Using Common Core State Standards of Seventh Grade Mathematics in the Application of NXT LEGO® Robotics for CReSIS Middle School Students

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Abstract—In 2010 Common Core Standards included critical content for all students in American education for forty-five states. Previously, every state had its own set of academic standards and students in each state were learning at different levels. In the new global economy, all students must be prepared to compete on a global basis. Students are expected to develop a deeper mastery of content and demonstrate what they know through writing and other projects. The North Carolina Department of Instruction's current curriculum and instruction are more student-centered with greater focus on skills, abilities, and a shift towards more performance assessments. This research was designed to focus on mathematical processes of the Common Core Standard in mathematics lesson plans for seventh grade students. Seventh grade students from two middle schools of Elizabeth City Public Schools in northeastern North Carolina were selected for this research at Elizabeth City State University (ECSU) for the Center of Remote Sensing of Ice Sheets (CReSIS). Pretest and posttest data were collected through student assessments and teaching observations to evaluate student growth in content knowledge, understanding and application. The Research Experience Teachers (RET) Team used mathematics strategies to teach various scientific, mathematical, and design concepts, through designing, by programming NXT LEGO® Robotics for the seventh grade level. The students received hands on experience for robotics construction and programming with application of mathematics, motion, and problem solving in a collaborative group setting

Index Terms— Common Core Mathematics Standards, NXT LEGO® Robotics, CReSIS

I. CRESIS

The Center for Remote Sensing of Ice Sheets (CReSIS) is a Science and Technology Center established by the National Science Foundation (NSF) in 2005, with the mission of developing new technologies and computer models to measure and predict the response of sea level change to the mass balance of ice sheets in Greenland and Antarctica. The NSF's Science and Technology Center (STC) program combines the efforts of scientists and engineers to respond to problems of global significance, supporting the intense, sustained, collaborative work that is required to achieve progress in these areas. CReSIS provides students and faculty with opportunities to pursue exciting research in a variety of disciplines; to collaborate with world-class scientists and engineers in the US and abroad; and to make meaningful contributions to the ongoing, urgent work of addressing the impact of climate change. [1]

Due to the harsh environments in which CReSIS research has been done, the use of robotics has become very necessary. The use of robots can take the place of human researchers who would like to explore these places. Teaching K-12 students to build and program robots will vastly shape the future of where robotics technology will go and how data will be collected.

II. INTRODUCTION

The North Carolina Mathematics Standard Course of Study is organized in five strands or goals for K-12: Number and Operations, Measurements, Geometry, Data Analysis and Probability, and Algebra. These are the objectives for each goal in competencies at each grade level and throughout the high school courses. It is the framework upon which classroom instruction and assessment should be planned. It is the ultimate guide for textbook selections and the foundation of the North Carolina testing program. On June 2, 2010, North Carolina adopted the Common Core State Standards in K-12 Mathematics and K-12 English Language Arts released by the National Governors Association Center for Best Practices and the Council of Chief State School Officers.

The Common Core State Standards Initiative is a state-led effort coordinated by the National Governors Association Center for Best Practices (NGA Center) and the Council of Chief State School Officers (CCSSO). The standards were developed in collaboration with teachers, school administrators, and experts, to provide a clear and consistent framework to prepare our children for college and the workforce. The Common Core Standard is designed to build upon the most advanced current thinking about preparing all students for success in college and their careers.

The mathematics teacher team applied the standard on grade seven. The team's project was designed to teach the students how to build NXT LEGO® Robotics and program them to complete an obstacle course using the 5E (Engagement, Exploration, Explanation, Elaboration, and Evaluation) style lesson plan. The 5E teaching style is inquirybased learning. In an inquiry-based classroom, the teacher's role becomes less involved with direct teaching and more involved with modeling, guiding, facilitating, and continually assessing student work. The team worked with middle school students. Within every section, the students were randomly grouped (3 to 4 members) with peers. The students used basic mathematical, problem solving, and teamwork skills to complete the assigned task. The members of the mathematics teacher team took the role of classroom instructors. The team followed the guidelines written out in the Common Core Standard as well as using the 5E lesson plan method. [2]

III. COURSE PLAN

Before working with the students, the RET team studied the Common Core Standard for North Carolina, NXT LEGO® Robotics, and the 5E lesson plan. The process started by studying the five strands for 7th grade mathematics. Using those five strands the RET team constructed a lesson plan using the 5E learning cycle. They then created a pretest of Common Core Standards-7th grade, from North Carolina Department of Public Instruction bank. After the students took the test, the team-taught content using the test items that the majority of student answered incorrectly and assigned Math Fun worksheets for homework. A posttest was administered the students after the lessons were completed in order to calculate the students' improvement after being taught. Later the RET team introduced NXT Lego robotics to the students. The students were divided into three competitive teams to be monitored by a member of the RET team for each team of students. The students assembled and programmed the robots using the application of the Common Core Standards and mathematics skills they had learned. The final phase of the research project was the students programming robots to complete an obstacle course designed by the RET team.

A. Methodology

- Introduction and pretest
- Teaching of lesson and posttest
- Components of a robot, the design and programming
- Break into teams
- Build and program robots

IV. USING THE 5E LESSON PLAN

With the assembly and program process of the robots mastered, the mathematics team moved to the teaching aspect of the project The team assembled seven 5E lesson plans for each level of student: three for elementary school, two for middle school, and two for high school. The lesson plan was based on a typical school day in which the students will encounter. See Appendix. The 5Es represent five stages of a sequence for teaching and learning: Engage, Explore, Explain, Extend (or Elaborate), and Evaluate. [3]

A. Engagement

The purpose for the engagement stage is to peak students' interest and gets them personally involved in the lesson, while pre-assessing prior understanding.

• The students became familiar with the project at hand and the learners shared their prior knowledge with robots and programming software. The team asked the students a series of questions such as "What do you know about robots?" "Have you ever assembled NXT LEGO® robots?" and "have you ever programmed a robot or anything pertaining to robots?"

B. Exploration

The purpose for the exploration stage is to get students involved in the topic, providing them with an opportunity to build their own understanding. Through self-designed or guided exploration students make hypotheses, test their own predictions, and draw their own conclusions.

• The RET team dissected the robots, telling what each part does. The team constructed a PowerPoint and the LEGO® tool chart to aid in this step. Afterwards, the students identified instruments and discussed how the robots function.

C. Explanation

The purpose for the explanation stage is to provide students with an opportunity to communicate what they have learned so far and figure out what it means. Explanation is the stage at which learners begin to communicate what they have learned. • Learners investigated the various NXT robots and a video of higher-level robots used by NASA to explore areas. Afterwards, the students shared what they've learned and understand about Robotics.

D. Elaboration

The purpose for the elaboration stage is to allow students to use their new knowledge while continuing to explore its implications. At this stage students expand on the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them in new ways.

• Learners applied their knowledge of robots and programming. The students were divided into two teams at each grade level; each team was to build, program, and test the robot while being timed. The mathematics team provided an instruction manual. There were no set time on the teams; therefore there was no pressure on the groups to configure their workings.

E. Evaluaton

The purpose for the evaluation stage is for both students and teachers to determine how much learning and understanding has taken place. Evaluate is the final "E", is an on-going diagnostic process that allows the teacher to determine if the learner has attained understanding of concepts and knowledge.

• Learners demonstrated their understanding of robotics by implementing skills obtained by building, programming, and testing the robot on a course built by the instructors. The groups debugged the errors found in their program after navigation of the course.

V. OBSERVATION

A. Curriculum Observation

The North Carolina Science Essential Standards maintain the respect for local control of each Local Education Authority (LEA) to design the specific curricular and instructional strategies that best deliver the content to their students. The pre test and posttest questions were extracted from the North Carolina Department of Public Instruction (NCDPI) test bank. Engaging students in inquiry-based instruction is a critical way of developing conceptual understanding of the science content that is vital for success in the twenty-first century. [4] Here is a list of competencies the team used.

• Applying geometric formulas, in order to find the area of a shape or object.

• Comprehending angles and learning how to adjust the degrees of an angle.

Develop understanding of fractions as numbers

• Solve problems involving measurement time and mass.

• Write and solve a number problem based on a realworld situation

B. Assembling Observation

The RET team was the facilitators over the groups. The team help mend problems in the build after the students finished building, along with facilitating in the testing and debugging phase. A problem that I noticed with all of the groups was the understanding of the instruction. However, the middle school students were very active in the construction of the NXT LEGO® robots. The facilitators spontaneously started a modern day "assembly line". The facilitators assigned each group member a page to assemble. The alternative enhanced the cooperativeness and dependency on one another. Each group member had to pay attention to the "assembly line" in order to know what portions needed to be done when it is their turn to assemble.





Fig. 1. Shows the scores of the pretest, posttest, and improvement scores.



Fig. 2. Shows the comparison of the pretest and posttest, along with test scores.



Fig. 3. Shows the improvement scores of the students.



Fig. 4. Shows the comparison of the pretest and posttest scores.

VII. CONCLUSIONS

The focus of this research project was to use the principles of the North Carolina Department of Public Instruction's Common Core Standard for 7th grade mathematics in a 5E lesson plan format and inquiry-based learning in application to Robotics. Effective use of a pretest to measure student content level, teaching needed mathematics skills in selected subjects, and posttest results from the End of Year seventh grade mathematics sample test showed growth in the achievement of Elizabeth City Middle School and River Road Middle School seventh graders.

Twelve highly qualified seventh grade students were selected for this program with nine completing the program. The RET team divided students into three research groups to assemble and program NXT LEGO robots to compete on an obstacle course using basic applications of seventh grade mathematics. Along with classroom observation, data was collected from the students' scores on the pre and posttest. The numerical range was between thirty-three and seventy-three on the pretest. However, results on the posttest had scores of sixty-three to ninety-three. The mean score of the students improved by twenty points per student with a mean improvement percentage of thirty-eight percent per student. This research resulted in significant improvement in understanding of seventh grade mathematics content.

VIII. FUTURE PLANS

The purpose of this research was to use the North Carolina Common Core mathematical standards for the application of NXT Lego robotics. CReSIS will continue to monitor the progress of the past CReSIS middle school students through middle and high school STEM related subjects. The CReSIS staff will continue to search for highly qualified students to participate in future CReSIS summer programs at Elizabeth City State University. Once they have completed the program, the students will be ask to fill out a survey of career interests in STEM related majors and their college choice, as well as, help the CReSIS staff become aware of what can be improved about the program.

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