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Noah Salzman
Boise State University

Thad B. Welch
Boise State University

Harish Subbaraman
Boise State University

Cameron H.G. Wright
University of Wyoming

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Dr. Noah Salzman, Boise State University

Noah Salzman is an Assistant Professor at Boise State University, where he is a member of the Electrical and Computer Engineering Department and IDoTeach, a pre-service STEM teacher preparation program. His work focuses on the transition from pre-college to university engineering programs, how exposure to engineering prior to matriculation affects the experiences of engineering students, and engineering in the K-12 classroom. He has worked as a high school science, mathematics, and engineering and technology teacher, as well as several years of electrical and mechanical engineering design experience as a practicing engineer. He received his Bachelor of Science degree in Engineering from Swarthmore College, his Master's of Education degree from the University of Massachusetts, and a Master's of Science in Mechanical Engineering and Doctorate in Engineering Education from Purdue University.

Dr. Thad B. Welch, Boise State University

Thad B. Welch, Ph.D., P.E. received the B.E.E., M.S.E.E., E.E., and Ph.D. degrees from the Georgia Institute of Technology, Naval Postgraduate School, Naval Postgraduate School, and the University of Colorado in 1979, 1989, 1989, and 1997, respectively. He was commissioned in the U.S. Navy in 1979 and has been assigned to three submarines and a submarine repair tender. He has deployed in the Atlantic Ocean, Mediterranean Sea, and the Arctic Ocean.

From 1994-1997 he was an Instructor and Assistant Professor teaching in the Electrical Engineering Department at the U.S. Air Force Academy, Colorado Springs, CO. During 1996-1997 he was recognized as the Outstanding Academy Educator for the Electrical Engineering Department.

From 1997-2007 he was an Assistant Professor, Associate Professor, and Permanent Military Professor teaching in the Electrical Engineering Department at the U.S. Naval Academy, Annapolis, MD. During 2000-2001 he was recognized as the Outstanding Academy Educator for the Electrical Engineering Department. During 2001-2002 he received the Raouf outstanding engineering educator award. During 2002-2003 he was recognized as the Outstanding Researcher for the Electrical Engineering Department. He was an invited scholar at the University of Wyoming, fall 2004, where he was recognized as an eminent engineer and inducted into tau beta pi. In 2006 he co-authored "Real-time Digital Signal Processing, from MATLAB to C with the TMS320C6x DSK" which was translated into Chinese in 2011. The second edition of this text was published in 2012 and the third edition was published in 2017.

From 2007-2010 he was Professor and Chair of the Electrical and Computer Engineering Department at Boise State University, Boise, ID. From 2011-2012 he was the inaugural Signal Processing Education Network (SPEN) Fellow. From 2012-2014 he and his wife lived with 20 engineering students in the engineering residential college (ERC) on the Boise State campus.

His research interests include real-time digital signal processing (DSP), the implementation of DSP-based systems, and sustainable energy systems.

Prof. Harish Subbaraman, Boise State University

Dr. Harish Subbaraman joined the Electrical and Computer Engineering Department at Boise State University in the Fall of 2016. Prior to that, he was a senior research scientist at Omega Optics in Austin, TX, where he worked on printed and flexible photonics and electronics; and silicon and polymer based optical interconnects. He completed his B.E. in Electronics and Communication from Chaitanya Bharathi Institute Of Technology in India. He earned his M.S. in 2006 and his Ph.D. in 2009, both in Electrical Engineering from The University of Texas at Austin. Dr. Subbaraman's current research areas include ink-jet printing and silicon nanomembrane based flexible electronic and photonic devices; fiber-optic sensors; optical true-time-delay; phased array antennas; RF photonics; polymer photonics; and slow-light photonic crystal waveguides. He has served as a PI and Co-PI on several federal and state grants. Dr. Subbaraman has 5 issued and pending patents and has over 120 publications in refereed journals and conferences. He is a member of IEEE, SPIE, and OSA.

Dr. Cameron H. G. Wright P.E., University of Wyoming

Cameron H. G. Wright, Ph.D., P.E., is a Professor with the Department of Electrical and Computer Engineering at the University of Wyoming, Laramie, WY. He was previously Professor and Deputy Department Head in the Department of Electrical Engineering at the United States Air Force Academy, and served as an R&D engineering officer in the U.S. Air Force for over 20 years. He received the B.S.E.E. (summa cum laude) from Louisiana Tech University in 1983, the M.S.E.E. from Purdue University in 1988, and the Ph.D. from the University of Texas at Austin in 1996. Cam's research interests include signal and image processing, real-time embedded computer systems, biomedical instrumentation, and engineering education. He is a member of ASEE, IEEE, SPIE, BMES, NSPE, Tau Beta Pi, and Eta Kappa Nu. His teaching awards include the University of Wyoming Ellbogen Meritorious Classroom Teaching Award (2012), the Tau Beta Pi WY-A Undergraduate Teaching Award (2011), the IEEE UW Student Branch's Outstanding Professor of the Year (2005 and 2008), the UW Mortar Board "Top Prof" award (2005, 2007, and 2015), the Outstanding Teaching Award from the ASEE Rocky Mountain Section (2007), the John A. Curtis Lecture Award from the Computers in Education Division of ASEE (1998, 2005, and 2010), and the Brigadier General Roland E. Thomas Award for outstanding contribution to cadet education (both 1992 and 1993) at the U.S. Air Force Academy. He is an active ABET evaluator and an NCEES PE exam committee member.

Using Veteran's Technical Skills in an Engineering Laboratory

Abstract

After years of dissatisfaction with student knowledge and ability to use electrical test and measurement equipment (T&ME), a veteran with significant expertise using this equipment was placed in a Circuit Analysis Lab. This paper reports on this trial and its assessment results. Based on the overwhelming success of this program, this one-semester trial was extended for a second semester.

Introduction

The ECE faculty at Boise State University has experienced an extended period of dissatisfaction with poor student knowledge and poor use of electrical test and measurement equipment (T&ME). Typically, graduate students were used as lab assistants, but the majority of these graduate students had only slightly more experience with electrical T&ME than the students they were tasked with helping. This problem became even worse when budget cuts prevented the replacement of the only electrical T&ME experienced technician on staff (after his retirement), even though this technician was primarily tasked with T&ME repair and calibration instead of laboratory support and instruction.

These issues combined to create a significant problem for the ECE curriculum. Specifically, the four-semester circuit/lab intensive sequence represents half of the required course sequence, as well as providing the basis for the two-semester senior design capstone sequence.

Background

In [1], Rabb, et al., introduced the idea of using veterans in leadership roles in the classroom. This reference emphasized the leadership capabilities of veterans and how they could fulfil a significant role in facilitating organizational activities and eventual success.

To address the T&ME problem and build upon the ideas put forward in [1], a current engineering student who was also a veteran with significant electrical T&ME experience was sought out. The veteran expert was *only* helping with the electrical T&ME. Other responsibilities, such as lab setup or grading, were handled by a traditional teaching assistant and laboratory instructor. The veteran lab instructor assisted in all lab sessions and provided limited outside assistance as well and was paid $1,500 for the semester. This was all made possible by a newly mandated upper-division classroom fee structure, which enabled a number of previously unfunded educational ideas to be implemented.

This paper describes the results of a one-semester trial starting with our Circuit Analysis lab. This is the first lab in which traditional electrical T&ME (e.g., oscilloscopes, power supplies, digital multimeters, etc.) is used. This lab had 23 students enrolled, a traditional Lab TA, and an experienced professor supervising the lab.

Methods

In order to assess the effectiveness of having a veteran with significant T&ME experience assisting in an introductory circuits analysis lab, the veteran (John, a pseudonym) was interviewed, and data from the students in the lab via an end of course questionnaire was collected. The semi-structured interview with John explored his experiences learning about and using T&ME equipment in the military, how he was able to utilize those experiences in the classroom, and the benefits and challenges he found working in the laboratory. To assess John's impact on the students, a paper and pencil end-of-course questionnaire that focused on the students' interactions in the laboratory working with John, and how they benefited from his expertise was administered. Of the 23 students enrolled in the lab, 22 returned the questionnaires.

The interview with John was recorded and professionally transcribed, and subsequently analyzed using thematic analysis [2] to identify ways that he was able to leverage his experiences in the military to help undergraduate electrical engineering students learn how to use test and measurement equipment, the challenges that he faced in the classroom, and how he felt he benefited from the experience. Similarly, we also analyzed the student questionnaires to assess the effectiveness of having John in the lab, and how John was able to use his military experience to assist the students in the lab.

Interview Results

While John did receive some formal training in using T&ME when he joined the Air Force, he primarily learned to use the equipment as part of his responsibilities related to satellite communications.

> I guess when I joined the Air Force, they put me into a group field called RF Transmission Systems, like radio frequency transmissions. We all go to Mississippi and we learn our job there, our technical training. The first week, we get put in to learn test equipment. We learn the oscilloscope, the signal generator, five other pieces of equipment we use. That was a weeklong training. After that, my first duty station just happened to be Ramstein (Germany) where we did satellite communications. I used a lot of the spectrum analyzer, monitoring set links so we could see, each peak on it was basically a link that we connect to. That's pretty much how it helped me learn the equipment.

John attributed his expertise with T&ME to his years of experience working with this equipment. He has worked with many different types and variations of T&ME and is not intimidated by the equipment. This is a very different experience than a typical student laboratory assistant, who typically would have much less experience with a more limited range of T&ME.

> I guess just experience with the actual equipment. I look at it from most people's perspective. When you walk in, there's like four pieces of equipment with what looks like 1,000 knobs. I've seen the equipment and I've seen different versions of it…Most people, yeah, they haven't seen anything like this. I think just being familiar and having, what,

> five years, in the military. I've used it for like five years, versus most people, what is a semester, like four months?

In addition to having familiarity with using T&ME developed over his years of experience in the military, John also provided students with real-world examples of the importance of being able to use the equipment. He contrasts his experience with the practical use of T&ME, versus the experience of students who have only used this equipment in an academic setting.

> I think if someone similar to me who has a lot of experience with the equipment versus someone who's just taken [the course] and just trying to help do the same job. I think I offer more of a practical use with it. I don't think the students, and even the students now, really understand how you can use the equipment in a real thing. I probably should focus more on that sometimes. When they ask about how to do something, I'm like, "It's important to know it," if you ever take a radio apart and you have to do a modulation test on it, you have to use the oscilloscope. You have to inject the frequency in it.

While John was able to use his experiences with T&ME to help the students in the laboratory be successful, being in the laboratory also helped him to be more confident in using the knowledge and skills he learned as an engineering student.

> I didn't really know how much I knew about circuit analysis until I helped with the lab. You remember doing it and stuff, but then when students ask me a question about, like, transfer functions, it's like, "Oh." Now I think back when I learned it. I remember. I actually know how to help them and stuff. You could take tests all day. It's like, "Okay," but when you actually talk about the stuff, it's like, "Oh." You think about it, it's like, "I kind of know what I'm talking about." I'd definitely say it benefits me as much as it benefits them. It helps me stay fresh on this stuff and then they get a good experience out of it as well.

The most significant challenge that John encountered in the laboratory was learning to embrace the role of an instructor and fight the tendency to want to fix students' problems by doing things himself. However, he came to realize that it was necessary for him to adopt a more hands-off approach in order for the students to learn.

> I would say the biggest challenge is not doing it just by myself. If someone has a question, especially with breadboard stuff, a lot of them ask questions and it's more of like, "We can't get our breadboard configured right." I guess a challenge would be to step back and be like, "Well just rebuild it," versus looking through and maybe even moving some wires around. Maybe something like that. It's really easy for me to just configure it. Then it's like, "Oh, there we go." Maybe just pull back a little bit. They're there to learn and to build the circuit. If I build the circuit for them, what do they really accomplish? Nothing.

Overall, John was able to use the training and experience he received in the Air Force to help students be successful learning how to use T&ME in an undergraduate Circuit Analysis laboratory. His experiences allowed him to provide real-world examples to motivate students to

learn how to use T&ME and felt that his experiences allowed him to provide a unique and valuable perspective compared to a traditional undergraduate laboratory teaching assistant. Helping students learn to use T&ME also helped him to recognize his own expertise, and gain confidence in his understanding of electrical engineering concepts. While he found it challenging at times to not do things himself when helping students, he came to realize that taking a more hands-off approach resulted in better learning experiences for the students.

Results from Student Questionnaires

22 students returned the end of course questionnaire, with 20 students indicating that they felt John was very helpful in the laboratory, with the remaining two responses not recognizing John as being significantly different or more effective than a non-veteran teaching assistant. Of the 20 positive responses, 13 students explicitly mentioned that John was helpful with learning the test and measurement equipment. The students said he "knew equipment very well", "was well informed and prepared", and "he understood the lab equipment at a much higher level, allowing him to diagnose the problems we were having."

Seven students explicitly mentioned and appreciated John's ability to help with troubleshooting in the laboratory. A student wrote:

> The many different problems encountered in our lab environment are very similar to the myriad of complications military technicians encounter in the field. [John's] ability to adapt to evolving situations made him instrumental in troubleshooting lab equipment and circuit components.

Another student also recognized the value of John's military experience, stating, "He has great troubleshooting skills, which takes time and deep understanding to acquire. I'm sure he got some of this from the military." The students also appreciated John's real-world experience working with test and measurement equipment, and his ability to "show us some tricks and tips we didn't learn in the lab."

Finally, responses on four of the questionnaires mentioned availability, both the ability to work with John outside of normal laboratory hours and having an extra person in the lab who was able to answer questions. A student said "He was always available to help", while another said "it was very helpful to have an extra person walking around helping people during labs after seeing how many problems there were during the course of the lab." Overall, the students felt that they benefited greatly from John's expertise and experience working with test and measurement equipment, and his willingness and availability to share that expertise in the laboratory.

While not formally assessed as part of this research, the laboratory instructor and other faculty members felt that the students had a better understanding of T&ME and more confidence using it as a result of John's assistance in the laboratory. The teaching assistant in the laboratory also felt that his T&ME skills improved as a result of working with John.

Conclusions

The survey results indicated that students felt it was extremely helpful to have a veteran with significant T&ME experience in the laboratory, while the veteran appreciated the opportunity to utilize his experience to help others be successful. Additionally, the veteran stated that he felt much more confident in his knowledge and skills after this experience. While a non-veteran with significant professional T&ME experience may have had a similar effect on student performance in the laboratory, historically these students are rare and tend to be part-time students already employed in industry and thus not a good source of fulfilling the need in the laboratory for a person skilled in T&ME. Similarly, John's T&ME experience and expertise far exceeds those of a typical laboratory teaching assistant, making his presence much more valuable than just having an additional person in the laboratory.

Anecdotally, the experienced professor, tasked with facilitating this first ECE T&ME laboratory experience, stated that the students did much better on both the labs and during the lab practical exams/exercises. Additionally, the extra help in the lab never left a student group waiting to have their questions answered.

Based on the overwhelming success of this program, this one-semester trial was extended for a second semester. The same veteran returned to help the new incoming class of students in their first T&ME intensive lab. Additionally, the veteran expert also followed the first semester's students into their second lab course, helping to remediate any student who fell short of equipment utilization expectations.

The employment of student veterans with unique technical skills is being discussed with all of the academic departments within the College of Engineering and the success of this trial will improve the effectiveness of engineering laboratory education. Veterans possess a wide range of practical and technical skills as a result of their military training and education. The results of this study suggest that their experiences can complement those of traditional teaching assistants and instructors in undergraduate engineering laboratories to improve student achievement.

References

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