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Teaching Computational Thinking at the Pre-K Level
Implementing a Pilot of the Junior Botball Challenge Program
For Students Aged 3-4

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Abstract

Awareness of the need to teach computer science and computational thinking concepts to all students has seen growth in momentum worldwide. Numerous programs have a focus on the K-12 space, but there are far fewer efforts targeting the Pre-K level. The KISS Institute for Practical Robotics, a 501(c)3 nonprofit organization, has been partnering with the Muscogee (Creek) Nation in Oklahoma for the last three years implementing the Junior Botball Challenge (JBC) program (45 schools), which empowers elementary educators to teach their students computational thinking coupled with engineering design and math concepts in the K-6th grades. This paper will describe the development, implementation and lessons learned from the pilot implementation of an adapted JBC program targeting the 3 and 4 yr. old level in Head Start programs. Teacher feedback from the pilot indicates that it is possible to begin teaching computational thinking and computer science concepts at the 3 and 4 year old levels when embedded in the curriculum. In addition, it is evident that school readiness skills, academic standards and central domains can be met by integrating the curricular activities into their daily routines.

1 Introduction

Awareness of the need to teach computer science and computational thinking (CT) concepts to all students has seen growth in momentum worldwide. Countries such as England, Finland, China and now Canada are requiring computer science be taught K-12 (Pretz, 2014).

Jeannette Wing head of the Computer Science Department at Carnegie Mellon University writes, "Computational thinking is a fundamental skill for everyone, not just for computer scientists. To reading, writing, and arithmetic, we should add computational thinking to every child's analytical ability. Just as the printing press facilitated the spread of the three Rs, what is appropriately incestuous about this vision is that computing and computers facilitate the spread of computational thinking."

At the elementary level computational thinking is often translated to teaching "coding". There has been a recent explosion as educators, lawmakers, and industry experts see great value in the computational and critical thinking skills that are developed while learning to code (Alba, 2017). A 2015 study showed that 3 out of 4 Asia Pacific students want coding in their daily curriculum, and yet a majority of these students feel that they are relatively unsupported by teachers and schools regarding their interest in coding (Microsoft, 2015). Numerous groups are working on developing educational standards, curriculum and related programming to help address this need. Examples include: Board games such as Robot Turtles; manipulatives like Cubetto, Code Caterpillar; along with numerous robot platforms such as: Bee Bot, Pro Bot, Dash & Dot, OzoBot and others. Other more computer based programs and applications include: Google's Made With Code project, Scratch, Tynker and tutorials from Code.org.

Teaching coding at the elementary level is not new. As early as the 1980's, Papert et al developed and used their Turtle Logo with elementary students. Substantial efforts are being made at the K-12 levels, however fewer efforts have targeted the pre-K level (3 and 4 yr. olds).

KISS INSTITUTE FOR PRACTICAL ROBOTICS

The KISS Institute for Practical Robotics, a 501(c)3 nonprofit organization, has been partnering with the Muscogee (Creek) Nation in Oklahoma for the last three years implementing the Junior Botball Challenge (JBC) program in K-6th grades and requested the development of a program to implement in Head Start programs. From our previous work with the JBC program (Miller, 2017) we were aware that we needed to select age appropriate robotic equipment, develop easy to use curriculum and provide ongoing professional development for participating educators. This paper will describe the development, implementation and lessons learned from the pilot implementation of an adapted JBC program targeting the 3 and 4 yr. old level.

2 Previous Work

The JBC program is a sustainable Computer Science (CS) and engineering, design-focused STEM program produced by the KISS Institute for Practical Robotics. This program is designed to support and empower elementary and middle school educators to teach their students coding and computational thinking coupled with, math and engineering design concepts using robots as manipulatives. Currently the program is being implemented in 354 partner schools (47% in-class) impacting approximately 4,000 students and 800 educators in 13 states. International participation includes schools in Austria, Canada and China. The program engages classroom teachers that have no experience teaching programming and CT concepts. The JBC strategy revolves around three main components: educator-friendly reusable robotics equipment, a standards-aligned curriculum and professional development. The inquiry-based curriculum has formative assessments with accompanying evaluation rubrics, which are performance-based and built into each of the lessons and accompanying activities. Summative assessments include the completion of performance-based challenges, where student groups demonstrate their mastery of the concept. Many times, these are publicly held challenge day events where buttons are awarded to students for each concept "challenge" mastered.

3 Head Start Program PILOT Overview

In combining a robotics platform, easy-to-follow curriculum and a proven professional development model, the pilot was designed during the summer of 2016 and implementation began in September of 2016 into 7 Muscogee (Creek) Nation Head Start programs located in Oklahoma serving ~390 Kids and 14 teachers. An additional 3 classroom implementations took place within Tulsa Public Schools, impacting 58 kids and 6 teachers. Participants worked with the program throughout the remainder of the 2016-2017 school year.

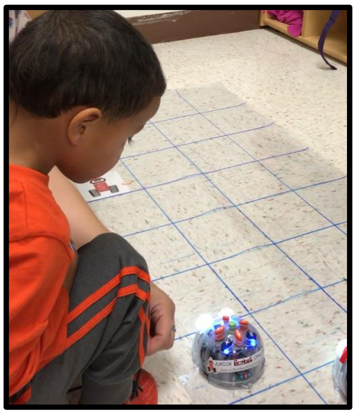
4 Robot Platform

A review of appropriate and available robot platforms was conducted with the goal of finding an economically friendly platform that did not require a computer and was easy to use by Pre-K children and teachers. Program design constraints included; limited resource classrooms, the need for hands-on manipulation, and the desire to limit screen time. The platform selected was the Blue-Bot by Terapin as it used what Seymour Papert called *"body-syntonic reasoning"*. Many educators use this strategy within the "be the robot activity" as it aligns with Jean Piaget's revolutionary notion of discovery learning, which asserts that children 'learn best through doing and actively exploring' (Manichander, 2005). Instead of a Turtle robot it is a friendly Bee robot. It has a clear shell allowing

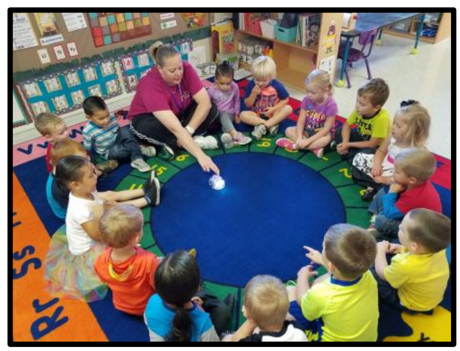
children to see inside the robot. Students can watch the components and make observations and discoveries. The robot is easily controlled by using a simple physical button interface on the outer shell without the need for a computer. The platform has the added benefit of being a multiyear tool for the student, given that it can be paired with a computer and programmed through Bluetooth as the student gets older and gains literacy skills.

5 Curriculum

The curriculum was developed with alignment to the Muscogee (Creek) Nation Head Start's monthly themes and with the Head Start central domains. These domains include: Math Reasoning, Science Reasoning, Language and Literacy, Social and Emotional Development, Language and Literacy Communication. In addition, the curriculum was aligned with the Oklahoma Academic State Standards for Pre-K.



The curriculum begins with unplugged, *"body-syntonic reasoning"* activities that the students give verbal directions for another student or teacher to move through an obstacle course. It continues using the Blue-bot by developmentally progressing through simple exploration activities that use the robot to learn socialization and school readiness skills. Using the four arrows and a Go button, children can program the movements and watch as the robot carries out their algorithm. Children quickly start debugging and re-programming their robots to complete simple tasks. Based on previous experience with the success of vinyl mats in the JBC program, clear grid mats and the JBC mat are utilized for activities. Robot command cards such as forward; stop, turn, are used to break robot motions down into individual steps. Botguy alphabet, number, and picture cards were developed and added to the activities to help motivate students and to provide a fun and interactive way to implement school readiness skills such as: alphabet recognition, number recognition, counting, phonological awareness, print awareness, and listening skills.

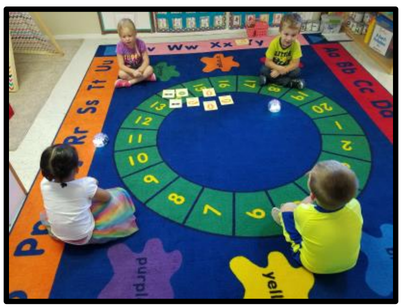


6 Professional Development

Teachers attend a 2-hour professional development workshop where they explore the Blue-bots, work through the curriculum and use the manipulatives. The teachers learn how the curriculum can easily be used and how the standards and skills can be integrated into the student's learning environment. During the workshop teachers realize how much pre-thinking and spatial skills the students will be using to complete the activities. Teachers leave the session with great ideas and ways to easily implement the program into their classroom.

7 Tentative Results

During the 7 classroom site visits that were conducted, the children were excited and focused while working in pairs or independently as they developed their strategies to meet their goals. Students were successfully using command cards to decompose and "pre-think" the task and were successful in debugging when their program didn't execute what they envisioned. Teachers reported that the students loved working with the robots and were amazed at the persistence and focus the kids had as they worked on completing the assigned tasks.



One head start teacher said, "The kids loved the Blue-Bots and caught on very quickly how to make it move forward and they started out seeing how many times they needed to touch the forward button to make the robot go to their friend sitting across from them!"

8 Conclusion

The pilot program success and teacher feedback indicates that it is possible to begin teaching computational thinking and computer science concepts at the 3 and 4 year old levels when embedded in the curriculum. In addition, it is evident that school readiness skills, Oklahoma academic standards and Head Start's central domains can be met by integrating Blue-Bots into their daily routines. The program continues to be implemented at the seven sites and the authors have received multiple requests from additional school districts for the program. Further research will include, both teacher and student efficacy and engagement.

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