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Introduction

Creating a model of a brain out of clay, measuring the speed of a balsa glider, writing the history of Ancient Egypt in sonnet form—these are all examples of the project-based, constructivist learning that takes place in the enrichment courses at the Center for Talent Development (CTD) at Northwestern University. The CTD mission is to provide resources, assessment services, and programs for academically talented students. We begin at age 3 in our Tadpole Academy parent-child courses. For students ages 4 through grade 8, we offer a wide variety of enrichment courses on weekends and in the summer.

In 2014, an article in *The New York Times* caught the attention of CTD program coordinators. "Reading, Writing, Arithmetic, and Lately, Coding" (Richtel, 2014) described the movement to adopt computer science as a core subject area in school districts across the country, most notably in Chicago and New York. The article discussed resources, such as the "Hour of Code" tutorials developed by Code.org, that allow young children to engage in introductory computer science learning. At CTD, we saw the need and opportunity to create a scope and sequence of computer science enrichment courses that create pathways for our youngest students to follow their interests and talents in computer science and robotics beginning in Pre-K.

In the summer of 2015 we launched our "Story Code" and "Robot Stories" curriculum tracks, eight one-week courses for grades Pre-K–3. Almost 500 students participated, and the course evaluations and assessments indicated that the pilot was very successful. We ran the courses again in the summer of 2016, inviting an interdisciplinary team of researchers from Northwestern University's School of Communication and School of Education and Social Policy to study student outcomes (Pila et al., 2016). For the summer of 2017, we created eight additional units organized into a coding track, "Coding Constructions," and a robotics track, "Robot Quest."

The challenge of creating this curriculum was that no model existed for how to teach computer science and robotics content to such young students. We began with the standalone lesson plans and activity guides that many of the robotic devices and apps provided with their products; combined these resources with what we already knew about constructivist, project-based learning; and created our own unique model that blends and balances virtual and tangible learning experiences and also provides creative challenges for advanced learners.

Another unique characteristic of our model is that the lesson plans are accessible and easy to implement by teachers with little or no background in computer science. Our priority is good teaching; we recruit instructors who have strong classroom management skills, are responsive to students, and are able to differentiate and challenge students at the appropriate level. The curriculum and resources are organized and presented using language and ideas that teachers find familiar and accessible.

During the initial development of the curriculum, we aligned our work with best practices in gifted education and developmentally appropriate practices for young children. Several resources proved to be essential, particularly from the National Association for the Education of Young Children (NAEYC), the Fred Rogers Center for Early Learning, and the Erikson Institute's Technology in Early Childhood (TEC) Center. The NAEYC position statement *Technology and Interactive Media as Tools in Early Childhood Programs Serving Children From Birth Through Age 8* (2012) inspired and empowered us to create a rich variety of learning experiences that involve tangible materials, social interaction, and play.

In October of 2016, after our Tech Beginnings curriculum had already been implemented for two summers, the K–12 Computer Science (CS) Framework was released. The framework was developed through a collaboration of key technology education organizations, such as the Computer Science Teachers Association, the National Math and Science Initiative, and Code.org. The K–12 CS Framework provides conceptual guidelines to inform the development of computer science standards and curriculum and build capacity for teaching computer science.

At CTD, we were gratified to see that the concepts and principles we used to create our curriculum aligned with the framework (K–12 Computer Science Framework Steering Committee, 2016). For example, the framework presented five "powerful ideas" that are relevant and significant in computer science learning at the early childhood level—play, patterns, problem solving, representation, and sequencing. The framework authors stated that when these five powerful ideas are applied to computer science, learning becomes "a natural extension of children's everyday engagement with their environment and builds on what educators already do in their daily practice" (p. 185).

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The Tech Beginnings curriculum is aligned with all five of the essential ideas outlined in the K–12 CS Framework. In particular, the idea of representation plays a significant role in differentiation for academically talented and creative students. Our experience in other subject areas is that students' learning deepens and their thinking becomes more complex when they have the opportunity to represent their thinking in more than one way. For example, a kindergarten-level student in the CTD "Blocks and Blueprints" course learns introductory geometry concepts through 3-D construction with wooden unit blocks. The student's learning deepens when the student is challenged to represent her structure using a different medium, such as sculpting clay, sketching on paper, or casting shadows on a wall. The Tech Beginnings curriculum emphasizes this kind of multimedia and cross-media learning, with an emphasis on the importance of connecting students' learning experiences in a virtual environment with meaningful and tangible experiences in real life.

Tech Beginnings Curriculum Overview

The Tech Beginnings curriculum is organized into tracks. Each track includes four courses or units. Each summer we offer two separate tracks of tech courses: a coding track and a robotics track. At CTD, each course/unit is implemented as a one-week summer enrichment course, offered 5 days in a single week, for 3 hours each day. Thus, the lesson plans for each course/unit included in this book are designed to cover 15 hours of instruction. These lessons can be adapted to use in a weekly or biweekly enrichment experience. For example, each 3-hour session could be divided into two 90-minute sessions. Each activity or learning center described in the lessons can also be used as a standalone activity or choice in a general classroom.

Each course/unit was created to serve a mixed-age classroom. CTD enrichment courses are usually organized into grade bands that cover two grade levels: Pre-K and kindergarten, kindergarten and first grade, first and second grade, second and third grade. This model allows for a broad range of interests and abilities in each classroom. The units in this book cover Pre-K through second grade, with built-in opportunities to scaffold activities for third and even fourth grade. The curriculum is structured to allow for constant differentiation; except for the group gatherings at the beginning and end of each class, all students are rarely engaged in the same activity at the same time. The learning center structure provides students many opportunities for choice. Each center activity is designed to accommodate four to six students. Instructors also have the opportunity of assigning students to specific centers and managing the center rotation to expose students to the activities in which they most need and want to engage.

The target population for these courses is academically talented students. At CTD, the requirements for admission in most enrichment courses are academic test scores that demonstrate achievement or ability in the 90th percentile or above. Many of the Tech Beginnings concepts are one or more grade levels above a general curriculum. For a general population of mixed ability, use the lessons at a lower grade band. For example, the units at the K–1 level are probably most appropriate for a general second-grade classroom.

Each unit is organized into a structure that includes the following components:

1. track description,
2. course description,
3. essential questions,
4. learning objectives,
5. lesson plans at a glance,
6. lesson details,
7. course-specific teacher preparation,
8. ideas for differentiation, and
9. course-specific resources (if applicable).

Following the lesson plans you will find additional sections on the following topics:

> teacher preparation,
> assessment practices,
> materials and equipment, and
> resources.

When preparing to implement a Tech Beginnings unit, read through the lesson plans first to get a general idea of how the unit is organized and what content the unit covers. Then, read the section on teacher preparation and consider which training or professional tasks you will need to complete in order to feel confident in leading the unit. For example, a teacher who is new to coding may choose to complete an "Hour of Code" tutorial online (many are available at https://code.org/learn) to become more familiar with coding concepts, or a teacher who is new to robotics may want to read the teacher guide or manual for the robotic devices that will be used in the classroom. If your school does not yet own the devices described in the lesson plans, check the Materials and Equipment section for resources and recommendations related to the purchase and use of the tech devices.

Before and during the implementation of the Tech Beginnings units, use the "Lesson Plans at a Glance" charts for easy access to the schedule and sequence of activities. The Assessment section (p. 151) includes the pre- and postassessment handouts. Finally, for additional resources and suggested picture books, consult the Resources section at the end of the book.

A Note About Block and Construction Centers

When these courses were first piloted, one of the most exciting discoveries was seeing how well the block and construction play supported and complemented students' coding activities on the tablets. Even when students were not given specific instructions, their block play seemed to naturally extend and build upon what they were learning about sequences, looping, and patterns. For example, after learning the repeat or loop commands on an iPad, a child built a "rainbow wall" out of colored blocks, demonstrating a repeating "loop" of a pattern of colors across her structure.

Instructors are encouraged to use block play as an opportunity to initiate spontaneous conversations about course concepts without directing students to build or play in a certain way. Let the play and construction develop and then make objective and specific observations: "I see you have made a pattern using triangles and squares." Ask open-ended questions that encourage critical thinking and metacognition: "Tell me how you made that. How did you decide which shapes to use?"

Whenever possible, draw students' attention to the ways their block play parallels or connects to the coding concepts: "I see you made a ramp that goes up and down. That reminds me of the way Daisy goes up and down when you program her with the jump command."

A Note About Expo

In CTD enrichment courses, parents and family members are invited to visit the classroom at the end of the course. This event, which we call *Expo*, usually lasts only 15–20 minutes, but we highly recommend providing this type of opportunity for students to demonstrate and reflect upon their work and for parents to learn more about their children's experiences in coding and robotics. Parents are usually very impressed to see how even very young children can begin learning significant computer science and robotics concepts. The at-a-glance charts in each unit demonstrate how Expo can be integrated into the courses. During an Expo event, the instructor welcomes parents with a brief overview and then students are invited to guide their parents through the learning centers.