Development of an Engineering and Technology Curriculum for Dominican Republic 6-12 Graders*

Steve Shumway, Ph.D.[1], Geoff Wright, Ph.D.[1], SClaudina Vargas, Ph.D.[2], Ronald Terry, Ph.D.[1]
[1]Brigham Young University, USA, steve_shumwayt@byu.edu, gwright@byu.edu
[2]Complex Systems Optimization Lab, USA/DR, scvargas@cosola.org

***Abstract*– This paper contains a report of the collaborative effort between the Brigham Young University (BYU) Technology and Engineering Education (TEE) Program and Complex Systems Optimization Lab (COSOLA) to develop, implement, and evaluate an engineering and technology curriculum for Dominican Republic (DR) 6-12 graders. We present a summary of the curriculum development process, including challenges, successes, and how the program has contributed to advance learning and interest in STEM.**

Keywords— Engineering and Technology, K-12 Curriculum, International Collaboration, Study Abroad, Backwards Design.

I. INTRODUCTION

In 2007, COSOLA instituted the Matemáticas, Ciencias, Ingeniería y Lenguaje (MACILE) education program to help advance engineering and science education in less-advantaged communities in the DR [2]. Two core objectives of MACILE are: (1) to develop solutions to optimally increase access to challenging and stimulating learning environments and quality MACILE resources; and (2) to nurture talented young people from less-privileged backgrounds, guiding them to rise to the highest educational standards, pursue studies and careers in math, science, and engineering fields, and make a difference in the country by furthering science, engineering, and sustainable development.

In 2009, COSOLA and the TEE Program at BYU began a collaborative effort to design a science and engineering program to improve Dominican students' academic knowledge and skills. This collaboration took the form of a study abroad program where BYU students developed curriculum, conducted research, taught, and received credit for participation. From the perspective of BYU, the primary purposes for initiating this collaboration were to provide TEE pre-service teachers an opportunity to engage in an authentic curriculum development (CD) opportunity, develop their teaching and classroom management skills, and to allow BYU students to engage and learn about another culture. For COSOLA, this collaboration with BYU allowed MACILE to introduce a 21st century 6-12 technology and engineering program in a low income and low education region of the DR.

In the summer of 2009, two members of the faculty of TEE visited the DR and spent 3 days training the teachers and observing the conditions [1]. 8 TEE students and three faculty from BYU returned summer 2010 to the DR. They spent 6 weeks, training the teachers and teaching 6th-12th grade students [2]. 12 BYU students and three faulty participated in 2012. In 2014, 16 students and one faculty participated. They spent 5 weeks each summer in the DR teaching 6th–12th grade students, in 2012, and 5th – 12 grade students, in 2014.

Under the supervision of three BYU faculty members, the university students selected to participate, developed the curriculum during spring term and then presented the material during summer term. This paper is based on a three-year implementation of the TEE curriculum. Data results from pre post survey instruments evaluating student understanding and interest in engineering content, concepts, engineering self-efficacy, and future education and career opportunities, as well as satisfaction of the program are presented. Although the data is specific to the Dominican Republic, this work can inform similar efforts in other Latin America counties, and can also be used for TEE curriculum development in more advanced countries, including the United States.

II. CURRICULUM DEVELOPMENT

A. MACILE Curriculum Goals

Three main goals for the curricula were: (1) to immerse learners in challenging and stimulating classrooms where reliance in memorization is discouraged and the focus is instead on critical thinking, creativity, discovery, and building leadership skills. (2) Motivate the learners' curiosity and instill in the young minds passion for learning. The Dominican classrooms consistently discourage curiosity, creativity, and inquiry. (3) Increase knowledge and understanding of science, engineering and technology to widen the horizons and motivate interest in STEM fields.

B. MACILE TEE Curriculum Development

They university students used the "Backwards Design" process [3] to design the MACILE TEE curriculum. They conducted research, identified objectives, assessment instruments, and instructional activities. They also translated the units into Spanish and identified the needed materials. Each year, once the feedback and requirements were evaluated and the basic content determined, the university students continued with the development process. They were put into four teams to develop curriculum for four multi-level classes.

Each year, a representative from MACILE, visited with the BYU faculty and students to engage in the CD process. A key item to emerge from these sections was the need for DR students to learn about and be able to engage in the engineering design cycle, as well as the need for them to learn what engineers and technologists do, the various types of engineers and technologists that exist, the types of problems they solve,

* This work is partially supported by funding from Buffalo Tungsten, Inc.

and the impact they can have on society, especially the Dominican society. Additionally, since, on average, over 54% of the MACILE Summer Academy students attend for three or more years, it was deemed strategic to lay out a multiple year curriculum plan for four class groups to ensure that DR students participating in MACILE for several years experienced a broad range of topics and an increasingly challenging TEE curriculum. Thus, a challenge for the design process was to complete a two-year plan for each group [2-3].

The first year, the BYU students and faculty identified and adopted the Boston Museum of Science's Engineering is Elementary (EIE) curriculum's engineering design cycle as the model to guide the curriculum development. Some units from the EIE curriculum were used to teach 5-8 grade DR students. In addition, the BYU students teaching these younger classes also identified several new units including an invention and innovation unit and units on power and energy concepts related to simple machines. These were developed using the backwards design process. The curricula for the high school students included robotics and units related to rocketry, energy, water filtration, environmental design, and biomedical engineering. The units integrated applications to the DR [2].

In 2012, after evaluation of feedback, requirements, and future goals, supervised by the faculty, the BYU students designed a multi-year and multi-level TEE curriculum plan for MACILE that included six main components: simple machines and structures, power and energy, engineering design and robotics, IT and communications, agricultural and medical technology, working with others and learning about oneself. Each component included activities and challenges specifically developed to meet the needs of program and the DR students. They were group-specific and level-graded. They leveraged recognized best-practices in K-12 TEE in USA and other advanced countries. The engineering design process is the theme throughout all the curriculum projects.

The CD process in 2014 focused on review and improvement of designed units, design of new activities, and advancing translations of the units into Spanish.

III. Challenges and successes

One of the most difficult challenges the first year was correctly identifying what the DR students should specifically know and be able to do after completing each unit of instruction. Moving from the general to the more specific objectives became more challenging as the process of developing the assessments and instructional activities progressed. It was necessary to use best judgment to identify and integrate more specific learning objectives, without knowing well the DR students' prior educational experiences and levels of understanding. Despite the best efforts, however, some objectives had to be modified during the actual teaching process in the Dominican Republic.

Another challenge was translation of the units. Some of the university students were fluent in speaking Spanish, but translating the lessons proved to be very difficult. Each year, the students underestimated the time needed for translation and difficulties inherent in using improper translations.

Additional challenges were teaching in a foreign language, adjusting to very different classroom conditions without significant modification of lesson plans, and adjusting to a different culture. The university students had to be prepared to work without power and, in some instances, with limited tools and materials. Besides communication barriers, they also had to account for the DR students' educational experience, work habits, and expectations, as well as to adjust to the facilities.

A final CD challenge was identifying and obtaining teaching supplies and materials, including basic tools that had to be attained in the USA. Ideally, the majority of the supplies would be readily available each year on site in the DR. However, many of the materials MACILE had to order from the US. Lists of materials had to be prepared with sufficient time to determine those available and those that needed to be brought by MACILE or the BYU students. Despite careful efforts, some materials were often unavailable when needed.

IV. Learning and interests

The collaboration opened an invaluable opportunity for talented Dominican youth from poor backgrounds to gain better understanding of engineering, science, and technology. Their understanding of engineering and technology (ET) evolved from very limited, when admitted to MACILE, into sophisticated and complex models as they participated in the summer academy. Concurrently. The data showed that the DR students improved their math, science, and communication skills significantly while learning more about ET. They also learned about teamwork, problem-solving, and peer assistance.

Another significant part of the collaboration was the opportunity it provided to DR students and local teachers to interact with teachers and professors from a US university while immersed for 5-week each year in challenging, stimulating, and fun learning environments much different from the traditional Dominican classrooms they are accustomed. Without exception, all the DR students rated this the most fascinating part of the experience. They indicated that they learned a lot, enjoyed being creative, and that the MACILE's approach instilled in them the desire to learn. The data also showed major positive shift in students' interest in ET and science subjects over time. On average, about 5% of the applicants indicated interest in ET and 21% liked science. By the end of the five weeks of instructions, however, 53% expressed interest in ET while 38% was interested in science. Only 5% indicated Spanish as their preferred subject area.

References

[1] Shumway, S., SC. Vargas, G. Wright, and Terry, R. 2010. A Collaborative Effort to Teach Technology and Engineering Concepts to Middle School and High School Students in the Dominican Republic. In Proceedings, Amer Soc of Eng Edu Annual Conference, Louisville, KY.

[2] Wright, G., S. Shumway, S., R. Terry, and SC. Vargas. 2011. A Study Abroad in the Dominican Republic: Mentoring University Students as They Prepare and Teach Technology and Engineering Concepts to 6th-12th Grade Dominican Students. In Proceedings, Amer Soc of Eng Edu Annual Conference, Vancouver, Canada.

[3] Wiggins, G., & McTighe, J. 1998. Understanding by design. Alexandria, VA: Association for Supervision and Curriculum Development.