The powerful influence of emotions in learning is widely recognized in the field of education. As educators, we have witnessed a wide range of emotions from students in response to the same circumstances involving their learning. For example, we have seen students cry in sadness, celebrate in joy, or be content when earning a C letter grade. We have seen some student’s excitement or dislike for our classes. This range of emotions impact students’ learning experiences inside and outside the classroom. Consequently, it is imperative to ask: Can we predict how students will react to different learning scenarios? Which students will be excited? Which are going to be anxious and fearful? Which will have neutral feelings? In-line with the aforementioned questions asked—Is it possible to modify students’ reactions to an educational scenario? For example, can we create interventions to reduce students’ fear for learning topics that make them uncomfortable? In this chapter, we argue that we could perhaps reduce some aspects of student’s fear of learning by integrating affective technologies.

Technology is a potential medium to improve students’ learning experiences (Foster, 2004; McMillan, 2009; Olive et al., 2010; Papert, 1980). Research supports the contributions that emotions, such as frustration and respect (from a teacher), can have on students’ achievement. Within the field of robotics, the subcategory of human–robot interaction (HRI) includes the study of how robots can learn to interpret human emotions and how robots should express emotions. The ability of robots to show and read emotions has been shown to be critical when robots interact with humans. When considering further the intersection of education and HRI, there is a need to understand the interdependency of emotions and cognitive growth. Future robots cannot be solely based on a cognitive component, marginalizing the emotions that facilitate or hinder cognitive development and growth. Rather, the cognitive and the emotional components must inform each other to improve the learning of the human and the robot.
This chapter presents a brief discussion of the role of emotions in education, then provides a rationale for why one might consider using technologies in the classroom, and ends by presenting cases where the emotional context of the HRI promoted, hindered, or failed to help students in the learning process.

THE ROLE OF EMOTIONS IN EDUCATION

When James (1884) posed the question, “What is an emotion?,” he proposed that emotions were physiological responses. Although not all researchers agreed with him, his idea was followed by the development of several competing theories of emotions. Even today, researchers have not agreed on a universal definition of an emotion. Yet, the general population is able to perceive and name different emotions. We all seem to know when someone is happy, sad, angry, or scared. James speculated that researchers studying the brain, in the 1900s, disregarded emotions because they were far too complex to study. Perhaps, at the time, it was more sensible for physiologists and psychologists to concentrate on other characteristics of the brain, such as its sensory and motor centers. Yet, James along with past and current educators believed in the influence that emotions play during decision-making. Through time, educators have sensed that learning is more than a set of cognitive processes. There is growing evidence that emotions influence the decisions people make (Cytowic, 1993; Damasio, 1994; LeDoux, 1996). Additionally, emotions are starting to be viewed in a more positive light. Emotions are not only part of the irrational decisions humans make, they are now starting to be recognized as integral to the rational decision-making process.

Why Should We Value Emotions Along with Cognition in Education?

Although researchers in psychology, cognitive science, and artificial intelligence have concentrated predominantly on the cognitive processes of the brain, recently attention has been given to understanding how emotions and cognition collectively influence our decision-making and our thinking (Gadanho & Hallam, 2001). For a long time, educators have sensed that learning is more than a cognitive process. There is more to learning than memorizing facts and processing information. Shih, Chang, Chen, Chen, and Liang (2012) found that although students in Taiwan, one of the high achieving countries in the TIMSS (2003, 2007), excelled in mathematics and
science in the international exams, they did not necessarily like mathematics and they reported less confidence in mathematics than students from other lower performing countries. For instance in 2003, when Taiwan was ranked fourth among the 49 countries that participated in the TIMSS exam, 34% of the 4th graders who participated in the TIMSS exam disagreed with the statement “I like to learn Mathematics,” and only 41% of the 4th graders reported high self-confidence in mathematics. It is possible that as the knowledge gains of the students were maximized, some of the students’ positive emotions for learning mathematics were hindered or perhaps overlooked altogether. Hence, demonstrating mastery of a topic does not translate into enjoyment of or a likening for the topic.

Sometimes students lack both a love for learning and competence in a subject area. One reason for this outcome could be a consequence of overlooking the emotions involved in learning by educators (Leonard & Martin, 2013). Several educational researchers have found that when students perceive their classroom teachers as supportive of their academic pursuits, students’ interest in their academic studies and consequently, their academic performance improves (Felner, Aber, Primavera, & Cauce, 1985; Goodenow, 1993; Midgley, Feldlaufer & Eccles, 1989; Wentzel & Asher, 1995). Hence, teacher support, defined as “the extent to which students believe teachers value and establish personal relationships with them,” is critical in the learning process of some students (Ryan & Patrick, 2001). It is possible that students who perceive that teachers are supportive, the students are more inclined to persevere academically and socially because they do not view the challenges from a negative perspective, as they know that their teacher will give them the support that they need after they explore on their own.

Wentzel (1997) found that students are indeed more likely to be interested in classroom activities when they feel supported and valued by their teacher. From the student perspective, a teacher that makes them feel valued and who cares about them displays the following characteristics: they model a caring attitude toward their work; they have individual expectations based on individual differences; they have democratic interactions with the students; and they are nurturing. Additionally, these teachers show concern for the student beyond the classroom walls, such as approaching students to inquire about their life when they notice something abnormal in the student’s behavior. Other researchers have reported similar findings. Students’ perceived support from adults has resulted in positive academic outcomes (Cauce, Felner, & Primavera, 1982; Felner et al., 1985; Phelan, Davidson, & Cao, 1991). Hence, when a learner perceives support and care from a
more knowledgeable adult, the perception could contribute to positive academic outcomes.

One concern regarding perceived care among researchers is the correlation between parenting and perceived care. Experts in African-American studies have argued that teacher care is interpreted and expressed differently. For example, the parenting dimensions described in Wentzel’s study did not result in positive academic outcomes for minority students (Steinberg, Dombusch, & Brown, 1992). Furthermore, Ware (2006) provides an example in which an African-American educator scolded her class for not doing their homework. Students perceived her demands as a demonstration of teacher care. Hence, culturally relevant pedagogy could expose different dimensions of teacher care that are critical for ethnic groups.

The emotions that a teacher promotes in the classroom impact the learning experiences of students and their engagement with the topic. After all, many of us have heard more than once a child or an adult say something along the lines of, “I need to learn this because I want to make my teacher happy” or “because my teacher loves me” or “I don’t want to disappoint my teacher,” or “because my teacher believes in me.” Assuming that in the near future, we manage to identify most of the dimensions of teacher care that nurture students’ learning, these dimensions should be used to improve the learning experiences of students.

WHAT ROLE CAN TECHNOLOGY PLAY?

Unfortunately, given some of the adverse realities in the teaching profession, it is unrealistic to expect that every student will have access to a supportive and caring teacher. Due to lack of support, among other reasons, the attrition rate for teachers within their first teaching year is over 40%, at the K–12 level (Alliance for Excellent Education, 2011). As budgets continue to shrink, while the student population continues to grow, educators face larger classroom sizes (Alliance for Excellent Education, 2011; Cuseo, 2007; Ingersoll, 2003; Miles & Darling-Hammond, 1998). Hence, even if we manage to place a supportive and caring teacher in each classroom, the teacher might not be able to reach out to every student. Large classroom sizes obstruct educators from giving students the individualized attention that engages them in the learning process (Cuseo, 2007). In the absence of increased budgets to reduce classroom size, more attention should be given to the allocation of instructional resources in our educational system, especially technological resources (Miles & Darling-Hammond, 1998).
Technology could improve the learning experiences of students in large classes and allow a supportive, caring teacher to reach more students. Kenneth Bowles, in the late 1960s, had a vision that 1 day, students will have their own personal computer with a “personalized system of instruction” (McMillan, 2009). He envisioned a future in which interactive computing could improve education by creating better, targeted learning experiences for students. Through his eyes, microcomputers had the potential to transform the big lecture halls of introductory programming classes into more interactive environments that would enable students to write programs, run them, edit them, and try them again during class time when the teacher could help students (Foster, 2004). The vision was beyond using technology to help students memorize information but aimed at improving the learning experience of students by creating an environment where students would receive the support they needed in the classroom, despite large class size. The key to his vision was the fulfillment of students’ needs.

Since experts in emotions argue that emotions give meaning to our lives by creating a structure where our needs, motives, and concerns are assigned different values depending on their importance by considering the needs of students when using technology in the classroom, Bowles was integrating emotions with technology (Bower, 1992). In this sense, when humans make a decision, the decision might be fulfilling a need of the decision-maker. Hence, if educational technologies are to enhance the learning experiences of students, then the designers must keep in mind the needs, motives, and concerns of the students who will be interacting with the technology.

Unlike Bowles’ vision, in the past, technologies functioning by artificial intelligence have failed to incorporate human intuition and emotions in their decision-making process. These technologies are designed to simply use algorithms to maximize the outcome of situations, but if a human’s value system does not match the machine’s value system, then the machine will fail to fulfill the needs of the human. For example, imagine a teenager that gets accepted to Harvard, among other local colleges and universities. If the technology optimizes the teenager’s future based on school’s rankings without taking into account the teenager’s emotions, the machine may select Harvard. Yet, the teenager may choose to attend a less prestigious local college because they value proximity to their family significantly more. The teenager still used cognitive processes to make a decision, but the internal maximization algorithm involved the emotional ties to family. The decision was based on the type of happiness valued.
In short, for technology to have a chance at truly impacting the learning experiences of students and aiding the supportive and caring teacher to reach more students, it will have to treat each student uniquely. It will have to know the needs, motives, or concerns of each student. It will have to embody the characteristics of a supportive and caring teacher. Otherwise, the technology will treat every person the same (Cowley & MacDorman, 1995; Hinde, 1988). This will hinder its performance in an educational setting because we know that humans do not treat everyone the same. Social interaction is a highly unique experience. When we meet people, we like some more than others, based on their personality, what we share with them, how they make us feel, etc. In terms of promoting learning, it is even more important for students to be treated uniquely. After all, from students’ perspectives, having individual expectations based on individual differences is one of the characteristics they value in supportive and caring teachers.

**CASES WHERE EMOTIONS INFLUENCE STUDENTS’ LEARNING IN A TECHNOLOGY ENVIRONMENT**

The main role of a teacher is to help students. In this vein, considering that technology strives to be an effective instructional tool, an educational technology’s main role ought to be to help students. By coupling the human capacity of supportive and caring teachers with an effective technology, the needs of more students might be fulfilled. This, in turn, might result in an increase of positive emotions associated with learning experiences and a reduction of bad emotions, such as fear.

Today, robotics technology seems to possibly fulfill a void, in the area of technology enhanced learning, for contemporary learners. There is a growing number of after school programs, school classes, and competitions based on robotics (Cho, 2011). However, according to Cho (2011), the majority of the existing curricula involving robotics are biased toward engineering-related topics. This is limiting the potential of robots in K-12 education because children with diverse interests outside of engineering or engineering-related fields are excluded from robotics activities and curricula. Other researchers have voiced the need to have more entry points to robotics (Rusk, Resnick, Berg, & Pezalla-Granlund, 2008). By moving away from a robotics-based curricula to a robotics-enhanced education curricula, people from different interest areas will be able to engage with robots (Cho, 2011). At this point in time, their inclusion is important because as the technology continues to gain momentum and support in education circles, it is
important to empirically identify the needs of the learners and how those needs might be fulfilled by robotic technology to assure that the technology continues to foster positive emotions among learners. Below, we share examples of technologies, which either excelled or failed at fulfilling the needs of the learner, as examples of the potential emotions robotics technologies could evoke or displace.

Fixing Work Instead of Fearing Learning

In the 1970s, Seymour Papert (1980), an educational theorist, promoted the use of computing technology as an “object to think with” that children could use to explore, discover, and construct their own knowledge. He believed that computing technology could serve as a medium to eradicate math phobia, which he interpreted in two ways. First, “math phobia” can be described as fear of mathematics. But, much more interesting, is Papert’s second description of math phobia, which stems from its Greek meaning: Math in Greek relates to “learning.” Hence, he presented math phobia in the broader sense, as a “fear of learning” (Papert, 1980).

Fear of learning is not an unknown phenomenon. How many times have we heard a friend, relative, or student mention that they are incapable of excelling at something (e.g., math, writing, dancing, cooking, gardening)? Yet, inquiring further about the inability exposes the fact that they shy away from the topic or activity when faced with the possibility of failure. Perhaps, it may be more accurate to say that at some point, they decided to avoid failure. It may not be the actual math, writing, cooking, etc. that limits a person’s achievement in an area, but a prospective failure. What may be impeding them from pursuing the learning opportunity or activity might be a lack of “courage” to persevere in an area where they have developed the emotionally safer approach of giving up as soon as difficulties arise, rather than daring to spend time in an activity that does not guarantee success (Wertime, 1979). Preliminary research in neuroscience is starting to reveal that certain parts of our brains are activated when deciding to tackle or to avoid a problem. The left and right sides of the dorsolateral prefrontal cortex activate. Whether a person chooses to tackle or avoid the problem corresponds to which side experiences greater activation (Wu, 2014). Although this finding is in its infancy, it is valuable to make the learner aware that their brain considers both possibilities: those of tackling or avoiding a problem and it is up to them to make the final decision. Of great importance is to find out how students approach learning opportunities that evoke uncomfortable emotions, when aware of the possibility that they are unconsciously
sabotaging their potential. If students are asked to approach a learning opportunity every time that their brain chooses otherwise, will their emotions toward that type of learning opportunity change over time? Papert would conclude “yes,” as he believed that a rich learning environment could alter students’ emotions toward learning (Papert, 1980).

In an attempt to eradicate fear of learning, Papert (1980) used technology to create a learning world, where children learned geometry in a more organic way. He introduced “Turtle geometry.” The Turtle was an animal-like robotic toy that moved over ground. The Turtle was also represented digitally on the computer, as a cursor. Children controlled the movements of the Turtle, whether physically or digitally, via a computer using the programming language LOGO. Initially, the Turtle can only perform some basic movements, such as a move forward, a turn, and then puts the pen down to create a trace of its traveled path when given the computer commands of FORWARD, RIGHT, and PEN DOWN, respectively. Next, children were given the learning opportunity to teach the Turtle new words by creating new computer commands, such as TRIANGLE, SQUARE, or any other command the children desired. Through this process, the Turtle exposed children to a learning world, where their mathematical thinking developed by exploring their own ideas and fantasies. Thus, children became creators of mathematics.

In the world in which the Turtle lives, children were not expected to get it “right” the first time they tried to create a new word for the Turtle. In this world, children had to keep on correcting their work until the Turtle worked properly. With this new model for learning, children are not fearful of getting it “wrong.” Instead, they focused on how to correct their work or figured out if their work was even fixable.

Similar to Papert (1980), Fernandes, Ferme´, and Oliveira (2006) observed middle-school students focused on fixing their working out, not on simply accepting that they were wrong, while discovering the definition of a function via a robotics activity. Students were given two graphs of the distance traveled by a robot versus time (one depicted the graph of a function and the other one did not). Students were asked to program their robot to reproduce both graphs. The class was set-up in small groups. The researchers reported the conversations arising from two groups, which were close to each other. Rui, a member of group no. 1, noticed that there was something wrong with one of the graphs and told the teacher that the graph was not good because it required the robot to walk backwards and he thought the robot had to always move ahead. Ricardo, a member of group no. 2,
who was listening to the conversation, added that it “can’t be because the robot cannot walk backwards in time.” Then, the teacher asked them, “What will happen if the robot walks backwards in time?” A few minutes later, Rui answered, “the robot had to be at two places at the same time.” Students recognized this situation as impossible and decided that the second graph could not be achieved.

The study created a situation where the students would fail to achieve the task of the robot’s activity. Usually, students who fail to accomplish a task in a classroom setting tend to blame themselves, feel like a failure, blame their lack of ability, or simply get frustrated and give up. Nevertheless, here, these students kept on thinking about the movements of the robot until they arrived at the conclusion that the task was impossible. At no point, did they express negative emotions toward the learning activity. It is possible that physically seeing the movements of the robot kept on fueling their imagination of what they could do next to fix their work to reach the their goal. Once they realized that it was physically impossible to accomplish the goal of having the robot reproduce the graph, they moved on. By allowing students to keep on exploring and fixing their code, students had a tangible avenue to explore their ideas without fear of being wrong. In a way, their needs for comfort and security were met.

Displacement of Emotions

Educational robots could also serve as a platform to displace students’ emotions. Goh and Aris (2007) conducted an 8-week study of six secondary school students who were participating in a robotics competition, the Robot Transporter Event. They used the RCX LEGO Mindstorms, a robotics kit consisting of sensors, motors, and Lego pieces. During the study, the researchers interviewed and observed students to determine whether the competition had an effect on the students’ interest in math, science, engineering, and technology as well as their social skills and teamwork. One observation made during the study involved conversations of students, expressing their emotions or feelings toward the robot. For example, one student said that his robot was too tired when the robot failed to perform the expected task.

The scenario in which students verbally assign an emotion, feeling, or state to the robot they are working with, instead of internalizing it themselves, is promising for education. It is possible that as long as students project their emotions of happiness, frustration, etc. onto the robot, they will continue to explore the challenge at hand, since it is the robot’s inability and not their inability. In future studies, it will be of particular interest to identify the
emotions that are internalized by the student versus those that are externalized by the student onto the robot. Ideally, students should internalize emotions that will continue to nurture their intellectual growth and externalize those emotions that might hinder their learning. On the other hand, from the educators’ perspective, how the emotions are projected is a concern. Even when these emotions are projected toward the robot, they can disrupt the classroom. Perhaps, future work might involve what to do with the projected emotions. Is it more beneficial for the student to learn to process some of the emotions instead of simply displacing the emotion toward the robot? If so, which ones?

**Affection and Gratitude Display Toward a Robot Versus Disengagement**

The same way students value individual attention from a supportive, caring human teacher; they value the same from a robot teacher assistant. Han, Kim, and Kim (2009) took a humanoid-like robot, Tiro, to serve as a teaching assistant in a 4th grade music class in Korea. They presented their classroom observations of one of the classroom lessons. The robot helped the teacher take attendance; it presented the goals of the lesson; it performed the music activities along with the teacher; and it selected students to practice the activities with him. Three male students who were selected by the robot to perform the activity together showed their gratitude to the robot before going back to their seat for selecting them. The authors shared a picture where a boy is giving the robot a kiss. The authors also noticed that male students showed more affection, paid more attention, and were more motivated with the robot than female students. There were also some students who ignored the teacher because they preferred the robot.

The expression of gratitude of the students toward the robot is in agreement with the findings in Wentzel’s (1997) study. In her study, when the teacher “asks if I need help, takes time to make sure I understand, calls on me,” it is perceived by the student as a demonstration of teacher care. It is possible that when the robot picked students to work with on the activities, the students perceived the gesture as a form of teacher care. It also highlights the importance of giving individualized attention to students in the classroom setting. By doing so, instead of a child showing frustration for not been able to follow class activities, the child shows gratitude for getting attention and help.

The identified failure of the robot to engage females needs further exploration. Although the factors that led to their disengagement are unknown,
given that the classroom is a dynamic learning environment, robots should be programmed to deal with as many scenarios related to student learning as possible. If the technology lacks the intelligence to read human emotions or comprehend the impact of its processes, the educator should maintain an awareness of these deficiencies and have the ability to control the technology to assure that the robot meets the needs of all students, not only a subgroup.

Pity—a Caring Emotion from Student to Robot

When the robot excels at developing a relationship with students, some students display caring emotions toward the robot. Otherwise, students can become indifferent to the robot. Kanda, Hirano, Eaton, and Ishiguro (2004) performed an 18-day field trial in an elementary school, in Japan, with 1st and 6th grade students. The researchers were interested in exploring whether robots could form relationships with children and if children can learn from robots as they learn from their peers. Two “Robovie” humanoid robots, one for each grade level, were placed outside the classroom; in a corridor close to the students’ classrooms. Four cameras and two microphones were installed along the corridor to capture the interaction of the students with the robots. The physical infrastructure was the same for the 6th graders. There were 119 1st graders and 109 6th graders. Each student physically carried an ID tag with him/her. The robot used the ID tag to identify the child and to keep track of the interaction with the child. The robot’s aim was to improve the English proficiency of the students. Hence, researchers administered an English quiz three times during the field study: pretest, test no. 1 after week 1, and test no. 2 after week 2.

They found that students interacted with the robot frequently during the first week. However, during the second week, student interaction with the robot declined. The two students who continued interacting with the robot into the second week shared that they continued interacting with it because they felt pity for the robot, as there were no other kids playing with it. That is, the students who continued to engage with the robot did so due to their feelings of concern for the robot, not because the robot was able to connect with them. Consequently, while ensuring that a relationship exists between the students and the robot is important, the nature of their relationship is equally important.

Existing Emotions Will Emerge even in Robotics Technology

Silk, Higashi, Shoop, and Schunn (2010) found that the sole presence of mathematics within a robotics activity does not lead to mathematics learning
nor does it diminish the negative emotions students have toward the topic. For 3 years, their research team conducted research in middle-schools, in the technology education classrooms, after school programs, and with teachers using Lego Mindstorms NXT 2.0. They designed a robotics activity, which required the use of ratios to make robots with different size wheels to synchronize dancing. They found that for mathematics to be salient, lesson plans needed to be purposely designed to highlight the mathematics present in the activity. Otherwise, the technology would not result in mathematics outcomes gains for the students. Additionally, they found that students have internalized negative feelings toward mathematics. For instance, the researchers shared an experience in which a student was engaged in the robotics activity until he realized that he was doing mathematics. After the realization, he dropped out of the discussion. This does not mean that robotics activities cannot empower students with math but what it may mean is that the design of the robotics activity was not solid enough to preserve the interest of the student and the “coolness” of the robot wore off before the student had developed a deeper engagement with the robotics activity. To divert the existing negative emotions toward math while the students learn math with the robot, the researchers redesigned the activity based on four principles. The robotics activity must be able to sustain students’ engagement, it should focus on the key content to be learned, it should generalize understanding, and it should require that students explain their work and how it works. Silk et al. (2010) conjecture that by properly designing a robotic activity, students who lack interest or have strong negative feelings toward a topic can be motivated to learn the topic using a robotics activity, as long as the activity is properly designed.

CONCLUSION

In 1990, Lemerise (1990) contemplated whether Papert’s (1980) Turtle geometry would survive in our educational system and if so, what would it take to assure its survival? Would it have to compromise its spirit and conform to the traditional school system? Or could it survive while preserving its spirit? Unfortunately, for those of us who like Turtle geometry, the technology did not survive over time in its original form. However, its spirit did survive through Lego robotics in afterschool programs, and more recently in technology classrooms. Today, we are still wondering: What is it exactly that students are learning or can learn by playing with robots? Can we use robots to promote or enhance the learning of school topics?
The conversations about the potential of robotics are going beyond the perception that a robot is an “object-to-think” with (Papert, 1980). Humanoids are being developed to serve as peer tutors and teacher assistants. Whether the robot is used as an “object-to-think-with” as Papert envisioned, or as a humanoid that is assisting the educator, the cases presented in here give reason to believe that what we have learned in the classroom regarding teaching and learning, should be taken into consideration when designing lesson plans and robotics technology.

Students’ emotions that were present in the technology-free classroom still seem to be present in technologically enhanced classrooms. Students still react positively to a caring teacher (whether human or humanoid); there may still be negative feelings toward learning certain topics which become an obstacle in the learning process; and there may still be gender differences, etc. Therefore, for robots to help educators improve the learning experiences of students, designers need to be aware of the advances in psychology, cognitive science, neuroscience, and their interdependencies with emotions. In the entertainment industry, they are already taking into consideration the emotional basis for HRI, to assure that their products are enjoyed over long periods of time (Arkin, Fujita, Takagi, & Hasegawa, 2003). This should also be the goal of the educational community.

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