Development of Veteran Friendly, Military Technology and Instrumentation Mechanical Engineering Course

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Abstract

The University of North Carolina at Charlotte developed a veteran friendly, military technology and instrumentation course as part of their ongoing efforts to recruit and retrain members of the military community and to expand the military science and technology workforce. The larger project included four interrelated initiatives (e.g., systematic veteran recruitment activities, specialized mentoring support for student veterans) and institutional data analysis on veteran recruitment and graduation. ENGR3999 (pseudonym) was originally planned to link prior military experience of veterans to what they learn in academic courses and to increase non-veteran engineering students' knowledge base and professional interest in military science and technology careers. This paper presents the successful outcomes of a three-year long curriculum development and implementation undertaken by the team of engineering and education professors and student veterans. The class focuses on experiential learning to engage the undergraduate engineering students for a wide variety of topics introduced in other classes. The topics for the class are presented here along with the course learning objectives, qualitative and quantitative assessment methods and results.

Introduction

This paper discusses the development of a veteran friendly, "Military Technology and Instrumentation" Mechanical Engineering course. Higher education has long played an important role in military veterans' civilian transition. Post- 9/11 Veterans Educational Assistance Act passed in 2008 offers comprehensive education benefits to over two million service members who enlisted in the military after 2001. Not surprisingly, over the past ten years institutions of higher education have witnessed a soaring number of military veterans on their campus using the G.I benefits to earn a college degree and to maximize their employment opportunities in civilian society. Considering the growing number of student veterans enrolled in universities and colleges nation-wide, further research is necessary to provide relevant programmatic support to engage this new group of non-traditional students. One possible way to facilitate student veterans' social integration and academic success is offering them a chance to link their prior military experience and experiential knowledge to what they learn in academic courses. However, despite the significant number of student veterans on college campuses, very little effort has been made to develop a specific curriculum or academic course that integrates military veterans' prior experiences and knowledge in higher education.

The University of North Carolina at Charlotte (UNCC) is a large urban public research institution with over 29,500 students [1], 7,400 of which are considered non-traditional or adult students. The university has shown a 21.5% growth in military (veteran, active, reserve and family member) enrollments over the past six years (2013-2019)[2] in contrast to the minor decline in other student groups. This growth has resulted in over 1060 military affiliated students enrolled in Fall 2019[2]. The university Veteran Service Office (VSO) supports these veterans and family members through a wide variety of student services. The office has many programs which include a veterans specific orientation programs, counseling sessions (individual and group), and Green Zone Training for faculty. The office also maintains a veteran lounge and conference room. The College Of Engineering veterans program, Veteran Education Continued Through Engineering Research (VECTER), provides additional services to veterans which include peer to peer tutoring, a faculty veterans advocate and dedicated graduate school opportunities.

To support an ongoing veteran recruitment and retention program, the University of North Carolina at Charlotte, Mechanical Engineering and Engineering Science Department developed an elective undergraduate course (ENGR 3999). This course was designed to use imagery and hands on, military based research laboratory experiences to engage veteran and non-veteran engineering undergraduate students. The class is available to all engineering students, but predominately attended by Mechanical Engineering and Mechanical Engineering Technology students.

Our curriculum development process was guided by the Integrative Approach for Curriculum Development Framework [3]. This framework explains that curriculum development is largely shaped by four dimensions: a) Education leadership (i.e., the engagement of the university/college's leadership to support veteran friendly campus and program), the environment variables (i.e., the lab-based engineering learning contexts), graduate competencies (i.e., key learning outcomes and competencies for learners), and pedagogical strategies (i.e., utilization of various teaching strategies such as lecture, lab experiments, and guest speakers). Figure 1 below illustrates the systematic approach for curriculum development starting with a careful and thorough scanning of environmental factors and determination of specific competencies and learning outcomes for students. Knowledge gained from the previous two stages supports the actual curriculum development in Stage 3 followed by the selection of the most effective and relevant strategies to deliver the designed curriculum. The final stage is the phase of implementation, evaluation, and feedback which is essential to continuing improvement. This model also highlights the importance of institutional leadership and the reciprocal role played by larger society, industry, and government in the curriculum development process and outcomes.

Figure 1: Curriculum Development Model

Our curriculum development and teaching methods were also grounded in Constructivist learning theory and the concept of experiential learning. Constructivist learning theory argues that learning takes place when the learner actively engages in the process of sense-making and knowledge construction [4]. Carefully selected content knowledge [5] and reciprocal interactions with others (i.e., instructor, peers)[6, 7] will mediate and facilitate learning. This perspective challenges the traditional view of teaching and learning that portrays a learner as a passive individual simply receiving the knowledge provided by an authority figure. Experiential learning, a concept and pedagogical practice inspired by Constructivist learning theory also upholds the learner's active role and focuses on "learning through reflection on doing" [8]. Experiential learning is represented as a cycle of four stages, a) Concrete experience, b) Reflective observation of the new experience, c) Abstract conceptualization, and d) Active experimentation[9]. To accomplish experiential learning, the learner's willing and active engagement in the experience and subsequent reflection are necessary. It is equally important that the learner applies analytical skills to conceptualize the experience and subsequently get involved in the problem-solving process to apply the new ideas derived from the experience[10].

Course Development

ENGR 3999 (Initially "Military Technology and Instrumentation", later renamed to "Advanced Experimental Methods") is an innovative engineering course that was developed to engage undergraduate students in experiential learning through varied instructional strategies including lecture, research, and experimental labs. The course was designed as part of a funded project to offer a classroom experience that bridges the standard mechanical engineering or engineering technology theoretical curriculum with the military experiences of the veterans so that they develop interest in engineering research and pursue an advanced degree in graduate programs. The second goal is to expose non-veteran engineering undergraduate students to various military technologies and their defense applications and increase their knowledge and interest in defense industry employment. Based on these two goals, the class topics were broken down into two

areas: Military Technology Applications and Research Tools. The course was developed and offered as a technical elective for all engineering undergraduate students including veterans and non-veterans.

Course objectives emphasize gaining knowledge on instrumentation and data acquisition as well as developing key technological competencies and application skills (e.g., operating PIV) in undergraduate engineering students. Developing technical writing skills was also part of the course objectives. Student projects and experiments were designed to be conducted in groups of two to ten students depending on the topic. Each group provided opportunities for collaboration between veteran and non-veteran students. The topics of the class were initially determined by a working group consisting of two veteran students, one professor and a representative from Naval Air Systems Command (NAVAIR).

As determined in the initial working group and later verified and published[2, 11] by an independent source, veterans desire priority or early registration as well as better connections to faculty and staff. Based on the focus groups inside of the mechanical engineering department, it was determined that 50% of the available class slots would be reserved for veterans and they would have priority registration. The class was widely advertised inside the college of engineering to fill those slots. During the last week of registration, the unfilled slots are released to the rest of the student population. To make a better connection with faculty and staff, it was determined that other veteran students would act as the teaching assistants for the class.

Military Veteran Teaching Assistants Bring Real World Military Experience

During the initial funding of the project, a veteran graduate student was hired as a research assistant and assisted in developing the topics based on military experience and recommendations from topics working group. When a new teaching assistant is hired, they add valuable information and experiences to the class. The first veteran graduate student assisted with class preparation and presentation during the first iteration as well as recruiting and hiring of the first teaching assistant. The first veteran teaching assistant had experience in the military with parachuting and communications, which allowed him to speak first hand in the lectures and labs on those two topics.

During the second and third iteration of the class, a second veteran graduate student was hired with more experience in radio communications, networks and unmanned aerial vehicles. His first hand knowledge added to the lectures and improved the associated labs. The fourth and most recent teaching assistant has been working on adding a new topic, hypersonics, to the course.

Instruction and Hands on Mix

The course outline follows a project-based learning model and is directly tied to real word activities. The students attend a single lecture that covers the topic, often refreshing fundamental lessons from other classes. The following one to three classes are conducted in the lab where the students get the hands on experience to reinforce the lesson. Each lab activity is followed by a report detailing the lab set up, execution and analysis of any data that was gathered. Some of the

topics show a more direct application that a new graduate might come in contact with in industry, where other topics (Water Channel, Wind Tunnel and Planar Rocket Nozzle) are more research related.

The objectives of the developed course are to:

- To teach students about the design and development of wireless communication.
- To develop students' understanding of how wind tunnel and water channel measurements are performed.
- To introduce students to performance issues and industry practices for unmanned aerial vehicles.
- To teach students to develop physical and mathematical models to predict the dynamic response of rocket engines.
- To introduce students to gas turbine design performance criteria and how to use the criteria to evaluate engine dynamic response.
- To teach students about the process of repairing composite airframes.

These objectives are met through the following course topics:

- Introduction to wireless communication
- Particle Image Velocimetry (PIV) in a water channel.
- Airflow measurements in a wind tunnel
- Schlieren Imaging in a Rocket Nozzle
- Carbon Fiber repair techniques
- Unmanned Aerial Vehicle (UAV) tracking of ground vehicles
- Railgun technology
- Gas Turbine (jet engine) operation

Class Topics

Each of the topics listed above are shown in Table 1, followed by a brief explanation of each. Table 1 shows the course topic, its current mechanical engineering class where the topic is first introduced to the students and the military significance. It is important to note that the military significance is not a direct usage of the technology (we do not repair an aircraft or jam a radio), but only examples of engineering topics in military applications. Since the class is required to be an open enrollment class for any engineering student, topics must be general and non-classified in the event non-us citizens are enrolled. The one exception was that some of the guest lectures were restricted to U.S. citizens due to content. Because of these restrictions, attendance is not mandatory for these specific lectures.

Table 1: Course Topics

Topic	Relevant ME Class	Military Significance
Wireless Data Options Design, Build and Test	Instrumentation and Instrumentation Lab	Communications and Jamming Operations
Composite Materials	Materials and Materials Lab	Repair of Composite Material Equipment
Failure Analysis	Machine Analysis	Battle Damage or Routine Maintenance Assessments
Parachutes	Thermodynamics, Fluids and Fluids Lab	Parachute Design and Airborne Operations
Stability, PID Controls and Tracking	Dynamics and Flight Dynamics	Unmanned Aerial Vehicle (UAV) Design and Applications
Water Channel and Particle Image Velocimetry	Fluids	Research in Aircraft and Ship Design
Wind Tunnel	Thermodynamics, Fluids and Fluids Lab	Research in Aircraft and Vehicle Design
Planar Rocket Nozzle Schlieren Imaging System	Compressible Flow	Research in Missile Defense and Space Launch Systems
Rail Projectile Theory	Dynamic Systems and Thermodynamics	Rail Gun Design
Gas Turbine Operation	Thermodynamics, Fluids and Machine Design	Auxiliary Power Unit and Gas Turbine Maintenance and Operation

Wireless Data Options: Circuit Design, Build, Test

This lecture is the first of the semester and provides a quick class overview and discusses the history of military communication from runners to modern communication systems. The students are introduced to different types of networks and the benefits associated with each. Current military applications from satellite phones to unmanned aerial vehicles are highlighted. Communication disruption capabilities are briefly discussed. At the end of the lecture the students are broken down into teams of two and are issued a wireless communication equipment box. The box contains micro controllers, radio antennas, breadboards and a variety of sensors. The topic covers three labs over three class periods. The first lab uses a temperature sensor circuit to transmit temperature readings in various situations throughout the day. The second and third lab requires the students to build a second circuit with a Passive Infrared (PIR) sensor and place it in a location of their choice for 24 hrs, transmitting movement data to the laptop.

Composite Material in Defense Applications

The lecture provides an overview of composite materials, their advantages and common uses in defense applications. Different methods of processing, manufacturing and testing composites are also discussed. Two lab periods are utilized to demonstrate composite materials. During the first lab, individual students layup a carbon fiber plate and place it under vacuum. Once the plates are cured, typically the next lab session, students cut the plates into various shapes to demonstrate the

difficulties in manufacturing with composites.

Failure Analysis

The lecture provides an overview of some common failures in mechanical devices, focusing mostly on gears and turbines. Root cause analysis is discussed. Several examples of failed or damaged equipment have been donated to the class, allowing the students to do hands on inspections. There is no lab associated with this lecture, which is typically presented before a guest lecture or natural break in the semester.

Airborne Recovery Operations

During lecture, parachute types, function, design and applications are discussed as well as their daily uses in the military. Emphasis is placed on the math behind parachute design based on the different applications. The lab session consists of the students breaking up into two teams. The first team releases different size and style parachutes with varying amounts of weight off of a five story structure. The second team is on the ground level recording drop times and using stop watches and video cameras. The data is then used to calculate and compare variables such as coefficient of drag.

Stability, Proportional Integral Derivative (PID) Controls and Tracking

The lecture focuses on autonomous military vehicles and how they operate. Emphasis is placed on the complex math behind UAV design and PID controllers. The lab session is a demonstration on quad-copter flight and autonomous tracking. A second autonomous vehicle is tracked by the quad-copter at a known distance and altitude.

Water Channel and Particle Image Velocimetry Operation

UNCC has the nation's fourth largest water channel (by flow rate) and one of only a handful of Tomographic Particle Image Velocimetry (TomoPIV) systems. This research tool has a 1m high x 1m deep x 3m long test section and with a maximum flow velocity of around 1 m/s. Each iteration of the class has utilized a different model in the water channel, from a cube shape to a model of a torpedo. The lecture describes the operation of the water channel and TomoPIV and their importance in research. The class then moves straight to the water channel location where they are broken down into three groups and brief blocks of instruction on water channel control systems, model placement and laser alignment and TomoPIV system operations. During the next lab session, the students conduct an experiment in their groups under the supervision of the teaching assistant. The data is then made available to the students for future use.

In 2019 a second Educational PIV (EduPIV) was added to the lab so two groups could work simultaneously on different experiments.

Wind Tunnel Operation

The lecture describes the operation of the wind tunnel, helium filled soap bubble generator (HFSB), smoke generator, LabVIEW data acquisition equipment and manometers. The class then

moves straight to the wind tunnel location where they are broken down into three groups and given demonstrations of the operation of each piece of equipment. During the second and third class, the students conduct two predetermined experiments in their groups. These experiments vary from year to year. Typically, one of the experiments utilizes flow visualization over an experimental model using smoke or HFSB and the second compares pressure data on or around a model using LabVIEW and manometers.

Planar Rocket Nozzle and Schlieren Imaging System

The planar rocket nozzle is a powerful tool which allows students to visualize the flow and shock wave structures inside the rocket nozzle through the use of a schlieren imaging system. The system records pressures and temperatures inside the nozzle as well as forces and moments the nozzle is subjected to. The high speed camera is triggered with the data acquisition and records images at 5000 Hz. A single 500 PSI tank of Argon gas is expelled through the nozzle in less than 1 second. The students operate the gas, imaging, and data acquisition systems and calculate the exit Mach number as part of the lab report.

Rail Projectile Theory and Operation

The rail projectile theory does not have an associated lab exercise. The lecture describes the benefits and draw backs to rail projectiles as well as the complex mathematical equations used to model the system. Once a rudimentary understanding of the math has been established, simplified problems are presented and solved.

Gas Turbine Operation

The gas turbine operation lecture discusses the design, operation, and maintenance of an auxiliary power unit (APU) of a helicopter. An APU was decommissioned from the Navy and donated to the university for use in the lab. This lecture occurs in the lab space with introduction of topics utilizing a cutaway version of the APU. Once the instruction is completed, the working APU is primed and started using an APU training control panel that allows the students to monitor the vitals of the APU while it is being operated.

Guest Speakers

During the development of the course, partnerships were created with naval interest companies and government entities. These partners consulted on the course curriculum based on knowledge they felt were important for new hires. One such organization, NAVAIR, sent senior engineers to conduct guest lectures in the class that were in line with syllabus at different points through out the semester. This partnership with NAVAIR quickly expanded to other roles inside the college of engineering such as membership in the college board of advisors and participating in the college's multidisciplinary senior design program. To date, The NAVAIR has sponsored 14 senior design projects, participated in 10 hiring events, conducted over 100 mock interviews and raised the number of new hires from 2-3 per year to over 15 per year.

Methods

The evaluation team used a sequential mixed-method approach collecting both quantitative and qualitative data [12]. The quantitative data were pre- and post-surveys collected from students enrolled in the class; the qualitative data set included diverse textual data such as student focus group interviews collected at the end of semester, journal reflections submitted as part of course assignments (non-graded), and participant observations in the classroom and labs. The mixed methods design was chosen because it offers a holistic understanding of both students' learning experience and outcomes.

Pre- and post- surveys were implemented as a formative measure for the evaluation of student learning outcomes and motivational constructs. Formative measures for the study were developed by a team of faculty members consisting of two engineering faculty members and one external evaluator. One of the two engineering faculty members was the ENGR 3999 course instructor. Survey questions were created based upon ENGR 3999 course objectives and learning outcomes. The last two questions (survey questions 10 and 11) measured two key motivational constructs of interest. In 2018, the research team made a slight revision in the pre and post surveys reflecting the changes in the course curriculum and related lab experiences.

Three types of qualitative data—student journals, class and lab observations, and focus group interviews—were collected each year. The evaluation team members made at least two observations—one lecture class and one laboratory activity. Each observation lasted the entire class period and therefore took about one hour and 15 minutes. Four reflective journal entries were collected from each student throughout different periods of the semester. Students were asked to reflect on their expectations of the course, the most helpful and challenging aspects of the course, and what they learned after successful completion. By the end of the semester, the research team also conducted four to six focus group interviews with students. Each focus group interview had 2 - 5 engineering students enrolled in the course. Each focus group interview lasted about 20-30 minutes and was based on a loosely structured interview protocol listing several key questions about their overall experiences during the course. All interviews were audio-recorded for verbatim transcription later

Table 2: Student Enrollment in ENGR 3999

Year	Number of Students	Number of Veterans	Male Students	Female Students
2015	30	3	24	6
2016	30	4	26	5
2017	30	4	24	6
2018	20	3	15	5
2019	21	1	20	1

The entire sample accumulated by the evaluation team consisted of 131 engineering students enrolled in the ENGR 3999 course in 2015 through 2019. Since the course was designed for upperclassmen, almost all student enrolled in the course were juniors and seniors. Each class size ranged from 21 to 30 and three or four veterans were enrolled in the class each year except 2019. While most students were male, five to six female students were also enrolled in the class each year except the 2019 semester. (See Table 2). The enrollment drop in 2018 was caused by a

change in the enrollment cap in order to provide a more meaningful lab experience for the students. The drop in veteran students in 2019 was due to a scheduling conflict with a required junior level class that a majority of the veterans students were enrolled in.

Results

To evaluate positive outcomes in student learning, a paired t-test was conducted for each objective (see Tables 3 and 4). There is a statistically significant difference between the mean scores of pre-surveys and post-surveys for all five objectives throughout the five years. The only exception was the last construct (students' intent to pursue science and technology careers opportunities in the military) in 2019 surveys. The results suggest that the objectives of the course curriculum were successfully obtained. Engineering students in the course increased their knowledge on military technology applications, as well as their interests in pursuing science and technology careers in the military.

The qualitative data showed that students enjoyed many activities in the ENGR 3999 course, expanded their knowledge of military technology applications, and fostered an interest in engineering jobs in the military. Their most favored activities included participation in lab experiments, guest lecturers, group discussions, and varying lab topics. Majority of students identified the hands-on experimental labs as the most important factor contributing to their positive learning experience and effective learning outcomes in the course.

"There are many things that the nature of this class provides that you cannot get in the conventional classroom. The lab style environment of this class is very fun and interactive in a way that the normal 'death by Powerpoint' classroom is not."

"The best thing about the class is the experiments. Experiencing the hands-on approach to experiments is very interesting and is more engaging and educational than just a lecture. I find these particularly helpful because I learn by doing."

Engineering students also indicated that the special lectures by invited guest speakers from NAVAIR and Navy Nuclear were both enjoyable, educational, and beneficial to information retention. They acknowledged that presenters and industry contacts afforded by this class facilitated professional networking and internship opportunities for them.

"I also really enjoyed the guest lecturers so far. These guests helped me to obtain multiple perspectives/opinions of the class topics, which is important to me. They have provided insight into what daily life is like in careers that I knew little about, so this was beneficial to me."

"I have especially enjoyed the guest speakers. Their personal experiences allowed me to have a better understanding of how these technologies can be applied to real-world problems."

Table 3: Pre-Post Survey Means, Standard Deviations, and p-value (2015-2017)*

Year		2015			2016			2017		
Concept	Survey	Mean	SD	P-value**	Mean	SD	P-value	Mean	SD	P-value
Student knowledge of water and wind tunnels	Pre	1.45	0.91	0.00	1.46	0.96	0.00	1.32	0.65	0.00
	Post	3.96	0.40		4.07	0.73		3.82	0.79	
Student knowledge of military technology application	Pre	2.03	1.11	0.00	2.06	1.03	0.00	1.64	0.83	0.00
	Post	4.55	0.37		4.55	0.64		4.37	0.71	
Student knowledge of mechanical system damage	Pre	2.68	1.24	0.00	2.84	1.06	0.01	1.98	0.84	0.00
	Post	4.49	0.32		4.17	0.68		4.06	0.84	
Student interests in science and technology career opportunities in the military	Pre	2.26	1.27	0.00	2.31	1.14	0.01	2.41	1.22	0.00
	Post	4.71	0.21		4.59	0.57		4.58	0.58	
Students' intent to pursue science and technology careers opportunities in the military	Pre	2.74	1.427	0.002	2.86	1.16	0.01	2.85	1.26	0.00
	Post	3.90	0.90		3.96	1.10		3.25	1.29	

Table 4: Pre-Post Survey Means, Standard Deviations, and p-value (2018-2019)*

Year		2018			2019		
Concept	Survey	Mean	SD	P-value**	Mean	SD	P-value
Student knowledge of water and wind tunnels	Pre	1.54	0.69	0.00	1.18	0.36	0.00
	Post	3.60	0.62		4.04	0.62	
Student knowledge of military technology application	Pre	2.35	1.01	0.00	2.02	0.63	0.00
	Post	4.33	0.48		4.36	0.48	
Student knowledge of mechanical system damage	Pre	2.72	1.05	0.00	2.36	0.70	0.00
	Post	3.86	0.73		3.72	0.83	
Student interests in science and technology career opportunities in the military	Pre	2.72	1.10	0.00	2.44	1.20	0.00
	Post	4.67	0.58		4.44	0.51	
Students' intent to pursue science and technology careers opportunities in the military	Pre	2.50	1.31	0.004	3.39	1.14	0.4660.00
	Post	3.06	1.32		3.61	0.98	

*The pre and post surveys used in 2015, 2016, and 2017, were identical and the 2018 and 2019 surveys were a revised version.

**p<.01 (two-tailed test)

What is most noteworthy is that the multi-faceted learning strategies (combining a lecture with active lab engagement, shared leadership among the course instructor, veteran teaching assistant, and invited speakers) implemented by course instructors contributed to students' positive course experience and learning outcomes. Students reported that they enjoyed the dual nature of the course that allowed them to apply the information learned through lectures. Students also felt as active agents of learning. During their laboratory activities they were able to apply the knowledge, skills, and competencies required by professional engineers. By engaging in these exercises that required them to problem solve, experiment, work in teams, lead, and report their findings, students' application of theory increased their self-competency and proficiency with technology design, trouble-shooting strategies, and real-world applications of military technology.

"I enjoyed the way that this was structured, by first teaching us about the robustness of wireless networks, then showing us first-hand how such networks could operate. Now I feel confident in explaining and having a conversation with someone about the basics of sensor communication, and data acquisition, along with how these things can be applied to military technology."

"This balance between formal lectures and application of what has been taught is very conducive to learning new material well and retaining that knowledge. Being able to physically see what was taught about in theory is a major help to each student's understanding of the material."

Qualitative data also revealed that student veterans enrolled in the course had the opportunity to develop a connection with their program of study through a sense of familiarity in utilization of military experiences and trainings. The class provided a unique opportunity to non-veteran engineering students to understand the wide range of military technology applications. The instructor also actively invited student veterans to share their knowledge and experience when they have prior experience with the technology under discussion. One non-veteran student and one student veteran clarified this converging point.

"This very unique course gives students the opportunity to be exposed to a large variety of technologies, many of which are used in military applications. Not many students are given exposure to the wide array of topics covered in the course and it certainly gives the students that take this course an edge above others for familiarity."

"Just because I had worked with some of these systems, and some of these, uhm, air craft and stuff like that. I just wanted to find out more about it with a deeper interest. And plus as an engineering major now, it's been my interest since I was in the military, and I'm still pursuing air craft positions now in an aircraft field as an engineer. A lot of things relate to the same thing."

Through enrollment in the ENGR 3999 course, student veterans have an opportunity to develop a connection with their program of study through a sense of familiarity in utilization of military experiences and training. The learning outcome surveys were anonymous, so it is hard to examine any difference between non-veteran and veteran students. Yet, veteran students often expressed their prior military experience had helped contextualize the course contents during focus group interviews. Naturally, as compared to non-veteran students, student veterans were more knowledgeable about science and engineering careers in military. They also had a strong military identity and willingness to stay connected to the military. Based on this information, it is highly likely that student veterans had a higher score on some related items in the pre-survey

Furthermore, interview data revealed that non-veteran students appreciated the experiential knowledge brought by student veterans and gained significant learning experiences through authentic interactions and shared training experiences with student veterans.

“When veterans talk about some applications they have firsthand experience on and if it worked or not, it allows me to see things from a different perspective. This new perspective lets me try to figure out or listen to why that specific application didn’t work so well.”

The experiential learning component of the course also led to collaboration between veteran and non-veteran students, affording them to have a unique, mutually beneficial experience in group discussion. One Marine veteran stated,

“Yeah, I liked the idea that in every lecture a lot of people had input on it. Rather it was veteran students or non-veteran students, our professor, or TA. . . like everyone had a different point of view. A lot of people in the class had hands-on experience with something. One of the guys had hands-on experience with carbon fiber with Boeing, I think. Everybody had a little bit of something else to throw into the group and chime in on different subjects, and again not just the veteran students.”

Discussion

The results of this evaluation research provide strong evidence that the ENGR 3999 course had positive impact on students’ learning of military technology and increased their motivation/interest in military technology careers. Results from quantitative and qualitative data sets measure the effectiveness of the ENGR 3999 course in teaching engineering students about military engineering technology and its application in the field. A mixed-method research design also provided a solid evidence for the positive impact of the innovative curriculum design and constructivist pedagogical approaches. Through active engagement and participation in the ENGR 3999 course, both veteran and non-veteran students received the opportunity to increase their knowledge and awareness of military-related technology and tools. This observed learning effectiveness can be linked to the Constructivist framework that highlights students’ ability to actively construct knowledge and application of knowledge [4]. Students ability to actively construct knowledge in the ENGR 3999 course and to apply their emerging knowledge through lab experiences reflects all four essential elements advocated in experiential learning—concrete experience, reflection, conceptualization, and experiments [9].

This course continues to be updated, offered and assessed each Fall semester. Based on the success of the course, the format is being considered for other undergraduate courses.

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References

- [1] UNCC Undergraduate Admissions. University profile, Fall 2019, 2019.
<https://admissions.uncc.edu/about-unc-charlotte/university-profile>, Last accessed on 2020-1-15.
- [2] Student Affairs Research and Assessment Team. Final report: 2019 veteran student services needs assessment. 2019.
- [3] Mohammad Ayub Khan and Laurie Smith Law. An integrative approach to curriculum development in higher education in the usa: A theoretical framework. *International Education Studies*, 8(3):66–76, 2015.
- [4] Jerome S Bruner. *Beyond the information given: Studies in the psychology of knowing*. WW Norton, 1973.
- [5] Lee Shulman. Knowledge and teaching: Foundations of the new reform. *Harvard educational review*, 57(1): 1–23, 1987.
- [6] Moti Frank, Ilana Lavy, and David Elata. Implementing the project-based learning approach in an academic engineering course. *International Journal of Technology and Design Education*, 13(3):273–288, 2003.
- [7] Lev Semenovich Vygotsky. Thought and language (translated and edited by alex kozulin), 1986.
- [8] Patrick Felicia. *Handbook of research on improving learning and motivation through educational games: Multidisciplinary approaches: Multidisciplinary approaches*. iGi Global, 2011.
- [9] David A Kolb. Experience as the source of learning and development. *Upper Sadle River: Prentice Hall*, 1984.
- [10] Jennifer A Moon. *A handbook of reflective and experiential learning: Theory and practice*. Routledge, 2013.
- [11] Student Affairs Research and Assessment Team. Final report: Veteran student services needs assessment - spring 2018. 2018.
- [12] John W Creswell and J David Creswell. *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications, 2017.