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# Impact of STEM Focused Project Based Learning Activities on Career Education for K-12 and Community College Students

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## **AC 2012-3813: IMPACT OF STEM-FOCUSED PROJECT-BASED LEARNING ACTIVITIES ON CAREER EDUCATION FOR K-12 AND COMMUNITY COLLEGE STUDENTS**

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# **Impact of STEM Focused Project Based Learning Activities on Career Education for K-12 and Community College Students**

## **Abstract**

Low enrollment and high attrition rates in Science, Technology, Engineering and Math (STEM) based degree programs have created a workforce problem in industries like shipbuilding and repair which are important for national security. Part of this problem can be attributed to pedagogical issues like lack of engaging hands-on activities utilized for science and math education in middle and high schools. Lack of student interest in technical careers can also be attributed to lack of an integrated approach in teaching math, science and technical education. To engage student's interest in the technical career path, it is important that students establish a link between the theoretical knowledge and its application to solve real life problems early in their learning experience. Project based activities have a proven record as instructional tool. Effectiveness of such activities as a pedagogical tool has been supported by research in the acquisition and retention of knowledge.

Marine Career Tech (McTech) project funded by the National Science Foundation has attempted to address the workforce issues for marine industry by developing instructional modules for community college students and organizing Shipbuilding Repair and Maritime Career Day Events (SBRCDE) to engage K-12 students in STEM careers. The goal is to increase awareness about shipbuilding and repair careers. Four marine kits and four instructional modules were developed under these two grants to encourage creative thinking and keep students engaged in shipbuilding and repair processes. The teacher training component of these projects has provided training in using and implementing these modules. The paper presents the results from community college faculty workshops and from the survey of SBRCDE events.

## **Key words**

Project Based Learning; Workforce Development; STEM Education; Shipbuilding Industry.

## **1. Introduction**

Old Dominion University in collaboration with three community colleges i.e. Mountwest Technical and Community College, South Louisiana Community College and Mid Atlantic Maritime Academy along with marine industry and local school systems are attempting to improve STEM preparation using innovative experiences for students and teachers in nation's major shipbuilding and repair areas through McTech and Shipbuilding Repair and Career Day Events.

The program, led by Old Dominion University aims to advance technician education in marine technology as well as to increase STEM learning and build the STEM career pipeline. McTech project is in the third year of implementation. During year 1, project activities included development of four instructional modules for community college faculty and professional development workshops for 20 community college faculty in each of the three geographical

regions. The goal was to provide instruction and materials for faculty to integrate marine technology topics into their existing courses to increase student knowledge and awareness of the career field.

Year 2 activities included two-day professional workshops for 20 middle and high school teachers in project based learning using marine kits and sea perch robot in each of the three regions. These workshops were taught by two community college faculty who participated in year 1 activities. In addition during the spring of 2011, the Shipbuilding, Repair and Maritime Career Day event (SBRCD) was held in Hampton Roads on March 30, 2011. Approximately 800 students and 70 middle and high school teachers were in attendance. This event serves to disseminate awareness and content knowledge to secondary school students, providing them with career and future study options based on STEM learning in marine engineering, an industry prevalent in the three project regions, but often overlooked in formal schooling, both at the secondary and post-secondary levels. Two additional Shipbuilding, Repair and Maritime Career Day events were held during fall 2011 in West Virginia and Louisiana.

## **2. Need for Project Based Learning (PBL)**

The results from Virginia's Standards of Learning (SOL) assessments reveal that there is an achievement gap between minorities and Caucasians/Asians in all grade levels in Southside Virginia. Achievement gaps may be caused by numerous complex reasons such as economic or psychological conditions, or family-school disconnects beyond a school's control. Nonetheless, many factors such as curriculum, effective instruction, and classroom management are within the control of the school environment and can be changed through organized professional development programs. This project aims to transform the pedagogical practices in the high-need schools by providing training in project based learning. In initial preparation for this project, the principal investigator interviewed many of the instructional specialists from the participating high needs schools. They stated that only a few teachers of physical sciences and chemistry use inquiry-based project-based learning strategies in their classrooms. However, research reveals that inquiry-based learning and project-based learning strategies develop communication, problem-solving, and critical thinking skills and improve student achievement<sup>2</sup>.

## **3. Future Workforce Needs in Marine Engineering and Technology**

Marine engineers and naval architects are expected to experience employment growth of 11 percent in the period 2006 - 2016. Excellent employment opportunities are expected for these professions because of growth in employment, an aging workforce and limited number of students pursuing careers in these occupations. Another flourishing area in the marine field is merchant marine; phenomenal employment growth of 16 percent is expected in this field. There are good prospects in the engineering technician field that also require good STEM skills. Employment growth for environmental engineering technicians over the period of 2006 -16 is expected to be 25 percent. The occupation of an Industrial Engineering Technician is also a high growth area with the employment growth rate of 10 percent<sup>5</sup>. While we are preparing our students to improve their knowledge of math and science and to develop technology skills, it is critical that we provide awareness about various types of STEM careers such as marine

engineering. In this project, teachers will be able to understand about the demand for marine engineers and have an increased understanding about the way students need to enter the career.

#### **4. Survey to Assess Student's Knowledge about Shipbuilding & Repair**

A survey was designed to assess the impact of the SBRCDC activities on the student's knowledge about shipbuilding and repair. This survey contains questions about ships components, ship design and physics principles like buoyancy. Student responses are aggregated and average score is obtained on a scale of 1-10. Students are assessed using the same instrument after they have gone through the four simulation sessions. The difference in the score between the pre and post survey provides a measure of change in the knowledge base of the students.

#### **5. Delivery Method for Instructional Modules**

The course is instructor-led classroom training combined with in-class hands-on activities designed to invite class participation. This approach aids in the individualized instruction given to the participant. Instructional methods include facilitated discussion, hands-on activity, and on-the-job practical applications. PowerPoint presentations are used to deliver the course, supplemented by a series of videotapes from Society of Manufacturing Engineers and Productivity Inc.

#### **6. Professional Development Workshops for K-12 Teachers**

Two-day professional development workshops were held during year 2 of the project in each of the three regions served by the project. Special attention was given to recruit minority a female teachers. The focus of these workshops was to provide K-12 teachers with tools and resources to incorporate project based learning within their classrooms and strategies for implementing them. Day 1 of the workshop covered four marine kit activities are related to operation of a shipyard, ship construction, ship stability and best practices in the shipping operations.

- a) Shipyard Operation Activity simulates operations within a shipyard. Plasma cutting, bending and welding shops are simulated. Students use card stock paper to build a container ship. This simulation demonstrates modular construction of a ship.
- b) Ship Construction Activity simulates construction of a clipper ship and a submarine. This simulation also covers calculations related to bill of material, sales tax and labor cost.
- c) Ship Stability Activity involves the understanding of center of gravity, center of buoyancy, and Archimedes Principle. This simulation uses foam hull shape to conduct experiment to identify center of buoyancy and observe the effect of salinity on buoyancy.
- d) Ship Disaster Investigation simulation involves ship disaster case studies. Students play the roles of Ship Disaster Investigation Agency (SDIA) agents analyzing the ship disaster. They identify possible causes behind the disaster. In this open ended problem based simulation students learn fundamentals of ship design, basic terminology used in the shipbuilding and

shipping industry and the correct practices followed in ship design, construction and shipping industry.

Figure 1 shows the contents of the four Marine Kits.



**Fig. 1 Marine Kits 1-4**

Day 2 of the workshop included Sea Perch building and testing activities. Sea Perch curriculum covers concepts like density, buoyancy, electric circuits, motors and propulsion. The underwater robot was developed at MIT and since then been used in a number of programs nationwide. Figure 2 shows teachers building the Sea Perch robot.



## Figure-2 Sea Perch Activity

### 7. Implementation of SBRC D

Shipbuilding Repair and Maritime Career Day Events (SBRC D) 2011 were organized by the Lean Institute at ODU in partnership with the community colleges in three regions . During the year 2011 and 2012, SBRC D is supported by the Marine Career Tech (McTech) project funded by the National Science Foundation (NSF) to improve the future workforce in shipbuilding and maritime industry. In addition, the event is sponsored by the local shipbuilding, repair and maritime industry.

Shipbuilding Repair and Maritime Career Day Event in Norfolk was held at the Ted Constant Convocation Center in the month of March. About 1,000 students and 100 teachers from different schools in Hampton Roads area participate in this daylong event. Recently Maritime industry component has been added to this event. The event offered an educational and fun-filled environment for middle and high school students to learn about various career pathways and opportunities in shipbuilding, repair and maritime industries.



**Figure-3 Pictures from SBRC D in Norfolk, Virginia**

Figure 3 shows the hands-on activities and the shipyard tours which are part of SBRC D

### 8. Results from Student and Teacher Surveys

Collected data includes:

1. Summer workshop interviews:  $n = 19$
2. Summer workshop surveys:  $n = 30$
3. Summer workshop observations
4. Year 2 instructor survey:  $n = 24$
5. Year 2 Shipbuilding/Career Day student survey pre/post:  $n = 387/157$



The evaluation analyzes these data to help address the project goals:

*Goal 1* To increase relevance and modernize technician education in marine technology.

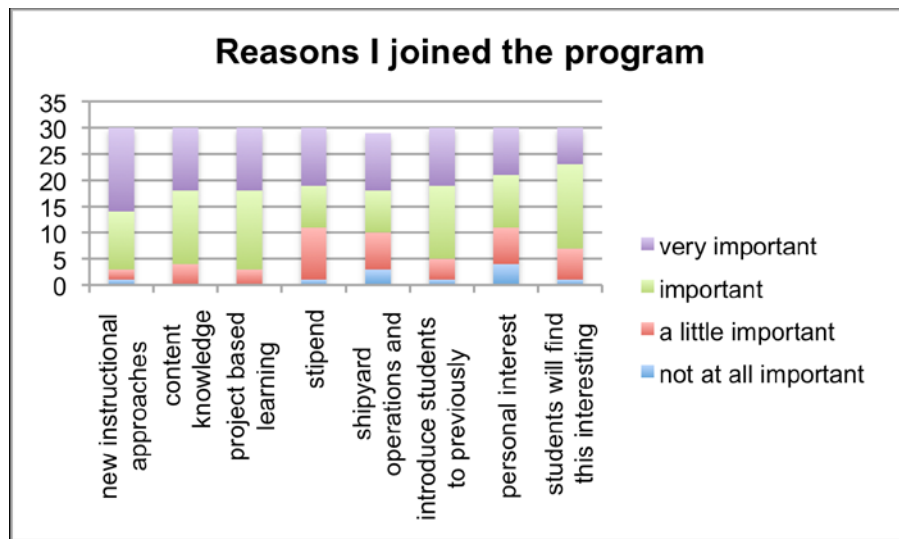
*Goal 2* To equip secondary school teachers with resources and professional development to improve mathematics and science instruction through project based activities in marine engineering and technology.

*Goal 3* Incorporate work-based experiences for both school and community college students in marine industry.

*Goal 4* To attract students towards marine engineering and technology careers to meet the critical shortage of workforce in this area.

For the upcoming school year (2011-12), the project will bring on the participation of middle and high school teachers; 73 over the three regions have been recruited for the summer, 2011 workshops. These teachers will receive instruction and guidance from community college instructors from the Year 2 cohort; providing a local level mentorship model rather than an expert-delivery model of instruction and support. These teachers, in turn, will integrate Marine Career Tech topics, content, and modules into their local instructional practices. During the next year, we expect to collect impact data on middle and high school as well as continued community college knowledge integration related to the project materials.

Dispositions from instructors indicated they were aligned with program goals and the potential to impact their students, as evidenced by reasons they chose to participate:



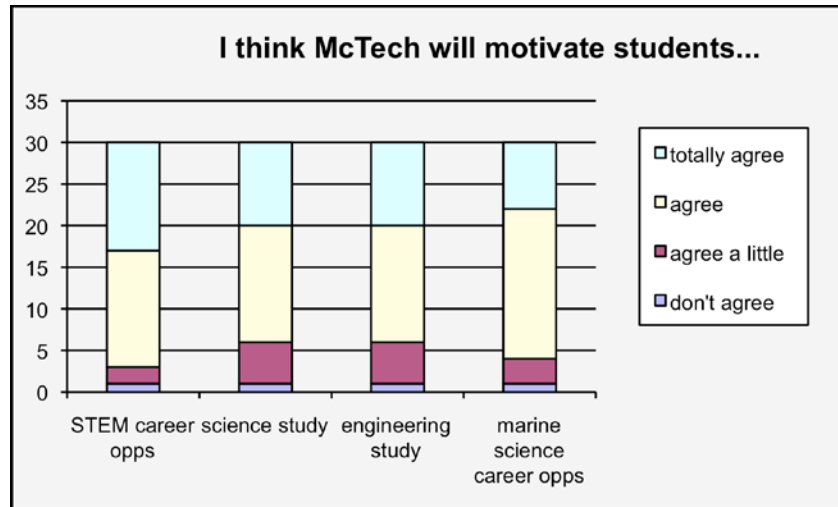
**Figure 4 Reasons I joined the program (sorted by very important)**

The Figure 4, sorted by the highest response, “very important” shows the top reasons as discovering new instructional approaches, content knowledge (suggesting they seek new materials for existing courses and validating the relevance of marine engineering topic), and



engaging project-based learning. Note that while “students will find this interesting” is last on the graph for the “very important” rating, it scores the highest for “important.”

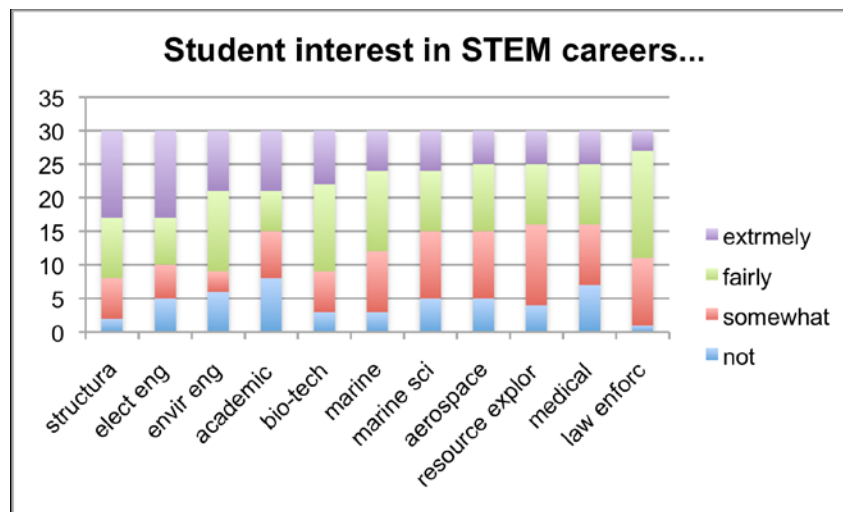
Instructors felt the program would motivate students in a variety of ways:



**Figure 5 I think MCTech will motivate students... (Sorted by totally agree)**

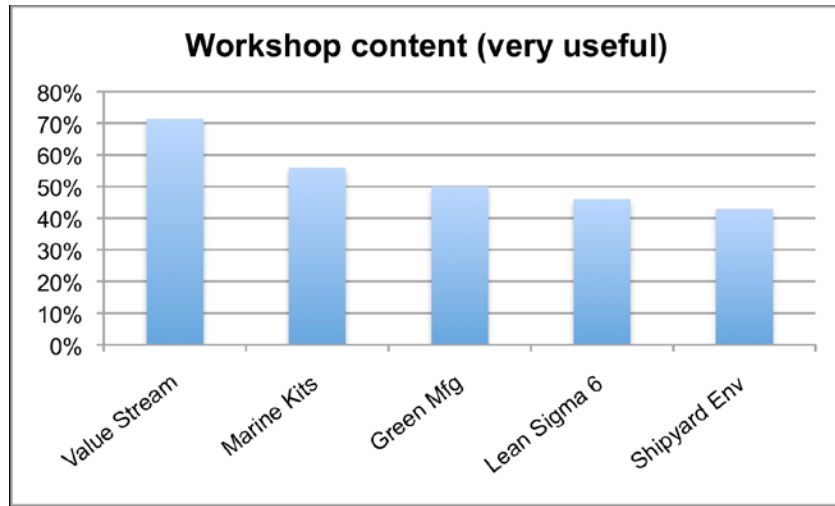
Figure 5, sorted by the highest rating “totally agree” we see STEM career opportunities, followed by science study. Also, while “marine science career opps” is last for the highest rating, it does rank the highest for “agree,” possibly explained by instructors believing the topic to be of great interest but unknown to students at the time.

Regarding instructors’ estimation of their students’ interest in STEM careers, as shown in the figure 6, the areas of structural engineering, electrical engineering, and environmental engineering were rated the highest for the highest rating category “extremely interested:”



**Figure 6 Student interest in STEM careers (sorted by extremely interested)**

Note that the marine fields are in the middle range, suggesting a strong base from which to improve through integration of concepts and activities.

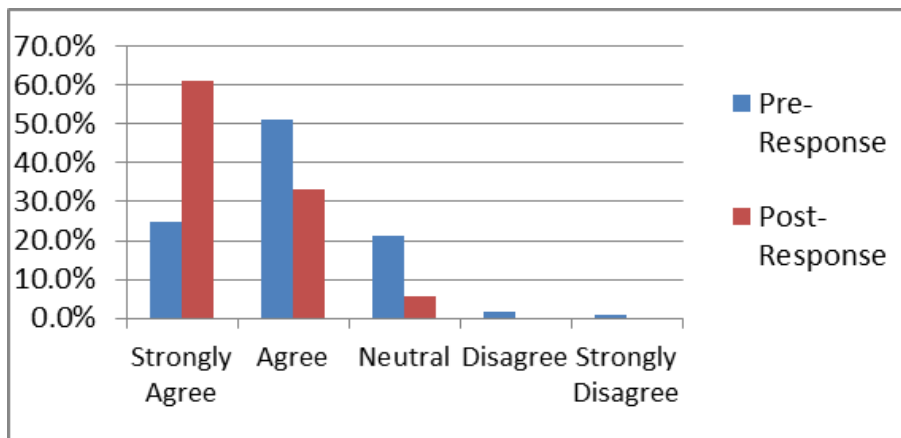


**Figure 7 Usefulness of workshop content (sorted by very useful)**

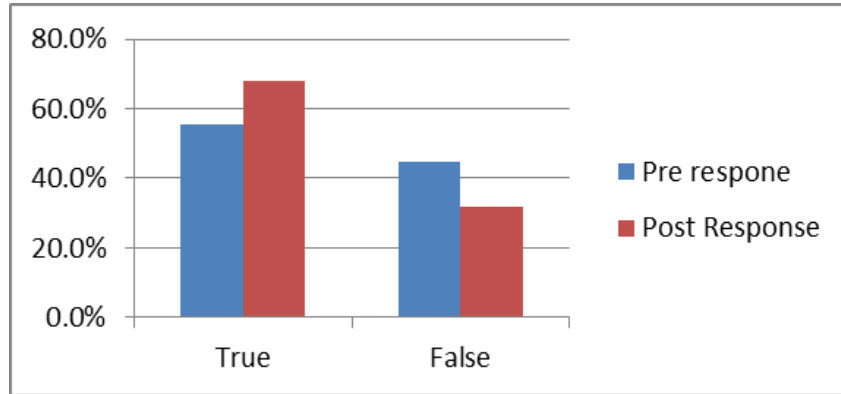
This was further documented as the value of the content to their coursework, in figure 7 measured by usefulness (as compared with the quality of the instructional module or workshop presentation) was validated by instructors. They felt that Value Stream Engineering was the highest, Shipyard Environment the lowest:

These are scores of the highest rating “very useful.” Note that Value Stream Engineering, Green Mfg and Lean Sigma 6 are all generic engineering and manufacturing topics, Marine Kits, specifically designed for the program and a specialized industry, scored second overall; a strong indicator that the material may be relevant to the student communities.

A pre and post survey was conducted to assess impact of SBRC D events on Student disposition about careers in Shipbuilding and Maritime industry. Results are presented in Figure 8 and 9.



**Figure 8 There are lot of career opportunities in the field of ship building and repair**



**Figure 9 I would consider a career in the shipbuilding and repair industry**

Comments from one of the principals indicate the impact McTech project is having on local school divisions. *“I am delighted that each year John F. Kennedy Middle School is invited to participate in the Shipbuilding, Repair and Maritime Career Day. This innovative program uses hand-on activities to provide authentic opportunities for students and teachers to explore marine engineering concepts and careers. Additionally, our school has benefitted from the Marine Tech Sea Perch training. This project allowed our students the opportunity to explore underwater robotics and marine technology.*

*.....Historically, female and minority students are less likely to enroll in these types of courses; therefore we especially promote the STEM courses within these sub-groups. We appreciate your dedication to bringing STEM concepts to all students.*

*I am excited to be a part of these endeavors with ODU. We need innovative programs such as Career Day and Marine Tech for our students to explore STEM fields to prepare for a globally competitive workforce. I am very thankful that the students at John F. Kennedy Middle School have benefitted from these programs.” – Vivian P. Covington, Principal*

## 9. Conclusions

The project has enhanced the technician education by developing instructional modules on four contemporary topics and by training the faculty in its use. In addition, the project has successfully developed and integrated project based learning activities within the middle and high school curriculum. The Marine Kit activities and the Instructional Modules compliment the standards of learning for middle and high schools. The project demonstrates that, learning about ship design, construction, ship operations and ship stability concepts are made easier by incorporating project based learning activities within the curriculum. Open ended problems provide opportunities for group discussion and creative thinking. Student’s comments from course evaluations indicate that students find these learning experiences very enjoyable. Participating community college faculty and K-12 teachers believed that the activities were well designed and will engage students in classroom. In addition, survey results from SBRC event in Norfolk

indicate that as a result of participation in the event, students had a positive change in their disposition towards STEM careers in shipbuilding, repair and maritime industries.

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