GC DELI: A collection of online/hybrid modules for an introduction to engineering course, developed for high school and university level students (Evaluation)

Ms. J. Jill Rogers, University of Arizona

J. Jill Rogers is the program coordinator for ENGR 102 HS at the University of Arizona. ENGR 102 HS is an AP type, college level, introductory engineering course offered to high school students. Over the years Jill has developed K-12 science summer camps, conducted K-12 educational research, developed engineering curriculum for formal and informal education venues, and developed robotics outreach programs for children’s museums and K-12 schools. Jill is a certified teacher and holds a Master’s of Science in Education. Her Master’s thesis topic examined middle school student attitudes towards robotics and focused on gender differences. She is a member of the National Science Teachers Association, Philanthropic Educational Organization (P.E.O) and American Society for Engineering Education. She has long been an advocate for improving K-12 STEM education. Her interest lies in the K-12 pipeline to engineering and the ways to bring young people, particularly under represented populations, into STEM careers.

Ms. Noel Kathleen Hennessey, Program Coordinator
Dr. Sanlyn Buxner, University of Arizona

Sanlyn Buxner is an assistant professor of research in Teaching, Learning, and Sociocultural Studies at the University of Arizona. Her research includes undergraduate teaching reform, science literacy, quantitative literacy, and the impact of industry and research experiences on preservice and inservice teaching practice.

Prof. James C. Baygents, The University of Arizona

James C. Baygents is the associate dean of the College of Engineering at The University of Arizona. His primary responsibilities include academic affairs and recruitment, admissions and retention programs. Jim is a member of the Department of Chemical & Environmental Engineering (ChEE) and the Program in Applied Mathematics at The UA. Jim joined The UA Engineering faculty as an assistant professor in 1991, the same year he received a Ph.D. in chemical engineering from Princeton University. He also holds an M.A. (Princeton, 1981) and a B.S. (Rice, 1980) in chemical engineering.

Jim has received the Arizona Mortar Board Senior Honor Society award for outstanding faculty service and the College of Engineering Award for Excellence at the Student Interface. In 1997, he was awarded an International Research Fellowship by the National Science Foundation for study at the University of Melbourne. Jim is head of the ENGR 102 HS team that was recognized in 2014 by ASEE for best practices in K-12 University partnerships. He is a member of Phi Beta Kappa, Tau Beta Pi and Phi Lambda Upsilon honor societies, and the College of Fellows at Rice University’s Will Rice College.

Jim’s research interests include: transport processes in natural and engineered systems; separations and water treatment processes; diffusion-reaction-precipitation in aqueous electrolyte systems; electrokinetic theory, measurements and separations; electrically driven fluid motion and transport processes, including microfluidics; and industrial water treatment for recycle and re-use.

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GC DELI: A collection of online/hybrid units for an introduction to engineering course, developed for high school and university level students (Evaluation)

J. Jill Rogers, Noel K. Hennessey, Sanlyn Buxner, James C. Baygents, University of Arizona, Colleges of Engineering and Education

Abstract

The Grand Challenges: Discover, Explore, Learn and Imagine (GC DELI) online curriculum project at the University of Arizona was developed with a National Science Foundation (NSF), Transforming Undergraduate Education in STEM (TUES) grant. Inspired by the 14 Grand Challenges for Engineering, as defined by the National Academy of Engineering, the goal of the online units is to give freshmen engineering and prospective engineering students an opportunity to explore the broad and socially relevant topics a career in engineering offers. GC DELI unit topics include: Engineering Better Human Health and Providing Access to Clean Water. Students enrolled in the College of Engineering course, Introduction to Engineering (ENGR 102) choose from five online units and study at a self-guided pace. GC DELI units provide students with information about engineering topics that interest them at this critical time in their academic career.

The GC DELI project, now in its third year, has recently been adapted for ENGR 102 High School (HS) students. ENGR 102 HS is a three credit, college course taught by high school teachers, to high school students. ENGR 102 HS classrooms have piloted GC DELI units over the past two years. A hybrid version for four of the GC DELI units was developed, providing high school students and their teachers with supplemental hands on projects and other scaffolding. In academic year 2014-15, four hybrid GC DELI units were rolled out to 21 ENGR 102 HS classrooms. This paper contains detailed information about the progress of the GC DELI hybrid units in high schools, responses to forced-choice questions and qualitative data from teachers who have worked with the units. Additionally, we include responses to forced-choice questions from the 31 student evaluations collected after delivery of one hybrid GC DELI unit.

1. Introduction

Over the past decade, concern has been growing among educators, government agencies and private industry about the lack of qualified STEM undergraduates and the declining state of STEM education in the United States. According to a 2012 report released by STEM Connector and My College Options, nearly 28% of high school freshmen in the United States declare an interest in science, technology, engineering and mathematics (STEM) related fields. However, of these STEM attracted students, 57% will lose interest in STEM by the time they graduate from
high school\(^{(1)}\). The United States must find ways to attract and retain our brightest young people into STEM fields of study.

The greatest need in the future STEM workforce will be for engineers. The United States Bureau of Labor Statistics predicts that by 2018, there will be 8,654,000 STEM related jobs in the United States and 87% of all STEM jobs will be in engineering fields\(^{(2)}\). To address this need, the National Academies of Science and K-12 education professionals have developed the Next Generation Science Standards (NGSS) that include engineering as part of the regular PreK-12 science curriculum. As the United States and engineering educators look to build the future workforce in engineering it is critical to develop high school engineering programs and methodologies that are effective, motivating and scalable.

With the recent national conversation about AP engineering courses for high school students, engineering educators are wondering if such an idea is even plausible. Along with doubts about teacher qualifications, and concern about what content should be taught, one question has arisen: Do high schools have adequate resources to even offer AP Engineering? How can a single high school teacher adequately introduce topics as wide-ranging as aeronautical, chemical, electrical and biomedical engineering? How can a high school afford the equipment and materials necessary? We believe online engineering curriculum, like our GC DELI hybrid units can address the concerns of these engineering professionals. Efforts should be made to improve and expand the GC DELI program and others like it. Ultimately, more work needs to be done with online engineering curriculum and methods so that best practices can be identified and implemented.

<table>
<thead>
<tr>
<th>GC DELI Unit</th>
<th>Summary</th>
<th>Design and Build Activities (hands on)</th>
<th>Additional Classroom lecture/Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering Better Human Health</td>
<td>Exploration of the integration of the physical, chemical, mathematical, and computational sciences with engineering principles in order to study biology, medicine, and behavior</td>
<td>-Biomechanical hand (Fig. 3)</td>
<td>-Biomimicry - Cochlear ear implant</td>
</tr>
<tr>
<td>Providing Access to Clean Water</td>
<td>Investigation of the engineering opportunities and challenges of providing everyone access to clean water</td>
<td>-Water purification demonstration</td>
<td></td>
</tr>
<tr>
<td>Energy, Water and the Environment</td>
<td>Examination of the issues related to water and energy separately and then investigate the interdependencies of the challenges related to two resources</td>
<td>-Solar panel efficiency (Fig. 4)</td>
<td>-Alternative energy storage activity</td>
</tr>
<tr>
<td>Restore and Improve our Infrastructure</td>
<td>Introduction to infrastructure engineering; working to construct the infrastructure of the future, while trying to maintain the systems already in place</td>
<td>-Analyzing structural quality using household objects</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Summary of the available GC DELI hybrid units as of December 2014
The Grand Challenges: Discover, Explore, Learn and Imagine (GC DELI) project offers online units about various topics in engineering. Inspired by the 14 Grand Challenges for Engineering, as defined by the National Academy of Engineering, these robust units have been pilot tested on University of Arizona (UA) freshman engineering students and iteratively improved each semester since Fall, 2012. Designed by university experts in their field, each unit contains lectures, videos, homework assignments and online assessments. For the UA, Introduction to Engineering (ENGR 102) students, the units are completely online and students are given four weeks to complete one unit of their choice. The on-campus students proceed through the content independently while attending regular ENGR 102 lectures and lab meetings and submit all assignments online.

In Fall 2012, GC DELI units were tested in high school engineering classrooms. Initially, units were presented completely online and then at the request of participating teachers, hands-on activities and classroom/lecture materials were added creating hybrid units. Table 1. provides a brief overview of the units currently in use and outlines the additional activities added to create hybrid GC DELI units for high school students. A detailed overview of the activities, learning objectives and expected outcomes for the four GC DELI units adapted for high school students can be found in Appendix A, B, C and D.

1.1 GC DELI for High School

Introduction to Engineering in High School (ENGR 102 HS) is an introductory engineering course offered by the University of Arizona, College of Engineering (COE). Taught by high school teachers to high school students, the dual credit program has been in operation for seven years. Like the on-campus version of the course, ENGR102 HS introduces students to engineering design principles and practices as well as to emerging and current challenges within the field. Winner of the 2014 ASEE “Best Practices in K-12 and University Partnerships” award, ENGR 102 HS is currently offered in 37 high schools. Details about the ENGR 102 HS program, including six years of student data, can be found in previously published papers (3, 4, 5). See Table 2, for more details about ENGR 102 HS enrollments over the past seven years.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Participating High Schools</td>
<td>1</td>
<td>6</td>
<td>14</td>
<td>20</td>
<td>22</td>
<td>29</td>
<td>37</td>
</tr>
<tr>
<td>No. Participating Districts (+private schools)</td>
<td>1</td>
<td>5 (+1)</td>
<td>8 (+2)</td>
<td>13 (+2)</td>
<td>14 (+4)</td>
<td>16 (+4)</td>
<td>20 (+5)</td>
</tr>
<tr>
<td>High School Course Enrollment</td>
<td>20</td>
<td>82</td>
<td>197</td>
<td>295</td>
<td>303</td>
<td>301</td>
<td>337</td>
</tr>
<tr>
<td>Subsequently matriculated to UA Engineering</td>
<td>5 (25%)</td>
<td>25 (31%)</td>
<td>38 (19%)</td>
<td>51 (17%)</td>
<td>54 (18%)</td>
<td>42 (14%)</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Table 2. ENGR 102 HS student enrollments over seven years

In academic year 2012-13, three ENGR 102 HS teachers presented the Engineering Better Human Health GC DELI online unit to their students as a pilot program. Feedback was collected from teachers about the feasibility of the unit for high school classrooms. Along with difficulties with the online content delivery website, or Learning Management System (LMS), teachers
noted that they wanted to add hands on projects to the unit, thus creating a hybrid unit. Four GC DELI hybrid units for high school students were developed in four ENGR 102 HS pilot classrooms and then rolled out to 21 high schools in Fall 2014. This paper will focus on student evaluation data collected for the Engineering Better Human Health unit from two private high schools and teacher survey data collected from teachers who have attended training and/or used the GC DELI units.

1.2 Research Questions

Course evaluation data from a student’s perspective is a robust indicator of course effectiveness (6, 7). Results from the ENGR 102 HS student course evaluations have shown that our high school teachers consistently provide a high quality educational experience for our students (3, 4). To assess the GC DELI units, additional student evaluations were administered after online unit completion. The following research questions concerning the impact of the GC DELI units will be investigated in the Results section of this paper. According to student and teacher, self-reported evaluations:

*What impact does the GC DELI hybrid unit have on students’ perceptions of engineering and career opportunities in engineering?*

*Which components of the GC DELI unit impact student learning in a positive way?*

*How do the GC DELI units impact ENGR 102 HS teacher satisfaction?*

2. Background and Framework

*Distance Education* can be broadly defined as any educational mode that creates a learning environment for those who are geographically distant (8, 9). Traditionally, distance education was provided by correspondence courses via the postal service and later through video lectures on closed circuit television. The Internet has generated a whole new mode of Distance Education called *Online Education*. Online Education, arising in the late 1980s along with the prevalence of the Internet, is a comprehensive term that garners many definitions in the current literature. For the purposes of this paper, Online Education will be defined as any distance educational mode using the Internet for all of the course content delivery, student participation and assessment. And thus, *Hybrid Online Education* is online education with portions of the content delivered online and portions delivered to students face to face, in a traditional classroom setting.

The Online Learning Consortium (OLC) formally called the Sloan Consortium (Sloan-C) was funded by the Alfred P. Sloan Foundation. OLC is a non-profit organization committed to organizing and disseminating best practices in online education and has the goal of making education available to anyone, anytime, anywhere. Sloan-C reports that 32% of all university students in the United States took at least one online course during the 2012-13 academic year.
and they predict that this number will continue to grow at a rapid rate\(^{(10, 11)}\). As the need for more engineers and an affordable college education increases so will the need for online engineering education that offers quality, accessibility and breadth.

Engineering education has lagged behind other fields in adapting online teaching methodologies\(^{(10, 11, 12, 13)}\). Reasons for this lag include the need for hands on engineering experiences in laboratories with often expensive equipment and substantial computing power\(^{(10)}\). Until recently, this type of computer power was not available in distributed networked environments. However, the easy accessibility of cloud computing, free online design applications and open source, learning management systems (LMS) have removed many of these technological barriers. It seems online engineering education in now poised to improve and grow at a quick pace in the coming years.

2.1 Framework

Five pillars of quality online learning have been defined by Sloan-C/OLC\(^{(10, 12)}\) and we have used these as a framework for GC DELI program development and assessment. These five pillars are: 1) Learning effectiveness 2) Access- anytime, any place, equally for a broad audience of learners 3) Student satisfaction 4) Teacher satisfaction 5) Scalability- high enrollments with maintained quality at a low cost. The five pillars are illustrated in Figure 1. Access, effectiveness and scalability have been an integral part of the unit development process and will be discussed in this paper, but they are not the primary focus the data collected. This research on the GC DELI hybrid units for high school students and the data collected will focus on student and teacher satisfaction.

The Technology Acceptance Model (TAM), developed by Davis\(^{(14, 15)}\), describes the importance of a person’s perceptions in the implementation of a new technology. The TAM explains that a person’s decision to use a particular technology is composed of two primary factors: perceived usefulness and perceived ease of use. Davis theorizes that people quickly develop perceptions, negative or positive, about the usefulness of a particular technology as well as the “user friendliness” of that technology. These are human perceptions and not necessarily based on measures of objective reality but they effect the user’s satisfaction in a positive or negative way. TAM has been applied successfully to various distance learning studies over the years\(^{(16, 17, 18)}\)
and the TAM effect justifies the inclusion of teacher and student satisfaction in the OLC five pillars of quality online learning. For this research we collected evaluation data looking at the impact of GC DELI units on teachers’ and students’ satisfaction.

3. Methods

In Fall of 2012, work began on the high school GC DELI units as part of the proposed tasks for the National Science Foundation (NSF), Transforming Undergraduate Education in STEM (TUES), grant awarded to the UA, COE. Intel Foundation added matching funds specifically for the high school program allowing for expanded classroom pilots and two summer trainings for the whole ENGR 102 HS teaching team. Sarah Streb, a teacher from Salpointe High School, in Tucson, Arizona was the first high school teacher to participate in the program.

3.1 GC DELI for high school project timeline

<table>
<thead>
<tr>
<th>Type of Activity</th>
<th>Fall 2012</th>
<th>Spring 2013</th>
<th>Summer 2013</th>
<th>Fall 2013</th>
<th>Spring 2014</th>
<th>Summer 2014</th>
<th>Fall 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Details of work</td>
<td>Pilot</td>
<td>Workshop</td>
<td>Classroom</td>
<td>Pilot</td>
<td>Workshop</td>
<td>Classroom</td>
<td>Classroom</td>
</tr>
<tr>
<td>Same content as on campus, 100%</td>
<td>Pilot</td>
<td>Training</td>
<td>rollout</td>
<td>Classroom</td>
<td>Training</td>
<td>Classroom</td>
<td>Classroom</td>
</tr>
<tr>
<td>online-Livebinders LMS</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Develop 2 hands on+ classroom</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>activities for Engr. Human Health</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>unit</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Train whole group on unit and</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hands on activities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 schools, no data collected</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>problems with online tool</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Develop hands on activities for</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 more units, moved to Canvas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LMS</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Train whole group on 3 units and</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hands on activities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21 schools participate 2 schools</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>submit data on Human Health unit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. Schools/teachers</td>
<td>1</td>
<td>2</td>
<td>22</td>
<td>3</td>
<td>2</td>
<td>28</td>
<td>2</td>
</tr>
<tr>
<td>No. students</td>
<td>27</td>
<td>30</td>
<td>n/a</td>
<td>41</td>
<td>n/a</td>
<td>n/a</td>
<td>23, 8</td>
</tr>
<tr>
<td>No. Units in development</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>No. Units completed</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 3. Timeline for high school hybrid GC DELI project development

Past research on the ENGR 102 HS program revealed that the flexibility of the curriculum was a key attribute to the success of the program. For this reason, the same flexibility was allowed for high school GC DELI hybrid units. Each participating teacher delivers the GC DELI content at a time in the school year that is right for them, their students and their district. Additionally, the teachers decide how they use the content. Some teachers allow students to choose the unit topic they want to work on; this is how the on-campus units are administered. This approach leads to a nearly complete online course and students tend to work independently through most of the content. However, some teachers feel their high school students need more scaffolding than a free choice system allows. These teachers select a unit or two and work through the materials methodically, as a group. The two schools studied for this research have taken the scaffolding
approach to the delivery of a single unit and both selected the Engineering Better Human Health curriculum.

To date, 28 ENGR 102 HS teachers have received training on some or all four of the GC DELI hybrid units. Ten of those 28 ENGR 102 HS teachers have used all or some portions of the GC DELI hybrid units with their students over the two years the program has been implemented and a total of 21 teachers have plans for implementation during the AY 2014-15.

Classroom pilot studies began in Fall 2012 at one ENGR 102 HS school. The Engineering Better Human Health unit was moved to the free version of Livebinders\(^{(21)}\), an open source Learning Management System (LMS), and 27 students were led through the various tasks in the unit with careful teacher scaffolding. Early on, it was determined that high school teachers preferred a hybrid approach to online learning, so in Spring 2013, two additional schools were added to the pilot and all three began working on a design and build biomechanical hand (see Figure 2) and artificial heart valve activity (see Figure 3) to add to the online content. After iterative improvements to the additional hands-on activities, a complete training on the new hybrid Engineering Better Human Health unit was delivered to 22 teachers at the 2013 teacher workshop in hopes that they would rollout the content to their students the following fall.

In the Fall of 2013, 14 ENGR 102 HS teachers expressed a desire to use the GC DELI units in their classrooms. This number of participating high schools was encouraging and plans were made for their support and delivery of the online content. Unfortunately, problems arose from the beginning with nearly half of these schools reporting that they could not access Livebinders through their district firewall. This was a problem the UA ENGR 102 HS team had faced before with failed implementation of the LMS, Desire to Learn (D2L). Prior experience with this access problem informed the team that convincing 15 individual school districts to modify their district policies was not a surmountable task. All but three schools dropped from the 2013
implementation due to access problems. In Spring 2014, the GC DELI team regrouped and made plans for aggressively improving the program based on lessons learned.

At this point, the GC DELI team engaged a teacher/consultant to identify an appropriate LMS, conduct trainings at the summer workshop and to serve as an informal webmaster during the 2014-15 school year. With a high school teacher taking the lead, a focus on common user concerns was more adequately addressed and the Canvas LMS is now in use. According to the Canvas website, it is designed specifically for K-12 teachers and students. Canvas is a cloud-based LMS that connects all the digital tools and resources teachers use into one place. Moreover, the Canvas system is already in use at many of the participating school districts and it was hoped this would improve the perceived ease of use, a key factor from our framework; the Technology Acceptance Model - (TAM).

3.2 Participants

Participants in this GC DELI hybrid unit study are 31, upper level high school students who were enrolled in ENGR 102 HS, an introduction to engineering course taken during the 2014-15 academic year. While 21 schools were working on all or sections of the GC DELI hybrid units during the 2014-15 school year, due to the paper submission deadlines and in one case, online survey failure, data was collected from only two high schools. One participating high school was a private, parochial school in Tucson, AZ, and the other was a private, secular school Anaheim, CA. The students in this study were a socioeconomic and racially homogenous group making limitations on understanding how this unit might effect a larger more diverse population of students. However, as a baseline for the student satisfaction levels of GC DELI hybrid unit users and for future improvements of the program, there is much value in the information gathered.

The students in the study group were 16% Female and 83% Male and included students from a range of racial and ethnic backgrounds including White (35%), Hispanic and Latino (20%), Asian (35%), American Indian (3%), African American (6%) and Native Hawaiian (3%).

3.3 Instruments

For this work, the student evaluation survey used for GC DELI program assessment on campus was shortened for use with the high school students. The resulting 10 question instrument has one question identifying which GC DELI hybrid unit was taken and two demographic questions, one on gender and the other on ethnicity. The remaining seven questions focus on student
opinion and satisfaction with the content, hands on activities and overall impact of the unit. Students who completed the student evaluation survey received 10 points towards their final grade on the GC DELI unit. The survey was designed to be delivered at the end of each GC DELI unit, online via the LMS. These responses were transcribed for analysis. A copy of the student evaluation survey can be found in appendix E at the end of this paper.

The teacher mid-year status survey was administered via surveymonkey to the whole ENGR 102 HS team in December 2014. This survey is conducted annually, as part on the ongoing program evaluation and as a tool to address teachers’ needs. The teacher survey contained five questions dealing with GC DELI units’ ease of use, training and teacher satisfaction. Twenty-seven teachers completed the survey and of these, 12 reported on the GC DELI training and eight reported on actual classroom implementation of the GC DELI units. Each multiple choice question included space for open-ended remarks and teachers were encouraged to freely expand on or explain their answers in text. A copy of the five GC DELI questions from the teacher mid-year status survey can be found in appendix F.

3.4 Data Analysis

Student surveys were analyzed using descriptive statistics to look for trends in their answers. Inferential statistics were not used because the research questions were not comparing groups or pre-post responses. Teacher surveys were analyzed using descriptive statistics to look for trends in their responses. Non-parametric statistics were used to investigate answers of teachers who did and did not implement units to look for differences when appropriate.

4. Results and Discussion

Research question #1: What impact does this hybrid GC DELI unit have on students’ perceptions of engineering and career opportunities in engineering?

In order to answer this question, we analyzed questions on the survey that asked the students which of the following characteristics they would use to describe the Engineering Better Human Health hybrid unit: exciting, too time-consuming, informative, too easy, helpful for formulating
Students’ Perceptions of GC DELI career interests, too difficult, helpful for clarifying perception of engineering, and boring. The students were allowed to choose all options that applied (see Graph 1). The online content for the GC DELI units has been carefully refined over three years in the on-campus sections of the ENGR 102 course. It is not surprising that 22 out of 31 high school students reported that the unit was “informative.” In this sample, 11 of 31 students said that the course helped them to formulate their career interests.

Although only one-third of the students indicated that the hybrid course helped them to formulate their career interests, other survey questions provided insight into how the hybrid course impacted students’ knowledge and interest in engineering. For example, 25 out of 31 students surveyed agreed with the statement: “The unit activities helped me discover new information or concepts that developed my interest in the topic.” In response to another survey question, 16 students responded that the hybrid course had a positive impact on their interest in or commitment to engineering, while 13 responded that it had a neutral impact, and two responded that it had a negative impact. The fact that only one student reported that the unit was “too easy” and six reported that the unit was “too hard” indicates that the content in the unit was an appropriate level for 24 of these ENGR 102 HS high school students. This alleviates an initial concern of the GC DELI team, that the units might be too difficult for high school students.

These results imply that the hybrid course helped increase the participants’ awareness and understanding of engineering, but does not necessarily encourage personal reflection about individual career goals. It is reasonable to expect that students need to complete multiple GC DELI units in order to get a broader perspective on engineering as a career choice.

*Research question #2: Which components of the GC DELI unit impact student learning in a positive way?*

We analyzed students’ responses to two survey questions to answer this research question. Students were asked to rate how important the following factors were in forming an opinion
about their GC DELI unit: the online content, the hands-on projects, the details and lecture materials added by the instructor, and the interest they had in engineering before completing the unit. Students reported that the online content was important in forming an opinion on the unit, with 24 out of 31 students responding that it was important, four responded with “neutral” and three responded that that the online content was “not important” (see Graph 2).

The students in this sample were more divided on the impact of the other components on their opinion of the GC DELI unit. Their responses were similar for how they felt about their instructors’ input and how their own interest prior to starting the unit impacted their opinion. For both survey questions, 16 out of 31 students reported that their prior interest in engineering and the instructors’ lecture materials had a neutral impact on their opinions about the GC DELI unit. Fifteen students reported that the hands-on projects added to create the hybrid unit were important in forming their opinion, 13 reported that they were neutral, and 3 students said they were not important in forming their opinion. However, when asked if the hands-on projects had a positive impact on their learning, an overwhelming majority (25 out of 31 students) indicated that the hands-on activities positively influenced their learning. This is an interesting finding, because it indicates that students acknowledge that although hands-on learning may not strongly impact their overall opinion of an educational unit, it does impact their learning and synthesis of a concept.

Research question #3: How do the GC DELI units impact ENGR 102 HS teacher satisfaction?

For this research question, we reviewed the 2014 ENGR 102 HS mid-year teacher survey. It is critical to the success of ENGR 102 HS that new curriculums like the GC DELI units not be overly burdensome to implement for teachers, therefore, we compared the satisfaction of GC
DELI users with non-users. Teachers were asked to rate their overall satisfaction with their experiences in the ENGR 102 HS program. From their responses, we were able to discern who had used the GC DELI online units in their classroom and who had not. We applied a chi-squared analysis with these data as the independent variable and teacher satisfaction ratings as a dependent variable (see Table 4). The chi-squared analysis showed that teacher satisfaction was statistically dependent on whether or not the instructor had used GC DELI in their classroom ($p = 0.315$).

These results suggest that using the online GC DELI units increased teacher satisfaction with their overall experiences in the ENGR 102 HS program. There may be omitted variables of data that we do not have that correlated with the GC DELI delivery system and impacts teacher satisfaction. For example, in the comments section of the survey, one teacher remarked, “I plan on eventually using GC DELI units. The challenge is implementing technology in my district.” This is an important factor to be considered when interpreting these results, because the integration of technology in the classroom overall might increase teacher satisfaction.

<table>
<thead>
<tr>
<th>Impact of GC DELI units on ENGR 102 HS teacher satisfaction</th>
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<tbody>
<tr>
<td>GC DELI used</td>
</tr>
<tr>
<td>Neutral</td>
</tr>
<tr>
<td>No</td>
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<tr>
<td>Yes</td>
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Table 4. Comparison of ENGR 102 HS teachers’ satisfaction- GC DELI users with non-users

Additional questions asked on the ENGR 102 HS teacher mid-year survey revealed more details about the impact of the GC DELI units on teacher satisfaction. Fourteen out of 22 teachers who attended the summer workshop training were either satisfied or very satisfied with the GC DELI summer workshop training, the remaining respondents were neutral. A question about the Canvas LMS revealed that of the 14 teachers who had used the online content delivery system, nine were either very satisfied or satisfied. Finally, when asked if the GC DELI units are helpful in the ENGR 102 HS classroom, ten teachers responded that the units were either very useful or useful, seven teachers were neutral on the subject and 10 had not used the GC DELI units.

Teachers using the units reported, “Students need to be exposed to online learning and it helps me teach content I am not familiar with.” “It (GC DELI) is a great resource,” and “the built in quizzes are a plus.” These results all indicate that the GC DELI experience impacted teacher satisfaction in a positive way; however, there is certainly room for improvement in the areas of training and LMS user perceptions.
5. Lessons Learned

The results of this study underline the importance of Sloan-C/OLC five pillars of quality online learning. To reiterate, the five pillars are: 1) Learning effectiveness 2) Access- anytime, any place, equally for a broad audience of learners 3) Student satisfaction 4) Teacher satisfaction 5) Scalability- high enrollments with maintained quality at a low cost. Each of these pillars stand behind successes uncovered in the GC DELI program through analysis of student and teacher survey data.

The GC DELI hybrid program failures, particularly in access and issues with actual and perceived ease of use, might be expected when you apply the Technology Acceptance Model (TAM) to the events that unfolded. When asked if she would use GC DELI units in her 2014-15 classroom one teacher remarked, “I would love to use them. But, there seemed to be an issue in accessing the materials. Not sure if we ever got that worked out this past summer. So I have been leery to try it out. Especially since I don't have much planning time available.” This statement was made after the LMS problems were corrected, however, apparently the teacher’s perceived ease of use was not repaired. Overcoming these perceptions will take further study, iterative improvements and primarily, time for user perceptions of the GC DELI units to improve. Aside from our research questions and data results, this study revealed three important lessons for online engineering educators: a) Choose the right LMS b) Keep the content flexible and c) Include hybrid content options.

5.1 Importance of selecting a Learning Management System (LMS)

When selecting a LMS that is easy to use, dependable, accessible and effective, it is important to make the right choice for your users, the first time. On campus, the GC DELI materials are delivered via Desire to Learn (D2L), the learning management system (LMS) used by all University of Arizona students. However, prior experience with the ENGR 102 HS program revealed that use of the reliable, on-campus D2L system for high schools was not at all pragmatic. The Livebinders LMS was first selected by the university GC DELI team because of the free educational features. Many members of the on-campus team had used the Livebinders as part of their own classroom and felt it was an excellent tool. However, after multiple attempts to implement the GC DELI units by ENGR 102 HS teachers during the Fall 2013 classroom rollout, Livebinders was deemed lacking for our purposes due to common school district firewall restrictions.

Finally, the GC DELI team engaged a teacher/consultant who identified an appropriate LMS, conducted trainings at the 2014 summer workshop and served as an informal webmaster during the school year. With a high school teacher taking the lead, a focus on common user concerns is more adequately addressed and the Canvas LMS is now in use. According to the Canvas website, it is designed specifically for K-12 teachers and students. Canvas is a cloud-based LMS that connects all the digital tools and resources teachers use into one place. Moreover, the
Canvas system is already in use at many of the participating school districts and it is expected this will improve the actual and perceived ease of use of the GC DELI program.

5.2 The importance of Program Flexibility

In the December 2014 teacher mid-year survey, 21 teachers described plans to use the GC DELI hybrid units. However, when asked to provide student data in time for this paper, only two high schools had finished one full unit. When asked why, one teacher anecdotally shared, “The best part of the GC DELI is the selection of materials. I use one or two modules in a unit to help address a particular topic. We haven’t completed a full unit.” In much the same way on-campus GC DELI students select topics that interest them, high school GC DELI teachers pick and choose content that serves the needs of their students and classroom. The DELI acronym was chosen to imply choice and this seems to include choices for high school teachers and students. As mentioned earlier, this same type of flexibility is incorporated in the ENGR 102 HS course and seems to be a key to that program’s success.

5.3 The importance of Hybrid Online Content

Adding hands-on activities and teacher lecture materials to the GC DELI unit was done on the request of the three pilot teachers. They felt that the additional material would enhance their students’ learning. They also felt that delivering a completely online unit made their jobs as classroom teachers redundant. This took away from teacher satisfaction with the unit since the teacher is not really necessary for the student’s success. Not all teachers would feel this way, but it is important to note considering one of the five pillars of quality online learning is teacher satisfaction. Interestingly, our results showed that participating students agreed with the idea that hands-on activities enhanced their learning and half of them felt that the activities improved their opinion of the unit as a whole.

6. Conclusion

One way to increase the pool of students seeking engineering degrees is to reach out to those who are less inclined to choose and be prepared for an engineering degree program. Many high school students and teachers have little exposure to the engineering profession. A narrow view of engineering; one focusing on the stereotypical might dissuade some students from a career in engineering, particularly those from under represented populations. The ENGR 102 HS program with the GC DELI hybrid units deliver broad, university level, introduction to engineering content to high school students, but in the familiar and low risk environment of their high school classroom. Students who might not otherwise consider taking a university engineering course are able to sign up and “try it out” without the commitment of taking a whole semester of freshman engineering courses.
The NAE Grand Challenges offer a pragmatic and socially conscious portrait of the work of engineers. The NAE Grand Challenges provide the mechanism to stimulate student interest and, when combined with the learning structure of the GC DELI units, cultivate that interest. GC DELI hybrid units increase the breadth of engineering topics one ENGR 102 HS teacher can deliver in a single academic year. Due to the online nature of the units, this breadth is accomplished at little additional cost to the high school. The range of topics offers teachers and students choices and is critical to the objectives of the ENGR 102 HS program.

The authors set out to examine the impact of the GC DELI hybrid units. High school student and teacher satisfaction and ease of use with the online units was explored. It was expected that problems with program logistics would be uncovered and we are using these findings to improve the high school GC DELI program. Student unit evaluation results from our small data set revealed that the content in the Engineering Better Human Health unit impacted students’ perceptions about engineering in a positive way. Students also seemed to appreciate the hands-on activities added and reported that they had a positive impact on their learning. Teacher satisfaction of those who incorporated GC DELI hybrid units in their classroom was also impacted in a positive way. We hope that our lessons learned and modest study results will inform other institutions attempting to implement online engineering curriculum.

*Special thanks to the National Science Foundation, the Intel Foundation and The Salt River Project for their generous support and funding for the high school GC DELI project.

References


Appendix A

GC DELI Unit: Energy, Water and the Environment

In the Energy, Water and the Environment Unit, students examine the issues related to water and energy separately and then investigate the interdependencies of the challenges related to these two important resources.

Objectives: The objectives of this unit are: (1) to develop a fundamental understanding of the challenges related to energy and water, (2) to master a basic vocabulary and understanding of what energy is, its forms, types and sources, as well as the units of measurement, (3) to understand the issues related to fossil fuels and the impact on the environment, (4) to develop a basic knowledge of water properties, the amount and quality of water available, (5) to explore strategies for conserving water and improving access to clean water, and (6) investigate the interdependencies of the challenges related to these two important resources.

Activities: Initially, to stimulate interest and to encourage students to recognize the magnitude of these challenges, they evaluate the past, current and future demands for energy and water in the US and worldwide. Students are directed to the Environmental Protection Agency (EPA) website which contains extensive information about both energy and water consumption. Students are asked to create graphs depicting energy and water use over time. Students calculate their carbon footprint and create a method for determining their personal water consumption. These and other activities such as problem-solving, mini-projects, discussion groups, surveys, self-assessments and quizzes are used to encourage higher level thinking. In addition, students listen to lectures from leading experts that reinforce the importance of these issues.
Once students gain an appreciation of the scope and significance of these challenges, they are asked to develop an understanding of the principles that govern the behavior of energy and the basics of water science. For example, students learn about the types of energy and its various forms as well as the law of conservation of energy. They learn about the advantages and disadvantages of renewable and nonrenewable energy sources and the role of renewable energy in the US. Because solar energy is an abundant resource in our State, the costs and benefits of various technologies for capturing and converting solar energy to electricity, such as photovoltaic devices and solar thermal collectors, are investigated in greater depth. In addition, students learn about greenhouse gases—in particular, where they come from and how they impact the environment. Equipped with an understanding of greenhouse gases, they explore the controversy over climate change. The Energy Information Administration and the US Geological Survey websites and many other reliable sources have excellent tutorials on energy and water. Next, students review recent literature on the interdependence of water and energy. For example, the Water Resource Center has published several articles questioning the viability of large scale production of power from solar energy due to the high demand for water in many of the current technologies for collection and conversion of solar energy to electricity. Conversely, the significant amount of energy required to harvest freshwater from non-potable sources is a major concern as well. Students are encouraged to think critically about these issues and to understand the trade-offs that engineers must make. Finally, students learn about some of the emerging technologies and use their newfound knowledge to scrutinize the feasibility of these technologies. They are asked to determine which are the most promising technologies considering the pertinent social, environmental and economic factors and they are required to identify the barriers that may hinder successful commercialization of these technologies.

Expected Outcomes: The expected learning outcomes from this unit are that students should be able to: 1) demonstrate an understanding of the range and magnitude of the challenges related to energy and water, 2) use on-line resources to develop a fundamental knowledge about energy, water and the environment, 3) form an educated opinion about the issues related to the dependence on fossil fuels, 4) recognize the interdependencies of the challenges related to energy and water, and 5) evaluate the economic viability of some of the solutions to the world’s energy, water and the environment concerns.

Appendix B

GC DELI Unit – Provide Access to Clean Water

Virtually all human activities—including agricultural, industrial, household and recreational activities—require use of water. As the world population increases and many nations become more industrialized, water resources are being depleted at a rate that exceeds the rate of their replenishment. Potential changes in climate patterns further complicate the situation. For instance, increased droughts will result in increases in water demands. Many students enrolled in ENGR 102 view “clean tap water” as a “given” while this is still a big luxury for the many parts
of the world. Even in the US, arid and semi-arid regions (such as Arizona) are experiencing population growth which results in depletion of vital water resources. It is critical for the next generation of engineers to understand the technological as well as economic and social challenges in this area.

Objectives: The objective of this 4-week elective unit for ENGR 102 is to present the next generation of engineers with the engineering opportunities and challenges of providing access to clean water. We note that while this is an engineering class, our activities include increasing awareness of different aspects of the problem such as societal impacts. Thus, the planned activities and instructional modules will offer students opportunities to acquire base-level engineering knowledge related to water and water purification as well as a “systems approach” to thinking about providing access to clean water.

Activities: Students will begin the unit by learning about the grand challenge. Why when approximately 75% of the world’s surface is covered in water, providing access to water is an engineering grand challenge? (Because water is often not where we need it and not at the quality that we want it, and bringing water to where we need at the quality we want at a low cost requires engineering ingenuity.) The students will first refresh their memory on water, a substance with fascinating chemical and physical properties. They will participate in online discussions about this multi-faceted problem, and think about how engineers could contribute to solving this grand challenge. They will learn more about the grand challenge through presentations, videos, and reading materials. Throughout the unit, learning will be assessed via quizzes, surveys, online discussions, and writing assignments.

After the general introduction to the grand challenge, the unit will delve into the four elements of access in a deeper level. These are (i) quantity, (ii) quality, (iii) reliability, and (iv) cost. (When sufficient quantity of water of desired quality is delivered reliably at a reasonable cost, then we have access to clean water.) The students will examine the world to see how these four elements interact with each other and other socio/economic factors. This will be done through an interactive writing assignment that refers to several world atlases and specific data about water access and climate patterns. The students will then examine their own water use and learn about water conservation. Water conservation focuses on controlling the first and third elements, the “quantity” and “reliability” of (freshwater) resources with minimal “cost”—the fourth element.

It has been said that engineers have saved more lives than doctors, through innovations such as clean water. The students will be asked to defend or refute this argument using a combination of historical data and current information. This activity is to engage students in the second element—“quality” of water—and how engineers can make a big difference in water treatment technologies. The students will then learn about water treatment, through reading materials and online educational resources. They will be asked to perform a hands-on experience on water treatment and report their findings. In this experiment, they will investigate the removal of color from water via advanced oxidation (e.g., using UV light).
Another critically important area that the engineers contribute to provide access to clean water is the water distribution systems. Designing of such systems with minimal cost requires a systems thinking. The students will learn to use the EPANET software, a tool that models the hydraulic and water quality behavior of water distribution piping systems, developed by the Environmental Protection Agency (EPA). They will also solve an optimization problem to transport water (e.g., Colorado River water) to different users (e.g., California, Arizona, etc.) with minimal cost. This will be done by introducing the students to the concepts of mathematical optimization (in particular, transportation problem) and Excel Solver software.

The unit will end with a discussion assignment that asks the students to come up with ways how each engineering department at the University of Arizona can contribute to solving this problem. This activity is designed to show the students that innovative solutions require an interdisciplinary approach and every engineering discipline can contribute to solving this grand challenge. The students will be asked to visit the department websites, talk to faculty, and learn about their research.

Expected Outcomes: At the end of the unit, the students will: 1) gain an understanding of engineering principles that are critical to tackling real-world problems in providing water; 2) work on hands-on experiments and learn new software; 3) gain an understanding of the multi-disciplinary aspect of this grand challenge (the unit itself has elements from agricultural and biosystems, chemical, civil, environmental, and systems engineering disciplines); 4) learn about the current active research conducted at the university regarding water and therefore 5) will be introduced to engineering concepts and applications that will help them throughout the rest of their engineering careers.

Appendix C

GC DELI Unit – Engineering Better Human Health

Maintaining or improving health is a desire of virtually every person living today. Good health allows us to enjoy the things in life that make us happy. Having a healthy population is also an important societal issue that has significant impact on the productivity, economy security and general well-being of our nation and the world. Throughout history, engineering has played an important role in this effort, and continues to do so today. From prosthetic legs to stem cell therapies, engineers are playing a vital role in the development and implementation of devices and procedures to improve our health. Much of this work now falls under the category of Biomedical Engineering (BME), a modern and specialized discipline of engineering that specifically trains individuals to work at the intersections of medicine, science and engineering. Advances in biomedical engineering are accomplished through interdisciplinary activities that integrate the physical, chemical, mathematical, and computational sciences with engineering principles in order to study biology, medicine, and behavior. Biomedical engineers will play an increasingly valuable role in numerous areas of biomedical research and human health.
Objectives: In this unit, students will 1) learn how engineering principles are being utilized to address a variety of human diseases and disorders. 2) develop an understanding of the role that engineers play in the design, development, manufacture and implementation of medical devices and procedures. 3) be exposed to the variety of BME subspecialties including biomechanics, biomaterials, tissue engineering, biosensors and biomedical imaging.

Activities: Students will begin the unit by learning about the role that engineering has played in human health and medicine throughout history (e.g. prosthetics, devices, sanitation, etc.) and the role that it is currently playing today (artificial organs, joint replacements, etc.). Materials will include readings, websites and videos. Students will read about the thirty achievements included into the “Hall of Fame” developed by the American Institute for Medical and Biological Engineering (AIMBE) and reflect on how these have impacted their own lives or the lives of friends or family. Students will be exposed to a variety of biomedical engineering activities being carried out nationally, via NOVA and Scientific American videos, and locally, via websites and Power Point presentations. They will also learn about the professional societies for biomedical engineering, the Biomedical Engineering Society (BMES) and the Engineering in Medicine and Biology Society (EMBS) which have tremendous resources for students interested in this area. Learning in all of these areas will be assessed via quizzes, surveys and small group discussions.

After the general introduction to the scope of engineering and human health, students will delve deeper into the procedures and devices used to address heart diseases. The heart will be the focus of this section because i) heart disease is an important and ubiquitous medical and societal problem, ii) the basic functions of the heart can be understood by freshman engineering students and iii) the variety of treatments for the heart provide many examples of engineering design, manufacture and use. The sequence of learning will be to 1) understand the anatomy and function of the heart, 2) understand a variety of diseases of the heart and 3) understand how engineering has addressed the treatment of these diseases. The disease/treatment pairs will be arrhythmia/pacemaker, heart valve disease/heart valve replacement, coronary artery disease/angioplasty and stenting. Students will learn about the function of the heart and its diseases primarily via resources at produced by the National Heart Lung and Blood Institute (NHLBI) as well as original material and industrial websites and videos.

Students will then carry out a “hands on” project where they will use a computer aided design (CAD) program to design a fixation plate for a broken bone. The student will be supplied with Computed Tomography (CT) images that will show an obvious fracture. They will utilize ImageJ, a free image viewing and analysis program developed by the National Institutes of Health (NIH), to view and analyze their images. Students will learn how to segment their image making a model of the broken bone which will be read into the CAD software Solidworks (a software package that they have used in a previous section of the course). Student will then use these objects to help develop a “treatment,” i.e. a piece that will help secure the brake. Students
will turn in the Solidworks rendering of their objects along with a short description of the problem they were trying to address and the type of materials they would use.

At the end of the unit, students will work through a section on biomedical ethics, which will guide them through the Human Subjects Protection Program (HSPP) as well as the Institutional Animal Care and Use Committee (IACUC) training for student researchers. This not only teaches them about the ethics involved in working with humans and animals in research, but provides them the necessary training they need to work in a laboratory during their undergraduate careers.

Expected Outcomes: At the completion of this project, students will 1) have a general understanding of the role that engineering plays in biomedical research and healthcare, 2) understand terminology of biomedicine and examples of how engineering has developed solutions to health problems, 3) understand how medical images are stored and how to manipulate them with common software and 4) understand how computer modeling is being combined with rapid prototyping to personalize implants and 5) understand the ethical issues regarding engineering in human health.

**Appendix D**

**GC DELI Unit - Restore and Improve Urban Infrastructure**

Infrastructure is a common element to economic development and economic prosperity, both in urban and rural areas. The word "infrastructure" is a broad term, implying fixed facilities that serve society as a whole, including roads, bridges, buildings, water networks, wastewater systems, power grids, communications systems, and similar facilities. In this unit, students will be introduced to infrastructure engineering, examining how civil engineers, together with other engineers and planners, are working to construct the infrastructure of the future, while trying to maintain the systems already in place.

Currently, more than half of the world's population lives in urban areas. By 2030, it is estimated that more than 5 billion people will live in the world's cities, with over 80% of that population in the developing world. Maintaining existing infrastructure and providing new infrastructure to these urban areas is a critical ingredient to stimulate social and economic development, and to maintain and improve our quality of life.

It is well documented that the technical and financial needs of US infrastructure systems are enormous, with worsening conditions overall, and many urban infrastructure systems reaching the end of their normal life cycle. In addition, rising costs of infrastructure construction, renewal and rehabilitation make the role of the engineer even more important, as more cost-effective designs, construction methods, and operations are needed. This unit is intended to stimulate students’ creativity to solve real-world problems associated with civil infrastructure.
Objectives: The objectives of this unit are: 1) to give students a fundamental understanding of the condition of the nation’s infrastructure; and, 2) to appreciate some of the economic and technical challenges to restore and improve that infrastructure. The student should learn about infrastructure needs, and they will be challenged through hands-on experiments and computer simulation tools to design cost-effective infrastructure elements.

Activities: The unit will begin with an introduction to both transportation and drinking water / wastewater infrastructure in urban areas. The goal of this introduction is to help the students understand the extensive nature of this infrastructure and the costs associated with its maintenance and improvement. Students will be oriented to web resources at the federal, state, and local level to discover current infrastructure condition, and to begin to understand the financial and technical challenges associated with this infrastructure. Most notably, many public agencies maintain extensive data on the condition of infrastructure in their respective areas; students will be able to use spreadsheet tools to evaluate the condition of roads and bridges and of water / wastewater systems.

A second element of the unit will focus on the underlying processes that affect the condition and performance of infrastructure. To provide some context in the area of civil infrastructure, students will explore simple statics, understanding the use of trusses and other structural elements to support loads. Students will also design a simple structure using common items (straws, toothpicks, etc.) to explore the design process and to apply their understanding of structures. Finally, students will design a bridge using the West Point Bridge Design program, which determines the forces in each element of the bridge under different loading scenarios, to calculate the cost of the structural elements, and to visualize the deflections and stresses on the bridge. This exceptional tool allows students to learn about both the performance of infrastructure and its economic costs.

A third element of the unit will focus on drinking water and wastewater systems. The students will explore some simple fluid dynamics, particularly in the area of pipe flows and head losses. Students will also conduct an experiment, using water containers and straws, to investigate the pressure changes in pipe networks. Finally, the students will investigate the design and analysis of pipe networks, including pipe sizing and materials, pump systems, and terminals and water treatment sites. This will be done using the software tool, EPANET, to model and analyze water distribution networks.

Expected Outcomes: The expected learning outcomes from this unit are that students should: 1) demonstrate an understanding of the range and magnitude of infrastructure needs in the US; 2) use on-line resources to identify infrastructure needs in their own communities; 3) solve simple problems from statics, and demonstrate a basic ability to design bridges and other structures while considering costs; and, 4) solve simple problems from fluid dynamics, and demonstrate a basic ability to design pipe systems while considering costs.
Appendix E

Student Unit Evaluation Survey

Question 1

What is your gender? (Circle one)

Male  Female  Prefer not to respond

Question 2

What is your Ethnicity? (Circle all that apply)

Hispanic or Latino
American Indian or Alaska Native Asian
Black or African American
Native Hawaiian or Other Pacific Islander  White
Prefer not to respond

Question 3

Please indicate which GC DELI Unit you just completed. Circle the one that applies:

Engineering Better Human Health  Energy, Water and the Environment
Provide Access to Clean Water  Restore and Improve Urban Infrastructure

Question 4

Indicate how important the following factors are in forming a good opinion about this GC DELI Unit. Circle: “Important, Neutral or Not important” for each factor

The online content and assignments provided in the unit  Important, Neutral, Not important
The hands on projects that went with this unit  Important, Neutral, Not important
The details and lecture materials added by my teacher  Important, Neutral, Not important
Interest that I had in this engineering challenge before I completed this unit  Important, Neutral, Not important
Question 5

Some of the GC DELI units include hands-on projects. How did having a hands-on project impact your learning? Circle the best answer:

- Negatively impacted my learning
- Had no impact on my learning
- Positively impacted my learning
- We did not have a hands-on project with this unit

Question 6

Regarding your experience with this GC DELI Unit, please indicate if you agree or disagree with each statement below. (Please circle one)

- The unit activities helped me discover new information or concepts that developed my interests in the topic
- The unit activities facilitated my learning about the engineering profession
- The unit activities required application of problem solving skills
- I liked the subject matter of this GC DELI Unit
- I liked the flexibility and independent learning of the online format

Agree, Disagree

Question 7

What sort of an impact did this GC DELI unit have on your interest or commitment to Engineering? (Please Circle one)

- A positive impact on my interest in Engineering
- Did not impact my interest in Engineering
- A negative impact on my interest in Engineering

Question 8

Please write a few sentences that describe how you would improve this online GC DELI unit.

Question 9

Which of the following describes the GC DELI Unit overall? (circle all that apply)

- Exciting
- Too time-consuming
- Informative
Too easy          Helpful for formulating my career interests          Too difficult
Helpful for clarifying my perception of engineering         Boring

**Question 10**

Please list what you think the central concepts of this GC DELI Unit are (list two or three):

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**Appendix F**

Teacher mid-year survey (five questions dealing with GC DELI and one with ENGR 102 HS)

1. Have you already used the GC DELI online materials in your classroom, either this year or last?
2. Overall, How useful do you think the GC DELI units are for you as a teacher in the ENGR 102 HS classroom?
3. How satisfied were you with the ease of use of the canvas website (content delivery) for the GC DELI unit(s) your students worked on.
4. How satisfied are you with the content in the GC DELI units?
5. Please rate your level of satisfaction with the Training on the GC DELI online units presented at the workshop.
6. Please rate your overall satisfaction with your experiences as an ENGR 102 HS teacher so far.