Executive Function & Coding: Developing Skills for School and Life

Kristine M. Calo
Hood College

Abstract: Heeding the call to incorporate executive function professional learning in teacher preparation, the author describes a study of teacher candidates using Lesson Study to research, co-plan, implement and reflect on a coding lesson embedding executive function skills. After researching what executive function skills are, why they matter and how to support their development, teacher candidates collaboratively planned a coding lesson. A volunteer taught the lesson which was recorded. The other teacher candidates reviewed the lesson then collaboratively revised it. Candidates learned about the power of collaboration and the impact of intentionally planned lessons to support young children's executive skill development.

Keywords: Teacher Preparation, Executive Function, Coding

Introduction

Executive function skills are critical for young learners to begin developing in their early childhood years. These essential cognitive skills include attention, cognitive flexibility, inhibitory control, and working memory. Executive function skills serve as the foundation to helping children manage themselves and their ability to achieve goals. By using a collaborative, strengths-based lesson study approach, teacher candidates are in a unique position to learn about, practice, implement, and reflect upon effective ways to support young children's development of executive functioning skills. This, in turn, will help to ensure that future teachers are equipped to support and build executive function skills in their own classrooms.

What is Executive Function (EF)?

One way to conceive of executive function (EF) skills is to think of these skills as the "air traffic control" system of a child's brain (Center on the Developing Child at Harvard University, 1). Executive functions help children set goals, make plans to achieve goals and carry out these plans. Select areas of the brain where these skills reside are responsible for attention, working memory, self-regulation and cognitive flexibility. According to De Biase et al., (2014),

> Different regions of the brain specialize in different tasks. For example, when a teacher instructs his students to take out paper, crayons, scissors, and glue and to copy the art example on the wall, many different centers of the brain

SRATE Journal

A peer-reviewed publication of the
Southeastern Regional Association of Teacher Educators (SRATE)
2023, Volume 32, Issue 1
SRATE.org

> are called into action. Brain regions involved in auditory and language processing enable children to understand the instructions, and visual and motor regions of the brain direct the movements necessary to gather art supplies and begin working. In addition, several less obvious cognitive skills are equally critical for successful completion of this task. To comprehend the spoken instructions, children must pay attention to the teacher and filter out competing stimuli. And they need sufficient working memory to hold in mind all aspects of the instructions while carrying out the necessary movements. Finally, self-regulation is needed to remain on task and avoid engaging in other activities that may seem more desirable" (p. x).

The great news for early childhood educators is that these critical cognitive skills can be taught. In fact, according to the Center on the Developing Child at Harvard University, "Given the importance of young children's executive function skills and emerging evidence that these capacities can be improved through focused early intervention programs, efforts to support the development of these skills deserve much greater attention in the design of early care and education programs" (p. 12). In other words, not only can these skills be taught, but they should be taught.

Executive Function: Core Cognitive Skills

Attention. One of the first aspects of executive function that infants acquire is attention. Families and educators have long known intuitively that attention and learning are connected. That intuition is now grounded in science. Recent brain imaging shows us how the areas of the brain connected to attention play an essential role in learning and memory. In fact, some researchers call attention the gatekeeper for learning because of the role it plays with working memory.

Working Memory. Working memory is often referred to as the "scratch pad" of the brain. It is "the ability to hold in mind and manipulate small amounts of relevant information for short periods of time…Working memory also helps you comprehend language, solve problems, and follow instructions" (De Biase et al., 2014). Research over the past decade indicates that working memory is a better predictor of academic success than IQ (Alloway & Alloway, 2010).

Cognitive Flexibility. In today's fast-paced, interconnected world, the ability to shift one's thinking, switch strategies, find alternatives, and think flexibility about a problem or situation is exceedingly important. This capacity to find alternative ways to achieve a goal and to adjust one's behavior to different contexts and situations is referred to as cognitive flexibility (Kehagia, Murray, & Robbins, 2010).

Self-Regulation. The ability to resist impulses, delay gratification, recognize the emotions of others, manage behavior and reactions, and pursue challenging goals all fall into self-regulation. According to the Child Mind Institute (Rouse & Martinez, 2023),

> Self-regulation is the ability to manage your emotions and behavior in accordance with the demands of the situation. It includes being able to resist highly emotional reactions to upsetting stimuli, to calm yourself down when you get upset, to adjust to a change in expectations, and to handle frustration

> without an outburst. It is a set of skills that enables children, as they mature, to direct their own behavior towards a goal, despite the unpredictability of the world and our own feelings (p. 1).

Practices for Supporting Young Children's Development of EF Skills

Evidence shows that executive function not only affects children's learning in school, but also their overall life outcomes. Fortunately, there are specific practices that early childhood educators can teach and support to build children's executive function skills. Educators are also in the position of being able to help families learn about this important area of cognitive development and share ways families can easily and effectively support their child(ren)'s cognitive development. According to Ryan (2023), specific practices include helping children create and follow healthy habits and routines, simplifying directions, chunking large tasks, and setting goals. The Center on the Developing Child at Harvard University (2014) provides activities that adults can implement to support children's development of healthy executive function and self-regulation skills. For three-to-five-year-olds, for example, these activities include imaginary play, storytelling, movement songs and games, and quiet activities/games such as matching and sorting, puzzles, and even cooking. For five-to-seven-year-olds, additional recommendations include board games, card games, and physical activity games among others (Center on the Developing Child at Harvard University, 2014). Interestingly, Arfé, Vardanega, Montuori, and Lavanga (2019) found through their research that computational thinking via coding boosted children's spontaneous development of executive functions.

Using Lesson Study to Research, Plan, Implement and Reflect on Practice

Because executive function skills shape a child's capacity to learn, and the documented links between executive function and physical health, financial productivity and stability, and criminal behavior exist, the consequences of neglecting the development of children's executive function skills extends well beyond each individual child to society at large, (De Biase et al., 2014). Executive function skills are essential cognitive skills that have tremendous influence on the wellbeing of a child today and in their future.

In the Center on the Developing Child's report (2011), they state that teacher preparation programs provide little or no time in the instruction of executive function and its development. They state, "Early care and education professionals—as well as kindergarten and early elementary teachers—would be better equipped to understand and address behavioral and learning challenges in their classrooms if they had professional training in (and easy-to-use tools for) the development of executive function skills" (p. 13). To ensure that teacher candidates in our early childhood education program are aware of the importance of executive function, and have a repertoire of evidence-informed strategies to teach and promote all children's development of and use of executive function skills (EFs), the author embedded EFs into an ECE Lesson Study Cycle in a Theory & Practice in ECE course in a traditional teacher preparation program. We used robot coding as the tool to embed the EFs. The ECE Lesson Study Cycle promoted the professional learning of teacher candidates by providing a space for teacher candidates to conduct collaborative research,

lesson design, and reflection. The four steps of our ECE Lesson Study Cycle included Study, Plan, Teach & Observe, and Reflect (Calo, 2023).

ECE Executive Function Lesson Study

Step 1: Study

The teacher candidates engaged in collaborative research to understand what executive function is, why it matters, and how to support the development of EF skills in early childhood classrooms. The teacher candidates watched videos and read research underscoring the importance of these aspects of cognitive development. One core takeaway from the research was the tremendous impact of executive function skills on learning and life. Knowing that these skills shape a child's capacity to learn, the teacher candidates further researched specific evidence-based strategies for supporting the development and use of executive function skills. During this semester of their teacher preparation program, all the teacher candidates were interning one half day a week in inclusive PreK classrooms in local schools. Given their field placements, they refined their research to look specifically at PreK, focusing on children ages 4-5. During this research the teacher candidates decided to focus on coding as a vehicle for their EF lesson (Arfé et al., 2019; Çakır et al., 2021; Macrides et al., 2022). This broadened their research to incorporate coding with young children. Once the teacher candidates had a strong understanding of executive function skills that could be developed using coding as the vehicle, they were ready to begin their collective brainstorming of lesson ideas.

Step 2: Plan

After looking at several different types of robots, the teacher candidates decided to use the Code & Go Robot Mouse (Learning Resources, 2023) for this lesson. Teacher candidates decided that they would need a way to hook the children's interest prior to beginning the actual coding activity. To do this, they decided to begin with a whole group read aloud. They reviewed several children's books that built on the concept of coding, eventually landing on *Pete the Cat: Robo-Pete* by James Dean. A key vocabulary term they pulled from the book was "program". Using the context of the story and the images, the teacher candidates unpacked what it means when Pete "programs" his robot friend. They said that "Pete entered, or put in, a code that Robo-Pete followed. The code tells Robo-Pete what to do." Throughout the rest of the book, the teacher candidates asked questions about the code, such as "What did the code tell Robo-Pete to do in this part of the story?" and "Now what did the code tell Robo-Pete to do?" After much discussion, the teacher candidates decided that after the whole-group read aloud, the best way for the young children to engage in the coding lesson would be in small groups. To get the students excited about the center activity, one teacher candidate suggested that the teacher tell the students that they would have the opportunity to code their own Robo-Mouse to tell it what to do just like Pete the Cat coded his Robo-Pete.

The teacher candidates then crafted a center with activities at three different levels, allowing for varying degrees of complexity in the coding and support to meet the small group needs of students. As they discussed how the center activity would be differentiated, much of what they focused on was the questioning that the teacher would engage in as well as the number of steps in the code. The depth of teacher scaffolding, they decided, would depend

on the executive function skills of the children in each group. To encourage effortful thinking on the part of the young children, the teacher candidates intentionally focused on including question starters such as why and how. As they created the center activity lesson, they focused on the EFs being supported—inhibitory control as students wait for their turns and watch the mouse follow their code, regulating emotions as they watch their code gets followed or as the mouse goes in a wrong direction, cognitive flexibility as they realize they need to alter their code, and working memory as students remember each step in the code to program the code into the mouse using the correct buttons. The teacher candidates discussed how they would draw other students' attention to the use of these skills. They created sentence stems that they could incorporate such as "I like how you knew you needed to change the code so Robo-Mouse would turn in the correct direction" or "I like how ____ and ____ are watching carefully to see how you code the mouse. We're a team working together!" and "Let's watch as ____ remembers to code all # steps." They anticipated ways that they could scaffold support as needed.

After designing the lesson and considering where they could best support EFs and manage any misconceptions, the teacher candidates determined how they would observe the lesson. They decided to video record the lesson and create a feedback form with guiding questions. The guiding questions they created included:

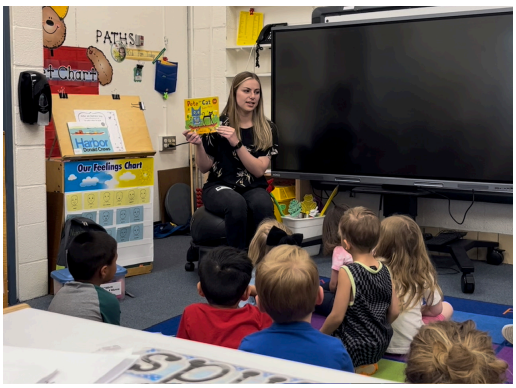
- What evidence did you notice of students using EF skills? (Notice children's inhibitory control, working memory, cognitive flexibility. Watch what children do. Listen to what they say.)
- How did the facilitator support the children? (Focus on interactions. Notice adult directions and scaffolded support.)
- How was play or a game-like atmosphere created?
- How were the different groups of students engaged?
- What suggestions do you have to improve this lesson or next steps for making this lesson more challenging for those who are ready for added challenge?

Step 3: Teach and Observe

One of the teacher candidates volunteered to teach the initial lesson in a local PreK classroom. As the course instructor, I observed the lesson as did her mentor teacher. We recorded the read aloud and two of the three student groups. One group was not videotaped as there were students in that group who did not have media releases. All the other students' families had returned signed video releases.

The teacher candidate introduced the book and activated students' prior knowledge about coding. Figure 1 shows the teacher candidate introducing the Pete the Cat book to kick off the lesson on coding. After reading the book and ensuring students understood the terms program and code, she introduced the centers. Students beamed with excitement to get to her center.

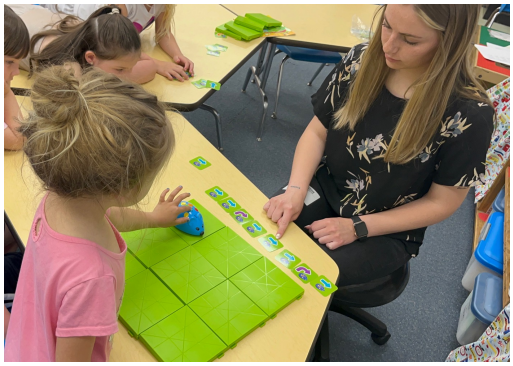
Figure 1. Lesson Introduction



Note. The teacher candidate introduces Pete the Cat and his robot friend.

At the teacher candidate's center, the PreK students took turns programming their Robo-Mouse just like Pete the Cat had programmed Robo-Pete. The teacher candidate set the situation up as a problem/solution exercise. The problem was that Robo-Mouse was very hungry. The students needed to help Robo-Mouse find the cheese. But the only way that they could tell the mouse where to go and what to do was by programming it with a code. Using cards to identify actions (e.g., turn right, turn left, go straight), the students created codes of various complexities, as seen in Figure 2.

Figure 2. PreK Student Programs the Mouse to Find the Cheese



Note. Other students patiently wait their turn and watch to see how the mouse follows the code.

The other teacher candidates watched the three videos, and took notes on what they noticed, heard, and saw. They used the guiding questions the group had created to focus their reflections. All teacher candidates came to class ready to debrief the lesson.

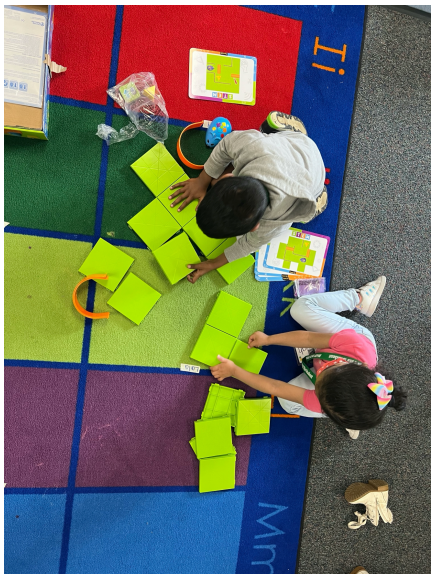
Step 4: Reflect

The teacher candidates shared their insights into what they noticed about what the children said and did as well as what the teacher candidate had said and done. They

specifically shared what they noticed about how the children used their executive function skills and how the teacher candidate supported their use of these executive function skills. At the end of the reflection and debrief, the group shared suggestions for how to strengthen the center activity. One suggestion was to provide opportunities outside of the center for students to continue to play with the Robo-Mouse and code on their own. One teacher candidate remembered a quote from Harvard's Center on the Developing Child, "Children's executive function and self-regulation skills grow at a fast pace during this period [ages 3-5], so it is important to adapt activities to match the skills of each child. Younger children need a lot of support in learning rules and structures, while older children can be more independent. Ultimately the goal is to shift children away from relying on adult regulation, so when the child seems, ready, try to reduce the support you provide" (p. 6). Other suggestions included more opportunities for the students to reflect on how they themselves used EFs. They added questions such as "How did you plan your code?" [visual working memory and planning skills], "How did you ignore distractions?" [practice inhibition and focus attention], and "What did you do when you noticed that the first code didn't work?" [monitor and adjust their actions and persist to achieve their goal]. The lesson was refined to incorporate the suggestions of the group.

As a second teacher candidate incorporated the newly revised lesson into her PreK classroom. This teacher candidate also included opportunities for students to use the robot and materials on their own or in pairs. Figure 3 shows students exploring coding after having engaged in the coding lesson. This paired practice not only fostered coding skills but provided an opportunity to further boost EFs as well as problem solving, collaboration, and communication.

Figure 3. Paired Practice



Note. Two PreK students explore collaborative coding during free time.

Lessons Learned from Lesson Study

Teacher candidates noted that the experience of collectively researching an important topic in early childhood helped them see different perspectives and have a strong sense of what young children needed to do and why. Specifically, teacher candidates gained knowledge on what executive function skills are, why they are important, and how to support children's development of these cognitive skills. The collaborative lesson creation allowed teacher candidates to gather ideas from one another, refine and synthesize ideas, and see firsthand that there are different ways to approach teaching and learning. The observations and reflections on the teaching were completed from a strengths-based perspective. The goal was refining the lesson to continue to make it stronger, while learning from one another. One teacher candidate noted, "I learned that EF can look different in different students. You might think a student is lacking in executive function, but then in reality they might show the opposite when you sit down and really focus on what skills they're using." Another teacher candidate shared, "I learned that some students have better executive function skills than others. I found that every student in my class could do this, but some would need more structure and support put in place for them to be successful." Echoing this statement, a fellow teacher candidate said, "I learned more about executive function. One thing in particular I picked up on is that some students will need a lot more teacher regulation because they might not be used to structure and rules. Another is that it is very important to establish structures within the classroom before engaging in EF activities." A fifth teacher candidate commented on the value of using coding as a way to develop executive function skills, "In my lesson I had quiet students come alive and engage in the coding activity. I also had some students who were excited and participated as expected. Coding was an engaging way to get them to problem solve, collaborate and practice their EF skills."

Overall, embedding executive function and coding into a Lesson Study framework allowed teacher candidates the opportunity to delve into current research, communicate ideas, reflect on practice, and adjust lessons based on students' needs. Teacher candidates not only learned professional behaviors and the power of collaborating with colleagues, but they also refined their skills as reflective practitioners. Moreover, through their research they learned about the power of executive function on learning and life, and through their collaborative lesson design and reflection they designed effective lessons that promoted positive development in these cognitive skills.

References

Alloway, T. P., & Alloway, R. G. (2010). Investigating the predictive roles of working memory and IQ in academic attainment. *Journal of Experimental Child Psychology, 106*, 20-2. https://doi.org/10.1016/j.jecp.2009.11.003

Arfé B., Vardanega T., Montuori C., & Lavanga M. (2019). Coding in primary grades boosts children's executive functions. *Frontiers in Psychology*. https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2019.02713/full

Çakır, R., Korkmaz, Ö., İdil, Ö & Erdoğmuş, F. (2021). The effect of robotic coding education on preschoolers' problem solving and creative thinking skills. *Thinking Skills and Creativity, 40*(1). https://doi.org/10.1016/j.tsc.2021.100812

Calo, K. M. (2023). Dialoging about dialogic reading: A lesson study approach for teacher candidates. *Southeastern Regional Association of Teacher Educators Journal, 32*(2). https://www.srate.org/z_journal_archive_32_2.html

Center on the Developing Child at Harvard University. (2011). Building the brain's "Air Traffic Control" system: How early experiences shape the development of executive function. *Working Paper No. 11*. http://www.developingchild.harvard.edu

Center on the Developing Child at Harvard University (2014). *Enhancing and practicing executive function skills with children from infancy to adolescence.* www.developingchild.harvard.edu

De Biase, L. M., Calo, K. M., & Magsamen, S. (2014). *Putting scientific research into practice: A scalable early childhood and family learning model for 21st century learning*. Houghton Mifflin Harcourt, 3-48.

Kehagia, A.A., Murray, G.K., & Robbins, T.W. (2010). Learning and cognitive flexibility. *Current Opinion in Neurobiology, 20*(2), 199-204. https://doi.org/10.1016/j.conb.2010.01.007

Macrides, E., Miliou, O, & Angeli, C. (2022). Programming in early childhood education: A systematic review. *International Journal of Child-Computer Interaction, 32.* https://doi.org/10.1016/j.ijcci.2021.100396

Rouse, M. H, & Martinez, A. (2023). *How can we help kids with self-regulation? Child Mind Institute.* Retrieved February 17, 2025, from https://childmind.org/article/can-help-kids-self-regulation/

Ryan, S. (2023, September 19). *How to help kids develop executive functioning skills*. CHOC. https://health.choc.org/how-to-help-kids-develop-executive-functioning-skills/

About the Author

Kristine M. Calo, PhD, is a Professor and Department Chair at Hood College. Her areas of research interest include lesson study in early childhood teacher preparation and literacy teaching and learning in elementary classrooms.