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Engaging the Imagination of Young People to Increase Technical Literacy

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AC 2012-4269: ENGAGING THE IMAGINATION OF YOUNG PEOPLE TO INCREASE TECHNICAL LITERACY

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Technology and Tornadoes: Using Imaginative Education to Foster a Technologically Literate Society

I. Abstract

This paper examines the use of cognitive tools in designing an educational website that helps middle school learners improve their technological literacy. The *Talk to Me* website consists of a young adult novel, online activities that expand on concepts introduced in the novel, and a blog written by college engineering students about their experiences attending college and taking engineering courses. *Talk to Me* is designed using Imaginative Education, a learning theory developed by Kieran Egan that outlines learners' different phases of development as their level of understanding and linguistic ability becomes more sophisticated. Beta testing occurred in 2010 with a group of elementary, middle, and high school teachers; the teachers responded with positive feedback, stating that they both could and would use *Talk to Me* in their classrooms. Additional testing with students in a summer robotics camp also supported the use of *Talk to Me*, showing that the website engaged students with concepts related to technological literacy.

II. Introduction

There is a global need for technologically literate citizens. Although some groups have recognized the value of technological literacy, it has not yet become a priority in our society. The National Academy of Engineering (NAE) holds, "The idea that all Americans should be better prepared to navigate our highly technological world has been advocated by many individuals and groups for years...Nevertheless, the issue of technological literacy is virtually invisible on the national agenda. This is especially disturbing in a time when technology is a dominant force in society"¹. The International Technology and Engineering Educators Association (ITEEA) shares this view on an emphasized need for technological literacy. "We are a nation increasingly dependent on technology. Yet, in spite of this dependence, U.S. society is largely ignorant of the history and fundamental nature of the technology that sustains it"². Technological literacy, as noted by these groups, is crucial, especially as the role of technology continues to expand. Despite its importance, expanding technological literacy has not been defined as a key societal goal for the coming years.

Nor have we defined technology and technological literacy fully. The NAE notes that most definitions of technology are too narrow. The definition should encompass "both the tangible artifacts of the human-designed world (e.g., bridges, automobiles, computers, satellites, medical imaging devices, drugs, genetically engineered plants) and the systems of which these artifacts are a part (e.g., transportation, communications, health care, food production), as well as the people, infrastructure, and processes required to design, manufacture, operate, and repair the artifacts"¹. Technological literacy shouldn't simply inform citizens about computers; it should give citizens an understanding of the broader forms of technology and the world in which they have been invented, used, and produced.

Developing a society that is not only technologically literate but also capable of innovation has been linked to a need for engineering talent¹. Fostering engineering talent, however, can be a

difficult task. Students who choose not to pursue engineering often make that choice because they are no longer engaged with the undergraduate engineering curriculum.⁴ Smith, Sheppard, Johnson and Johnson³ have emphasized the need to increase student engagement in engineering education. Engagement, they hold, allows students to learn deeply and may help improve retention in engineering. Deep learning moves beyond the simple repetition of facts or application of standard procedures and schema. When students learn deeply they can use their existing knowledge in new ways and also in acquiring new knowledge.⁵ Learning deeply allows them to adapt in response to changing technology and new contexts.

In general, then, worthwhile education to promote technological literacy should not only aim to introduce learners to the basic things we consider “technology,” such as computers, but should also introduce the context in which technology is developed and the reasons for its development and use. Thus engineering is a critical component of technology education. In order to form a more technologically literate society, engineering and technological education must be engaging and begin early in order to interest students and encourage deep learning.

Talk to Me was created with the goal of engaging young people in learning about engineering and technology. Consisting of a novel and a website with interactive activities, *Talk to Me* introduces students to the field of engineering and allows them to explore several elements of technology. To foster engagement as well as the kind of deep learning described above, *Talk to Me* employs Imaginative Education (IE), a learning theory developed by Kieran Egan that focuses on different levels of understanding that correspond to phases of linguistic proficiency.^{6, 7, 8} This theory corresponds to the idea, outlined by the ITEEA, that standards of technological literacy “are crafted to build increasingly sophisticated understanding and ability as students mature”². IE also structures learning more carefully, solving what Egan recognizes as our current “fundamentally incoherent concept of education.”⁶ In addition, Egan describes IE as the development of learners’ literacy about the world. This parallels the desire to develop people who are literate about technology, its effects, and its context in all parts of society.

To promote effective teaching and the development of students’ world literacy, Egan outlines five types of understanding that are summarized in Table 1. Each type of understanding builds on previous stages. Learners progress to new stages by mastering the cognitive tools associated with the understanding. (Cognitive tools are mental devices that have been developed by our ancestors to help them make sense of the world and to operate more effectively in it.) Egan proposes the cognitive tools most effective for teaching each form of understanding. These phases are only intended to be an outline; no two students are expected to be identical.^{7, 8}

According to Egan, story or narrative is a valuable cognitive tool: “Narrative understanding is a tool related to our ability to best make sense of things when we can grasp their emotional impact. A narrative context for knowledge can establish its emotional importance while also conveying the knowledge—about physics or mathematics no less than about history or literature.”⁷ In addition, narrative can be the conceptual framework that the National Research Council recognizes as important for effective learning.⁹ Narrative is in fact one of the most useful and powerful IE tools, because it allows students to understand the material more deeply by providing a framework and emotional context for learning. *Talk to Me* uses narrative throughout

the novel and the website to convey knowledge while explaining and exploring its emotional importance.

| Type of Understanding | Cognitive Tools |
|--|--|
| Somatic (pre-linguistic) | Bodily senses; emotional responses and attachments; rhythm and musicality; gesture and communication; referencing; intentionality |
| Mythic (oral language) | Story; metaphor; abstract binary opposites; rhyme, meter and pattern; joking and humor; forming images; sense of mystery; fantasy; games, drama and play |
| Romantic (written language) | Sense of reality; extremes and limits of reality; association with heroes; wonder; humanizing of meaning; collections and hobbies; revolt and idealism; context change |
| Philosophic (theoretic use of language) | Drive for generality; processes; lure of certainty; general schemes and anomalies; flexibility of theory; search for authority and truth |
| Ironic (reflexive use of language) | Limits of theory; reflexivity and identity; coalescence; particularity; radical epistemic doubt |

Table 1: The five phases of understanding and the cognitive tools upon which IE is based. Adapted from [7 and 8].

In addition to narrative, *Talk to Me* uses the cognitive tools and features of mythic and romantic phases of understanding—the phases most relevant to middle school learners. Mythic understanding begins as learners develop enough linguistic ability to discuss and understand things they haven’t physically experienced. They have a desire to arrange their worlds and do so with binary contrasts, like “hot” and “cold,” “male” and “female,” etc. At this age learners also become aware of a sense of mystery that surrounds our knowledge.^{7,8} Romantic understanding begins as learners see the world more realistically. An interest in binary contrasts becomes a fascination with the limits and extremes of reality, since romantic learners are trying to find the edges of the world they are beginning to comprehend. Romantic learners are also interested in heroes and how they face the challenges of reality. To help themselves feel secure that not all knowledge is infinite, students at this phase love collecting.^{7,8} *Talk to Me* uses Imaginative Education—specifically some of the cognitive tools associated with Mythic and Romantic understanding—to engage learners in technological literacy in a way that takes advantage of how the mind develops.

III. Applying Imaginative Education to Further Technological Literacy

Talk to Me Novel

A young adult novel is the focal point of the *Talk to Me* website (see Fig. 1). The novel is presented from the point of view of fourteen-year-old Sadina Reyes. Sadina’s mother is accused of a crime, and Sadina thinks that her younger sister, Maddie, has information that could prove their mother is innocent. But Maddie can’t talk: she has a real anxiety disorder called selective mutism that prevents her from talking about what she knows. Sadina works with her friends to design a robotic cat that can communicate with and Maddie record her answers to questions about the crime. In the process of building the cat and solving the mystery, Sadina and her

friends learn about brainstorming, respect, teamwork, and communication. They also find themselves involved in ethical dilemmas that parallel the kinds of situations that professional engineers and technologically literate citizens might face.¹¹

The novel introduces middle school students to different kinds of technology (such as artificial intelligence) and also to ethical decisions that are inherent in using technology. The storyline puts the implementation of technology (the robotic cat) in the broader context of Sadina’s ethical dilemmas with her friends and also her desire to prove her mother’s innocence. In addition, the characters learn that technology isn’t just about electronics, it’s about helping people and helping society by making sure the innocent stay out of trouble. Finally, *Talk to Me* gives teachers the opportunity to teach technological literacy across disciplines because it provides both a novel (which could be used in an English class) and engineering-related activities. This integration of technology into multiple disciplines is essential; as the ITEEA states², “When taught effectively, technology is not simply one more field of study seeking admission to an already crowded curriculum...Instead, it reinforces and complements the material that students learn in other classes.”

The “mystery” that Sadina must solve in the novel is a cognitive tool that supports Mythic understanding. This use of IE effectively engages children and helps them learn concepts deeply. In addition, the characters provide students with relatable role models—another essential element of engagement.



Figure 1: The *Talk to Me* homepage (available at www.talk2mebook.com)¹²

Talk to Me Home Page

In addition to providing access to the novel through an on-line reader, the *Talk to Me* home page presents profile pages that highlight the “top 10 facts” about each character; blogs by college students that explore what it is like to study engineering; and three units through which learners can explore concepts introduced in the novel. These units currently include activities in the areas of artificial intelligence, engineering design, and engineering ethics. A fourth unit with sustainability activities has also been developed and will be added to the website.

Artificial Intelligence

This unit explores examples of technology (e.g., computers that try to appear more “human” in what they can do) and how they fit into the broader scope of technology’s human roots and place in human society (e.g., a computer’s ability to seem human and the idea that computers are the result of human invention). The unit provides a rich opportunity to explore technological literacy; according to IE theory, Mythic and Romantic learners are particularly interested in limits and extremes of reality and the humanization of knowledge.^{7, 8} The questions and ideas that frame the AI unit were developed according to these understandings and include, “Do you think chatterbots will ever pass for humans?”, “How are humans and computers different?”, and “Are computers smarter than humans?” These questions encourage students to consider what makes humans and technology different by examining the most extreme limits of technology and knowledge.

Rio (a character from the novel with an interest in AI) hosts the unit’s activities. The first activity in the unit is a comic strip about Rio and his recent dream. The dream is based upon Daniel Dennett’s classic essay “Where am I?”¹⁴. In the dream, Rio has to retrieve a bomb from underground, and to enable him to do so “safely,” scientists remove his brain from his head and keep it in a vat. Students complete the comic strip and are asked to consider a series of questions such as, “Where is Rio: with his head or with his brain?”, “If his body blows up, where is he then?”, and “What is consciousness and where does knowledge exist?” Through this activity students see that technology often pushes us to ask and explore intriguing and challenging questions.

The second activity is called the Imitation Game. Students play the part of Rio, who is chatting online with two of his friends from the novel, Monica and Paulie. Monica and Paulie have screen names that don’t allow Rio to identify who is who, and both are pretending to be Monica. Students ask preset questions in order to identify the real Monica. The activity introduces learners to the Turing Test developed by Alan Turing and described in his well-known paper, “Computing machinery and intelligence.” The activity also allows learners to explore stereotypes (how “should” a girl sound?).

The third activity, “Chatting with Chatterbots,” expands on many of the same concepts, primarily the humanization of knowledge. Students are provided with online links to age-appropriate chatterbots available on other websites and are encouraged to ask a variety of questions, with the goal of exploring the chatterbots’ ability to imitate humans. The goal is to help learners develop a deeper understanding of the limits of computers and technology in general. In addition, learners explore the nature of language. Early versions of the unit have been shown to be effective in a language arts class¹⁶.

Chatting with Chatterbots also introduces the idea of ethics (which is explored more fully in the engineering ethics unit of the site, discussed below). In “What’s the Connection?”, students are introduced to the idea that while many chatterbots are fun and helpful, some chatterbots can spread viruses or steal information. The idea of teaching ethics in combination with technology and engineering fits with the NAE’s view that “most people think that technology is little more than the application of science to solve practical problems. They are not aware that modern technology is the fruit of a complex interplay between science, engineering, politics, ethics, law, and other factors.”¹

Engineering Design

Both the NAE and the ITEEA² cite the engineering design process as a vital part of technological literacy. The NAE asserts that a technologically literate person “Is familiar with the nature and limitations of the engineering design process”¹. The engineering design unit on the *Talk to Me* website provides two activities in which students are introduced to the engineering design process. One activity involves Monica, a character from the book, choosing a pair of jeans to buy. The other activity relates to the design of a “chattercat” that can communicate with Maddie (see Figure 2). Based on the *Massachusetts Science and Technology/Engineering Curriculum Framework*¹⁷, both activities are set up as circles of eight steps that outline the engineering design cycle. Through these two activities, the unit aims to present the design process as a loose and adaptable framework that structures and guides brainstorming and design, rather than a concrete list of steps for students to memorize. The chattercat activity in particular has “footsteps” on certain steps of the cycle that expand on concepts covered in the design cycle. These pages help students understand the complexity of identifying problems, communicating with different types of people, and examining “hidden costs” (explained in more detail below).



Figure 2: Design cycle activity showing the creation of “chattercat”.¹²

The engineering design cycle activities employ IE by connecting to the characters and overall narrative of *Talk to Me*. The *Talk to Me* characters are portrayed as heroes, an interest of Romantic learners. Egan notes that, “The hero can embody unusual degrees of such qualities as sanctity, compassion, selflessness, elegance, wit, ingenuity, patience...equally as well as testosteronic violence”⁷. In the novel, Sadina proves herself to be a selfless and caring hero as she designs the chattercat. The design cycle activities also utilize IE by illustrating that all our knowledge and technology has human roots, being discovered or created by a human following some version of the design cycle.

Another example of technological literacy within the engineering design unit is one of the “footstep” activities accessed from the TeknoTurf Design Cycle activity (Figure 3). Students learn about broader “costs of their lunch” (beyond simply the monetary price) by clicking on different buildings around a map to find “hidden costs.” On the first page of the NAE’s *Technically Speaking*, food itself is used as an example of a way in which we should be more technologically literate. “We fill shopping carts with highly processed foods but are largely ignorant of their content, or how they are developed, grown, packaged, or delivered”¹. In the activity, students see that their food has environmental, social, and manufacturing costs, and this helps them realize the ubiquity of certain kinds of technology (such as cars and factories) as well as the costs they bring to society. The activity introduces students to these ideas by using Egan’s cognitive tool of mystery—in this case, the mystery of “hidden” costs.



Figure 3: Footprint from one of the design cycle activities showing hidden costs of a pizza lunch.¹²

Engineering Ethics

Though both of the other units include ethics, the engineering ethics unit involves a number of activities related specifically to ethical situations and students' ethical views. The unit is presented as entries in Sadina's journal, a narrative to which young learners can easily relate. The activities primarily involve ethical situations that children and young adults may face. For example: what would you do if you saw a friend cheating on a test? These kinds of examples are used because they are directly connected to what students may experience and also because they often mirror real professional ethical dilemmas that are introduced later in the unit.

Users are introduced to ethics through several activities (such as taking an engaging quiz that requires them to respond to ethical dilemmas) that help them explore their current "ethical style" and introduce them to a framework that helps them think ethically. After trying out the framework on ethical dilemmas that a young person might encounter, users then apply the framework to a real engineering ethics case study relating to the CitiCorp building. In this interactive case study, the user makes a series of decisions that lead to different outcomes depending on the path the user chooses.

Sustainability

This unit addresses the question "What is sustainability?" and includes activities specifically related to technological literacy. This unit is the one that perhaps best illustrates the application of IE. A real-world Romantic narrative involving a tornado striking Springfield, Massachusetts—an extreme weather phenomenon that pushes the boundaries of reality and illustrates the binary contrast of safety and danger—was chosen to engage learners and frame their learning. Tornadoes, while providing a connection to IE and to the engineering possibilities of evaluating their impact on structures and community, also brings up questions about how to rebuild (and how to do so sustainably).

As in each unit, the sustainability unit was connected to the characters in the *Talk to Me* novel. The sustainability activities are developed within a Mythic mystery context: "Catalina's Little Black Book of Secrets." Catalina, one of the most outspoken and hot-tempered characters in the novel, shares her hopes, her fears, and her friends' embarrassing secrets while simultaneously discussing and introducing learners to ideas related to sustainability. Gossip, a key part of the unit, is another Mythic tool. Egan states, "The trick is to think about whatever topic one is teaching, and introduce items of gossip that will enhance understanding and engage students' imaginations"⁷. The gossip in this case is Catalina's secrets about herself and her friends with regard to tornadoes and sustainability. Egan adds, "Gossip in early childhood is one of the easiest ways to develop the foundations for rich orality on which we can then build a rich literacy. Good literacy skills rely heavily on the development of good orality skills"⁷.

One part of the sustainability unit is a discussion of different kinds of environmental justice, including inter- and intra-generational justice. These concepts and terms are simplified for middle-school students into different kinds of "fairness." At one point in the narrative of the unit, Catalina has a discussion with her teacher, Mr. Jaworski, about using one form of technology pertinent to tornadoes: tornado warning sirens (Figure 4).

Catalina: Do you think it's fair that Matt [a homeless man] wasn't warned about the tornado, just because he doesn't have a cell phone or a TV or a radio?

Mr. J: That's a good question. There's one type of fairness that I like to call Right Now Fairness. That means: are we being fair to everyone who's alive right now?

Catalina: Definitely not! I mean, couldn't the town use tornado sirens, so that everyone can hear that a tornado is coming?

Mr. J: Sure, that sounds like a great idea. But think about it. Tornado sirens are really expensive to buy and keep running. So if the town spends money on tornado sirens, maybe it won't have enough money to spend on other things.

Catalina: Yeah, like paying its really awesome teachers, right, Mr. J.?

Catalina [in thought bubble]: I guess it's more complicated than I thought. As far as I can tell, this means I should start caring about other people. Something kinda new for me.

Figure 4: Example of discussion between Sadina and Mr. Jaworski from the sustainability unit of *Talk to Me*.

This discussion introduces students to a type of technology, the tornado siren, while also discussing its advantages and disadvantages. This is one goal of technological literacy, as outlined by the NAE. A technologically literate person “Appreciates that the development and use of technology involve trade-offs and a balance of costs and benefits”¹. It also answers the questions “Who will benefit and who will lose by the technology?” and “Who will have access to the technology?”¹. By teaching about a specific technology *and* its ramifications, within a broader context of sustainability, several of the technology activities introduce students to how to weigh costs and benefits of technology and see their human effects.

The sustainability unit also includes an energy quiz in which users answer questions about their own energy use. The quiz addresses and discusses certain kinds of technology such as batteries, lights, air conditioners, cars, and fans. Their benefits and costs are weighed in support of technological literacy. These types of quizzes can be seen as parts of games or play, which are Mythic cognitive tools.

Another activity in the unit introduces students to life cycle analysis. Life cycle analysis is another way to assess the costs and benefits of technologies and their related processes. The activity presents “life cycles” of a frog and of a piece of paper (a cookie wrapper). This helps students see both a “natural” life cycle as well as a technology-based one. Paper is presented as a technology—something invented and created by humans to serve a particular human purpose. Paper was chosen as the illustrative technology as yet another reminder that technology and knowledge are human, as well as to engage learners’ preconceptions on the topic of life cycles. In addition, presenting paper as a technology in the life cycle analysis provides a way for students to “Recognize...the pervasiveness of technology in everyday life”¹ by viewing paper as a form of technology with its own risks and benefits.

IV. Assessment

An early version of the *Talk to Me* website was field-tested in summer 2010 in a workshop with Springfield Public School (SPS) teachers. In the workshop middle school technology teachers were introduced to the *Talk to Me* website, learned about engineering concepts related to the book and website, and were involved in discussions about potential use of *Talk to Me* in the classroom. An independent teacher survey administered by the Donahue Institute at the University of Massachusetts indicated the following:

- Over 85% “strongly agreed” or “agreed” the *content* of the *Talk to Me* website is more likely to engage students in engineering than what was currently available for them to use.
- Over 92% “strongly agreed” or “agreed” the *characters and story* of the *Talk to Me* website are more likely to engage students in engineering than what was currently available for them to use.
- Over 92% “strongly agreed” or “agreed” the *look and feel* of the *Talk to Me* website is more likely to engage students in engineering than what was currently available for them to use.¹³

Since that initial testing, the website has been improved and expanded. In Summer 2011, the *Talk to Me* novel and AI unit were tested during a three-hour session at a summer robotics camp held at Springfield Technical Community College (see Figure 5). The camp is designed to support students who are at risk for academic success. A summary of how *Talk to Me* was used is provided in Table 2.

Prior to *Talk to Me* Session:

- *Talk to Me* novel was read aloud to students over several days.

***Talk to Me* Session:**

- Began by playing the Imitation Game with students, encouraging them to come up with questions that would best help them determine the gender of the respondent (see http://talk2mebook.com/artificial_intelligence/imitation_game/index.html for more details.)
- Transitioned from the Imitation Game to the Turing Test, in which a computer tries to convince you that it is human (rather than a male trying to convince you he is female).
- Using the same format as the Imitation Game, students guessed whether a respondent was human or computer.
- Discussion of AI, what it meant, and how and why it could be used.
- Discussion of what “good” questions to ask chatterbots would be, in order to reveal whether they are computer or human.
- Students moved to computers with the TTM “Chatting with Chatterbots” homepage (http://talk2mebook.com/artificial_intelligence/chatterbots/index.html) active, and were given time to chat with the different chatterbots.
- Final discussion of the chatterbots, good questions, and overall reactions.

Table 2: *Talk to Me* session at STCC Robotics Camp, July 2011.

After the morning session, all fourteen students completed an anonymous online survey assessing their engagement and learning. The results showed that 77% of respondents reported that they liked the book and 100% of respondents liked the AI activities. When asked to specify what, in particular, they liked about the book, 30% of those who liked the book mentioned the mystery aspect –one of the cognitive tools that Egan identifies for this age group.

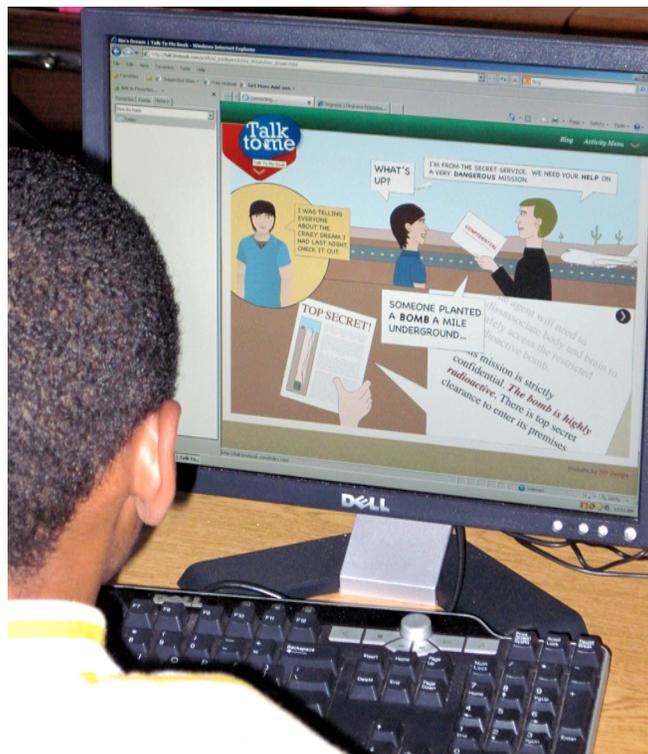


Figure 5: A student in the summer robotics camp reading a comic strip in the AI unit of *Talk to Me*.

The camp participants were also asked several questions to assess their learning. One question measured replicative knowing¹⁸ with respect to the novel: “Sadina works together with her friends to design a robotic cat that can help Maddie talk. List three things they do to design the robotic cat.” Most of the students (86%) were able to correctly identify elements that went into designing the cat. Another question measured applicative knowing¹⁸: “You are texting with someone who could be either a human or a chatterbot. Give an example of a good question you could ask to help you find out which it is. Please explain why you think the question is good.” One third of the respondents were able to give an answer to this question that indicated an advanced understanding for their age of the Turing Test. For example, one student answered, “‘What’s your favorite childhood memory?’ This is a good question because chatterbots don’t have childhood memories. Real humans will describe in detail, whereas chatterbots will probably just say what it is and not describe it.”

Finally, because an important goal of the website is to increase children’s interest in technology and engineering, the survey included two questions about their interest in the concepts introduced by *Talk to Me* and how it affected their interest in engineering. All respondents reported that *Talk to Me* either increased their interest in engineering (45%) or maintained their

current interest in engineering (55%). In response to the question, “Three things in the book are artificial intelligence, designing things (like a robotic cat or a cell phone), and ethics (like what to do if you think a friend stole something). Did the book make you want to learn more about any of these things? Please explain your answer.” Most responses (73%) were positive. One wrote, “The book made me want to learn more about AI because it showed me that you can do some very fun things with it.” Another wrote, “yes it helped me learn more. i learned what artificial intelligence is, and i learned that you can design things.” Finally, one wrote, “i[n] some way. it made me want to build some thing to help out some one who is disabled.”

V. Discussion

The current version of the *Talk to Me* website is a first step in exploring how IE can be used most effectively to both engage learners and help frame their learning in a meaningful way. The assessment data for teachers showed that they believe *Talk to Me* will engage students. The assessment data for students in the robotics camp supports this belief. Certainly engagement is a key ingredient for learning with understanding. While preliminary results show that by some measures learning took place during the robotics camp, more research is needed to better understand what the students learned and what factors impact their learning. Some questions include:

- *Talk to Me* is designed for use in informal and formal educational settings. How does the setting impact learning?
- The teacher read *Talk to Me* to the students in the robotics camp. How will the results differ if learners read it on their own?
- The sustainability unit is more strongly based on IE theory than other *Talk to Me* units. How does this impact learning?
- Does *Talk to Me* support what Schwartz et al.⁵ refer to as “transfer-in”?—i.e. does *Talk to Me* prepare students for future learning?

Although recently made available on the Internet, *Talk to Me* remains a work in progress. The website continues to expand with the sustainability unit described in this paper to be added soon and a flight unit being developed. Like the sustainability unit, the flight unit will be strongly grounded in IE theory and will use Chesley Sullenberger’s heroic landing on the Hudson River as a Romantic narrative to frame the unit. Another upcoming change to the website is the inclusion of videos of middle school students talking about their ideas on concepts included in *Talk to Me*.

Feedback from teachers has indicated a strong interest in using *Talk to Me* as a tool to promote literacy (including ESL learners) and integrate technology throughout the curriculum. To support that effort an audio book is currently being developed and plans are being made to translate *Talk to Me* into Spanish. We also recognize that while some of the concepts explored in *Talk to Me* will be familiar to teachers, many of the concepts (such as AI) will be new. To address this concern a teacher’s guide is being developed that will include an introduction to IE, tips for how *Talk to Me* can be used most effectively in a variety of informal and formal learning environments, and content readings that will give teachers the background and confidence needed to integrate *Talk to Me* in their classes.

Finally, there is a growing consensus that solutions to the most important problems facing future engineers will require the production of new knowledge. An example is developing new sources of energy (the National Academy of Engineering Grand Challenges provides numerous additional examples). Future engineers will need to be able to combine their technical expertise with an ability to collaborate with colleagues in order to produce innovative solutions to complex problems. Introducing learners to these types of knowledge-age problems is a significant departure from the traditional approaches to formal and informal K-12 engineering education and requires educational approaches that actually engage learners in the kind of collaborative knowledge work needed to solve complex problems.

To address this need, we plan to add a forum for knowledge building into the instructional design of the *Talk To Me* website. Knowledge building is an approach to learning that has been employed in a variety of countries, grade levels, and subject areas and has a strong research base.^{19,20,21,22} In a knowledge-building environment the focus of the learning community is on continually improving ideas. It begins with a question of understanding, such as *Could a computer ever have feelings?* The next step is to encourage learners to generate and post their ideas about the topic (typically in an asynchronous, online group workspace). In the process the community organizes itself into working groups that grow and change in response to the interests of learners. The workspace preserves the discussions so that the learners can return to them for comment and reflection. Scardamalia¹⁹ provides twelve determinants that define knowledge building discourse, such as exploring real ideas and authentic problems, “rising above” the discourse to create higher level concepts, taking collective cognitive responsibility and using authoritative resources.

VI. Conclusions

Overall, there is a need for increased technological literacy and the development of approaches for supporting learning that are based on the research in the learning sciences. *Talk to Me* provides an example of how one particularly promising approach—Imaginative Education—can be used to create a novel and website for middle school students pertaining to technology and engineering. Preliminary results have shown that teachers feel *Talk to Me* will engage their students in learning about technology and engineering and field-testing with students supports the teachers’ belief.

VII. Acknowledgements

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