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# Harnessing Robotics and Coding to Foster Social-Emotional Learning in Students With Autism

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**Abstract**
Science, technology, engineering, and mathematics (STEM) curriculum and learning activities may help students learn social-emotional learning (SEL) competencies needed to support independence and community living, as well as 21st-century career development skills. Including robotics and coding curriculum in elementary classrooms can offer all students engaging academic experiences that include opportunities for students to problem solve, discuss ideas, and collaborate to find solutions. This article presents a vignette about a teacher's use of technology and robotics to engage a student with autism while supporting their SEL needs. The vignette was inspired by real scenarios in classrooms where educators have utilized technology to support students with disabilities and promote inclusive learning environments. Options for attainment and use of robotics and coding in the classroom are presented, including a future option through an open-educational resource, Project RAISE.

**Keywords**
elementary school, age/grade level, science technology engineering and mathematics, content/curriculum area, autism, exceptionality, instructional design, instructional/policy perspectives, robotics, technology perspectives

## *Vignette*

*Ms Roberts is a fourth-grade inclusion elementary school teacher. One of her students, Frankie, has autism and has an individualized education program (IEP) goal to increase his reciprocal communication in social interactions with peers. Ms Roberts has worked with the special education teacher to plan activities that facilitate peer collaboration and verbal exchanges. Frankie still primarily responds to others with one-word answers and requires prompting from Ms Roberts or the paraprofessional to initiate a verbal interaction. Frankie likes technology and prefers to work on the computer or iPad by himself. Ms Roberts has been searching for ways to use the iPad or other technology to support Frankie's goal of supporting his reciprocal communication during peer interactions while supporting academics. During her search for tools, she learns of a pilot program called Project RAISE that she would like to consider for Frankie.*

## Introduction

Science, technology, engineering, and mathematics (STEM) curriculum has become more commonplace in early childhood and elementary classrooms (Oppermann et al., 2021). Introducing STEM activities to all students at an early age is critical to ensure future STEM-related college and career options. The Every Student Succeeds Act (ESSA, 2015) documented the need for STEM skills to be taught in schools, with federal support to help recruit, prepare, and train teachers to instruct in these areas. While legislation like ESSA (2015) include references to preparing students for STEM-based careers, not all students will find these careers the best fit for them (Opperman et al., 2021). However, engaging in STEM learning experiences presents students with additional benefits apart from STEM career readiness, including a powerful way to expose students to social-emotional learning (SEL; Lee, 2022; Su & Guo, 2023). Social-emotional skills include the ability to manage emotions, make positive relationships, and act in socially appropriate ways. These skills are important for children's success in school, in relationships, and in their future workplace. By engaging in STEM experiential learning activities, students learn to work together and acquire skills like collaboration, understanding others' points

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of view, problem-solving, creativity, and decision-making (Seage & Türegün, 2019). Students may also learn to regulate their emotions, work towards goals, and think critically (Strawhacker & Bers, 2019). These skills are paramount to independence and community integration for all people (Rios et al., 2020).

The ability to collaborate is a core competence that students need to learn in school to be prepared for the realities of the 21st-century (Liebech-Lien & Sjølie, 2021). Collaborative learning "involves groups of students working together to solve a problem, complete a task, or create a product" (Laal & Laal, 2012, p. 491). Collaborative learning activities challenge students' social-emotional skills as students are required to communicate and support their ideas while also actively listening to the views of others (Laal & Laal, 2012). Classroom robotics and coding (i.e., computer programming) activities provide an opportunity to integrate 21st-century technology skills with learning and innovation competencies (Chen et al., 2020). Students can share ideas and opinions about robotics programming, naturally practicing communication and collaboration skills throughout the process (Cheng et al., 2013).

According to the Collaborative for Academic, Social, and Emotional Learning (CASEL; 2023), key social-emotional competencies that all students need are self-awareness, self-management, responsible decision-making, relationship skills, and social awareness. The collaborative nature of robotics activities fosters the development of these core SEL competencies as students learn to communicate, overcome obstacles, manage frustration, and make choices. Setbacks in school and life activities provide opportunities for students to learn to manage their emotions, regulate frustration, and persevere through challenges. As such, robotics activities provide powerful opportunities for all students, with and without disabilities, to learn social-emotional skills and academic content in applied learning contexts (Chen et al., 2020).

Su and Guo (2023) noted STEM projects can align with CASEL's SEL competencies in the following ways:

- Self-Awareness: STEM projects require students to assess their own strengths, interests, and limitations, and establish a sense of self-efficacy.
- Self-Management: STEM projects require planning, setting goals, regulating emotions when problem-solving, and adapting to changing circumstances.
- Social Awareness: STEM projects often involve collaboration and teamwork. Students interact with peers, engage in discussions, and learn social norms for behavior.
- Relationship Skills: Collaborative STEM projects provide opportunities for students to enhance their communication, active listening, negotiation, and cooperation. They also develop skills in resolving conflicts, working in teams, and valuing the contributions of others.
- Responsible Decision-Making: STEM projects require students to make informed decisions, evaluate options, and solve problems. They learn to think critically and consider the ethical implications of their choices.

Specifically, robotics and coding have emerged as promising STEM technology tools for supporting the social-emotional development of students with autism (Carmona-Serrano et al., 2020). Students with autism spectrum disorder (ASD) have difficulty with social interactions, behavior management, and interpersonal skills (e.g., collaborating with others, problem solving, persistence; Centers for Disease and Control Prevention [CDC], 2023). Robotics (e.g., KASPAR, NAO, Misty) have been used in research studies to provide support in social skill development for students with ASD (Saleh et al., 2021). Fewer studies have been conducted that focus on teaching students with ASD coding using robotics to support SEL skills (Knight et al., 2019). Knight et al. (2019) found students with ASD may have success in learning coding and STEM skills through robotics, while also learning problem solving and social skills. Students with ASD are often drawn to technology (Crossman et al., 2018) and a shared interest in robotics may support students with ASD in interactions with peers (Knight et al., 2019).

Currently, researchers are developing studies (e.g., Project RAISE) to continue learning about students with ASD and their engagement with robotics/coding, learning SEL skills, and being supported using socially assistive robots (SAR; Hughes et al., 2022). Project RAISE was developed as a five-year collaborative project between UCP of Central Florida and the University of Central Florida (UCF). The project aims to improve the social-emotional and communication skills of students with autism (and other intellectual or developmental disabilities) by creating a teaching toolkit and curriculum featuring robotics (i.e., Dash by WonderWorkshop), a team created blockly application (i.e., blocks of code are moved and connected in sequential order to dictate movement to a robot, referred to in this manuscript as "Project RAISE blockly"; Shah et al., 2023), and an AI-driven SAR avatar called ZB™ (pronounced "Zeebee"; designed, created, and patented by a team of researchers at UCF; see Figure 1).

The Project RAISE toolkit, named "ZB's World™," is focused on supporting students with disabilities in learning real-world 21st-century skills like problem-solving, collaboration, cooperation, strategic thinking, and communication while immersed in robotics programming activities in a safe, distraction-free environment. Students using the toolkit are first guided through a social story introducing them to ZB and then time to learn how the Project RAISE blockly application functions (e.g., listening to directions, moving blocks, asking questions). Following the social story, students have opportunities to increase coding skills, STEM content knowledge, and SEL skills in three phases:

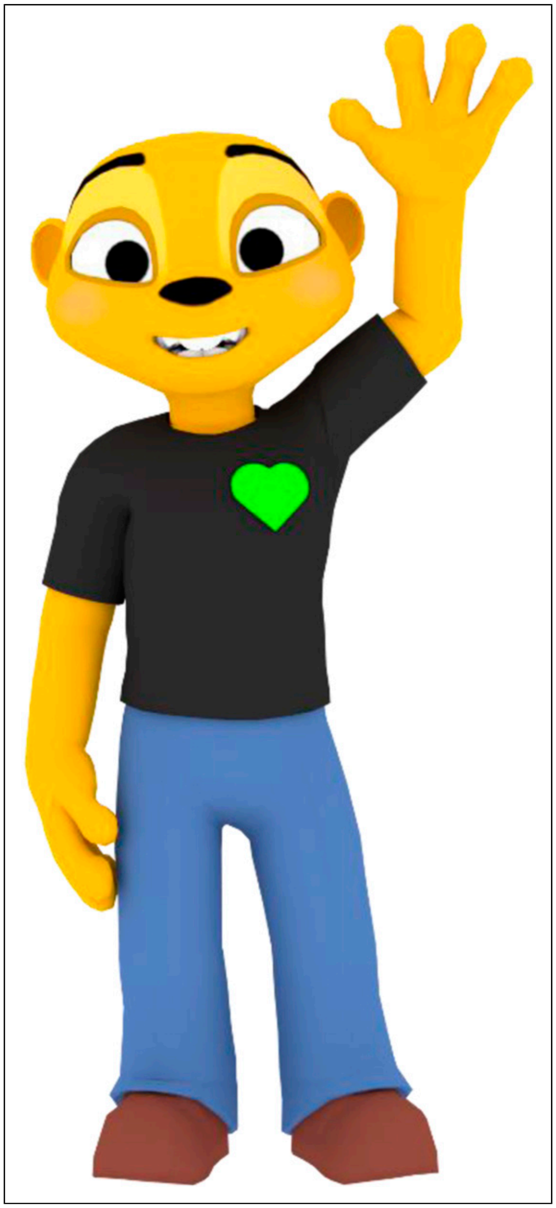

**Figure 1.** Socially Assistive Avatar ZB™.

(1) Students learn coding skills using the Project RAISE blockly application (developed by the research team which will be able to connect to Dash or use an onscreen virtual robot) and receive social-emotional coaching with the support of ZB; (2) Students share their new coding skills by teaching a neuro-typical peer coding with the same Project RAISE blockly application; (3) ZB provides support in other classroom activities and academics to allow students maximum support (e.g., verbal affirmation, redirection) with social-emotional skills in the general education setting. The Project RAISE toolkit is expected to be fully developed and available as a free open educational resource in 2025, but teachers can get started now by integrating robotics and programming into their classes.

### *Vignette*

*Ms Roberts wants to explore basic coding with her class using a robot and tablet to engage and teach the students. While there are many options of robots and programs to use, she decides to follow recommendations from the Project RAISE toolkit using the Dash robot from WonderWorkshop and its corresponding Blockly application* (blockly is a generic name for the coding software; WonderWorkshop also named their program Blockly and will be referred to as "Blockly" with a capital "B"). *Since the Project RAISE toolkit has not become an open education resource currently, Ms Roberts uses WonderWorkshop's Blockly application to learn the basics in coding. Ms Roberts found that she quickly understood the directions provided by the ZB avatar through the Blockly application to learn how to make Dash move and follow directions. She believes the application can also help teach Frankie about coding. Ms Roberts is interested in Frankie's response to the technology and coding. She wonders if it could help him interact with his peers while developing life skills like collaboration and problem-solving. Ms Roberts decides to work with Frankie in a one-on-one setting to teach him basic coding skills and scaffold his learning. Once he learns how to interact and use the tablet with Dash, she would like him to try to teach a friend the same skills.*

## Embedding Coding in Elementary School

Many simple robots can be found already in mainstream society, and continued growth in robotics use in daily life is predicted (National Media Consortium, 2017). For instance, today, many people own a Google Home or an Amazon Alexa, which can be used by children to ask questions and receive answers to basic information. Robots like Lego Mindstorms, Sphero, Ozobots, and WonderWorkshop's Dash emerged in the 2000s/2010s to engage students and provide devices that can physically move when given direction by the user (often through a software application like Blockly). These robots offer a variety of learning opportunities at various skill levels. Teachers are encouraged to research and try different robots to find the best fit for their students and classroom.

### *The Dash Robot*

Ms Roberts found the Dash robot to be the best fit for Frankie and the rest of her class. The Dash robot (Figure 2) is an interactive physical robot that early elementary students can program using a collection of applications from WonderWorkshop. One application, titled Blockly (see Figure 2), was developed to teach students to code using puzzles, as well as a "blank slate" to allow for novel and unique code created by the users. By following prompts in Blockly through puzzles (e.g., "Driving School"), students can establish an understanding of code to solve a problem and observe if Dash moves as expected. If students make mistakes, the program provides hints

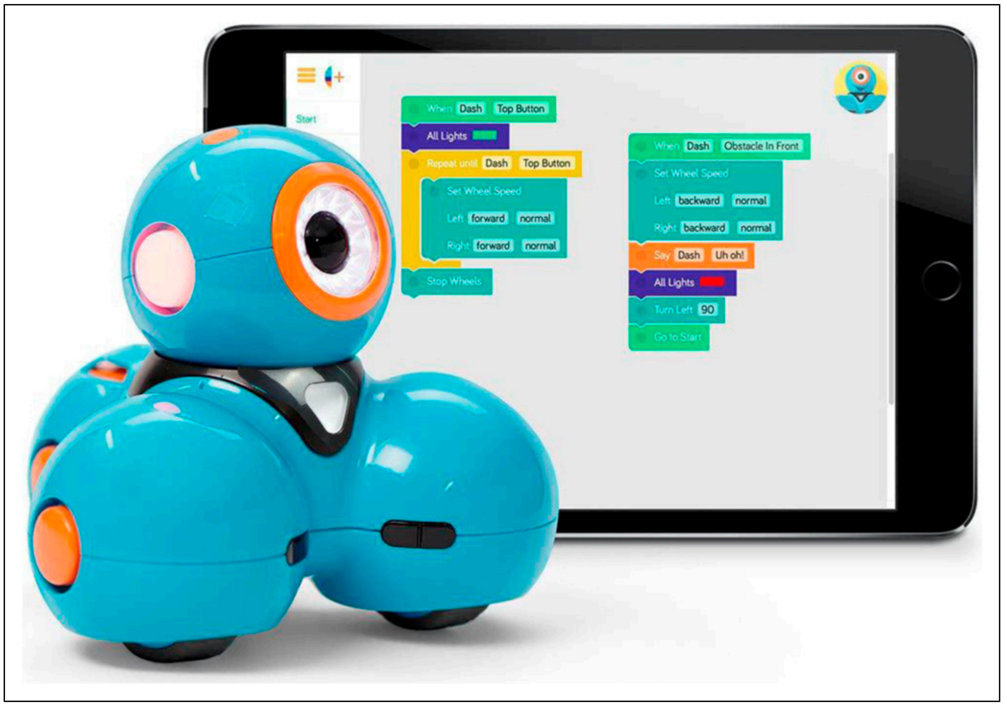


**Figure 2.** Dash Robot and Blockly by WonderWorskhop.

of what to try next and where the code might need to be changed. Each puzzle builds off previous coding learned, providing students with opportunities to build on prior knowledge systematically. Blockly's "blank slate" allows users to design lines of code to guide Dash at their own pace and direction.

While Dash may suit the needs of Ms Roberts' class and the learning of Frankie, the robot and technology may prove difficult depending on the age, grade, and/or disability of the student(s). Students that struggle with reading, including phonemic awareness and phonics, may experience difficulty in understanding the Blockly application's blocks of code. Further, the application must be portrayed on a smart device and the font size on the blocks may be difficult for the user to see. These difficulties may cause frustration and lack of access for students, which is an area Project RAISE aims to support.

## *Getting started with Dash*

When first using Dash, we suggest allowing students to explore the robot (e.g., pressing buttons) as they are naturally curious. When ready, students should be provided instructions to turn the robot on and connect to a device (e.g., iPad, Kindle) using the Blockly app. Once students are directed to the first puzzle, "Driving School", they can begin learning the basics of coding independently or with a peer. At this point, the teacher can implement the constructionist pedagogy (i.e., users attempt to create code and base learning on successes and mistakes to enhance understanding; Papert, 1980), allowing students to work on puzzles or create their own lines of code. If a student needs support, teachers can provide instruction i.e. scaffolded based on the learner's needs.

One way for students to start coding on their own with Dash is for the teacher to assign simple problems and expand on them using the "blank slate". An example of coding a square is provided in Table 1 as a starting point that can be expanded upon or reduced, depending on student learning and ability. Squares are a basic geometry concept understood by most students PreK and older. Taylor (2018) and Taylor et al. (2017) demonstrated students as young as PreK with and without disabilities could learn to code a square using the Dash robot. The Blockly app uses blocks of code with basic coding language embedded to help the user begin without worrying about the degree of angles (i.e., turn left or right is set at 90°) or "forward" moves the robot (i.e., 30 cm is automatically selected). As users become more familiar with Blockly and coding, the blocks of code can be manipulated (e.g., degrees changed, distance to move altered, speed of robot increased or decreased). Once the basic square is coded, students can add or alter code to fit different learning goals or to problem-solve. As noted earlier, the WonderWorkshop's Blockly application may be difficult for students to follow if they have difficulties with reading, fine motor skills, or vision. Once available, teachers and others can use Project RAISE's toolkit to support students' learning of coding by attempting to remove difficulties (e.g., reading text, fine motor) through a process of guided instructions by the ZB avatar. The guided instructions included a social story to meet ZB and learn how to use the blockly application, directions that are in both

**Table 1.** Learning Basic Coding of a Square With Dash.

| | Goal | Suggestions |
|---|---|---|
| Step 1 | Students identify (e.g., draw) the constructs of a square (i.e., four lines of the same length with four corners at right angles) | Be sure to note the number of sides and congruence, corners and angles. |
| Step 2 | Students act as the robot (inserting themselves into the problem) to show how to make a square. | Ask students to sequence their steps and consider detailed instructions as they act as the robot (e.g., move in a straight line in five steps, turn left). |
| Step 3 | Students use Blockly to code Dash to move in a square. | Students should check their code before executing (i.e., pressing play). If Dash does not follow commands as expected, students should reflect on what went wrong and try to fix the problem. |
| Step 4 | Once students have successfully completed coding Dash to move in a square, additional prompts can be added. | Example prompts:<br>• Identify any patterns in the code and use “repeat” blocks to shorten the code while Dash still achieves movement in a square.<br>• Insert sounds or movement into the code at specific instances.<br>• Change the problem from making a square to making a rectangle.<br>• Add obstacles for students to code Dash to move around, perhaps changing angles of turns and length of straight line movements. |

verbal and text form, highlighted key words/blocks (e.g., forward, turn left), and verbal affirmations and praise from ZB.

As students learn to code, they should be encouraged to share how they completed and solved problems, including areas that were challenging. If mistakes were made, teachers could prompt students to explain what did not work as expected and how the students tried to fix the problem. Problem-solving activities with coding can encourage students to collaborate with others, share thoughts and ideas, learn to adjust understandings, and discern that many problems can have multiple solutions (Kahn et al., 2014; Sullivan & Bers, 2013). If teachers and/or students need ideas of questions to answer or problems to solve, WonderWorkshop and other robotics companies offer education curricula both online and in print form. Some teachers may feel they do not have the skills or understanding of robotics and coding to successfully implement a resource like Project RAISE (e.g., Shernoff et al., 2017). Project RAISE and other robotics programs can begin teaching any learner, including the teacher, how to use and implement STEM resources like coding into the classrooms using easy to follow instructions, professional development, and opportunities to experiment with the technology.

### *Vignette*

While working with Frankie one-on-one, Ms Roberts found Frankie to be highly engaged with the Dash robot. The robot’s presence seemed to spark Frankie’s natural curiosity. He immediately expressed a desire to know more about Dash as soon as it was turned on and started moving and making sounds. Beginning with simple puzzles, like moving Dash in a square, has allowed Ms Roberts to help Frankie learn and problem-solve using the Blockly application. Ms Roberts provided minimal prompting as Frankie explored the process of maneuvering Dash to trace a square. She found scaffolding support (e.g., ZB provides prompts and directions only as needed) works well for Frankie as he desires to complete preloaded Blockly puzzles without assistance. Once Frankie grasped the concepts, Ms Roberts decided it was time to use these technology tools with her class, and asked Frankie to begin teaching it to one of his peers in hopes of facilitating conversation and collaboration. Frankie began by selecting one student he felt comfortable with to teach how to use Dash and Blockly. While Frankie’s communication/language difficulties were not “fixed” by using the robotics, he eagerly tried to provide instructions on how to power-on the robot and connect it to the tablet, as well as the coding required to make Dash perform specific tasks. Furthermore, when faced with challenges or unexpected glitches, Frankie tried to collaborate with his peers attempting to provide explanations, trouble-shooting, and devising solutions together. Although a preliminary exploration of robotics and coding activities, Ms Roberts was inspired by the interest, engagement, and interactions of Frankie and the rest of her students as the activities were introduced. She recognized the potential of robotics to increase social emotional and communication skills of students, particularly those like Frankie who traditionally have minimal interaction with peers in class. Ms Roberts wants to know simple goals that she can bring to her school system to support the use of robotics in the curriculum. Given that the Project RAISE curriculum will be an open educational resource, funding would need to be allocated to provide students with iPads and Dash robots.

## Goals for Classroom Implementation

Classroom implementation of robotics and coding can begin in early childhood and elementary education by focusing on

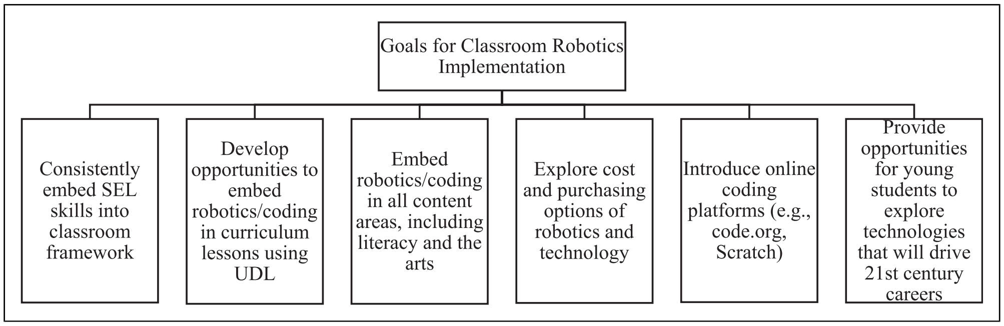


**Figure 3.** Goals for classroom implementation.

implementation goals (see Figure 3). One of the priorities of robotics and coding in Project RAISE is development of SEL skills. These skills should be a focus in the classroom whether or not teachers are embedding robotics/coding into their class activities. Social Emotional Learning skills are designed to help students understand themselves and others through equitable learning environments (Greenberg, 2023). Teachers should attend professional development workshops and/or use the resources from CASEL to continue their learning and understanding in implementation of SEL.

When launching a robotics curriculum in elementary school, it is important for teachers to collaborate with others to develop opportunities to embed the curriculum in lessons. At this point, the principles of Universal Design for Learning (UDL; i.e., multiple means of engagement, representation, action and expression; CAST, 2011) can be explored for students in the core content areas. Universal Design for Learning allows for flexibility in learning for students to demonstrate their strengths and knowledge, as well as practice SEL skills like self-awareness and self-management. Science and mathematics are perhaps obvious subjects to include robotics, as students can program the robot and learn about directionality, problem-solving, real-world problems, collaboration, and engineering design. Students may benefit from using programming/coding in language arts, including sequencing tasks and letting the robot tell a story through actions and movement (e.g., Bravo et al., 2021). Teachers can further implement the STEM curriculum in language arts by introducing the engineering design process and asking students to solve problems based on class readings. For instance, students learning fairy tales can apply engineering to solve problems for the houses built by the three little pigs or alternate ways for Rapunzel to escape her tower. Students could work in small groups to solve problems during lessons or learning stations. Coding also supports sequencing skills, as the robot follows specific instructions in order (Strawhacker & Bers, 2019).

School districts' administrators could begin to look at cost and purchasing options of robots and technology for elementary classrooms. The Dash robot was referred to in this manuscript, but many other options exist (e.g., Sphero, Ozobots, Lego, Kubo). Small technology grants can support costs for the robots and technology (e.g., smart devices or tablets). Partnerships with local universities and businesses might be invaluable for collaborations and expert design for STEM and coding curriculum implementation. While waiting to purchase robots and other hardware, teachers can use online resources to introduce coding to their students (e.g., www.code.org; Scratch).

As teachers introduce robotics and coding at the early and elementary grade levels, students will learn about technologies that will undoubtedly drive careers while also being involved in active learning, engagement, intrinsic satisfaction, and problem-solving skills. Students should practice skills that allow them to generalize their learning from school tasks (e.g., programming/coding) to real-world problems (Plaza et al., 2019). Obtaining and developing a curriculum may take time and money, but the effects could be invaluable. Coding and programming could be options in K-12 grades to develop knowledge for those who want to pursue a career in computer sciences, and those who want to move in a different direction but need both STEM and SEL skills to support future goals.

## Conclusion

STEM activities like coding may help to build and strengthen students' SEL skills when focused on collaboration, problem-solving, adaptation, decision-making, and flexibility (Seage & Türegün, 2019). Finding and understanding students' strengths and abilities may also help all students feel able and included. Many students, including those with ASD, are drawn to technology and learn basic technology operations quickly (Ghanouni et al., 2020). In the vignette included in this manuscript, Frankie represented one student with ASD, and what worked for him may not work for others. However, implementing curriculum and activities using robotics and coding (e.g., Project RAISE) may be a way to engage students, practice SEL skills, and prepare students with 21st-century skills (National Media Consortium, 2017) and provide opportunities students have not seen or experienced before. Introducing ideas around subjects like coding with robotics or simply engineering with project-based learning, can help students experiment and grow. Through collaboration, students communicate with one another, support ideas, and offer suggestions to engage in learning, which support development of SEL skills (Laal & Laal, 2012). Collaboration through projects in STEM can help prepare students with and without disabilities for future careers and life skills (Liebech-Lien & Sjolie, 2020).

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**Eileen M. Glavey**, PhD is a research associate and technical assistance coordinator for the Florida Center for Students with Unique Abilities at the University of Central Florida in Orlando, FL. In addition to her work in the area of inclusive postsecondary education for individuals with intellectual disabilities, Dr. Glavey is passionate about exploring the use of innovative technologies to impact the long-term educational and career outcomes of individuals with disabilities.