122nd ASEE Annual Conference & Exposition
June 14 - 17, 2015
Seattle, WA
Making Value for Society

Paper ID #13599

Student Learning in Challenge-based Ocean Engineering Project

Prof. Shyam Aravamudhan, North Carolina A&T State University

Shyam Aravamudhan is an Assistant Professor and Graduate Coordinator of Nanoengineering at the Joint School of Nanoscience and Nanoengineering (JSNN), North Carolina A&T State University. Shyam received his PhD in Electrical Engineering (2007) from University of South Florida, Tampa, FL. Shyam previously worked as a Visiting Research Fellow at the Centers for Disease Control & Prevention (Emergency Response and Air Toxicants Branch in the Division of Laboratory Sciences) and as a Post-doctoral Fellow in Biomedical Engineering (Neuroengineering) at the Georgia Institute of Technology, Atlanta, GA

Student Learning in Challenge-based Ocean Engineering Project

Introduction

It is increasingly being realized by educators that when students are posed with challenges, it can motivate them to explore and seek the desired science, technology, engineering and mathematics (STEM) knowledge and skills. This type of education is called Challenge-Based Instruction (CBI). Studies have suggested that CBI, as compared to traditional approaches can increase students' conceptual knowledge and their ability to transfer acquired knowledge to newer situations [1-3]. Furthermore, exposure to real-world challenges, especially when presented in an active and practical learning environment increases both student interest and pedagogical effectiveness. The National Academy of Engineering (NAE) in its report, "Educating the Engineer of 2020," contends that solving the Grand Challenges will require more than just providing students with technical training. It argues that an engineering education must produce graduates who combine technical excellence with a multitude of other skills including communication, teaming, ethical reasoning, and contextual analysis. Students without exposure to real-world projects during the course of the technical education may neither develop these important skills nor gain sufficient motivation to pursue careers in engineering. We therefore believe that the introduction of challenge-based engineering curricula and/or projects will create a favorable atmosphere for creativity, innovation, increased participation and teamwork.

In this paper, we present the experiences and student learning outcomes when a group of undergraduate students from diverse science and engineering disciplines (non-ocean engineering disciplines) were exposed to challenge-based ocean engineering project. The team consisted of 7 undergraduate students (1 freshman, 2 sophomores, 2 juniors, and 2 seniors) from Mechanical Engineering, Physics, Atmospheric Science and Meteorology, and Computer Science and Technology disciplines. This group of students under the guidance of faculty advisors were tasked to address a specific ocean engineering challenge named Perseus II, sponsored by the Office of the Secretary of Defense's Rapid Reaction Technology Office (RRTO). Briefly, this project involved the design, assembly and demonstration of an Unmanned Underwater Vehicle (UUV), Remotely Operated Vehicle (ROV) or Autonomous Underwater Vehicle (AUV) that is capable of searching for, locating, and collecting information on objects that are potentially unexploded ordnances (UXO). More project details on the vehicle assembly and demonstration can be found in Ref. [4]. The focus of this paper is to report on student outcomes especially on the student's ability for Adaptive Expertise (AE) or learning, as assessed by the faculty advisor. It is important to note this effort will only excite and challenge adaptive learners to tackle problems outside of their comfort zone but also yielded non-traditional and out-of box solutions. The expected outcomes are valuable technical and problem-solving skills, teamwork, project and time management and other soft skills.

Adaptive expertise is the ability to develop advanced technical expertise in a field independent of an ability to innovate when presented with a novel problem to solve. In a seminal work, Hatano et al. distinguishes the two forms of expertise - routine and adaptive expertise [5]. Routine experts, even though are technically proficient in their established domains of knowledge and application, can fail to adapt their expertise in a new context for a novel problem. However, adaptive experts tend to seek out challenges, review multiple solutions and perspectives for new problems and view their knowledge base as dynamic [1]. This paper explores if student exposed to a challenge-based ocean engineering project is likely to develop AE within the project period (of two-semesters in this case). The model proposed by Schwartz et al. that there are two essential and complementary dimensions of AE, namely knowledge and innovation is applied in this case [6].

Challenge-based Ocean Engineering Project (COEP)

The top-level objectives of this challenge-based ocean engineering project were two-fold: (a) respond to a report of potential UXO sighting and search a rectangular area approximately 100 feet by 75 feet with depths of water up to 40 feet for the potential UXO; (b) If potential UXO was located, then (1) provide as precise of a geo-location as possible in order to enable the Explosive Ordnance Disposal (EOD) expert to respond to the exact location and (2) provide as much information as possible on the located object(s) to an EOD subject matter expert (SME) on shore. The goal of providing this information was to enable the SME to assess if the object was potentially dangerous, not dangerous, or potentially so dangerous that perhaps divers should not be in their vicinity. Finally, the project culminated with demonstration of the acquired engineering methods and skills by running the underwater vehicle in a dive lagoon in Key West, FL.

Student Learning Outcomes

The ABET 2015-2016 Criteria for Accrediting Engineering Programs, Criterion 3, Student outcomes (a-k) specifically lists the general set of expected outcomes that may be articulated by a program. In this challenge-based project, a number of learning outcomes have been impacted through means of adaptive expertise or learning.

Outcome 1: COEP impact on “an ability to apply knowledge of mathematics, science, and engineering.” The top level objectives provided to the student team were purposely generalized and not directive in nature in order to encourage not only non-traditional and out-of-box solutions but also to give students space to innovate and think creatively, while applying already acquired science and engineering knowledge. COEP made students to seek out advanced knowledge not usually found in standard books and curriculum. COEP provided the students invaluable inquiry and research experiences.

Outcome 2: COEP impact on “an ability to design and conduct experiments, as well as to analyze and interpret data.” The team was tasked to: (1) identify and examine candidate technologies for the mission, (2) document information and methods (including those selected and rejected), (3) select enhanced detection methods and calculate required power, vehicle weight, buoyancy and propulsion requirements, (4) develop potential course of action and timelines, (5) document vehicle design, trade-offs and challenges during the process, (6) assemble/build the vehicle, (7) document and cost the “as built” Bill of Materials, (8) do field demonstration, (9) submit a final report of the mission scenario, design, build and test process, including on lessons learned and recommendations.

Outcome 3: COEP impact on “an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.” The strategy of the team was to design and build a simple Remotely Operated Vehicle (ROV) using a multitude of commercial off-the-shelf (COTS) components only. The vehicle consisted of two major units – the surface raft and the underwater vehicle with an on-shore RC operator control. Each unit was independently steered and controlled using separate set of underwater thrusters and servo motors. However, both units were connected via a water hose to carry power and communication cables. Further details on the vehicle assembly and demonstration can be found in Ref. [4]. Lastly, the student team also learnt resource and economic optimization, in terms of keeping the system costs to modest levels.

Outcome 4: COEP impact on “an ability to function on multidisciplinary teams.” The overall team was divided into four sub-groups, with each sub-group responsible for one of four thematic areas involved in the project – (1) Mechanical Design (MD), (2) Power and Propulsion (PP), (3) Detection Technologies (DT) and (4) Navigation and Communication (NC). Each sub-group had a thrust leader, along with one or two members. Thrust assignments were based again on interest, background and tenacity. Overall, co-leaders were elected to be responsible for team management, decision making and resolving conflicts. COEP helped establish greater degree of interaction among students from diverse disciplines. A culture of working in small groups towards a larger problem was inculcated. Each student learned a lot working on their tasks and came away with a better understanding of the challenges and how their specific tasks tied into the greater accomplishments of the group.

Outcome 5: COEP impact on “an ability to communicate effectively.” A number of hard and soft communication skills were nurtured over the course of the project including document preparation for preliminary design review (PDR) and critical design review (CDR), trade-offs and challenges, bill of materials, power point and poster presentation to DOD personnel, project management, time scheduling and final report of mission scenario, design, build, testing, lessons learned and recommendations for future work.

Outcome 6: COEP impact on “a knowledge of contemporary issues.” The student team learnt on about a current, real-time scenario involving unexploded ordnance (UXO). There are estimates UXO of over 200 million pounds of on ocean/sea floor around the world and millions in US. UXO ranging from WWII mines to small arms munitions have been found by recreational swimmers, divers and fishermen.

In summary, this challenge-based ocean engineering project based on a real-life problem was able to put the students in a situation where both fundamental knowledge and raw innovation came in handy to sort out the problem at hand and arrive at a solution. Students found it difficult and demanding at the beginning, however I believe that challenge-based instruction is extremely essential to prepare them as adaptive and life-long learners.

Bibliography

1. Martin, T., Rivale, S. D., & Diller, K. R. (2007). Comparison of student learning in challenge-based and traditional instruction in biomedical engineering. Annals of Biomedical Engineering, 35(8), 1312-1323.

2. Pandy, M., Petrosino, A, Austin, B. and Barr, R (2004). Assessing Adaptive Expertise in Undergraduate Biomechanics. Journal of Engineering Education, 93(3), 211-222

3. Barr, R.E., Pandy, M.G., Petrosino, A.J., Roselli, R.J., Brophy, S., and Freeman, R.A. (2005). Challenge-Based Instruction: The VaNTH Biomechanics Learning Modules. Advances in Engineering Education. 1(1), 1-30.

4. Aravamudhan, S., Schmidt, D., and Nakhla, H. Challenge-based Engineering through the Design, Assembly and Testing of Underwater Vehicle. 2014 ASEE Annual Conference, Indianapolis, IN

5. Hatano, G., and Inagaki, K. (1986). Two courses of expertise. In: Child Development and Education in Japan, edited by H. Stevenson, J. Azuma and K. Hakuta. New York: W. H. Freeman & Co. 262–272

6. Schwartz, D. L., Bransford, J. D., and Sears, D. (2005) Innovation and efficiency in learning and transfer. In: Transfer of Learning from a Modern Multidisciplinary Perspective, edited by J. Mestre. New Jersey: Erlbaum, 1-51.