Improving Student Engagement with Coding and Robotics: An Elementary School Case Study

Written by: Sharon Clements, TVDSB

Coding and robotics have become an increasingly important part of teaching students 21st century skills. The workforce is changing rapidly, and students need to be prepared to handle the types of jobs they will be required to fill in the coming years. The challenge, however, is learning how to engage students in order to prepare them for their future careers. Video games, social media, streaming platforms, and the complications of a global pandemic have all created an interesting challenge for educators. Students have different expectations about school than they did 20 years ago, or even 10 years ago. In many ways, students behave as if they need to be entertained in the classroom rather than taught. The traditional pencil and paper methods no longer work consistently, and rather than holding students' attention, the opposite sometimes occurs. We see students who have a difficult time maintaining focus and attention for prolonged periods of time, and unfortunately, we also see negative behaviours arise.

While robotics and coding are an important part of helping prepare students for the future by developing problem-solving and computational skills, they can also be integrated into regular classroom programming to help increase student engagement. High-tech jobs will require people with a unique set of skills. As outlined by Costa (2017), "almost all of the 30 fastest growing occupations in the next decade will require some background in STEM. Between 2014-2024, the number of STEM jobs will grow 17% as compared to 12% for non-STEM jobs" (p. 32). The expectation is that increased student engagement would lead to greater focus and attention, and hopefully, decrease behaviour issues while also teaching essential skills to help students become 21st century thinkers.

There is no argument that teaching robotics and coding benefits students by developing problem-solving skills, creativity, communication skills, organizational skills, critical thinking, co-operative skills, perseverance, and computational thinking. Educators must also consider that, "educational robotics (ER) has such positive side effects as improved learning motivation and improved interest in learning itself" (Daniela & Lytras, 2019, p. 219). Completing a simple Google search produces article after article touting the benefits of exposing students to these experiences. Where the research lacks, however, is a focus on the emotional aspects of student exposure to coding and robotics. According to Salas-Pilco (2020), "research on AI and robotics in education has been carried out mostly in relation to intellectual outcomes, but little research has included social emotional and physical outcomes" (p. 1809).

As part of my partnering time in the Library Learning Commons (LLC) this year, I was able to test this theory of increased engagement through coding and robotics with a variety of groups. In particular, I attempted projects with Junior and Senior Kindergarten, Grades 3-8, and our Discovery Classes (known in most school boards as developmental classes). For the purposes of this paper, I will be focusing on my experiences with a Grade 5 group.

Considerations for Engagement:
The integration of coding and robotics is now a requirement of the Ontario Science and Technology curriculum. Until recently, however, there were no specific expectations in the curriculum for such high-tech endeavours. With the inclusion of coding and robotics in the curriculum, it is important for us to consider the positive impact that these areas can have for both students, and educators considering that, “the use of educational robotics has shown great potential in affording learning opportunities to engage students and help them develop creativity” (Yang, Long, Sun, Van Aalst & Cheng, 2020, p. 1826).

As outlined by the Center for the Professional Development of Teachers: Columbia University (CPET), there are three main categories of student engagement: academic, intellectual and social-emotional (p. 2). The challenge for educators, however, “is to redesign what engagement looks like, what it feels like, and what it takes to get kids onboard - because engagement is everything” (CPET, p. 3). Without engagement, a classroom can feel chaotic and full of disrespectful behaviours towards classmates and the adults in the room. According to Keels (2021), “during engaged instructional time, acting-out behaviours are minimized because students’ attentions and energies are focused on academic learning they perceive as meaningful and relevant” (p. 5). The integration of coding and robotics provides an ideal opportunity for teachers to model problem-solving and co-operative skills, to develop relationships with their students, and to demonstrate that they are learning along with their class.

Class Description and Target Student Profiles:
There are three Grade 5 classes within our school. The particular group that I focused on comes with some challenges. They are a high energy group most of the time, which presents issues on a regular basis for the classroom teacher. There is a pocket of students who can change the classroom environment instantly with their behaviours. In a class of 27, I chose to focus my observations on three students in the group.

Class Profile:
- 27 students (along with their Grade 3 Reading Buddies)
- 2 with I.E.P.’s
- 1 identified as gifted
- 2 who require support or intervention from an adult for behavioural challenges
- 2 who will act out based on an immediate need for attention
- 2 who will act out to get a reaction from classmates

Student #1:
Grade 5 (male)
- academic challenges
- frequently supported by an Educational Assistant
- social challenges both in the classroom and on the playground

- behavioural challenges; frequently argumentative with adults and classmates

Student #2:
Grade 5 (male)
- average academics
- strong personality
- makes himself the center of attention by acting out
- social-emotional challenges if he has difficulties with class work
- will participate in lessons or class discussions

Student #3:
Grade 5 (female)
- average academics
- quiet with little participation in lessons or class discussions
- shy, but will stand up for herself within her group of friends

Lesson Focus: Lego Spike Prime Robotics Kits
Day 1:
- **Build** (30 minutes) - discuss rules and contract for appropriate use/responsibilities
- **Introduction to coding blocks** (10 minutes) - most have some previous coding experience
- **Exploration time** (20 minutes)
- **Troubleshooting time and introduction to challenge cards** (20 minutes)

Day 2:
- **Discuss and complete challenges** (30 minutes)
- **Meet with Grade 3 partners**
    - Grade 5 students show partners coding basics (10 minutes)
    - Time for Grade 3 students to explore and code with guidance from Grade 5 partners
- **Sharing time** - whole group (15 minutes)

Key Observations:
I did not know what to expect with this activity. I predicted engagement in the beginning while building, and then frustrations setting in with the coding portion of the activity. Lego Spike Prime kits are designed for Grades 6 and up, and are coded using blocks similar to Scratch. The students surprised me, and not just the three students I was focusing on for observations. The room was full of just over 45 students, and there was not a single behaviour issue during Day 1 or Day 2.

Student #1 was the biggest surprise because I was prepared for the student to give up and then create problems for his group members, as well as the remaining 44 students in the room. He was determined to complete all six tasks that were outlined on the challenge card, in particular, a parallel parking task that required students to use advanced coding skills. Only three groups were able to perform this particular task. Student #1's group was the first to complete this part of the activity correctly, and with a significant level of creativity. When the activity concluded on Day 2, I

asked the student if he had ever considered a career in computer programming. His response was, “No, but I’m thinking about it now.” This was every teacher’s version of a touchdown, a home-run, or a hole in one! Student #1 was used to people focusing on the negative, and he was finally seeing himself as someone who could achieve amazing things if he could harness his attention positively. For the first time all year, this student worked without the support of an Educational Assistant to motivate him, or re-direct his behaviour. His teacher watched in awe as he worked co-operatively with his group members, persevered when faced with challenges, and when he took on the job of mentoring his Grade 3 partner.

Student #2 was a very similar scenario. When the activities of Day 1 began, he spoke out constantly, made noises that distracted the people around him, and attempted to attract attention from everyone in the room. His classmates were very quick to ignore him so that we could move on to the fun part of the activity. Once his group got started on building their robot, we did not hear another word from this student, other than questions related to the activity, or problem-solving conversations with his fellow group members. His group did a great job of persevering, and only asked for help once. At the end of the second day, Student #2 made a point of thanking me for showing his class how to use the kits, and asked if they could do this again sometime.

While **Student #3** maintained her quiet composure, just as she does in class, she did take on a leadership role within her group. Her team worked together to build their robot, and then problem-solve the coding portion of the activity. When I stopped by to check on their progress, she was the group member who asked relevant questions and sought advice on how to get their robot working properly. Her level of engagement was a pleasant surprise, and the fact that she independently took on the role of group leader was an even bigger surprise. Everyone in the group persevered to complete all but the final challenge on their card, and they made sure their Grade 3 partner had an opportunity to learn how to successfully code their robot.

Conclusions and Challenges:
While these observations focused on the engagement level of three students, I feel confident in saying that engagement with the entire group was high. The students enjoyed the tasks, perseverance was strong in all groups, as well as co-operation and communication. According to Keels, “when educators focus on students’ needs for emotional engagement, they create the conditions for the behavioural and cognitive engagement that facilitates learning. When students are emotionally motivated to learn, the burden of behavioural self-regulation is minimized because they don’t have to fight against boredom” (p. 7).

Integrating regular coding and robotics classes is not without challenges. Many classroom teachers do not have the training or experience to confidently or comfortably add regular blocks of coding and robotics time to classroom programming. “One major obstacle is the absence of effective pedagogical practices for the use of educational robotics in classrooms…and learning materials. These barriers have led to a shortage of experienced and professional teachers in the productive use of educational robotics” (Yang, Long, Sun, Van Aalst & Cheng, 2020, p. 1827). The issue of tech equity also comes into play. Schools have different priorities when it comes to allocating

budget dollars. Not all schools have focused their funds on building inventories of robotics, or devices such as Chromebooks and iPads. Some schools may not have the commitment of their parent council for fundraising, or schools may be located in geographic areas where there are economic challenges. Unfortunately, there is also the issue of trying to convince some teachers to "buy in"; meaning some educators get stuck in a cycle where they continue to teach the same things, the same way, year after year.

While there are some obvious challenges to integrating coding and robotics, such as availability of resources and teacher training, these do not necessarily have to be barriers. Schools could consider partnering with a local high school, community college, or university to share resources, source community partners who might be willing to make financial donations, or find people who would volunteer to offer their expertise (e.g., Computer Programmers coming out to help run a coding session, Engineers offering to help with the design phase of projects, etc.). Teacher-Librarians are also a terrific resource for planning and presenting lessons, and sourcing much needed materials. We are no longer the people who simply sign books out and sign books in; we have become the technological experts who "wear many different hats" in a single day.

Exposure to 21st century skills benefits both students and educators by increasing engagement, reducing behaviours, and preparing students for future jobs that may not even exist yet. Educators should not require much convincing when it comes to integrating coding and robotics to increase engagement in the classroom. We are teaching a new generation of children; a generation that has witnessed technological changes occur at a staggering pace, a generation that consumes social media as a hobby, and a generation that has survived the complications of a global pandemic. Students think differently, and we need to adjust our programs and teaching methods to recognize this change.

Addendum:
The original creation date of this paper was May 2023 in order to fulfill the requirements of the Teacher-Librarian Specialist course through Queen's University. The observations outlined in this paper were gathered over the course of two days. I have, however, continued to present this same set of lessons and activities to groups of students from Grades 5 to 8, along with several simplified robotics lessons designed for our students in Grades 1 to 4. Out of all the robotics and coding lessons I have taught since the Spring of 2023, there was only one student who outright refused to engage in the activity that was being presented. When looking back at this particular situation, the student was having a challenging day from the moment he arrived at school, and was not in the right mindset to work collaboratively with his peers. I think it is safe to conclude that one student, out of the hundreds I have worked with, proves a significant success rate for student engagement when working on coding and robotics activities.

References

Center for the Professional Development of Teachers: Columbia University (CPET) (2021). Engagement is Everything: Three Pillars of Student Engagement. https://cpet.tc.columbia.edu/news-press/engagement-is-everything-three-pillars-of-student-engagement.

Costa, C. (2017). Robotics K-12 and Your District: The Essence of STEM Education and the E-Tickets to Unlimited Possibilities. *Leadership*, Vol. 46, No. 4: 32-35.

Daniela, L., & Lytra, M.D. (2018). Educational Robotics for Inclusive Education. *Technology, Knowledge and Learning*, Vol. 24, No. 2: 219-225.

Keels, M. (2021, October). What Schools Need Now: Relational Discipline. *Association for Supervision & Curriculum Development*. https://www.ascd.org/el/articles/what-schools-need-now-relational-discipline/.

Negrini, L., & Giang, C. (2019). How Do Pupils Perceive Educational Robotics as a Tool to Improve Their 21st Century Skills? *Journal of e-Learning and Knowledge Society - The Italian e-Learning Association Journal*, Vol. 15, No. 2: 77-87.

Rebora, A. (2021, December). Engagement is Everything, Especially Now. *Association for Supervision & Curriculum Development*. https://www.ascd.org/el/articles/readers-guide-engagement-is-everything-especially-now.

Salas-Pilco, S. Z. (2020). The Impact of AI and Robotics on Physical, Social-Emotional and Intellectual Learning Outcomes: An Integrated Analytical Framework. *British Journal of Educational Technology*, Vol. 51, No. 5: 1808-1825.

Stokes, A., Aurini, J., Rizk, J., Gorbet, R., & McLevey, J. (2023). Using Robotics to Support the Acquisition of STEM and 21st-Century Competencies: Promising (and Practical) Directions. *Canadian Journal of Education*, Vol. 45, No. 4: 1142-1170.

Yang, Y., Long, Y., Sun, D., Van Aalst, J., & Cheng, S. (2020). Fostering Students' Creativity via Educational Robotics: An Investigation of Teachers' Pedagogical Practices Based on Teacher Interviews. *British Journal of Educational Technology*, Vol. 51, No. 5: 1826-1842.

Zmuda, A. (2008). What Does It Really Look Like When Students Are Learning in the Library Media Center? *School Library Media Activities Monthly*, Vol. 25, No. 1: 25-27.

.