AC 2011-1909: INTRODUCING K-12 TEACHERS TO LEGO MINDSTORM ROBOTICS THROUGH A COLLABORATIVE ONLINE PROFESSIONAL DEVELOPMENT COURSE

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Introducing K-12 Teachers to LEGO Mindstorm Robotics Through a Collaborative Online Professional Development Course

Abstract

In recent decades, engineering and robotics programs such as First Lego League (FLL) have allowed children ages 9 to 14 to deeply engage with Science, Technology, Engineering, and Mathematics (STEM) disciplines and inspired them to explore careers in STEM fields. In 2009, NASA awarded Georgia Tech a contract to develop online professional development (PD) courses for STEM teachers. Electronic professional development (ePDN) courses are designed to model best practices in teacher PD by incorporating inquiry-based learning and by promoting the types of active interaction and reflection by participants that normally occur in effective face-to-face professional development sessions. In this study, the collaborative online courses and their impact on teachers' professional development are described. Additionally, a case study approach was employed to examine the effectiveness of online PD courses in classrooms and schools. Each teacher experience after completing the robotics course was presented as a case, and each case was used to explore the impact of robotics courses on teacher practices.

Key words: Professional development, K-12 teachers, robotics, online learning

Introduction

During the last decade, the use of robotics as an educational tool has dramatically increased[1]. It is mostly used to simulate the learning of concepts in Science, Technology, Engineering and Mathematics (STEM). Learning through designing, building and operating robots can lead to the acquisition of knowledge and skills in high-tech electrical, mechanical, and computer engineering areas that are in high demand in industry. It promotes the development of systems-oriented thinking, problem solving, self-study, and teamwork skills. A study conducted by Papert (1980)[2] about the use of LEGO robotic products in a constructive learning/teaching environment showed that this kind of environment provides children with the tools to become active rather than passive learners. Other studies have shown that students have a better understanding of the target concepts when they express themselves through invention and creation.

Robotics is also becoming an effective vehicle for teachers to introduce students to important areas of STEM curricula[3] and effective learning paradigms. For example, students' involvement in robotics contests has produced significant educational benefits[4]. Teachers have discovered that robotics allows children to experiment with different levels of design concepts through hands-on activities. In robotics activities, students engage in collaborative learning processes while designing and assembling LEGO robots. In order to solve a problem, students share opinions with one another about how to modify and improve their robots. Children learn more about the real world by working with robots[5].

Collaborative learning requires that teachers use technology to create a problem-based learning environment in which the problem drives the learning[6] .Robot construction kits such as

LEGO Mindstorm are developed to allow users to build fully autonomous robots while teaching the principal concepts of mathematics and engineering. The LEGO Mindstorm kit is a programmable teaching tool. The kit was designed to be consistent with educational concepts derived from Piaget's theories of cognitive development[7]. Using the kit, students can design and develop their own robots in a competition and learn in the process, which results in increases in student motivation, as well as improved skills in mathematics, science, programming, problem solving, and collaboration[8]. LEGO Mindstorms is today the most effective product which allows students to experiment with robotics while maintaining concurrent focus on the academic aspect of learning. A crucial component of the LEGO Mindstorm concept is the provision of high quality professional learning opportunities for K-12 teachers. For example, this would involve having teachers participate in formal professional development (PD) activities that expose teachers to robotic design activities which can be integrated into classroom practices constructively. Well-trained teachers, along with an appropriate educational philosophy, curriculum, and learning environment are critical to the successful integration of LEGO Mindstorm robotics in the classroom.

Based on this principle, in 2009, NASA awarded Georgia Tech a contract to develop online professional development (PD) courses for STEM teachers. One goal of this project is to support teachers' professional development through an online curriculum designed to enable teachers to learn skills for utilizing robotics concepts in conjunction with the Lego Mindstorm kits in math and science classes, and within an integrated STEM course. Traditionally this type of professional learning has been conducted face-to-face in workshops and summer institutes led by school systems, colleges and universities, educational support agencies, and private corporations. However this model only reaches teachers who are either within commuting distance of the service provider or are willing and able to travel to a remote site for sometimes weeks at a time. Further, this model does not provide follow-up support to the teachers after the workshop. Often, teachers need mentoring, refreshment of the information provided in the workshops, or simply confirmation that they are on the right track in their thoughts on how to use the knowledge they have gained. These limitations, and the need to minimize travel due to high energy costs and the impact on the environment brought the new models of professional development that rely primarily on electronic communication. These models leave behind a reliance on videotaped lectures and are instead grounded in new distance learning tools and based on research on how people learn. This NASA funded project provides an opportunity to develop an online PD model and deliver it to K-12 teachers, and by extension to their students all over the United States.

Purpose

The aim of this study is to describe NASA electronic Professional Development Network (ePDN) Robotics online courses for K-12 teachers and its impact on teachers' professional development. We present data indicating the level of teacher satisfaction with the collaborative robotics courses and whether teachers felt confident manipulating and integrating LEGO robotics in their classrooms. Additionally, a case study approach was employed to examine the effectiveness of online PD courses in classrooms/schools. Each teacher experience after completing the robotics course is presented as a case, and each case is used to explore the impact of robotics courses on teacher practices.

Background

Each ePDN course consists of a combination of synchronous and asynchronous components and entails 52 hours of work time by each participant, generally over the course of 14 weeks. Each course is broken up into five 10-hour stand-alone modules, with a 2-hour introductory module that provides information about the types of virtual learning tools that will be featured in the course and how to use them. Teachers who successfully complete 52 hours of professional development, either from one course or as a combination of modules chosen from different courses, receive Continuing Education Credits and a non-credit certificate from Georgia Tech that can be used by school systems to award local professional learning units (PLU) or credits. The Learning Management System (LMS) used by Georgia Tech is a program called Sakai. Sakai is an open source LMS. The Georgia Tech version of Sakai is known as T-Square.

The ePDN courses were created using the ASSURE model of Instructional Design[9]. The ASSURE model is based on Gagne's Nine Events of Instruction[10]. Gagne believes that there are nine events or processes that need to occur for effective learning to take place. The nine events are: 1. Gain attention, 2. Inform learners of objectives, 3. Stimulate recall of prior learning, 4. Present the content, 5. Provide guidance for learners, 6. Elicit performance, 7. Provide feedback, 8. Assess performance, and 9. Enhance retention and transfer. These nine events provide the basis for the design of the instruction model and for choosing the right media.[11] The ASSURE Model emphasizes teaching with different styles and the active participation of the students in the learning process.

In addition to the ASSURE model, the Quality Matter (QM) rubric was used as an evaluation tool and guidance for the instructor to design the delivery of the curriculum. The QM rubric consists of 40 key online course elements distributed across eight broad standards shown to impact student learning. The most critical course components related to those standards are: "Learning Objectives," "Assessment and Measurement," "Resources and Materials," "Learner Engagement," and "Course Technology." These measures are designed to align and work together, ensuring that students achieve the desired learning outcomes. The main benefit of using the QM rubric is in assisting course designers and instructors in effectuating clearer alignment of course/unit learning objectives with assessment materials and instruments, as well as making thoughtful decisions as to where to place such materials in the course schedule and how to replace course materials and instruments for future course revisions. Additionally, the QM rubric provides a clear set of guidelines for instructors.

The ePDN Robotics course Model

The Robotics courses are designed to model best practices in teacher PD by incorporating inquiry-based learning and by promoting the types of active interaction and reflection by participants that normally occur in effective face-to-face professional development sessions. These courses, which are asynchronous but are offered over a set period of time and require weekly participation, incorporate constructivist pedagogy (project-based learning, student centered learning, and collaborative learning environments) and offer the types of support that are characteristic of actual face-to-face activities[12]. For example, participants are required to work collaboratively, contributing various perspectives through wikis, chat rooms and forum discussion boards. Participants also share work electronically, providing each other with useful ideas about how to incorporate new materials into the actual classroom. Instructors interact frequently with participants through discussion forums, blogs, and podcasts, reflecting on the work completed during that week.

Well developed online learning requires more than just a simple shift from one medium (traditional classroom instruction) to another (online instruction). Rather than making online courses an extension of and/or substitute for traditional classes, designers should perform a large scale online simulation in which a single task or project becomes the focus of the learning environment. Another innovative model for online courses that takes advantage of the pedagogical benefits of online learning and advances in situational learning theory is virtual “knowledge rooms” where learners are provided the collaborative space for deep learning[13]. From a constructivist perspective, the ePDN model of online instructional activities, tasks, and tools seeks to engage course participants in a rich and complex learning experience. The course tools, multimedia presentations, text, and narration are designed to help participants take control of their learning and monitor their own progress towards achieving goals. The main approach is to create a learning environment based on constructivist principals and problem-based learning. Student engagement is an important component in online learning, and the research literature documenting the importance of participant interaction in online learning is extensive.

One of the four Robotics certificate sequences, *Using Robotics to Enhance STEM Learning Certificate,* focuses on educating K-12 teachers to utilize robotics with the LEGO Mindstorm kits in their math and science classes is. This certificate sequence consists of four courses, for a total of seventy (70) hours of work.

Course 1- Getting Started in Robotics (30hrs.): This course is an introduction to the basics of the LEGO Robotics kit and LEGO vocabulary. The main goal is to allow participants to discover some of the foundational skills and techniques of working in an online inquiry experience as well as the LEGO Mindstorm NXT manipulative. During this course, participants work in groups and investigate the incorporation of robotics in planetary discovery and basic robot autonomous control. During these activities the groups discuss the mathematics, science and engineering concepts that are associated with robotic design. As they progress through the investigations, students engage with concepts of structural design and integrity along with rotational motion forces and gearing systems. This course culminates with a group project that requires the groups to design and program a robot that is capable of composing text that spells a prescribed word.

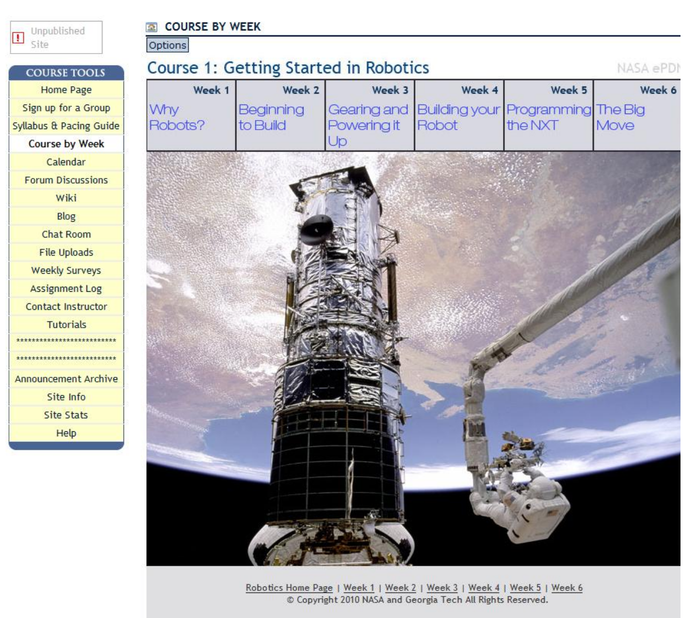


Figure 1: Example of Course Design

Course 2- Manipulators and End Effectors (15 hrs.): This course focuses on specific systems of robot design. It involves design and usage of manipulators and end effectors and discussions revolve around engineering strategies involved in the function of these two sub-systems. During the investigations, participants are led through designs that construct models similar to space station robotic arms and end effectors. Again, the linkage between engineering and science concepts are discussed and participants converse about methods to incorporate these concepts in their classroom curriculum.

Course 3- Advanced Programming and Sensors (10 hrs.): This course also focuses on developing advanced knowledge of robot designs. It allows participants to focus on sensory systems and programming with the main focus on how the sensors can be used to assist in navigation. In these investigations attention is focused in part on how the sensors operate and how they provide feedback to the navigation system. These investigations develop understanding of the electrical system and by the end of the course, participants have performed a number of trials that allow them to observe the effects of the different sensors.

Course 4- Grand Challenge (15 hrs.): The certificate program concludes by challenging the participants to incorporate all of their skills into a single navigation mapping exercise. In this experience, participants are asked to design a vehicle that can use gearing and traction systems to traverse uneven surfaces and ones with loose debris while continually tracking a line using light reflective sensors. During navigation the vehicle encounters an area where it must retrieve a sample and then avoid an obstacle before returning safely to base camp.

The robotic construction kit that was used in the ePDN courses was LEGO Mindstorms. This technology consists of both hardware and software . The software is called NXT and is a computer embedded in a LEGO brick (Figure 3). The *programming* for the NXT brick is a simple graphical flowchart type design.

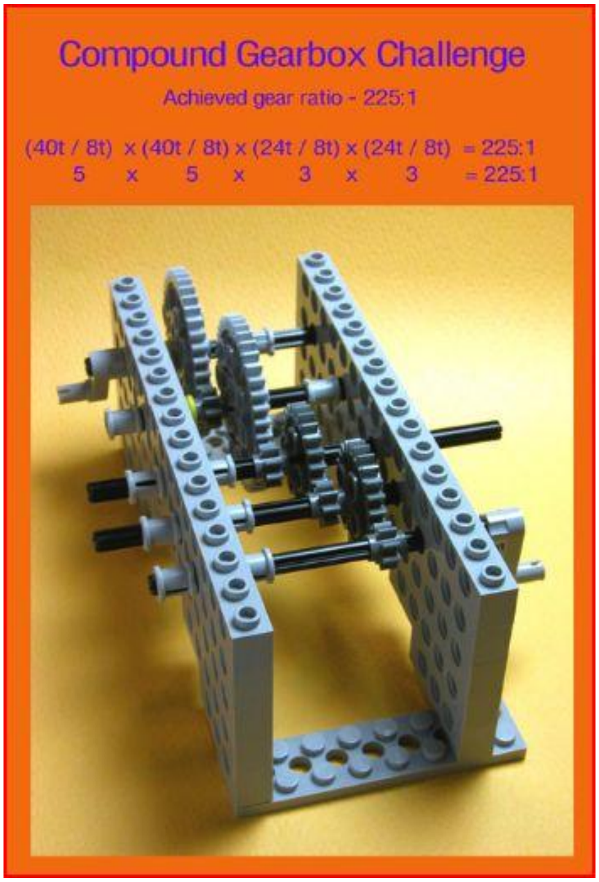
Figure 2- Robotics Software NXT

Figure 3- An example of a NXT Robot

An example of a course assignment: *Gearing up*

In the early part of course one, the participants are taken through an activity that explores the use of gears to alter rotational rates in motor outputs. During the activity participants are guided through a basic build of a gearbox with a 9:1 reduction ratio. A video details the materials and assembly of the gearbox and the completed build is represented in figures 4 and 5. After completing the build the participants are then instructed to view a video that explains how the ratio is then obtained as shown with the image in figure 6. At the completion of the gearbox construction and computation they are then assigned to create a gearbox using only the supplied parts with the largest gear ratio they can that is greater than 75:1.

Figure 4- Lego Brick



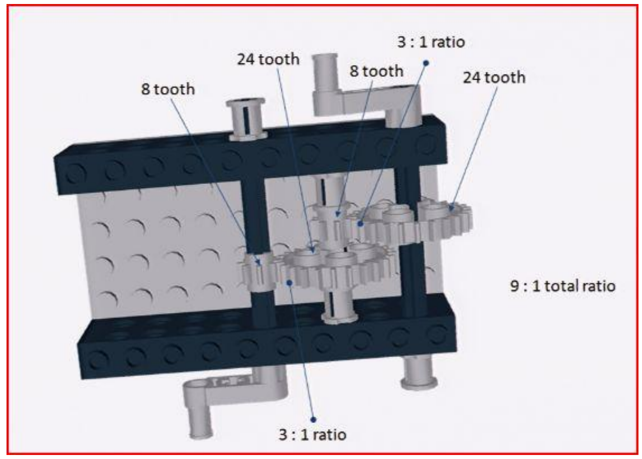


Figure 6- A screen shot from the gearbox construction video

Figure 5- Assembled gearbox

<u>A teacher's reflection on the "Gearing up" assignment from the forum discussion board</u>

Teacher Participant :

"I liked the experience with the gear boxes. I thought that it illustrated a lot of important math topics. The students are working with fractions (equivalent, simplifying), ratios, abd torque. I really liked the fact that the students could really "see" torque and ratios. I had a student guess what they thought the ratio would be (I brought my 25-1 gear box to school), and we could check the estimate by placing a peg into one of the gears and count the revolutions. Also, the student could feel the torque on gears. "

Methods

Sample

In 2010, fifty K-12 teachers participated in the first round of Robotics courses. These four Robotics courses, for a total of seventy (70) hours of work, took 14 weeks to complete. Demographically, 52% were female, 76% of the participants were Caucasian, 7% were Hispanic, and 3% were African American. Participants enrolled in the course from all over the United States including one participant from Puerto Rico.

Data Collection Methods

This study focused on in-depth understandings of participants' online collaboration and course satisfaction using case study methodology. According to Merriam (2001), a case study is an intensive, detailed description and analysis of a particular individual, group, or event. The purpose of using descriptive case studies in the instant context is to present basic information about areas of education where little research has been conducted[14]. The case study is the most appropriate qualitative method for this study because each case will be bounded by an ePDN certificate.

Ruhu and Zumbo's unfolding model[15] was used as the theoretical framework to collect data for this study. According to the authors, the following kinds of data need to be collected to accurately present scientific evidence.

- Scientific evidence:
    - Surveys/interviews/focus groups/online ethnographies to measure learner satisfaction with course components
    - Tutor
    - Online discussion group
    - Course Package
    - Course Materials
    - Checklist and rubrics to measure the environmental quality
    - Data/Statistics to track learner progress
    - Outcomes
        - Completion and retention rates
        - Student feedback

The evaluation research design was formative in nature. It emphasized multiple data collection methods and exploratory analyses. The key evaluation question was: *"To what extent were course participants satisfied with the course?"* A variety of data sources were used in this study, including participants' weekly feedback reports, forum and wiki discussions, end-of-course evaluations, and the course statistics provided through the Sakai course management system. Data on actual participation in online discussions were collected throughout the course. Students also completed a course evaluation survey at the end of the course which asked a series of questions addressing their overall experiences, especially as related to their learning and interaction with the instructor and the technology used.

The evaluation team monitored whether the goals of the Robotics certificate were being achieved by observing the following: a) student satisfaction with the Robotics courses; b) the value added to the educational experiences of teachers receiving professional development. Furthermore, the effectiveness of the Robotics courses was assessed by providing formative guidance to course implementation, educational components and educational partnerships and relationships.

The initial step of analysis involved written transcription of the data into qualitative analysis software. Once this was completed, open coding of the data began. According to Strauss and Corbin (1990)[16], "[d]uring open coding, the data are broken down into discrete parts, closely examined, compared for similarities and differences…" (p. 62). At this point, the qualitative analysis started with the breaking of the data into interpretive activities which involved categorization of small, discrete coded units. Although the intent was to minimize bias and erroneous findings, it is important to note the caveat that this study is designed to describe the course participants' experience-- not to make generalizations about Robotics professional development.

Course Evaluation Results

The participant background survey was administered at the beginning of the course and was completed by 32 participants. The participants were asked about their expectations from online learning. "*timely feedback from the instructor and small group discussions*" were described as the two most important components in online learning. At the end of the course, participants were again surveyed as to whether their expectations were met. 96% participants agreed (50% strongly agreed) that the course met their expectations. 96% of the students indicated that the instructor provided timely feedback, and 75% of participants were pleased with the small group discussions.

The participants were also asked about their reasons for taking the NASA ePDN Robotics course. The following was reported:

- 26 of the 32 participants plan to take other ePDN courses such as project based learning, and technology integration courses, and they are interested in completing their certificate.
- A majority of participants (94%) reported that they want to utilize and learn more about NASA materials in their classroom.
- 97% of teachers believed that the Robotics course could help them to teach academic content, knowledge and skills more effectively.
- There were 8 teacher participants who were currently teaching Robotics in their schools; however, they stated that they have never received formal training about Robotics. They felt the need for formal education.

The results showed that students were very satisfied with the teaching environment and thought that the teaching environment was very productive. Teacher participants' postings to the online discussions facilitated the development of community. Controversy, humor, personal experience and positive feedback all played valuable roles in the development of this Robotics online community. Cross postings, inviting comments and sharing leadership roles in group assignments served to mirror the dynamics of face to face communication. The total number of postings by individual students throughout the course ranged from a low of 8 to a high of 101 per week with a mean of 40 postings per week. It was observed that students were very engaged with the topic and very interested in developing their content knowledge.

The end of course survey results also showed that participants felt that the instructor clearly communicated important due dates/time frames for learning activities, and how to participate in course learning activities. In addition, a majority of participants (97%) agreed that overall effectiveness of the course and the instructor was very good.

All participants strongly agreed that the course increased their knowledge about NASA curriculum materials. Feedback from participants in the content course indicates that participants were generally satisfied with the course. 30% of participants found the course challenging, though not over their heads, and they appreciated the opportunity for online chats with other participants and/or the instructor. All of the participants of the survey either strongly agreed or agreed that the lectures contributed to their learning, with 57.1% and 42.9% respectively. Also, all of the participants agreed or strongly agreed that they could apply want they learned, that the work load was appropriate and that the course activities piqued their curiosity. The majority of the participants agreed or strongly agreed that feedback was timely and helpful and that the online discussions were valuable in helping them appreciate different perspectives. However, 3.6% were either neutral or disagreed that feedback was timely and helpful. Additionally, 10.7% were neutral about the statement that the online discussions were valuable in helping them appreciate different perspectives, and 3.6% disagreed with this statement.

A key finding emerged from qualitative data that enabling teachers to talk critically to one another is an important professional development process. Teachers reported that an asynchronous threaded discussion forums were a ”great” opportunity to engage in group discussions and to enhance the development of community amongst all teachers across the schools. This online discussion forum enabled teachers to talk critically about their pedagogy which could lead to utilizing Robotics in the classroom.

Course Impact On Professional Development

The teacher participants used the discussion board primarily to turn in their assignments and post questions. However, the way the questions were asked by the instructors gave way to open communication between the students. Students also commented extensively on one another's assignments, offering suggestions to each other as well as gaining insights on how to make improvements in their work. These discussions offered a platform from which to voice students' concerns and raise important questions about using Robotics in the classroom. Many of the students also posted at the end of the course what they felt were the answers to these questions. The students were also resourceful in adding additional insights from personal experience or website links to articles and videos that they believed would be helpful. It should be noted that at times the students veered off topic in their on-line discussions and had to be guided back to the task at hand. For the most part the Robotics course appeared to be helpful to the participants, and almost all of the feedback and/or comments provided through the discussion forum were positive.

During the course it was observed that students preferred to participate in collaborative activities. The results showed that halfway through the course, students did not have confidence in designing and assembling robots, but after participating in collaborative course assignments, students reported increasing confidence in that the discussion groups provided productive opportunities to learn from one another and generate more design ideas. Furthermore, students reported that when faced with a complex task, they would allocate task elements to members according to the member's strengths and then solve the problem together. Participants also used the chat room effectively to help each other with course assignments. During the chat room discussions, which took place mostly in the evenings, teachers shared their experiences and the difficulties they were facing in course tasks. They also used the chat room to discuss possible uses of Robotics in their schools/classrooms. Teachers also had in depth discussions about how to implement the robotics-enhanced constructivist learning in schools. Teachers reported their feelings about the course as follows:

"I learned a lot in this course. I think I can create a robotics based learning environment in my class. I teach science, and the activities that I learned in this class can easily be implemented in my classroom. My school just ordered some new LEGO kits. As a second year teacher, I don't think I did a good job of engaging my students, but using Robotics might really help in this area."

"I currently teach a yearlong space unit to my 4th and 5th grade gifted students, and although our program has a robotics unit, I have never taught it because I lack the skills and knowledge to do an excellent job with the unit. Because the two topics are so closely intertwined, my vision was to integrate the two units and teach space and robotics for an entire year. I would love to have my students participate in a challenge where the robots rescue a stranded astronaut and help with tasks on a lunar or Mars mission. Our school has been trying to start a robotics team, and the information provided by this course helped me to help get a team started. My expectations were to gain a working knowledge of the NXT robots, how to program them, and to learn more about how NASA is using robots in conjunction with humans as we explore space. Now, I feel confident that I can teach this course and help to build our Robotics team."

"After taking this course, I will integrate the course materials into my teaching. I believe it will enhance the traditional high school curriculum and offer our middle grade students an avenue to be more creative in applying their problem solving abilities. My expectations for my students is that this will foster a level of curiosity such that they will want to pursue post secondary careers in earth science, space science and at the very least continue to follow the activities of NASA. and our nation's earth and space programs."

Teacher participants also reported that they felt part of a community of practice between educators and teachers for facilitating and sustaining teachers' professional development in using robotic tools to support their students learning. One third of the course participants reported their desire to start a LEGO Robotics club in their schools and have their students attend National LEGO Robot competitions. Additionally, many participants were interested in being part of First LEGO League (FLL). The FLL is a global robotics program intended to start an interest for discovery, science, and technology in children ages 9 to 14. One teacher stated:

"I always wanted my students to be part of FLL; however, I did not have enough experience or knowledge to start a FLL in my school. After meeting all the other teachers in this class, I am confident that I can coach a team. FLL is not just about robotics, it is a journey that inspires students' interest in science and engineering, that emphasizes independent learning, teamwork."

"I have taken my students to Lego Mindstorms competitions and always wanted to educate myself about Robotics. I have a technology club and want to teach these students so that they can build and compete with the area's best middle schools and high schools in a local Lego Mindstorms competition in April/May. I also teach Project Lead the Way (Gateway to Engineering) and want my students to learn to build and program Lego Mindstorms. After taking these courses, I am equipped enough to do all of these."

Teacher participants also discussed the importance of obtaining Robotics certification. Several states are looking into implementing Robotics in math and science curriculum. Teachers acknowledged that being certified by NASA could help their school districts in implementing the Robotics curriculum. It will also give teachers the advantage of being a leader in their community.

Participants felt that the networking with the members of the class was *"invaluable"* and they learned a lot from each other by participating in critical discussion. As one teacher wrote *"I've already learned a lot from the members of my group, especially the ones who say they don't know much about robotics. They know a lot about teaching STEM and have provided me with different ways to look at things.*"

Teachers discussed their students attitudes towards LEGO Robotics. Some teachers were concerned that students would be attracted only to building robots but not learning academic-type content. However, some experienced teachers and the course instructors acknowledged that students benefit from learning a range of principles and techniques for solving problems. Additionally, they observed that students working on robotics projects developed conceptual knowledge involving understanding broad concepts and recognizing their application in various situations. One teacher pointed to the importance of teachers' informal instruction of concepts in science, technology, and problem solving because it promotes constructivist learning in the classroom.

A follow up survey was sent to participants who successfully completed the course through an electronic survey software program called Survey Gizmo. The survey results showed that 68% of the survey respondents were able use Robotics course materials in their teaching practice. Another positive finding which emerged from the follow up survey involved dissemination of the course materials in the schools: 60% of the teachers shared the course materials with other teachers. Several teachers indicated that they conducted workshops for fellow teachers about LEGO Robotics.

As a result, the impact of the Robotics professional development courses was viewed very positively by teachers. The experience increased not only teachers' personal knowledge, but also their commitment to developing new pedagogic skills and seeking out new ideas and new ways to improve teaching. The following section illustrates two examples of participants' post-course experience. It should be noted that because of time constrains the case studies are still in progress.

Case Study 1: A middle school teacher's experience upon completing the Robotics course.

The first teacher interviewed participated in the program from California. He teaches one class in Robotics and two each of 6th grade mathematics and 6th grade science in a high needs school. He described his school as an institution where *"over 80% [of students] are on free or reduced meals and over 80% have a native language other than English. Our dropout rate is too high. We have a lot of students with discipline problems."* Recently, he discovered that he can spark his students' interest in STEM by involving them in a STEM class. He believes that STEM classes or clubs can give students experiences that they cannot receive in a traditional classroom, and they also provide alternative learning methods that can reach low achieving students in STEM subjects. In that direction, he started a Robotics course in his school. He never received formal training for teaching the LEGO Robotics course. Hence, he was searching for professional development opportunities to improve his teaching practice and curriculum. After completing the four Robotics courses, he revised his classroom curriculum. He reported that taking ePDN Robotics courses made him see the gaps in his curriculum. He also mentioned that the Robotics courses had helped him to create a more positive climate for STEM teaching. One of the most important findings that emerged from this aspect of the evaluation was the role that the sense of "*online community belonging"* played in helping novice Robotics instructors such as this teacher to build the necessary level of confidence to effectively teach the Robotics course and to better relate to the students. For the novice Robotics instructor, it was less about improving their pedagogy and more about developing their ability to build LEGO Robotics products. In comparison, the most important impact on the experienced Robotics teachers, most of whom were already confident in their ability as teachers, was to help them build their capacity for effective teaching through improving their teaching skills and challenging them to try new approaches to engage students.

The above-mentioned teacher also provided an example of how he modified some aspects of the classroom curriculum. He changed the lesson on gears to include the gear train that was designed in the ePDN course. Before the ePDN experience, he would change the gears on Robotics but not have an individual activity to explore the basic build of a gearbox, which was hard for his students to understand or manipulate.

After the program, this teacher also pursued new opportunities for his students, *"I felt more confident after completing the Robotics PD to guide my students toward new opportunities."* Currently, his students are preparing to compete in the Southern California NASA Explorer School Robotics Championships (SoCaNESRoC) held annually at JPL. They also attended the 2009 NES Student Symposium where they gave a presentation about their robotics program. Additionally, he is also in a committee that mentors the new robotics programs in his district. He is planning to teach beginning robotics classes to several of the feeder elementary schools in his community starting in February, 2011, and will be hosting a district wide competition for their elementary schools in June, 2011. He concluded his remarks about the program with the following statement:

"*I feel like I am doing a better job after completing the Robotics certificate program. I also feel that I have a good support system that I gained during the course. I am still in touch with several classmates. I am very grateful that I took the online Robotics courses. I am encouraging other teachers in our district to apply to the program."*

Case Study 2: A teacher who started a Robotics after-school program

The second interviewed teacher was also a novice Robotics teacher who teaches middle school math. She had no prior knowledge about Robotics when she took the ePDN Robotics courses. Her experience after completing the course was very positive. She felt that the courses were very time consuming but worth it. After finishing the program, she was able to start an after-school robotics club with another teacher in Spring 2011. They have 20 students currently enrolled in the program, but she stated that the program is getting a lot attention and they will need more teachers who have experience with LEGO Robotics. By having her former classmates and the Robotics course instructor available to answer her questions and provide tips and resources, she became more confident in her role over the course of the semester and also realized that she is not "in this all alone." The key point that the teacher reported in coming to the ePDN Robotic course was that she felt the need to be educated to integrate Robotics into the school curriculum and to develop technological fluency. She also reported that she first needed to experience Robotics design experience herself and to engage in a learning by design experience through a professional development course in order to teach robotics courses effectively in her school. The LEGO Robotics ePDN courses met these needs. She concluded the interview by stating "*It s like a new era in my teaching career, I am so excited to bring this new teaching practice to my students"*

Conclusion

This paper describes the LEGO Robotics course and its impact on teachers' professional development. It has also explored the idea that the use of Robotics is an effective method for delivering STEM content in the classroom. Furthermore, there is a great need for teacher professional development oriented toward technology integration in the classroom. Today's students are increasingly more technologically "savvy," and K-12 teachers need to be encouraged to use more instructional technologies. Utilizing Robotics in K-12 classroom can be a vital strategy in engaging and motivating students in the classroom. This article introduced an online PD model for educating teachers to integrate robotics in the classroom through the use of LEGO Mindstorms.

The Robotics course is designed to model best practices in teacher PD by incorporating inquiry-based learning and by promoting the types of active interaction and reflection by participants that normally occur in effective face-to-face professional development sessions. The results of this study showed that this course was successful in meeting K-12 teachers' needs. Additionally, it demonstrates the importance of professional development for K-12 teachers and the potential of using robotics in their classroom. Students engaged in all the different facets of learning-by-design experiences. During the course, participants tested, evaluated, refined, and improved their knowledge of Robotics, and they developed effective skills for using LEGO Robotics in the classroom.

References

[1] Carbonaro. M. Rex, M. & Chambers, J. Using Lego Robotics in a Project-Based Learning Environment.

[2] Papert, S. (1980). Mindstorms: Children, Computers, and Powerful Ideas. NY, New York: Basic Books.

[3] Johnson, J. (2003). Children, Robotics and Education. *Artif Life Robotics*.,7, 16-21

[4] Verner , I.M. & Ahlgren, D.J. (2004). Robot Contest as a Laboratory for Experiential Engineering Education. *Journal on Educational Resources in Computing,* 4(2), 1-15

[5] Nalajala, T.D. (2003). *Internet Telerobotic System*. Unpublished Master's Thesis, University of Nevada, Reno.

[6]Slangen, Lou (2010) What pupils can learn from working with robotic direct manipulation environments. *International Journal of Technology and Design Education.*

[7] Piaget, J. & Inhelder, B. (1966) La psychologie de L'enfant. Paris: P.U.F.

[8] Klassner, F., Anderson, S.D.: Lego MindStorms: Not just for K-12 anymore. IEEE Robotics and Automation Magazine 10(2), 12–18 (2003)

[9] Heinich R., Molenda, M., Russell, J, & Smaldino, S. (1999). *Instructional Media and Technologies for Learning.* New Jersey: Prentice Hall

[10] Gagne, R. (1985). The Conditions of Learning (4th ed.). New York: Holt, Rinehart & Winston.

[11] Gagne, R., Briggs, L. & Wager, W. (1992). Principles of Instructional Design (4th Ed.). Fort Worth, TX: HBJ College Publishers

[12] Barab, S.A., Squire, K.D., & Dueber, W. (2000). A co-evolutionary model for supporting the emergence of authenticity. *Educational Technology Research and Development, 48*(2), 37-62.

[13] Herrington, J., Oliver, R. and Reeves, T. C. (2003). Patterns of engagement in authentic online learning environments. Australian Journal of Educational Technology, 19(1), 59-71.

[14] Merriam, S. B. (2001). Qualitative research and case study applications in education: Revised and expanded from case study research in education. San Francisco: Jossey-Bass Publishers.

[15] Ruhe, V. and Zumbo, B. (2009) *Evaluation in Distance Education and e-Learning* London/New York: Guildford Press

[16] Strauss, A. and Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques*. Sage Publications