2017 Summer Engineering Experience (SEE) Program

The Summer Engineering Experiences, SEE Program is designed with an objective to enhance students' hands-on, computational, programming, communication, and problem solving skills. The 2017 Summer Engineering Experience program covered topics related to engineering computation using MATLAB and C++, bridge truss design & analysis, applied fluid & aerodynamics, and computer aided design (CAD) & additive manufacturing, and technical writing.

The following learning outcomes have been established to assess student performance in the Summer Engineering Experience program. These student outcomes are as follows:

(a) Students will demonstrate an ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematics.
(b) Students will demonstrate an ability to design and conduct experiments, as well as to analyze and interpret data with the use of computer applications current to industry;
(c) Students will demonstrate an ability to design and apply creativity in the design of engineering systems, components and process;
(d) Students will demonstrate an ability to function effectively on teams that establish goals, plan tasks, meet deadlines, and analyze risk and uncertainty;
(e) Students will demonstrate an ability to communicate effectively with a range of audiences
(f) Students will demonstrate an appropriate mastery of the knowledge, techniques, skills, and modern tools used in the engineering field;

Attainment of these outcomes prepares students in the SEE program for the core courses within engineering disciplines and provides them with the ability to be successful in their professional career path.

Process for Assessment and Continuous Improvement

The main objective of the Summer Engineering Experience (SEE) program is to provide students with the basic computational and hands-on project-based learning in numerical analysis with MATLAB and C++ programming, aerodynamics, bridge truss design & analysis, technical writing and presentation. This program not only introduces students to basic skills in developing solutions to engineering problems, but also enhances their ability to develop programs to facilitate the solution of a physical system.

The SEE program is designed to enhance student learning outcomes related to analysis, programming, design, communication and teamwork, and to prepare freshmen engineering students for the core courses within their program.

To assess the effectiveness of the SEE program, a student learning outcomes assessment process based on topics covered in the program, as well as a continuous improvement loop have been implemented. This process includes the following direct and indirect assessment process:

- <u>Student's Evaluation Survey of SEE Program</u>
  As an indirect measure, a rubric survey based on the contents of the SEE programs has

been given to students to assess the effectiveness of the SEE programs.

- Faculty Evaluation Survey
  As a direct measure, a rubric faculty evaluation survey based on student learning outcomes provides assessment of those outcomes in students' projects and presentations.
- Monitoring and assessment of SEE students' performances within their discipline of study
  As a direct measure, the performance of two cohorts of students who participated in 2016 and 2017 SEE programs are monitored through core courses within their discipline of study and compared with those students who did not participate in the freshmen year of the Summer Engineering Experience program.

In assessing the SEE-STEM program, our overall goal is to ensure that at least 70 % of the students achieve a success rate of a score above satisfactory for each outcome, as indicated on the rubric. An outcome with a success rate below 70% requires action plans for improvement.

Mapping of student outcomes vs Topics in SEE Program: The mapping of student outcomes vs topics offered in SEE program were discussed and developed by the participating faculty members and is presented in Table 1.

Table 1: Relationship of Topics to Student Outcomes

Topics	a. Math, Science, Solve Engineering	b. Experiments, Computer	c. System Design, Components,	d. Function Effectively on Team	e. Communication	f. Techniques, skills, and modern tools
Truss Bridge Design and Analysis	•	•	•			
Computational Method with MATLAB	•	•		•		•
Computational Method with C++	•	•		•		•
Applied Fluid and Aerodynamics	•		•	•		
Computer Additive Manufacturing		•	•	•		•
Technical Writing and Presentation				•	•	

Computational Method with MATLAB and C++ Application

This topic in the SEE program provided students with some fundamental knowledge of engineering analysis and programming using both MATLAB and C++. Students were introduced to topics such as Taylor Series, finite difference, root determination, complex number, and numerical integration with application to engineering problems. Both MATLAB and C++ were introduced to students as a computing tool to generate results and facilitate the process of investigating behavior in an engineering system. Through both computational and programming (MATLAB and C++) sessions, students were introduced to the following computational processes

- Mathematical governing equation of an engineering system
- Development process of numerical formulation based on finite difference methods
- MATLAB and C++ Programming
  - How to work in MATLAB and C++ environment?
  - How to use logical control loops?
  - How to write a MATLAB and C++ program?
- Development process of numerical solution of an engineering system with MATLAB
  and C++ to investigate behavior of an engineering system.

In the first two weeks (Two hours per day for four days per week) students were introduced to both MATLAB and C++ programming and how to use logical control loops such as for loop, while loop, conditional loop, switch, and function to develop programs for specific application. In the third and fourth weeks students learned how to write a program with application to engineering problems related to root determination, numerical integration, beam deformation analysis, impulsive vibration, and numerical analysis of a governing engineering equation. In the last week, students worked with faculty mentors and developed a project titled "Computational Methods of Analysis Using C++ and MATLAB" and presented their work to faculty and the Vaughn community on the last day of the summer session. Their projects were assessed by faculty members according to the following learning outcomes

- Students will demonstrate an appropriate mastery of the knowledge, techniques, skills, and modern tools used in the engineering field – Both MATLAB and C++ are used as a programming and computational tool to solve analytical and numerical solution of an engineering system.
- Students will demonstrate an ability to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematics – Both the analytical and the numerical form of an engineering governing equation require knowledge of mathematics and engineering principles.
- Students will demonstrate an ability to communicate effectively with a range of audiences – Projects require both report writing and presentation.

Introduction to Aerodynamics and Wind tunnel Testing

In this section of SEE program, students were introduced to aerodynamics design as an example of applied engineering. They learned the basic formulation of fluid mechanics equations, which lead to application of continuity and Bernoulli's equations. Students had an opportunity to verify these equations through hands-on projects and direct measurements in the thermos-fluid laboratory. Also, students were introduced to basic force analysis on aerodynamic vehicles with an emphasis on lift generation airfoils, as well as an opportunity to use simulation tools to better understand flow properties and their effect on the aerodynamic loads.

Through this session of SEE program students were introduced to both theoretical experimental topics relate to:

- Bernoulli's and continuity equations.
- Aerodynamics of airfoil.
- Wind tunnel testing.
- Measurements techniques in wind tunnel testing.
- Introduction to aerodynamic simulation using COMSOL Multiphysics.

In the last week, students worked with faculty mentor and developed a project titled "Applied fluid and aerodynamics" and presented their work to faculty and the Vaughn community on the last day of the summer session.

Bridge Truss Design and Analysis

The "Introduction to Engineering" course introduces students to some basic concepts used in solid mechanics along with simple design and hands-on application. During this course, students were given an introduction to basic concepts such as stress, strain, deformation, and Hooke's law. Applications of these concepts were then introduced to students where they studied and analyzed a basic Warren truss bridge. Students were given an opportunity to design and build a simple Warren truss bridge which was required to support the load of a truck driving over it. During this design process, students use software such as excel and CATIA. As part of the class, students were also required to write a short report explaining their design process and build a small bridge based on their design. Figure 1 shows the bridge designed by students using CATIA.

Figure 1: CATIA design of a Warren truss bridge

The specifications of the bridge required to be designed are as follow:

- Material for Truss members: A36 structural steel (yield strength, 36ooo psi)
- Span a bridge : 63 ft. with 2 lanes (13 ft. each)
- The four bays, 15.75 ft. each
- Member assumed to have an initial cross-sectional area of 20 in2.
- Deal load: steel members (150lbs/cu.ft), an 8-in concrete deck(490lbs/cu.ft)
- Live load: Truck (dynamic amplification factor assumed to be 1.2)

The specifications of the truck required to be supported by the bridge are as follow:

- The truck has 3 axels, each one with different weight.
- The (1st) front axle of the truck exerts: 12,000 lb.
- The (2nd) central axel exerts: 48,000 lb.
- The (3rd) rear axle exerts: 50,000 lb.
- For this particular truck, the axels are separated by a distance of 15.75 ft. The same distance between each joint of the bays in the bridge.

Figure 2 shows a completed bridge made of Popsicle sticks.

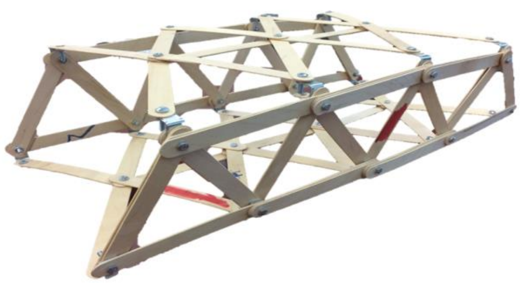

Figure 2: Popsicle sticks Warren truss bridge

Computer Additive Manufacturing

For this session of the SEE program, students worked on projects related to rapid prototyping, surface modeling, and 3D scanning. The program encouraged a hands-on mindset in our students in order to foster in them a desire to participate in club activities and to develop strong industry connections during their time at Vaughn College.

Projects were developed using SolidWorks and CATIA assembly design software as a tool for virtual prototyping and visual communication. Students designed assemblies such as a bridge, car, and computer case in SolidWorks. Part fits and tolerances were optimized before committing to the expense of 3D printing. Lectures related to MakerBot, Fortus 250 MC, and Form Labs 3D prints exposed students to new low cost accessible machines that can drastically accelerate part development. Reverse engineering was covered using the Catia Digitized Shape Editor, Quick Surface Reconstruction Workbench, and Artec Spider 3D scanner. At the end of the course students presented a PowerPoint presentation where they showcased projects related to rapid prototyping, 3D scanning, surface modeling, and product assemblies. After participation in the SEE program, students have moved on to prominent roles in the UAV and Robotics clubs where they routinely employ the techniques learned in this program.

An Introduction to Aerodynamics and Wind tunnel Testing

In this section of the SEE program, students were introduced to aerodynamics design as an example of applied engineering. They learned the basic formulation of fluid mechanics equations, which lead to application of continuity and Bernoulli's equations. Students had an opportunity to verify these equations through hands-on projects and direct measurements in the thermos-fluid laboratory. Also, students were introduced to basic force analysis on aerodynamic vehicles, with an emphasis on lift generation airfoils as well as an opportunity to use simulation tools to better understand flow properties and their effect on the aerodynamic loads.

Through this session of the SEE program students were introduced to both theoretical and experimental topics related to:

- Bernoulli's and continuity equations.
- Aerodynamics of airfoil.
- Wind tunnel testing.
- Measurements techniques in wind tunnel testing.
- Aerodynamic simulation using COMSOL Multiphysics.

In the last week, students worked with a faculty mentor to develop a project entitled "Applied fluid and aerodynamics". On the last day of the summer session, they presented their work to faculty and to the Vaughn community.

Technical Writing and Presentation

Students in Engineering often need to eliminate ambiguous terminology and industry jargon from their writing, and they should learn how to write industry reports in a manner that is accessible to their targeted audience. Because most of these students have received traditional grammar instruction, in which instructors have typically focused only on "rules" of grammar, the students have often developed an antipathy to writing. Rather than having students focus in this traditional and ineffective way on what is wrong with their writing, in this class students were redirected to focus their attention more towards the ideas they need to communicate. They were shown how grammar is best learned through the process of writing, rather than through the memorization of sets of rules. Students learned how to compose clear effective sentences through syntax imitation exercises. Through the imitation of these model sentences, students experienced, for example, how combining basic sentences can produce more complex and effective writing.

Since science writing is often complex students need to learn how to hang their complex ideas on the scaffolding of simple stories with characters and actions. They are used to thinking that stories are made-up and science is fact, but linguistic research supports the idea that when people read unfamiliar information they are looking for simple stories. For example, in engineering writing, the character could be a robot or a bridge truss. Students studied models of science writing to observe and imitate this technique in their own writing.

Collaboration played a key role in the SEE Technical Writing program. Each student group contained a drafter, a reviewer and an editor, and the groups traded papers and asked questions of the other groups. Each group then presented its final report in an oral presentation. Reading their own reports aloud and hearing others present their reports are effective ways for students to learn how to improve their own writing.

Friday's Seminars and Workshops

Friday's session of SEE program is designated for technical seminars and workshops. This session is designed to enhance students' learning outcomes related to critical thinking, problem solving, and life-long learning. Given the rapid pace of technological change, the Friday seminar series and workshop helps students in the SEE program to develop a mind-set receptive to changes in technology and prepares them for future challenges.

<u>Seminar #1</u>
Date: Friday, June 2, 2017, 10 am -3 pm
Presenter: Mr. Michel Lévis, Application Engineer, Quanser
Topic: The Quanser Aero Experiments

The objective of this workshop was to introduce the students' to the large, industrially-relevant fields of rapid controls prototyping, instrumentation, and control systems. Demonstrations using Quanser hardware were used to show how the hardware is actually implemented.

Rapid Control Prototyping (RCP) is used in various industries and was introduced using the MathWorks MATLAB/Simulink and the Quanser QUARC software. Using the Quanser Q2-USB data acquisition device, the time-saving benefits of graphical design and code generation were demonstrated using a simple analog loopback test.

The field of instrumentation was then addressed. Using the National Instruments LabVIEW software, Mr. Levis demonstrated how RCP-based tools can be used to interface to hardware systems. The Quanser AERO two-degree of freedom benchtop helicopter system was used to illustrate how to use RCP software to interface to the pitch position sensor and actuate the rotors.

Building on the concepts taught in RCP and instrumentation, the Quanser AERO helicopter was used again to introduce control systems and to regulate the position of the pitch angle. The different elements in a control system and the most common types of control were first described: on/off control and PID. A PID controller was designed step-by-step in MATLAB/Simulink and ran on the AERO (using the QUARC software). The way in which each term in PID affects the position response of the flight system was then illustrated: the derivative term attenuates the oscillations and the integrator removes steady-state error between the desired command and the measured.

This workshop ended with a presentation on Unmanned Vehicle Systems (UVS) to demonstrate how the concepts of RCP, instrumentation, and control systems can be used in these applications. The Quanser Qbot 2 mobile Unmanned Ground Vehicle (UGV) was used to show students different types of sensors (e.g. camera), and how RCP software can target remote systems and can be used for localization. The talk ended with a system overview and video of the Quanser Qball 2 Unmanned Aerial Vehicle (UAV).

<u>Seminar #2</u>
Date: Friday, June 9, 2017, 10 pm – 2 pm
Presenter: Mr. Oliver N. Scheel, Director of US Didactic, Inc.
Topic: Sustainable Energy and Advanced Manufacturing Workshop

The President of US Didactic talked about the Sustainable Energy and Manufacturing Fundamentals and System Applications at Vaughn College. Students who participated in the SEE Workshop were introduced to Fundamentals & Applications pertaining to Solar Photovoltaics, Solar Thermal Techniques, DFIG Wind Turbines, Small Wind DC Generators, and Renewable Energy Distribution and its relationship to Intelligent Micro Grids. The new Sustainable Energy courses and lab activities also provide an excellent complement to the existing Power Systems Option.

The second part of the workshop focused on the integration of new technology with current manufacturing practices. With most of the participants currently enrolled in the Mechatronics Program, the conversation quickly focused on Cyber Physical Systems, aka the Internet of Things (IOT), and the close connection to Smart Factory 4.0 concepts. The discussion touched on numerous processes including communications with transducers & actuators, subsystems, fault detection and analysis, linked facilities, and other anticipated changes for students to consider as they prepare for their entry into the workforce.

Seminar #3
Date: Friday, June 16, 2017, 10 am – 2 pm
Presenter: Mr. Waseem Hussain, Vice President of Union Crate
Topic: Python Programming

In this workshop session Mr. Waseem Hossain talked about Python programming and how python can be used to create object-oriented programming. He showed students how to create a file and use flow chart in developing and writing a python program for specific application. During the workshop session, students received one to one hands-on training working in the python environment in order to create an object-oriented code to conduct engineering analysis and generate results.

Waseem Hussain Co-Founder & VP of Union Crate Start-up Company

Seminar #4
Date: Friday, June 23, 2017, 10 am – 2 pm
Presenter: Prof. Manuel Jesus
Topic: CAD and Additive Manufacturing

Prof. Manuel Jesus, a faculty member in the engineering and technology department with extensive background in CAD and additive manufacturing, conducted a workshop covering 3D scanning and surface modeling with CATIA and the Artec range of 3D scanners. SEE students also had several lectures regarding 3D scanning, 3D printing, and some surface modeling labs in Solid works as part of their course offerings. By the time the scanning workshop began, students were familiar with this technology and they were eager to learn in a dedicated hands-on workshop.

Three dimensional scanning is used by the automotive, aerospace, and entertainment fields. Scans are acquired from real world objects, sculpted forms, and human anatomy. The acquired scan data is then used as a reference model for part creation. Modern manufacturing requires CAD data sets and CATIA CAD software is an essential tool for 3D scan based part development. CATIA has many tools to facilitate part design from 3D scans with strict tolerances. In this workshop a 3D scanned part was converted into a solid model from an older physical part for use in a modern Product Lifecycle Management (PLM) system.

The 3D scanning process started with capturing scan data composed entirely of triangles representing the 3d mesh surface of the object. Model development utilized many of CATIA's Workbench applications. Students first used the Digitized Shape Editor Workbench where a 3D scan point cloud was prepared for use in CATIA. Here students cleaned up the scan by filling in any holes in the surface geometry and optimizing mesh density though a reduction process called decimation. Cross sections shapes were then extracted with reference planes placed laterally along the wing structure. The sections were then taken into the Quick Surface Reconstruction Workbench where students extracted reference curves. Although the curves were clean representations of the wing shape, students further optimized curves to develop the solid model. Students then transferred to the Sketcher, Generative Shape Design, and Part Design Workbenches where they worked to insure good curvature continuity. Surfaces were then made using the Generative Shape Design Workbench. Once a surface body was constructed, the surface was converted to a solid model in the Part Design Workbench. Students were shown how boss, shell, rib, and other parametric features could be used to make the final component for manufacturing.

Students learned and practiced this workflow through the use of instructor developed exercise files, and they were encouraged to work on scans of their own. Students have already utilized this technology in our 3D Printing and Innovation lab for degree projects and personal research projects. As an instructor, I think it is vital to share technology that optimizes development resources and empowers student creativity. I was grateful to share my research and experience with 3D scanning in this workshop.