# A Pilot Study of Robotics in Elementary Education

**Edwar Romero[1], Annette Lopez[2], Omar Hernandez[3]**
[1]Universidad del Turabo, Gurabo, Puerto Rico, eromero@suagm.edu
[2]University of Puerto Rico, San Juan, Puerto Rico, alopezbemendez@yahoo.es
[3]University of Puerto Rico, San Juan, Puerto Rico, omar.hernandez4@upr.edu

## INTRODUCTION

Professionals agree that the inclusion of Science, Technology, Engineering, and Math (the popular STEM) in early education provides a strong motivation for students to pursue programs related with STEM, which is known to foster the economy in industrialized countries. Although educators advocate the importance of these areas, in reality little is done in the classroom to foster scientist and mathematicians (Chaille and Britain, 1997), let alone technologist and engineers. Most curricula include a number of concepts that cover science and math, but the emphasis applied is in literacy (recitation of concepts) not in the method of scientific inquiry, problem solving, and number sense.

This also has to do with the perceptions of learning in school: Constructivism vs. instructionism or learning vs. teaching (Papert, 1980a). In kindergartens and early-elementary classrooms, the use of manipulative materials is important in children's learning. These materials, such as Cuisenaire Rods (color rods of different lengths) and Pattern Blocks (blocks shaped as triangles, rhombus, squares, trapezoids) enable children to explore mathematical concepts (such as numbers or fractions) or scientific concepts (method of scientific inquiry, problem solving). This process develops thinking frameworks for later classroom concepts (Resnick, 1998). Early childhood education (Pre-K to 2) has found benefits on this constructivist methodology of learning by doing, by manipulation of materials, and by creating active inquiry. But as the child advances, these activities disappear from the curriculum. By the time they finish elementary school and start secondary education, those learning techniques are framed to be adequate to smaller kids. Interestingly enough, now the learning techniques used on upper grades (the recitation of concepts) are increasingly permeating Pre-K to 2, where it should be the other way around. The scope of this pilot study is twofold. First, it caters training for teachers in robotics while providing a space to evaluate relevant curriculum activities. Second, it supports robotic clubs from the participant's elementary schools while evaluating the children experiences.

## BACKGROUND

The typical approach to enhance technology in the classroom has been to include computers. However, the challenge still persists in how to integrate computers into the constructivist practice. Many teachers that pray and apply constructivism into the classroom revert to instructionist techniques of teaching when faced with the integration of computers into the lessons. More often than not, technology into the classroom means turning the computer into a TV set to watch videos or use video games, thus the mentality becomes into sit and watch (Bers et al., 2002). As described by Mitchel Resnick (Resnick, 2000), the interaction of children with technology and computer must be "*more like finger paint and less like television.*" Thus, it is not surprising that most teachers lack the training and required expertise to avoid fall into that trap.

In kindergarten math and science concepts are represented with manipulative materials, but what about technology and engineering, the missing pieces of STEM? In order to include them, Seymour Paper developed what is known as constructionism. It involves the use of technological tools for the inclusion of technology and engineering concepts in the education curriculum. This is directly related with the use of robotics and computers as new manipulative materials. It started as a way to integrate computational tools into the classroom with the Logo programming language (Papert, 1980b). One of the ideas involved was the transition from black-box (ready to use) software into the design of white-box (custom made) digital artifacts (Alimisis & Kynigos, 2009). The main advantage of this approach is that requires the user to construct objects and relations the same way as kindergartens do. The focus started as a way to investigate complex mathematical problems through the writing of computer programs with the Logo language. Many activities evolved into the programming of robotic constructions. By the mid 1980's, the LEGO bricks started to fuse with the Logo programming language, but still were wired to the computers in order to operate. Later, Programmable LEGO Bricks appeared. This made it possible to embed computation into the robotics creation and served as the foundation for the development of LEGO Mindstorms kits. They became the "digital manipulatives" that bridged the gap to include STEM, not just Math and Science. The design of their own robots has empowered children to gain deeper appreciation and understanding of many scientific concepts. Now, this is found through the entire spectrum from K-12 to college education.

## METHODOLOGY

Engineering education uses the project-based learning platform as a way to motivate students into STEM by constructing relevant applications of principles, promoting iteration, and by gaining problem-solving skills. Which it is exactly what kindergartens accomplish. Thus, it seems a disparity that one of the best learning techniques is disconnected from reality starting from elementary school and re-gained by the few that go into engineering. Lately, researchers have also being connecting engineering and pedagogy (Bers & Portsmore, 2005). The main advantage is the opportunity to integrate different areas of the curriculum, such as math and science, engineering, and technology with the humanities and social sciences. This strategy has also been documented for educators as a way to train teachers in their formative years. Hence, this pilot project builds upon elementary education with engineering expertise to bridge this gap.

Five elementary school teachers volunteered for this activity from the PIMAMC project. PIMAMC provides math and science professional curriculum development for K-12 teachers in the San Juan metropolitan area in Puerto Rico. The teachers from K-3 were among a diverse group that received workshops in robotics using the LEGO WeDo platform that is designed for elementary education. The LEGO WeDo was particularly chosen for the familiarity and ease of the integration with children activities, for the low learning curve of the programming language (visual programming rather than code writing), and for the educational content provided with it. Robotic clubs were planned at the participant's schools as pilot's programs to evaluate the children and their experiences.

## LEARNING EXPERIENCE

The experience for all the participants (teachers, engineers, and educators) in the PIMAMC sessions has been invaluable. Communication has been the key element since educational content, the curricular content, and the technical content must be contextualized at the children level. For this, listening is the most important part. Without the input and response of teachers the activities could not be planned. Motivation from the teacher's side is found to be the most important asset in this stage. Since this project is still being implemented, the teacher's observations of the student responses in the robotic clubs range from exceptional to being unfinished. The robotic clubs population sizes varied among participants, being as high as 8 children, to 2-3 on average. Curiously, the largest ones (6 and 8 students) have shown the best results. From the 5 teachers, 2 have reported exceptional results (one public, and one private school). Class attendance and class grades have increased since that is a requirement to be part of the club. Other teacher's students have improved behavior and grades in order to be able to participate, even requesting permission to be allowed in the same room as the club members during the activities. Motivation is really high among the participant students. Parents also express the desire to have such clubs open for all school students. This is desirable, but resources are scarce (space, robotic kits, computers, qualified teachers, curricular material).

## CONCLUSION

This pilot study provided insights about ways to improve the partnerships between teachers, engineers, and educators. Educators because they work directly with the curricula, engineers because they provide project-based learning activities as well as technical expertise, and teachers because they are responsible for the content in the classroom.

Adequate robotic tools and a planned curricular design are key factors for successful implementation of technology inside the classroom. In addition, the constructionism learning process of: learning by designing meaningful projects, constructing objects to explore and experiment, the use of powerful ideas to empower thinking, and the self-reflection are also inherent key factors for this methodology.

## ACKNOWLEDGEMENTS

The authors would like to thank the support provided by PIMAMC ("Proyecto Interdisciplinario para Mejorar el Aprendizaje de las Matemáticas y las Ciencias", interdisciplinary project to improve math and science learning) from the University of Puerto Rico, Rio Piedras Campus.

## REFERENCES

Alimisis, D, and Kynigos, C. (2009). "Constructionism and Robotics in Education". In Alimisis, D. (Ed.), *Teacher education on robotics-enhanced constructivist pedagogical methods*. Athens, Greece: School of Pedagogical and Tech. Education.

Bers, M. U., Ponte, I., Juelich, K., Viera, A., and Schenker, J. (2002). "Teachers as Designers: Integrating Robotics in Early Childhood Education", *Information Technology in Childhood Education*., pp. 123-145.

Bers, M. U., and Portsmore, M. (2005). "Teaching Partnertships: Early Childhood and Engineering Students Teaching Math and Science Through Robotics". Journal of Science Education and Technology, Vol. 14, No. 1, pp. 59-73.

Chaille, C., and Britain, L. (1997). *The Young Child as a Scientist: A Constructivist Approach to Early Childhood Science Education*. Boston: Pearson.

Papert, S. (1980a). "Constructionism vs. Instructionism", www.papert.org/articles/const_inst/const_inst1.html (2012/02/28)

Papert, S. (1980b). *Mindstorms. Children, Computers and Powerful Ideas*. New York:basic books.

Resnick, M. (1998). "Technologies for Lifelong Kindergarten". *Educational Technology Research and Development*, Vol. 46, No. 4, pp. 44-53.

Resnick, M. (2000), "Commentary: Looking to the future". *The future of Children*, 10 (2), pp. 173-175.