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# **AC 2011-1860: A STUDY ABROAD IN THE DOMINICAN REPUBLIC: MENTORING UNIVERSITY STUDENTS AS THEY PREPARE AND TEACH 6-12 GRADE STUDENTS TECHNOLOGY AND ENGINEERING CONCEPTS**

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# **A Study Abroad in the Dominican Republic: Mentoring University Students as They Prepare and Teach Technology and Engineering Concepts to 6<sup>th</sup>-12<sup>th</sup> Grade Dominican Students**

## **Introduction**

This paper contains a report of the ongoing, collaborative effort between Complex Systems Optimization Lab (COSOLA) and Brigham Young University (BYU) to design a science and technology program to improve Dominican student academic knowledge and skills. In 2007, COSOLA instituted the Matemáticas, Ciencias, Ingeniería y Lenguaje or Mathematics, Sciences, Engineering, and Language (MACILE) education program to help advance engineering and science education in less advantaged communities in the Dominican Republic (DR).<sup>1</sup> 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. It is hoped that these students will then rise to the highest educational standards, pursue studies and careers in mathematics, science, and engineering fields, and make a difference in the world by creating opportunities to further advance science and technology in their countries and communities and to promote sustainable development.

MACILE started in the Itabo-Nigua (Ytabo) region of the DR. Ytabo is approximately 20 miles southwest of the capital, Santo Domingo. The region includes six towns with an estimated K-12 student population of 11,800 (from informal records). The median monthly income is less than US\$150. On average, parents have completed through the 5<sup>th</sup> level of primary school. Less than 50% of students completing 8th grade continue to high school and less than 60% of those entering high school graduate.<sup>2</sup> MACILE in Ytabo is currently a summer program with the goal of becoming a year-around program in the near future. The summer program was piloted in 2007 and 2008. BYU became involved in 2009. Observations regarding BYU personnel's involvement in the summer program were presented in a previous ASEE conference.<sup>3</sup>

Eight BYU students spent 5 weeks during the summer of 2010 in the Dominican Republic teaching 6<sup>th</sup> -12<sup>th</sup> grade students. Under the supervision of three BYU faculty members, the university students developed the curriculum during spring term and then presented the material during summer term. The Dominican Republic students were assessed as to their learning and satisfaction with the instruction. The university students were assessed as to the effect that the study abroad had on their teacher development.

This paper contains a report of the curriculum development, the study abroad activities, and a summary of the assessment results of both the Dominican Republic and BYU students.

## **Curriculum Development**

**Overview.** From the university perspective, the major purposes for initiating a study abroad opportunity for the BYU students was to provide pre-service teachers an opportunity to engage in an authentic curriculum development opportunity, develop their teaching and classroom

management skills, and to allow students to engage and learn about another culture. The purpose of this section is to describe the curriculum development process.

As students progress through the teacher education program at the university, they take courses in engineering and technology content, as well as general education and teacher education courses. In their first semester in the major, students have a teacher exploration course where they visit local schools, observe classrooms, and teach some basic lessons. A teaching methods class, a practicum experience, and finally the student teaching experience follow this class. In the practicum, students are introduced to a curriculum development process called “Backwards Design.”<sup>4</sup> The main principles of this process call for curriculum developers to first determine what students should know and be able to do at the completion of a unit. The second stage is to determine acceptable evidence or the ability to assess whether students have learned or are able to do the items identified in the first stage. With the first two stages completed, curriculum developers can then effectively engage in the third stage, which is to develop learning experiences and instruction.

**MACILE: Curriculum Development.** During the 2010 Winter semester, 8 BYU students were selected to participate in the program. Seven (2 seniors and 5 juniors) were from the Technology and Engineering Education program and one (senior) was from Construction Management. After the university students were identified, one of the first things that needed to be completed was to determine what units of instruction were going to be taught during the summer study abroad. From previous discussions with MACILE, BYU faculty and students knew that they wanted the Dominican students to have opportunities to learn technology and engineering content. However, with four classes being taught at various grade levels, the faculty and students had to decide what specific content should be taught, and to which grade level.

During spring term, a representative from MACILE, visited with the BYU faculty and students to engage in the first stage of curriculum development. One of the first items to emerge was the need for Dominican students to learn about and be able to engage in the engineering design cycle. Additionally, it was deemed important for the Dominican students to learn what engineers and technologists do, the various types of engineers and technologists that exist, the types of problems they solve, and the impact they can have on society, especially the Dominican society.

Because of their prior exposure with the Boston Museum of Science’s *Engineering is Elementary* (EIE) curriculum, the (university name) students and faculty identified the EIE engineering design cycle as the model to guide the curriculum development. Additionally, because the curriculum units from the EIE curriculum represented a wide variety of engineering content, these units were purchased and used to teach several of the units to the elementary and lower middle school students. The curricula for the high school students included a robotics unit and activities related to rocketry, energy, and water filtration. MACILE identified the general content for these components.

Once the basic content was identified, the university students continued with the curriculum development process. This process was completed during the seven week spring term prior to the summer study abroad. To help supplement student expenses for travel and lodging in the Dominican Republic, the university students participating in the summer study abroad were

employed by the Technology and Engineering Education (TEE) department funded by a university Faculty Mentoring Environment (MEG) Grant to participate in curriculum development.

The eight students were put into four, two-student teams to develop curriculum for the identified classes. As mentioned earlier, for the younger grades, units from the EIE curriculum were used. Since these units already included identified objectives, assessments, and instructional activities, the main focus was to translate the units into Spanish and then identify how to obtain the materials needed in the Dominican Republic. In addition, to the EIE curriculum, the BYU students teaching these younger classes also identified several new units including an invention and innovation unit and developed appropriate curriculum using the backwards design process.

The university students teaching the robotics class used the backwards design process to develop robotics curriculum based upon the Lego© NXT system. The NXT was used because the university students were familiar with this system and because MACILE had previously purchased several NXT units. For the rocketry, energy, and water filtration class, university students developed a unit in solar energy (passive and photovoltaic) as it was deemed to be a unit with direct application to the Dominican Republic. In addition, units on power and energy concepts related to simple machines and rocketry were also developed. In addition, the engineering design cycle as well as the identification of the types of engineers and related engineering activities became a common theme for each of the developed units.

**Challenges and Successes.** One of the most difficult challenges related to the curriculum development effort was correctly identifying what the Dominican students should specifically know and be able to do (learning objectives) after having participated in each of the units of instruction. As mentioned earlier, general objectives were identified prior to curriculum development. However, as the university students started developing the assessments and instructional activities (stage two and three of the backwards design process), they discovered that more specific objectives should have been identified during the initial planning. The university students had to use their best judgment to identify specific learning objectives but without knowing the Dominican students and their prior educational experiences and levels of understanding many of the objectives had to be modified during the actual teaching process.

Another challenge was translation of materials. Five of the university students had significant experience speaking Spanish (three of the students had limited Spanish speaking abilities). Even though fluent in speaking Spanish, translating the lessons, especially technical terms, proved to be difficult for the university students. To avoid potential confusion, the university students needed to send their translated lessons to MACILE representatives for clarification. While the teachers and administrators from MACILE were ready and willing to help with these translations, the university students did not have time to complete the translation—which resulted in much of the translation work being completed after arriving in the Dominican Republic. Everyone involved in the study abroad effort greatly underestimated the amount of time needed to translate the curricular units.

A final challenge during the curriculum development process was identifying teaching supplies and materials, including basic tools that could easily be obtained in the Dominican Republic.

Obviously, for a new teaching program to have sustainability, the majority of the supplies needed to teach the units would need to be readily available in the host country. However, to advance the content taught to the Dominican students to include technology and engineering, it was deemed that there would be some materials that MACILE would have to order from out of the country. Prior to leaving for the study abroad experience, a list of materials readily available in the DR and a list of the materials that needed to be brought with the university students when they arrived in the Dominican Republic was made. Challenges arose during the first week when it was discovered that while many of the materials were available in the DR, it was a significant challenge to locate local businesses that sold the items requiring several trips into the city of Santo Domingo. This resulted in many hours spent locating materials that should have been spent preparing last minute changes to lessons or translating materials.

### **MACILE Summer 2010 Dominican Republic Students and Program**

The collaborative effort with BYU allowed MACILE to increase its capacity during the summer of 2010 and offer a full technology and engineering program. There is a growing perception that students attending MACILE summer academy perform better academically, are more interested in learning, and show better behavior at school. Teachers find the MACILE curricula and its process-focused approach to be innovative and helpful. They feel they learn new skills that help them to teach more effectively. The DR students find MACILE curricula challenging and stimulating. They feel that they learn a lot in the program and that MACILE's approach instills in them the desire to learn. They enjoy making new friends and being creative. Many have indicated discovering the joy of learning mathematics, science, and engineering with MACILE. This is telling since most students apply because they like mathematics or want to be engineers. As a result of the increasing recognition and high satisfaction with the program, demand for admission has been growing faster than capacity each year. In 2010 the number of students recommended for admission increased 137.5% from 2007 and 55% from 2009. Of a total of 152 applications, 68% were new applicants and 32% were returning students: 62% second year and 38% third year students. The mission of MACILE is to cultivate the creativity and imaginations of talented, underserved young people from less advantaged communities and motivate them to work and pursue studies and careers in the fields of science, engineering, and/or mathematics to advance knowledge development and improve human welfare sustainably. Retaining the students in the program for multiple years or until graduation from high school is important for achieving this mission. Thus, students are encouraged to return and are automatically admitted except in cases of serious violations of rules. Like new students, returning students must receive a teacher or school director recommendation. Applicants were from grades 6 to 12 and ranged in age from 9 to 19 years. The majority, 87%, were under 16 years old (84% 15 or younger). The gender composition continued to show an increase in the proportion of female to male. In 2010, 62% of applicants were female and 38% male. Given that good academic performance is a requirement for recommendation, this trend seems to indicate that girls are performing better than boys in school. This is significant and a reason for some concern. In the Dominican Republic, school desertion is very high in less advantaged communities like Itabo-Nigua, particularly among high school students.<sup>2</sup> Poor performance is usually an alerting sign. School participation also increased dramatically in 2010. Students and teachers came from 19 public and private schools, an increase of 533% from 2007 and 217% from 2009. All but one of the public schools in Haina-Nigua was represented. In addition, there were students and teachers from public schools in three

adjacent towns and two major cities: San Cristóbal and Santo Domingo. The private schools (5 total) were from inside and outside the region, including the capital. This growth in demand increased selectivity as well since capacity remained limited. Only 58% of the applicants were considered for admission—46 % of first year and 87% of returning students. Selectivity was also due in part to the continued effort to improve the reliability of the admissions process. The composition of the admitted and registered students (76) by gender was 69% female and 31% male. The age distribution was as indicated above.

Students were divided into four groups by grade and class levels. Groups 1 and 2 included mainly first year students (98%) whereas Groups 3 and 4 included mostly second and third year students (81%). By grade, Group 1 included students in grades 6 and 7; Group 2, grade 8; Group 3, grade 8 and 9; and Group 4, grade 9 to 12. Progression in the Spanish and mathematics curricula controlled in great part the allocation of students in Groups 3 and 4. Returning students experience the curricula differently even if the fundamental concepts may be the same. This makes it more difficult to admit new students at these levels at this time. Another factor is the class size. The goal is to cap class size at 21 students. In summer 2010, the number of students in each group was 22, 23, 15, and 16, respectively.

All students came from schools with very traditional Dominican classrooms that emphasize memorization of concepts rather than critical thinking. Students in Groups 1 and 2 had no previous experience in engineering and technology classrooms. This was also the case for some students in Groups 3 and 4.

Students attended MACILE from 7:45 AM to 3:30 PM Monday through Friday for 5 weeks, from June 28 through July 31. They received breakfast, lunch and one snack. MACILE summer programs are essentially free of charge, with students paying only for transportation to and from the program. A nominal contribution is suggested, but payment is not a condition for admission or attendance. In 2010 the suggested contribution for students was RD\$200 (US\$5.55); about 75% of the students contributed. The program is conducted in the Center Padre Zegrí, a school operated by Catholic nuns in Nigua.

The students received instructions in mathematics, technology and engineering, and language (Spanish). The science and English components of the curriculum have yet to be developed. Students work in small teams. This paper deals specifically with the technology and engineering (TE) component of the program. The TE curriculum included: basic electronics, simple machines, maglev transportation systems, Newton's Law: rocketry, forces and structures, invention and innovation, water filtration, and robotics. The engineering design process (EDP) was the theme throughout all the curriculum projects.

### **Assessment Results Regarding the DR Students**

At the end of the five-week program, each group was provided a test to assess their learning and satisfaction with the instruction. These instruments were designed by the BYU students and supervised by a member of the faculty. A test was designed for each group (4 total). The questions covered three domains: general, curriculum-specific, and evaluation. General questions

assessed the students' mental models or understanding of general concepts emphasized across the curricula: "engineering," "technology," "engineer," and "the engineering design process." These questions varied in each test or for each group. Curriculum-specific questions assessed the student's learning of key concepts. Some questions assessed how well the students memorized some concepts while others assessed how well they internalized key concepts. Evaluation questions elicited the students' perceptions about how much they learned, what they learned, and how to improve the class. Only some groups were asked these types of questions. In addition to the learning assessment instruments, the students completed a program evaluation to elicit their overall satisfaction with MACILE. This instrument was designed by the program director.

Table 1. Overview of End of Program Assessment Tool Administered to DR Students.

Group 1	Group 2	Group 3	Group 4
Grade	Grade	Grade	Grade
Age	Age	Age	Age
Gender	Gender	Gender	Gender
What is engineering?		What is engineering?	What is engineering?
Jobs done by engineers?			Things engineers do?
			Skills necessary to be a good engineer?
	What is technology?	What is technology?	
Steps of EDP? Explain each step	Steps of EDP?	Steps of EDP?	Steps of EDP?
	What is EDP used for?		When can we use EDP?
Questions about simple machines	Questions about technology, basic electronics, maglev transportation systems, structures (bridges)	Questions about structures (bridges), Newton's Law, basic electronics, energy	Evaluate how much you learn about robotics
			Interested in engineering or technology?
			How to improve this class?
	Evaluate how much you learn		Evaluate how much you learn

In this section, the findings of the post-tests are summarized. A descriptive analysis of the data was used as the primary disaggregation technique. Other methodologies were considered, but a descriptive model was the most effective method for this study because it provided an efficient approach to draw generalized inferences. The results provide tentative but useful insights for future improvements and studies. Following we consider several areas in which the results are insightful.

**Students' mental models.** It is reasonable to assume that students had formed mental models about engineering, technology, and problem solving prior to starting the summer 2010 program. The post-test provided pictures of these models. Without prior assessments, inference about how they might have been shaped, if at all, over the 5 weeks of instruction is difficult to draw. But contrasting the pictures of the models for depth, complexity, or sophistication of thinking provides valuable insights. The results show that students in Groups 3 and 4 have formed more sophisticated and complex mental models about such general concepts like engineering, technology, and things done by engineers than students in Group 1. This raises important

questions about the formation and evolution on these models and the contribution of MACILE to their formation and evolution. What factors shape these models over time? We can certainly ask questions about the significance of these models. For example, do the models influence or reflect the student's view of engineering, and can these mental models be a factor in affecting their decisions about a career?

**Memorization vs. internalization of concepts.** Although inconclusive, the results seem to show that students—particularly those in Groups 1 and 2—have fewer problems with memorization of concepts, but struggled with internalization of the concepts. For example, students could list the simple machines studied, but had difficulties differentiating one class of lever from the other. Also, the students could list the types of bridges studied and show what an arch looks like, but had difficulties understanding a concept like counter-force or explaining how the arch works in the bridge. Another example is the engineering design process. All the students could list the steps, but had difficulty explaining them and how to use them. These results are not surprising in that Dominican schools emphasize memorization. However, the results also may reflect problems with the design of the test instruments, the curriculum, or even the instruction. For example, it appeared that most students in Group 1 misunderstood the question that asked them to explain each step of the engineering design process in addition to listing them.

At any rate, these observations can help improve the curriculum design process and the classroom process to improve internalization or better learning.

**Perception of learning vs. results.** The results show that students' perception about how much they learned do not always align with the picture emerging from their responses about their understanding of concepts. However, their perceptions are correct because they reflect their experience. For example, most, students in Groups 1 and 2 learned about maglev transportation systems for the first time this summer. For them this was a great learning experience. Thus, while their responses to specific questions showed they had difficulties grasping the concepts taught, they all believed they had learned “a lot” (10 out of 10) about maglev. This phenomenon is recurrent across all subjects, including mathematics and Spanish. Many students indicated that they learned a lot about mathematics and could list specific concepts that they learned, but when tested about those same concepts the results indicate differently. This is an important result to keep in mind when introducing students to new concepts, developing new and innovative programs, and assessing learning or evaluating program effectiveness. The students' perception of learning matters and this may not always align well with skills or abilities actually learned.

**Student satisfaction and continuous improvement.** While all the students indicated high satisfaction with the instructions and MACILE in general, they were still able to find areas for possible improvements. In robotics, for example, the students showed high satisfaction with the class, but at the same time, about 50% of them suggested more homework, projects, and more content as ways to improve the class. Another example deals with student selection. Most students find MACILE excellent as a program, but some suggest that the admission process needs improvement. They suggest that only “students that want to learn” be admitted, indicating that they notice the behavior of their peers.



In summary, the results are still tentative, but they provide useful insights that can help improve the processes and shape future work. Including pretests in future efforts will improve data reliability. Following we review the results, considering each group separately.

**Group 1 Results.** Group 1: Grade: 6 – 7; Age: 9-13; Number of students: 22 (New = 20). Group 1 included mainly first year students. These students had difficulty adjusting to an activity-based hands-on environment, as well as adjusting to team work. In general, it was not easy for them to make the transition from the usually chaotic Dominican classrooms to this new environment. These difficulties were reflected in their behavior in the classroom. They were indeed a challenge for the university instructors. The test assessed the students' perceptions of general concepts like “engineering,” “the engineering design process,” and “engineers.” It also assessed their learning about simple machines—more specifically concepts about levers.

The students reported diverse views of the concept of “engineering.” Most frequently (38%) “engineering” is explained as a process—the process by which buildings or things are built; an engineer engages in engineering. Some students (29%) consider “engineering” a field of study or learning—a person studies engineering to become an engineer—while 14% of the students think “engineering” is a job. The rest define it either as a product or a tool for engineers. Most students (90%) associated the job of engineers with houses, apartment buildings, and bridges. Only a few (10%) associated engineers with other technologies (rocket, ships) or a creative process. These answers reflect beliefs shaped in the communities. In their daily lives, the DR students are surrounded by products or technologies designed and built by engineers (cell phones, TV sets, cars, motorcycle, shoes, buttons, backpacks) but these are not normally linked to jobs performed by engineers. The schools also play a role in reinforcing these views. The students clearly memorized the steps of the engineering design process. Virtually all of them (95%) could list all or most of the steps and some students (25%) were able to explain the steps. (It is likely that the question was misunderstood and that more students could actually explain the steps.) Regarding how well the students learned or recalled some concepts about simple machines—specifically lever machines—the results were mixed. Recalling concepts was easier than internalizing them. All the students could name the simple machines studied in the class, but many could not identify the class of levers from the figures given. Most (90%) identified Class 1 levers correctly and a majority (57%) identified Class 2 and Class 3 levers correctly. The remaining 43% confused Class 2 and Class 3. In addition 67% of the students could identify the parts of a lever. Overall, this group performed fairly well. They have a narrow view of engineers, but captured very well different dimensions of “engineering.” Memorization was easier than internalization for some of them, but they also demonstrate ability to understand complex concepts.

**Group 2 Results.** Group 2: Grade 8; Age 11-15; Number of students: 23 (New = 20). Group 2, as Group 1, included mainly first year students, but contrary to Group 1, this group adjusted quickly to the MACILE environment and showed a remarkable disposition toward learning. They were ready to be challenged and had great creative abilities. The test assessed their understanding of general concepts like “technology” and the EDP. It also assessed their learning of some concepts in three areas: electronics, maglev transportation systems, and structure (bridges). In addition, the students were asked to rate how much they learned on a scale of 1 to 10, 10 indicating a lot and 1 indicating very little.

It is clear that the students developed a strong general view of technology. For them technology is used to satisfy human needs. They memorized well the steps of the engineering design process (EDP) and showed that they gained good understanding about when and how to apply the EDP. The students identified some situations when EDP can be applied: when creating new technologies or things (57%), when building something such as bridges (29%), and to solve problems (9.5%). These results are indicative of fairly sophisticated mental models about engineering and technology. The results also show that the students were able to internalize these general concepts of the curriculum. The results of the curriculum-specific questions were mixed. The students had no difficulty with questions dealing with basic electronics. They correctly distinguished between an opened and closed circuit. They also explained very well the distinction between conductors and insulators. However, they had difficulties with other concepts tested. In general, the students were visibly confused with the concepts relating to maglev and to a lesser extent with concepts relating to structures (bridges). While they can show (drawing) what an arch looks like, they did not understand the function of an arch in a bridge. They also had difficulties with the concept of counter-force. It is possible that there was confusion with the structure of these questions. It is also possible that the students could not explain in writing what they learned. First year students, even after five weeks of intensive language instruction, still have very poor writing skills. In general, however, there seem to be issues with comprehension or understanding. But despite the fact that their answers indicated differently, when asked how much they learned, the students believe they learned a lot (score of 10) or very much (score of 8 or 9); average scores of 9.7 and 9.9 for maglev and structures, respectively. To explain the fact that the students' perceptions of learning differed from the understanding (or abilities) they demonstrated with their responses, we need to consider their answers from their perspective. From this angle, their assertions are correct. The students were evaluating their experience in an engineering and technology class, a completely new and exciting phenomenon to them. It is likely this was the first time that any of them learned about maglev transportation systems or studied about bridges and structure. For them, therefore, this class in itself was a great learning experience. Their difficulties grasping the concepts or explaining them clearly do negate the fact that they learned a lot about maglev and bridges. This is an important example to keep in mind when introducing students to new concepts, developing new and innovative programs, and assessing learning. The students' perception of learning matters and this may not always align well with skills or abilities actually learned.

**Group 3 Results.** Group 3: Grade 8-9; Age 12-15; Number of students = 15 (New = 2). Group 3, as indicated above, include mainly second and third year students. The test assessed their understanding of general concepts like “engineering,” “technology,” and the EDP. It also assessed how well they learned some concepts about structures (bridges), Newton's law, rockets, and energy.

The students have developed sophisticated deep mental models with respect to the general concepts of technology, engineering, and the EDP. Most (60%) consider “engineering” a science or process that we apply to solve problems. Some (27%) think engineering is a field of learning where knowledge is developed. In general for them, engineering is the capacity to apply the EDP to design, create, plan, build or produce new things (houses, rockets, bridges), and to improve the quality of life. Technology in their view is advancement and things/products that surround all of us. They believe technology is applied to things to create new things. With regard to the EDP,

however, the students did not understand what was being asked. All listed the steps, showing good memorization, but the questions asked them to explain what the EDP is. In all curriculum-specific questions—questions dealing with energy, Newton's law, rockets, and basic electronics—this group not only demonstrated good memorization skills but also excellent understanding or internalization of the concepts tested. Students could explain with remarkable detail complex processes or concepts such as why a rocket was able to fly; what functions the various components of a water-bottle rocket play in the process; and why energy could be produced from fruits and some vegetables. This group clearly demonstrated remarkable learning abilities.

**Group 4 Results.** Group 4: Grade 9-12; Age 14-19; Number of students = 16 (New = 4). Group 4 included a selective group of second and third year students chosen to be the members of the first Robotics class of MACILE. Introduction to Robotics is a five week course. It is part of a planned multi-level multi-year Robotics program, which is still at the initial stage of development. It was a very successful initial step.

The students had no prior experience with Robotics or programming. They had not worked with Lego Robotics or Lego NXT before. Like Group 3, this was a group of very talented young people that enjoyed the challenges and they all did very well. The curriculum focused mainly on Robotics fundamentals: building with Legos, learning about sensors, basic programming, and controlling the robots with Bluetooth technology. Students worked in teams. The post-test was not designed to assess skills or concepts learned. It asked the students to evaluate what they learned and how much they thought they learned. The test included three sets of questions divided into three parts, which are explained below. The first set assessed the students' perceptions about what they learned and how much they thought they learned about robotics and problem solving. The students were asked to rate their level of understanding on a scale of 1 to 5, 5 indicating very good understanding and 1 very little. The second set of questions elicited their understanding of the EDP and other concepts like engineering and technology. This set also asked the students about their interest in engineering and technology. The third group of questions asked the students to indicate things they were most satisfied with as well as how to improve the class.

This section contains an explanation of the parts. Part 1: The students were asked to assess their understanding of Lego Robotics on a scale of 1 to 5, 5 indicating very good understanding and 1 very little. The questions dealt with building with Legos, programming robots, teamwork, applying the EDP to solve robotics problems, sensors and their functions, and engineering and technology. Part II involved three questions. In it the students were asked to identify specific things they learned in the class and to rate how the class contributed to their understanding of problem solving. Part III dealt with three types of questions: (a) Students' understanding of concepts like engineering, technology, and the engineering design process; (b) Students' interest in engineering as field of study or career and their view of the steps necessary to study engineering; (c) Student evaluation of the class, indicating how it can be improved and how much they liked the class.

Overall, this group showed a high level of confidence about what they learned and a high level of satisfaction with the class. This confidence was also visible in the classroom.

Students asserted that they learned a lot about Lego robotics, teamwork, and about using the engineering design process to solve problems. The overall average score assigned to questions in Part I is 4.529 from a maximum of 5. Students most frequently indicated programming a robot, team work, and building with Lego as skills they learned in the class: 87.5%, 75%, and 56%, respectively (see Table 2 below). They also learned to use sensors and the EDP to solve problems.

Table 2. Results from Group 4 Assessment Tool Regarding What the Students Learned.

What did you learn	Frequency
Programming a robot	14
Team work	12
Building with Lego	9
Using sensors	8
Using the engineering design process to solve problems	7
Controlling the robot movement	4
Measuring distance correctly	3
Others: conducting experiment, creativity, science, tolerance, value of perseverance, English	7

On the general questions, the students showed that they had developed sophisticated and deep mental models about engineering, technology, and the EDP. While how the students explained these concepts may be irrelevant in some respects, their mental models showed how they internalized them—their understanding of these concepts and their views of engineering, technology, and science. We can argue that these models and how the students form them will play an important role in their decisions about pursuing studies and careers in these fields. For these students, “engineering” is much more than a field of study. Most (69%) view it as a science dedicated to solving problems, creating, and building things to satisfy needs. Only 19% considered engineering specifically as a career or field of study. While we cannot infer that their views are driving their interest, it is interesting to notice that 81% of these students indicated that they like engineering and will consider studying it. Overwhelmingly, these students associated things or jobs done by engineers with creativity, design, planning, and problem solving to improve human life—An engineer designs, created, plans, and improves; s/he solved problems with computers, robots, machines; an engineer designs, builds, and maintains robots, apparatus, rockets, ships; s/he create paper, perfume, pens, and many other things; an engineer conducts research and experiments. Only 6% (1/16) of the students considered the work of an engineer as building houses, bridges, and buildings. Contrasting their view with that of Group 1, the difference in complexity and sophistication shows an evolution in their learning.

**Comparing the students’ mental models.** For most students in Group 4, engineering is a science that solves problems, creates, designs, improves, and builds things to satisfy human

needs. Only a few (19%) view engineering as a field of study. Students in Group 3 express a similar view. Overwhelmingly (93.4%)—all except one— of these students associate engineering with solutions, creativity, building, and improving the quality of human life. Engineering in their view is a science that builds our capacity to improve the quality of human life. Contrasting these views with that expressed by students in Group 1 (first year MACILE students), the difference or evolution in depth of the mental models is clearly apparent. Students in Group 1 have a more narrow view of engineering. For 38% of these students, engineering is a process—the process by which buildings or things are built. An engineer engages in engineering and engineers build houses, buildings, and bridges, according to 90% of them. For 29% of the students, engineering is a field of study or learning—a person studies engineering to become an engineer. While 14% of them think engineering is a job and the rest define it either as a product or a tool for engineers. Alternatively, we can consider these mental models by contrasting Group 4's and Group 1's responses to the question: what are things or jobs an engineer do? Most students in Group 1—over 90%— answered that engineers build houses, bridges, and buildings. Less than 10% of these students associate the works of engineers with creativity, planning, or problem solving. In contrast, only 6% (1/16) of the students in Group 4 considered the work of an engineer as building houses, bridges, and buildings. For them, an engineer creates, designs, plans, and solves problems to improve the quality of life. Engineers solve all types of problems; design, build, maintain, and improve technologies; research, discover, and innovate.

Clearly the students' mental models about engineering and technology have evolved over time. We cannot indicate with certainty that MACILE has motivated this evolution, but it is not possible to negate that it must have played a part. How significant this part may be is another question, and potentially a very important one. To what extent a broader, more complex and sophisticated view of engineering and things or jobs that engineers perform motivate students' interest in the fields? This is certainly a question that needs to be explored. We are not certain that any work has been done on this area.

### **Assessment Results Regarding the University Students**

As discussed earlier, eight BYU students took part in this program. Their reasons for participating included: a.) Gain more experience teaching technology, b.) Be of service to others, and c.) Study in a foreign country. These reasons correlate with the primary focus of the program as outlined by the faculty sponsors and university's study abroad program, which was to provide students with an advanced educational experience that would enhance their pedagogy by allowing them to develop curriculum and teach it.

Participating students were surveyed and interviewed by their faculty sponsors immediately following their foreign teaching experience. In addition the faculty sponsors kept field notes containing observations of each university student's teaching. This was done to provide each student feedback on their teaching, and to help document teacher growth. In the surveys and interviews students were asked a variety of questions that corresponded with their reasons for participating and with the primary focus of the program. This was done to allow professors and department administrators to evaluate the success of the program and make decisions regarding its improvement. The following paragraphs include an aggregation of data from the survey and interview findings, organized by topic.

*Did the teaching experience improve your desire to teach and influence your pedagogy?*

All eight of the students (100%) reported that this experience increased their desire to teach, and had a positive influence on their pedagogy (instructional practices and classroom management). One student stated, “I figure if I can actually teach and enjoy teaching in another language in a third world country, then I will enjoy it even more in the United States. I learned to be a lot more patient and how to manage a class.” Another student added, “It was a great intro into the world of teaching, and especially teaching those from a different culture... It added to my pedagogy by stretching my imagination to think of ways to effectively communicate the ideas I was trying to convey.”

*Did this experience help or hinder your ability to create classroom activities/instruction?*

During the Spring 2010 semester, prior to leaving for the Dominican Republic, the eight students developed unit and lesson plans with associated instructional activities, assignments, rubrics, and assessments. Although each of the students reported that this was a very beneficial experience, each of the students also reported that most of their lesson plans and activities had to be further developed while they were teaching in the DR. The faculty sponsors noted that the teachers were daily adjusting and further developing their lessons—due to lack of resources, and varying levels of student ability. The faculty noted that this was a lot of work at first, however, as the university students became more familiar with their classes, the abilities of the students, and local resources, there were able to more efficiently prepare. When students were asked whether this experience helped or hindered their ability to create classroom activities, 100% of participating students reported that this experience (in one student’s words) “definitely helped.” “I thought that working with the professors before coming over to the DR was really helpful – it was a great mentoring experience. But I will also say, that having to lesson prep while living here was a great experience. I now have confidence that I can effectively write lesson plans no matter student ability or classroom supplies.” Overall, in a focus group interview, the students responded that this program gave them real life experience in dealing with classroom situations. One student reported, “It helped me to gauge the different skill levels and qualities that the different aged students have, and helped me to understand what kind of activities they were interested in and ready for.”

*Did you observe any increased interest to pursue careers related to technology and engineering fields in the Dominican Students?*

The primary purpose of technology education in the United States is to provide students with knowledge of the skills and abilities of the various careers and technologies of the day. This same purpose was used as a guiding principle for the content taught in the Dominican Republic. Consequently many of the university students tried to infuse a “career exploration” component in their lessons. However, many of the university students said this effort was not very successful. In fact, 25% of participants answered yes to this question, whereas 75% answered that no, they did not see an increase in Dominican student interest in careers associated to technology and engineering. One student stated, “In our class we planned on talking about the various career opportunities in the field of engineering, but it was a little difficult because of the language barrier and the fact that our students hadn't been exposed to many careers because of their living circumstances. Because of this, our students may not have had a clear idea of what careers directly related to what they were learning.” Another student said, “I tried to make career

connections, but it didn't work so well. Mostly because I was unaware of the types of industry most prevalent in the DR. Had I been more familiar with the types of jobs and careers, and even university programs in the DR, I think I could have done better in this domain. Of the students who reported actually being able to expose the students to various careers in the technology and engineering fields, she said, "I think it was a good introduction for them to technology and engineering ... and they got excited about the different things they could do with technology. Many never thought about jobs in technology and engineering. Now they seem a little more open to it – or at least aware of the opportunity."

*What were the positive things you experienced in this study abroad?*

When students were interviewed and surveyed regarding their overall experience in the DR, their responses typically centered on pedagogical issues. For example one student said, "I gained a greater respect for teachers and all the planning they put into a lesson. I also gained teaching experience and classroom management skills." Other students also stated that the teaching and interacting with the Dominican students was their favorite part of the experience. For example one student reported that "Meeting the students and seeing them succeed, was my favorite part." Other responses that were also common among the university students had to do with having the opportunity to explore the world, interact with other cultures, and learn from an international community. One representative comment of this was captured in the exit survey. This particular student reported that, "Living in a different country, experiencing the culture and living real life in the town rather than just being there as a tourist, gaining teaching experience that is applicable to my career choice made for an awesome experience."

*What were the negative things you experienced in this study abroad?*

The experience was not all positive. Many of the students listed a broad range of items that prevented the experience from being more successful, and that caused many hardships. The primary issue reported by nearly all of the students was the miss communication of expectations regarding interactions with the DR teachers and classes to be taught. The second most common feedback regarding negative components of the experience was the poor living conditions. Many of the university students got sick while living in the DR. Although the university students knew the living accommodations would not be what they were used to, they were not fully prepared. Some of the health issues were related to the weather conditions as well. Right before the students arrived, the Dominican Republic was hit by a massive storm that led to the breeding of many mosquitoes near the complex where the students were staying. A significant part of the DR native population also suffered illnesses from these conditions.

## **Conclusions**

Overall both the university students and their faculty sponsors believed the experience to be a success, because it achieved the goal of the study abroad experience: to provide students with an advanced educational experience that would enhance their pedagogy by allowing them to develop curriculum and teach it. Though there were drawbacks to the experience, and the program has room for improvement, the students' reports show that this was a very valuable learning opportunity that met the primary focus of the program. The students' desire to teach was increased, their teaching skills were enhanced, they gained a greater understanding of their content areas, and they made an educational impact on their Dominican students.

As the results of the assessment of the DR students indicate, the MACILE program is proving to be a success in helping young people learn about technology and engineering and how they can become part of improving their own lives and the lives of people in the DR. As the program continues to develop, this success will continue to grow.

## References

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