-D objects. _____

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4. I am good at finding creative ways to model 3-D objects. ______
5. I believe I have the talent to do well in 3-D modeling. ______
6. I feel comfortable using 3-D modeling software. ______
7. I feel confident in my ability to create 3-D objects in a variety of ways. ______
8. I feel I can communicate 3-D objects to other peers. ______
9. I always understand what 3-D images are trying to communicate. ______

eMentor Weekly Structure

Week	Activities	Outcomes
1. Getting to Know One Another	a. Assignment 1 : eMentees fill out demographic survey. b. Assignment 2: eMentees take the Purdue Spatial Visualization Test c. Assignment 3: Learn about your eMentor d. Activity : Build a Cell Phone	a. Demographic form b. PSVT pre-tests c. Build a Cellphone printout
2. Intro to Solidworks	a. What is a sketch? b. What is a feature? 1. Assignment: Fully define a rectangle in a sketch. 2. Optional: Extrude sketch	a. Fully defined rectangle
3. More Solidworks	Modifying Sketches a. Assignment: Sketch our basic phone! 1. Edit original sketch to include rounded corners. Sketch fully defined at the end. b. Wrinkle: Updating features (editing sketches) if optional was completed prior week	a. Fully defined sketch
4. Extruding a Sketch	Extrusions a. Assignment: Extrude our phone! 1. Extrude last week's sketch. Afterwards, go in and change the extrusion distance. Then try and edit the sketch. No changes need to be made, make sure you can get into the sketch.	a. Extruded sketch

5. Additional Features/ Introduce final project, begin working	a. Assignment: Add the buttons to last week's phone. Make sure they are on the correct side. b, Wrinkle: Some of these dimensions are awkward. Knowing how to change end conditions makes life easier. Teaching this is straight forward, but beyond what they need. c. Assignment: Decide on which phone (or phones?). Decide on case design. Figure out 'modeling procedures.'	a. 3-D modeled phone
6. Work on final project	a. Assignment: Start creating the case. Focus on getting all the material present. Cut out buttons/etc later.	a. N/A
7. Work on final project	a. Assignment: Get the basic case finished up. You should be able to focus on cutting out a space for buttons, cords, etc. 1. Should the cutouts be the size of the buttons or bigger? How much bigger? b. Mentors should check clearances of cases to make sure everything fits.	a. N/A
8. Final Product Delivered	a. Assignment: Refine the case so it is ready for your mentor.	a. Final Product

About the Authors

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