Inspiration Brief 2

# The DiSC and RoboKids Tools and Labs: Design and Testing

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COTF/B2/Jan-2006

#### About the NASA-sponsored Classroom of the Future

The NASA-sponsored Classroom of the Future program is helping to bridge the gap between America's classrooms and the expertise of NASA scientists, who have advanced the frontiers of knowledge in virtually every field of science over the last 40 years. The program is administered by the Erma Ora Byrd Center for Educational Technologies<sup>®</sup> at Wheeling Jesuit University in Wheeling, WV

The Classroom of the Future<sup>™</sup> serves as the National Aeronautics and Space Administration's premier research and development program for educational technologies. In this capacity the Classroom of the Future develops and conducts research on technology-based learning materials that challenge students to solve problems by using datasets and other information resources provided by the four core scientific missions underlying the work of NASA: Exploration Systems, Space Operations, Science, and Aeronautics.

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# nsp/ration

Figure 1. The Classroom of the Future inspiration logo.



Figure 2. The COTF model of systemic inspiration growth.

#### **TBPD-BBB**

Task, Behavior, Program, Create, debug, What does the robot **d**o?

**B**ot behaving badly: Behavior to boot Behavior to program Still behaving badly Begin again.

Figure 3. The COTF chant for the TBPD-BBB problem-solving technique.

#### **Executive Summary**

As 2004 drew to a close, the NASA Technology and Products Office led its Classroom of the Future<sup>TM</sup> (COTF) in the specification of a research agenda with the potential to charge formal and informal science, technology, engineering, and mathematics (STEM) education efforts: the Inspiration Initiative (see Figure 1). Over the course of the initiative, the Classroom of the Future will lead NASA in a research agenda that defines inspiration, develops tools to enhance inspiration, and tests and refines the effectiveness of those tools.

The 2005 COTF contract work on inspiration began in mid-March. By May COTF had synthesized relevant theory and empirical research into a model of systemic inspiration growth (see Figure 2) made up of five dimensions (identity, self-efficacy, mental models, imagination, and creativity) and "flow." By September COTF had developed prototypes of two inspiration technology tools and the research instruments and protocols to study and refine the tools through controlled experiments conducted within educational environments. By December COTF had conducted the initiative's first experimental studies, one exploratory study for each tool.

# Case 1. RoboKids: An Affective Tool to Enhance Self-efficacy Within Informal Education Environments.

COTF developed the TBPD-BBB problem-solving technique for programming LEGO MINDSTORMS<sup>™</sup> robotics (see Figure 3). COTF trained 13 adolescent boys and girls in using TBPD-BBB to solve robotics challenges. The RoboKids CD-ROM/DVD documents their problem-solving activities and the robotics challenges they solved. RoboKids connects those challenges to the Carnegie Mellon Robotics Academy ROBOLAB<sup>™</sup> Video Trainer CD (2005, see www.rec.ri.cmu.edu/education, used with permission) instruction. Thus, RoboKids presents peer-aged role models solving robotics challenges. It is designed to enhance robotics self-efficacy. Creation of an effective tool will require cycles of development as researchers uncover the relationships between the targeted learners and the sense of identity they develop for the RoboKids role models.

The 2004 NASA agreement stipulated that COTF study the RoboKids tool within an informal event. COTF partnered with the Oglebay Good Zoo and Benedum Planetarium in Wheeling, WV, to conduct a controlled study COTF robotics workshop increases participants' robotics self-efficacy by 40 percent

Girls increased identification with RoboKids role models who took leadership roles in solving robotics challenges. Boys significantly increased their identification with the entire set of RoboKids role models.



Figure 4. The DiSC tool interfaces for scaffolding scientific discussion: practice screens.

of students during two four-hour robotics workshops. Thirty-four middle school-aged youths participated in the study.

On average over the course of the workshop, participants' self-efficacy increased from about 40 percent to about 80 percent of the total points available on the Reese-Cummings LEGO<sup>®</sup> MINDSTORMS<sup>™</sup> Introductory Robotics Self-efficacy Scale. This increase in participants' robotics self-efficacy indicated a very successful learning experience. Workshop youths who studied with RoboKids videos as role models built a stronger identification with the actors than did those who studied videos of the same actors in nonrobotics activities. However, there was a difference in the way boys responded to RoboKids. Boys watching role models engaged in solving robotics challenges significantly increased their overall identification with those role models. Girls were more selective. When girls watched videos of RoboKids role models who were engaged in solving robotics challenges, the girls' identification gravitated toward the RoboKids individuals who took leadership roles in solving the robotics challenges.

For example, all workshop girls reported high initial identification with the most mature and attractive female RoboKid. This identification with the mature, attractive female continued throughout the workshop for girls watching nonengaged role models. Girls watching the engaged role models reported a *decrease* in their identification with this RoboKid.

These results suggest that girls' identification with role models is driven by pragmatic concerns, that identification with role models might transcend gender alignment for middle school-aged youths, and that boys are more likely to identify with a set of task-specific role models while girls discriminate identification with specific individuals from the set according to the leadership and skill level. This is an exploratory study, and these results must be followed by confirmatory studies using a larger number of youth.

#### Case 2. DiSC (Discussion in a Scientific Context): A Social Tool to Enhance Learners' Mental Model of Scientific Discussion Within Formal Learning Environments

Scientific discussion with their peers is a socially mediated activity through which students engage in authentic scientific practice. That is, during scientific discussion students support their claims with evidence and reasons and subject their reasoning to review by their peers. Although scientific argumentation is a fundamental component of inquiry-based learning environments, the concept and skills are novel,



Figure 5. The DiSC Tool Interfaces for Scaffolding Scientific Discussion: Quiz Discussion Screen.

abstract, and challenging for both students and their teachers. Thus, both students and teachers require scaffolding to recognize the components of argumentation and fruitfully engage them. COTF synthesized seminal work from the argumentation literature and applied it toward the design specification of an introductory argumentation tool for middle school-aged students. The DiSC Tool (see Figures 4 and 5) is web based and designed to support any inquirybased learning environment. The current iteration is a prototype and would need to be populated anew with questions and topic summaries specific to each targeted unit of instruction.

The Classroom of the Future was tasked with selecting a NASA-approved product and testing it as a component of an "Inspiration Challenge" within the NASA Explorer Schools testbed. COTF selected the Challenger Learning Center<sup>®</sup> e-Mission<sup>™</sup> Operation Montserrat and populated the DiSC tool with practice activities, three quizzes, and three sets of topic summaries related to Operation Montserrat. Preparation for the e-Mission involves a 3-5 week unit of classroom study. Then comes the e-Mission—a live simulation conducted via videoconferencing. During the simulation students take on the role of scientists to solve real-life problems, using their math and science knowledge by gathering, analyzing, and interpreting data. COTF developed a four-week version of the unit for the Inspiration Challenge.

COTF developed research protocols and instruments specific to the Systemic Model of Inspiration Growth to investigate the effects of DiSC when integrated within authentic learning environments. COTF targeted the inspiration dimension of mental models in these areas:

- Operation Montserrat-related career knowledge.
- Operation Montserrat-related science knowledge.
- What is the practice of science?
- What is a scientist?
- What is scientific argumentation?

Inspiration Challenge instruments measured baseline and change for participating students in these mental model areas as well as in the dimension of self-efficacy within three domains:

- Academic self-efficacy
- Social self-efficacy
- Scientific argumentation self-efficacy

The model of systemic inspiration growth defines flow as its proxy for inspiration; therefore, COTF used the



Figure 6. Distribution of the first group of participating teachers, randomly selected from 70 NES volunteers. The numbers represent the number of teachers selected from each state (see Appendix for full-size map).

COTF facilitators communicated with Inspiration Challenge teachers weekly and more often as necessary.

Each teacher's implementation of the study was idiosyncratic.

Systematic and meticulous recordkeeping was essential to study implementation. flow Experience Sampling Method (ESM) to measure students' flow over the duration of the study. Ideally, each Challenge teacher administered the ESM instrument 30 times.

Because DiSC usage would be randomly assigned at the classroom level, running a research-based experiment with control and treatment groups required recruitment of 30-50 NASA Explorer Schools (NES) classrooms. Seventy NES teachers originally volunteered to participate in the study. The 50 classrooms randomly drawn from the volunteers ranged geographically from Vermont to Hawaii, and North Dakota to Texas (see Figure 6). The remaining 20 teachers served as alternates.

COTF managed the scope of this large and complicated study at a distance through a team of COTF facilitators, a data processing team, and assessment/ evaluation technologies (Scantron and online data collection). COTF converted the standard ESM instrument to a Scantron sheet and formatted all of its other tests and surveys for online and Scantron administration. Participating teachers had their choice of using paper-based or online versions of tests and surveys.

The Inspiration Challenge study protocols were written for each day and activity of the study and presented to Challenge teachers through the Blackboard online course management system. Teacher progress through the DiSC tool and administration study instruments was logged, and facilitators communicated with Inspiration Challenge teachers weekly by e-mail and telephone (and more often as needed).

Despite study specifications, teachers' implementation became idiosyncratic. To help teachers maintain the integrity of the protocols, facilitators developed personalized versions of the Inspiration Challenge calendar for many participants. The fact that the Inspiration Challenge was a real-world implementation within an authentic educational delivery setting makes implementation a negotiation between researchers and teacher-as-researcher partners—a very different type of research from a laboratory study.

COTF developed an implementation construct to statistically control for some of this variance. However, it may be that some value to be gained from the Inspiration Challenge study will be derived from analysis of the effect of those implementation variations and how they interacted with inspiration dimensions. The Challenge sample size is large enough to afford analysis of the data through many lenses, and COTF's systematic administration of the study data collection and processing coupled with facilitator knowledge makes it possible to structure those analyses. Authentic educational delivery settings control and constrain research implementation.

Informal events are designed for participant success; this precludes design of research conditions that predispose participant failure or distress.

Constraints produce opportunity: The informal event grain of analysis is more refined.

# Two Tools and Two Studies Situated Within Authentic Educational Delivery Settings.

The Inspiration Challenge (study of the DiSC tool) and the inspiration informal event (study of the RoboKids tool) were both research studies in which participants were randomly assigned to treatment and control conditions, either at the individual or classroom level. Both studies were planned according to rigorous protocols. However, both occurred within authentic educational delivery settings rather than the educational research laboratory. In both studies the characteristics of those authentic settings had direct effects that constrained and directed the course of implementation.

#### The constraints of an informal event.

A laboratory study of RoboKids would be structured such that RoboKids provided the primary robotics instruction. Youths assigned to the control condition would not participate in the vicarious success of RoboKids role models solving robotics challenges. Within such a design youths assigned to the control condition should have greater difficulty in solving the challenges. Researchers would expect the control group to experience frustration because the only scaffolding would be supplied through role models provided for the treatment group. However, informal events must be constructed so that every young person who attends is successful and goes away happy. In the case of the robotics informal event, instruction should enhance each participant's self-efficacy. This is even more important when the research institution (COTF in this case) has partnered with another organization. Consider the young people assigned to this study's control condition:

- Could we structure an event that left young people with negative impressions of our organization, the Classroom of the Future? No.
- Could we structure an event that left young people with negative impressions of our partner organizations, the Oglebay Good Zoo and Benedum Planetarium? No.
- Could we structure an event that left young people with negative impressions of robotics? No.
- Could we structure an event that left young people with a negative impression of NASA? No.

Thus, COTF instructional designers developed highly effective instruction that was a huge success at building participants' LEGO MINDSTORMS self-efficacy and programming knowledge. The RoboKids research study, then, needed to concentrate on more fundamental and Authentic educational settings reduce the researcher's control, but afford testing under realistic implementation conditions.

Constraints produce opportunity: Large-scale studies within classroom settings provide insight into authentic implementation across individual implementation interpretations.

"... not much instruction follows the prescriptions which our research has shown are most effective for efficient and effective learning. I'm happy to say that the DiSC tool is a very good example of effective concept instruction for a difficult to teach concept. This team is to be commended for an outstanding piece of work." -Dr. M. David Merrill (see Appendix A) formative components of the hypothesis than self-efficacy. COTF identified the fundamental question of how taskrelated pragmatic concerns and gender interact over the course of a workshop with participants' identity with engaged and nonengaged role models.

#### The constraint of classroom implementation.

The researcher has dominion within the laboratory. The researcher controls the environment, determining each environmental characteristic and each stimulus that will affect the participant. The classroom is the domain of the teacher. Especially in the case of NASA Explorer Schools (by definition underachieving and underserved student populations), environmental characteristics affecting students tend to be problematic. Recall that the Inspiration Challenge is a large-scale empirical study conducted over 1.5 to 2.5 months. During the Inspiration Challenge:

- Teachers' control of their calendars was limited, at the mercy of the weather, politics, and other school activities.
- Teachers tended to view research protocols as lesson plans to be modified.
- Some teachers, even teachers of science, appeared to have limited appreciation and understanding of how to participate as research partners in practice of their own science, the science of education.

COTF staff quickly learned that flexibility and accommodation were as key to implementation of a largescale research project as excellent and weekly communication and meticulous recordkeeping. However, the scale of the project and the identification of idiosyncratic implementations will allow researchers to study just how those variations interact with the effectiveness of the DiSC tool.

The Inspiration Challenge was scheduled to complete data collection the second week of November 2005. Because of teacher illness, national political and physical disasters, idiosyncratic school calendars, and teacher implementation practices, COTF modified the schedule to fit the five-week study to each teacher's situation. Most teachers completed the study during November and December. Eight teachers did not return their complete set of study materials until January.

#### The Inspiration Research Agenda

The vision, guidance, and financial support of the NASA Technology and Products Office has resulted in a model of "The effect of programs on participant knowledge gain is important, but even more important is their capacity and belief in their abilities to excel beyond what they had previously hoped for (selfefficacy). . . . The work in aerospace, robotics, and other areas in 4-H could benefit a great deal from your inspiration research." -Dr. John A. (Tony) Cook (see Appendix A)

inspiration and prototypes for two Inspiration Tools designed to foster selected dimensions of inspiration and flow. Dr. M. David Merrill, a noted and awarded expert in instructional effectiveness, commended COTF for its DiSC tool (see Appendix A). The two Inspiration Lab studies that followed supported the development of research tools and protocols. Dr. John A. "Tony" Cook, national 4-H liaison for aerospace education, is currently investigating possibilities with other 4-H leaders for augmenting the 4-H robotics learning modules with the Reese-Cummings LEGO MINDSTORMS Introductory Robotics Self-efficacy Scale and the RoboKids tool (see Appendix A). The Carnegie Mellon Robotics Academy is actively partnering with COTF, and the academy's ROBOLAB Video Trainer videos will be incorporated into the next iteration of RoboKids (see Appendix A). COTF is also discussing collaboration activities with Yvonne Clearwater, project manager of the NASA Robotics Alliance Project and the Robotics Curriculum Clearinghouse (see Appendix A). At the time of this report, the COTF inspiration model is only six months old. DiSC is three months old, and RoboKids is two months old. This interest within the academic and informal education communities is a testimony to the timeliness and viability of the concept as well as the quality of the COTF deliverables. However, tool and theory development is an iterative process informed by cycles of laboratory and classroom qualitative and quantitative research. Inspiration is an audacious research agenda. Even if it limits the scope of its Inspiration research to these two tools and their dimensions, COTF has years of study ahead.

#### The Structure of This Report

Brief 2 begins by situating the DiSC and RoboKids tools within NASA Education priorities. A quick review of the model of systemic inspiration growth is followed by a section that established connections between the informal education literature and (a) the inspiration dimensions of identity and self-efficacy, and (b) flow. The RoboKids section discusses the development of the tool and results of the informal event that studied the interaction between gender, identity, and the RoboKids. The DiSC section reviews development of this tool and the implementation of the Inspiration Challenge study. The final section summarizes conclusions and lessons learned through the 2005 inspiration contract year and suggests directions for subsequent COTF research activities. Brief 2 also includes appendices of the images, study instruments, study protocols, and tables. Inspiration learning technology tools are designed to enhance the effectiveness of learning environments, using NASA science contexts, databases, and resources.



*Figure 8.* The Virtual Design Center navigational menu with Step 6, Learning Technologies, selected.

### NASA Education and Inspiration Tools: Where's the Fit?

The Technology and Products division of NASA Education sponsored the design and development of the COTF Virtual Design Center. This online workshop guides NASA design teams through research-supported best practices as they design an inquiry learning activity that aligns with both NASA science and national standards. Workshop participants design instruction that uses NASA resources or datasets and one or more learning technology tools. The workshop consists of six steps. Steps 1-4 comprise specification of the design space (see Figure 7). Steps 6 and 7 complete the design scenario. A quick overview of the design space and scenario will help the reader to situate the DiSC and RoboKids tools within NASA Education initiatives.



Figure 7. The Virtual Design Center design space.

Visualize the design space as facets of a cube that must align. Conceptually, designers must specify parameters that work together: targeted learner characteristics, national standards, an investigation question, an authentic NASA science question, and assessments of student learning. Once they specify the design space, team members follow steps 5 and 6 to guide them in completing a design blueprint called a design scenario. Step 5 introduces the team to practices that have been empirically demonstrated to enhance learning within inquiry-based learning environments, such as collaborative learning and argumentation. Step 6 (see Figure 8) introduces the team to the types and affordances of learning technology tools. The workshop prepares design teams to select learning technology tools that will support inquiry-based learning given the design specification of their scenario. The COTF DiSC and RoboKids tools are learning technology tools designed to scaffold learners' growth along

COTF inspiration research and development focus on the aspects of flow that lead students toward productive life choices.

Identity is crucial to learning: Learners must identify themselves as the "kind of person" who engages and succeeds. inspiration dimensions toward science, technology, engineering, and mathematics achievement. The design space determines alignment with NASA science. If a learning unit or activity is developed through a design space situated within NASA science, DiSC and RoboKids will support an inquirybased learning activity or unit that is situated within authentic NASA science and uses NASA resources or a database. Of course, the DiSC and RoboKids tools would also support learning units situated within other contexts.

# The Model of Systemic Inspiration Growth as Presented Within the Inspiration Challenge to Middle School Students

The full literature review defining the model of systemic inspiration growth can be found in Inspiration Brief 1 (Reese *et al.*, 2005). The version within this section was prepared and posted to the Inspiration Challenge web site for the Inspiration Challenge teachers to download and share with their students.

#### What Are the Five Dimensions of Inspiration?

Inspiration (see Figure 9) has five parts that work together to enhance inspiration. To increase inspiration, you must increase:

• Part 1. Mental Model.

You must construct mental models of science and how to do science. A mental model is how you connect what you know about a topic. A mental model is private. It exists only in your head. But you can share what you know with other people when you talk about it, write about it, draw pictures about it, or make things based upon it. Mental models that agree with what is known in science are essential to science inspiration.

• Part 2. Identity.

You have to construct an image of yourself as someone who can do science by yourself and with others.

• Part 3. Imagination.

You must move beyond time and space to invent yourself as someone who can do science. You must work as a class to invent yourselves as a community that can do science. Also, you must invent solutions to science problems.

• Part 4. Creativity.

You must invent ideas and things that you never thought of before. You must do this by sharing your mental models of science with your classmates and gaining their approval that your ideas are sound.

• Part 5. Self-efficacy You must come to believe that you CAN accomplish your science goals.



Figure 9. The COTF model of systemic inspiration growth.

Analysis of projects and programs that have succeeded in enhancing student success in STEM academics leading toward STEM literacy and the STEM career pipeline has indicated that growth must be systemic and sustained (Jolly *et al.*, 2004). The model of systemic inspiration growth (see Figure 9) emphasizes the difference between a state of inspiration and a trait of inspiration. Within the model inspiration is the result of growth over time—growth within the system of five dimensions that nourishes growth in skill attainment and challenge readiness leading toward STEM literacy and the STEM pipeline.

### Informal Education and Inspiration: The COTF Contribution

The model of systemic inspiration growth represents an interpretation of how five dimensions work together in feedback loops that reinforce productive life choices. In COTF inquiries for NASA, we have focused upon STEM inspiration. Although the literature indicates that the inspiration dimensions are domain specific—that is, that people are "inspired" or "efficacious" (Bandura, 1997) or "creative" (Csikszentmihalyi, 1997) or hold viable "mental models" about specific fields of study or activity—COTF

suggests the inspiration model is general to human endeavor. Thus, we would expect the system to apply across learning environments, whether formal or informal. In fact, much early flow scholarship derived from consideration of leisure activities (Csikszentmihalyi, 1990), such as rock climbing. COTF reviewed literature from two informal education organizations (4-H and Girl Scouts of the U.S.A.) as well as the general youth development literature.

#### Informal Education and Flow

Carlson's (1998) review of the 4-H approach toward informal education places the 4-H "youth-driven model" in alignment with the COTF model of systemic inspiration growth. The goal is to develop self-directed learners who find the learned activities intrinsically rewarding. One way to do this is to design learning environments that enhance learners' perception that they can accomplish learning goals. Thus, 4-H learning environments should be designed to enhance youth self-efficacy for each topic of study. Carlson stressed that it is the intrinsically rewarding sensation of flow (p. 45), coupled with discovery and choice, that motivates the self-directed learner.

#### Positive Life Choices Through Enhanced Self-efficacy and Identity

The youth development community has begun to specify the dimensions of youth and youth development experiences that will maximize youth propensity to make positive life choices (Killian et al., 2005). Environments that promote positive youth development must provide "opportunities for skill building" (e.g., mental models, p. 21) and support for efficacy (Killian et al., 2005; National Research Council, 2002, p. 90). Research has supported this finding across all groups studied, although little research has been conducted on Native American, recent immigrant populations, or Hispanic youths (National Research Council, 2002, p. 79). Self-efficacy can be nurtured when youths experience challenges. However, for young people to perceive experience as a challenging opportunity, those challenges must be meaningful. It is identity that makes challenges meaningful. Young people must hold or build a personal identity that allows them to identify with a challenge in order to foster self-efficacy (National Research Council, 2002). Youth programs should provide scaffolds that build youth identification with role models who succeed at accomplishing challenges (ACT for Youth, 2003). Interventions designed to enhance youth development dimensions have shown positive

effects on academic success and the transition from school to career (National Research Council, 2002).

Identify formation is "the critical development task" of adolescents (Erikson, 1968, as cited in ACT for Youth, 2002, p. 1). Young people, exploring identity, are often unsure who they really are, a state identified as "identity diffusion" (p. 2). They must often build an understanding of their ethnic and gender identities. Identity allows and enables individuals to make commitments to life choices (ACT for Youth, 2002; Astroth & Haynes, 2002). The fact that "youth identity differs across contexts" (ACT for Youth, 2002, p. 1) suggests an intervention strategy, that technology tools might be designed to enhance youth identity for challenges specific to targeted learning goals.

Young people learn through modeling (Bandura, 1997). In fact, the attainments of others who are similar to oneself are judged to be diagnostic of one's own capabilities. Thus, seeing or visualizing people similar to oneself perform successfully typically raises efficacy beliefs in observers that they themselves possess the capabilities to master comparable activities. They persuade themselves that if others can do it, they too have the capabilities to raise their performance (Bandura, 1982; Schunk, Hanson, & Cox, 1987). By the same token, observing others perceived to be similarly competent fail despite high effort lowers observers' judgments of their own capabilities and undermines their efforts (Brown & Inouye, 1978). The greater the assumed similarity, the more persuasive are the models' successes and failures. If people see the models as very different from themselves, their beliefs of personal efficacy are not much influenced by the models' behavior and the results it produces. (Bandura, 1997, p. 87)

Although self-efficacy can be enhanced through vicarious success, influence is determined by the degree of identification. A technology tool might be developed to enhance youth efficacy for a targeted goal through vicarious success. However, a precursor to development would be a research agenda that investigates, within the context of that goal, the relationship between role models and identity.

#### Informal Education and Role Models

The informal education community is well aware of the power of role models (ACT for Youth, 2003; Hamilton & Hamilton, 2005; Schoenberg, 2001a, 2001b; Spano, 2004). Often, youth programs concentrate on providing role models in the form of mentors who are older teens or adults (Hamilton & Hamilton, 2005; Killian *et al.*, 2005; Philliber Research Associates & American Camp Association, 2005; Schoenberg, 2001a, 2001b). Research has shown that role model effect on people's efficacy appraisals is dependent upon perceived similarity to role model attributes (e.g., age, sex, educational and socioeconomic level, race, and ethnic designation, see Bandura, 1997), especially age and gender. When interventions, in this case technology tools, are designed to increase goal-specific self-efficacy through observational learning, research suggests that youths may identify more strongly with peer-aged role models.

#### Identity, the Gender Difference and Technology

Identity factors into interest and participation gender discrepancies in information technology and computer science. The United States faces a shortage of skilled workers in information technology and computer science (Commission of Technology, 2000). One way to address this shortfall is to enhance adolescent identification and selfefficacy with STEM literacy and pipeline, suggesting that learning environments and curricula must project role models that increase identification and efficacy for adolescents of both sexes. This seems to be particularly important for girls, because research suggests that females (approximately half the labor force) are relatively uninterested in these careers (Commission of Technology, 2000, p. 56), and this tendency begins at a young age.

Although today's adolescent computer usage may be quantitatively equivalent across the sexes, usage is qualitatively different. Primary usage is via the Internet for both sexes, but male usage is for entertainment and recreation (primarily action gaming), and female usage is for communication and education (with communication and social connection affordances). Reports (Commission of Technology, 2000; Schoenberg, 2001a) indicate that girls use the computer as a tool<sup>1</sup> (for social and educational purposes), and boys use the computer as a toy (for entertainment and recreation). Research conducted by the American Association of University Women Educational Foundation Commission on Technology, Gender, and Teacher Education (2000) found that today's computer and video games are designed with characteristics that align them with male mental models of technology (Schoenberg, 2001a, see Table 1). Gaming helps to engender an early male predisposition toward computer-based technologies, providing a male pipeline that

<sup>&</sup>lt;sup>1</sup> Note that tool in this sense refers to the Internet, e-mail, and productivity software, such as presentation, graphics, and word processing software (Commission of Technology, 2000; Schoenberg, 2001a).

does not currently exist for girls (Schoenberg, 2001a). "Girls have reservations about the computer culture" (Commission of Technology, 2000, p. ix) because they "reject the violence, redundancy, and tedium of computer games, and they dislike narrowly and technically focused programming classes" (p. ix). In addition, girls prefer social applications of computerbased technologies (Schoenberg, 2001a) and tend to imagine computer professionals as "solitary, antisocial, and sedentary" (p. xii).

*Table 1.* Comparison Between Male and Female Mental Models of Technology, as Revealed Through Analysis of Their Fantasies by M. Honey (table derived from Honey, 1996, as cited in Schoenberg, 2001a).

Model of Technology		
Male	Female	
Product	Medium	
Weapon	Tool	
Control	Communication	
Power	Creation	
Instrumentality	Expressiveness	
Autonomy	Sharing	
Consumption	Integration	
Exploitation	Exploration	
Transcendence	Empowerment	
Speed	Flexibility	
Effectiveness	Efficiency	

In addition, researchers studying the relationship between girls and technology suggest that adolescent girls are cultured to build an identity that precludes advanced study of technology:

Girls look to adults and their peers for signals in the culture that help them figure out a sense of individual identity as well as group belonging. By and large, the media messages that girls receive suggest that the main goal in adolescence is to be cute, sexy, and popular. Being smart is rarely emphasized as a desirable characteristic. Because most girls don't want to be perceived as masculine, and we associate computers and science and math with masculinity (Brunner *et al.*, 1998), girls will reject becoming too deeply involved with computers unless it is for academic or social purposes. Persevering in computers, math, and science would require girls to devise strategies to resist the dominant culture, which

is signaling to them that the "real" use of computers should be left to boys.

... Although girls seem open to technology through late childhood, as they hit puberty they start to examine their own identity against what society expects of them as developing young women. (Schoenberg, 2001a, p. 25)

Researchers suggest that (a) girls do not identify as being like the type of young people who like advanced computer applications, and (b) the girls are not cultured to imagine themselves as individuals who will pursure advanced technologies in academic coursework or as a career (Commission of Technology, 2000; Schoenberg, 2001a).

Thus, there is a need for a research agenda that investigates how to increase youth identification with information technology and computer science. Researchers have demonstrated that constructive use of leisure time, especially within structured, goal-oriented activities, enhances academic achievement, intrinsic motivation, and occupational outcomes (Jacobs et al., 2004). These activities provide a way for adolescents to explore and develop identity: affirming "valued aspects of their personalities and allowing them to associate with others they believe are 'like them' "(Eccles & Barber, 1999; Haggard & Williams, 1992, as cited in Jacobs et al., 2004, p. 48). It seems efficacious, then, to combine identification, role models, informal education, and selfefficacy within an intervention and research agenda designed to increase preparation for, selection of, and achievement in computer technology careers.

# Self-efficacy/Identity Technology Tools: Research-based Implications for Tool Features

The self-efficacy research community has studied the effect of observational learning on self-efficacy and identity. Many of their findings can be applied as a research-based theoretical framework for specification of the features that should be present in technology tools designed to enhance identity and self-efficacy. A number of characteristics enhance identification and self-efficacy during observational learning (Bandura, 1997):

1. "People seek proficient role models who possess the competencies to which they aspire" (p. 88); that is, role models who possess knowledge, skills, and effective strategies (p. 89).

Implication 1: Role models should possess domainspecific knowledge, skills, and effective strategies. Implication 2: Effective models will express confidence throughout the session.

*Implication 3. Models must use strategies that help them to cope and succeed.* 

Implication 4. Models must encode problemsolving/coping methodology in a way that can be encoded overtly and symbolically-mnemonically.

Implication 5. Models should help learners to memorize and practice the problemsolving/coping methodology.

Implication 6. Models must enact how to complete subtasks.

Implication 7. The mnemonic must be generative rather than prescriptive.

Implication 8. Models must think aloud as they enact solutions.

Implication 9. Models must be similar to the learner.

Implicaton 10. Models' skill level should be equal or slightly higher than the learner's.

Implication 11. Learners assume their similarity to a role model predicts task achievement.

Implication 12/13. Use more than one salient model.

- "Models who express confidence in the face of difficulties instill a higher sense of efficacy and perseverance than do models who begin to doubt themselves when they encounter problems" (p. 88).
- 3. Modeled performances designed to enhance coping behavior emphasize predictability and controllability (p. 88).
- 4. Modeled behaviors must be remembered, and modeling should help the learner create rules, conceptions, and symbolic transformations (p. 90)
- 5. "Subskills required for complex performance must first be developed by modeling and guided enactment" (p. 90).
- 6. Modeling of effective problem-solving strategies increases efficacy (p. 93).
- 7. Modeling can "convey rules for generative and innovative behavior" (p. 93).
- "Models should "verbalize their thought processes and strategies aloud as they engage in problem-solving activities.... In complex activities the verbalized thinking skills that guide actions are generally more informative than the modeled actions themselves."... Verbal modeling of cognitive skills builds self-efficacy and promotes cognitive skill development" (p. 93).
- 9. "Similarity to the model is one factor that increases the personal relevance of modeled performance information to observers' beliefs of their own efficacy" (p. 96).
- "Self-efficacy is most affected by models who are similar or slightly higher in goal-/task-related ability" (p. 96).
- 11. "Self-efficacy appraisals are often based . . . on similarity to models in terms of personal characteristics that are assumed to be predictive of performance capabilities" (p. 98).
- 12. "Exposure to multiple skilled models (multiplicity or diversified modeling) produces stronger belief in one's efficacy to learn, higher perceived efficacy for notable attainments, and higher development of competence than does observing a single skilled model" (p. 99).
- 13. Holding other variables constant, similarity is a stronger influence than multiplicity (p. 99).

*Implication 14. Model coping behavior.* 

Implication 15. Models are in control while working through coping steps.

Implication 16/17. Model competence, especially for novice learners.

*Implication 18. Model success and salient reward.* 

Implication 19. Identification with role models increases as mastery of modeled skills, knowledge, and strategies increase.

- 14. Modeling coping skills (coping modeling) enhances efficacy (p. 100).
- 15. "Masterly modeling that conveys a lot of functional information on how to exercise control over environmental demands is uniformly effective in raising and strengthening efficacy beliefs" (p. 100).
- 16. "Competent models command more attention and exert greater instructional influence than do incompetent ones" (p. 101).
- 17. Model competence is an especially influential factor when observers have a lot to learn and models have much they can teach them by instructive demonstration of skills and strategies" (p. 101).
- 18. Models must find success and be rewarded.
- 19. Progressive mastery of modeled skills and strategies through observational learning increases perceived similarity to initially dissimilar proficient models (p. 101).

COTF translated these research-based implications into technology tool features (see Appendix B).

Self-efficacy is domain specific. Thus, COTF needed to specify a specific domain and develop a tool specific to that set of knowledge, skills, and strategies. After targeting a domain, COTF used these features to specify an affective instructional technology tool to enhance identification with role models that would enable learners to increase their efficacy for that targeted domain.

# The RoboKids Affective Tool for Enhancing Identification with Engaged Role Models: Tool, Study Instruments Design and Development

The literatures of both general (e.g., Gee, 2001; e.g., Sfard & Prusak, 2005) and informal (e.g., ACT for Youth, 2002; Schoenberg, 2001a, 2001b) education propose that identity is crucial to learning. Identification is crucial to the model of systemic inspiration growth, for it supports the projection from what is (what Sfard and Prusak labeled actual identity) to what can be (imagination within the model of systemic inspiration growth, but what Sfard and Prusak labeled designated identity). Albert Bandura's social cognitive theory made the connection between identity and self-efficacy and how they affect human agency. Empirical studies have shown that various success achieved by watching a role model succeed at a task enhances a person's self efficacy for that task if the person identifies with the role model (Bandura, 1995). The affective inspiration tool is designed to engage learners with peer-aged role models who are successful at a task to increase (a) learner identification with the role models and (b) learner self-efficacy for the task. Conceptually, COTF assumes the tool is domain independent. However, for the purposes of this research agenda, COTF had to select one domain as the focus of its identify/self-efficacy research agenda.

Given the need for information technologists and computer scientists, the current informal education interest in robotics among 4-H and Girls Scouts, and the centrality of robotics to NASA enterprise, COTF targeted the domain of introductory robotics. COTF selected the domain of LEGO<sup>®</sup> MINDSTORMS/ROBOLAB robotics because:

- Robotics is central to many NASA endeavors (see Appendix A, Dr. Yvonne Clearwater letter of support).
- There is a need to build male and female identification with advanced computer technology careers and professionals.
- This robotics product sits at the frontier for robotics integration into both informal and formal education (see Appendix A, Tony Cook letter of support).
- This robotics product can be aligned with the science education reform movement.
- Design with this robotics product is a generative (open-ended and creative) activity.
- Introductory activities concern a well-defined knowledge and skill set that transfers to advanced robotics and programming.
- A cognitive strategy can be developed to enhance the success of novices. The strategy will transfer to advanced robotics and programming.
- This robotics content is a field of expertise concentration at COTF/CET.
- Robotics introductory "sensor" programming is challenging for middle school beginners.
- The domain and practice of robotics align with the five dimensions of inspiration.

#### Development of the RoboKids Tool and the Study Instruments

COTF staff robotics expert Dr. Meri Cummings and COTF research conducted a task analysis of LEGO MINDSTORMS programming specific to introductory activities and the use of sensors. Subsequent design and development derived from the task analysis.

#### Self-efficacy scale development.

COTF then used Bandura's (2001) guidelines to develop a self-efficacy instrument specific to those tasks along three dimensions and their parameters (see Table 2). COTF piloted the instrument with two groups of novices and revised the scale after each pilot. The final scale, the Reese-Cummings LEGO MINDSTORMS Introductory Robotics Self-efficacy Scale, contains (see Appendix B) 24 self-report items. Participants rate themselves on a scale from 0-100 because Pajares (2001) and his colleagues found "that a scale with a 0-100 format is psychometrically stronger than a scale with a traditional Likert format," and middle school-aged youths can successfully discriminate self-appraisals using this scale.

#### Table 2.

LEGO MINDSTORMS/ROBOLAB Robotics Dimensions and Parameters

Har	dware
	Building basics–parts (labels and purpose)
	RCX brick-buttons, ports (input, output), battery,
	view (screen, button), program number
	Sensor-name/purpose/how to attach (light, touch,
	angle rotation*, temperature*)
Pro	gramming
	Basics-icon menu: pallets, navigation, commands
	(wait for, structure, modifiers)
	Basics-wiring: autoconnect, click-drag-click,
	shortcut, shoot a wire
	Basics–shortcuts: replace an icon
	Basics–download a program
	Basics-cursor option
	Basics-copying or removing multiple icons
	Basics-removing or fixing wires
Con	nputer interface
	Basics-computer functions (how to use without a
	mouse)
* Be	ecause of time constraints of the study's workshop form
thes	se sensors were not included within the self-efficacy
inst	rument or the instruction.

#### Identification instrument.

This instrument was designed to survey participant identification responses toward each of the 13 RoboKids. To maximize participant time for engagement with robotics, COTF used a single item, repeated for each of the 13 role How much like you is each person pictured below?





A little bit like me.

I don't know.

Not like me.

Not at all like me.

*Figure 10.* The format of the identity item. The same item was repeated using a photograph of each of the 13 RoboKids role models.

models (see Figure 10 and Appendix C). Each response was scored on a five point scale (0=not at all like me, 1=not like me, 2=I don't know, 3= a little bit like me, 4 = just like me).

# Administration of self-efficacy and identification instruments.

The RoboKids study was designed to be conducted within a four-hour time slot in a workshop format at an informal venue (see Appendix D). The self-efficacy/identification instrument was administered three times: as a pretest, halfway through the workshop, and at the conclusion of workshop activities, immediately preceding the debriefing. The final administration instrument concluded with four demographic items on its last page:

- Your current grade in school. (4th grade–10th grade)
- Your gender. (Female–Male)
- Your ethnicity. (Asian, Black, Native American, White, Other)
- Your age. (8 years–16 years)

### Development of cognitive strategy: TBPD-BBB.

Subsequent analysis of the programming task led to specification of the TBPD-BBB (TBPD-Triple "B") problem-solving procedure (see Figure 3). Using the researchbased implications and tool features from Appendix B, TBPD-BBB was developed and integrated within the features of an inspiration affective tool designed to enhance selfefficacy for introductory LEGO MINDSTORMS/ ROBOLAB challenges and identification with role models who successfully solve those challenges. The COTF tool is RoboKids, and the actors within the tool's video segments are also called RoboKids. TBPD-BBB is a cognitive strategy that serves as a coping mechanism. It was written to be practiced and performed during instruction as a chant, in a round, with three parts. During the RoboKids video segments the RoboKids perform the chant. They also use it in video segments as they think aloud to solve programming and design problems for the tool's five robotics challenges. TBPD-BBB is also reinforced when it joins the soundtrack that is played under the dialog and action when RoboKids solve their robotics problems. When a RoboKids workshop is conducted, workshop participants should learn and perform TBPD-BBB immediately after completing the pretest instruments and the workshop introduction.

There is a second cognitive strategy reinforced within RoboKids. That is the truism, "If we thought of it, the programmers probably thought of it first." Although the



*Figure 11.* The RoboKids interface main page. Links to each of the five challenges and the self-efficacy/identity instrument appear in the white section on the right. The text in the blue area of the main screen establishes the NASA context of the tool by placing robotics at the core of many NASA initiatives.



*Figure 12.* RoboKids Emma and Cristin model the intrinsic reward of successfully using TBPD-BBB to solve robotics challenge 2.

segment appeared with the video segments, the workshop conducted for this study did not present the concept to participants and did not test whether or not participants incorporated this concept into their robotics mental models.

#### The RoboKids Tool.

RoboKids (see Figure 11) is a set of five introductory LEGO MINDSTORMS/ROBOLAB challenges, available in a web page format on CD-ROM. Each challenge is accompanied by a set of one or more aligned RoboKids video segments (see Table 3). Each video segment presents a team of RoboKids solving a challenge or presenting a cognitive strategy. The RoboKids segments are the crux of the tool, the role models designed according to the research-based features listed in Appendix B. RoboKids segments were designed and rehearsed to enact features such as:

- Verbal modeling of problem-solving process by thinking aloud.
- Visibly demonstrate success through intrinsic reinforcement (see Figures 12-14).
- Use cognitive strategy (i.e., TBPD-BBB and If We Thought of It. . . )
- Work though subtasks.
- Demonstrate competence.

Other features were added during editing of the video (i.e., addition of the TBPD-BBB chant to the soundtrack when RoboKids were using the TBPD-BBB strategy). The tool also introduces the required skill set for challenges 1-4 aligned video segments from the Carnegie Mellon Robotics Academy ROBOLAB Video Trainer: Introduction to Programming (2005, see www.rec.ri.cmu.edu/education, used with permission).

For the purposes of the study, COTF made a second set of videos of the RoboKids in which they were not engaged in solving robotics challenges or interacting with robots.

#### Table 3.

RoboKids Challenges, RoboKids Video Sequences, and RoboKids Appearing in Each Sequence

**Challenge 1. Line Program** Create and test a program to make the robot go in a square. RoboKids sequences:

• TBPD-BBB (RoboKids–Devon, Maurice, Juliana, Sebastian).



*Figure 13.* RoboKids Zak and John Mark model the intrinsic reward of successfully using TBPD-BBB to solve robotics challenge 3.



*Figure 14.* RoboKids Maurice and Devon demonstrating TBPD-BBB through thinking aloud for Challenge 5.

- "If We Thought of It. . ." (RoboKids–Emma, Cristin, Casey).
- Robot Wiring (RoboKids–Elizabeth, Kathleen).
- Program Number (RoboKids–John Mark, Kyle).

# Challenge 2. Square Program

Create and test a program to make the robot go forward in a straight line for exactly one second. RoboKids sequence:

• Square Loop (RoboKids–Emma, Cristin, Casey).

# Challenge 3. Light/Dark Program

Create and test a program to make the robot:

- 1. Go forward until it finds a dark line.
  - 2. Stop for one second.
  - 3. Go forward until it finds light.
  - 4. Stop for one second.
- 5. Reverse for four seconds.

RoboKids sequence:

• Light Sensor Program (RoboKids–John Mark, Kyle).

### Challenge 4. Tracker Program

Create and test a program to make the robot:

1. Go forward until it finds a dark line.

2. Move forward along the edge of the line.

RoboKids sequence

• Line Tracker (RoboKids–Travis, Zak).

# Challenge 5. Touch Program

Create and test a program to make the robot:

- 1. Go forward until it finds a wall.
- 2. Turn moving backward for two seconds.
- 3. Repeat these behaviors for five "wall bounces."

RoboKids sequences

- Touch Sensor Program (RoboKids–Elizabeth, Kathleen).
- Touch Sensor Bumper (RoboKids–Maurice, Devon).

# **RoboKids Profiles**

Thirteen adolescents volunteered to train and perform within the RoboKids videos. The literature has found that learner identification and efficacy responses through observational learning are dependent upon superficial role model characteristics and role model competency. This section



Figure 15. RoboKid Emma



Figure 16. RoboKid Casey

provides a short profile of the role/s played by each of the RoboKids within the robotics video segments.

#### Emma

Emma (age 12, Caucasian, see Figure 15) is the oldest of three sisters who appeared together as a team in two engaged RoboKids video segments and one nonengaged segment. The three sisters have an intermediate level of robotics design and programming expertise. During the school year Emma attends a weekly robotics club and has studied for and competed in two West Virginia FIRST LEGO League robotics competitions.

#### Engaged.

Within the engaged segments she was knowledgeable, skilled, and proficient at problem-solving. She was positive, solved the challenge with her own robot, and helped her sister, Casey, solve her programming challenge. She used think alouds to solve hers

#### Nonengaged.

The nonengaged segment used a delicate, sweet, and pleasant soundtrack. All three sisters received equal camera time as they chatted with each other. They were positive, quietly energized, and focused on their conversations. They were aware they were being videotaped, and this inspired them to smile often.

#### Casey

Casey (age 10, Caucasian, see Figure 16) is the middle three real-life sisters who appeared together as a team in two engaged RoboKids video segments and one nonengaged segment. During the school year, Casey attends a weekly robotics club, and has studied for and competed in two West Virginia First Lego League robotics competitions.

#### Engaged.

Within the engaged segments she was less knowledgeable, skilled, and proficient at problem-solving than Emma. When attempting to run her robot, she commented "it's not working." directly to the camera. She made a similar comment later in the segment, when her two sisters joined her at the computer to help with her programming issue. Although she could verbalize her robot's problem, she was not able to solve this problem until her older sister came to her assistance.



Figure 17. RoboKid Cristin



Figure 18. RoboKid Devon

#### Nonengaged.

The nonengaged segment used a delicate, sweet, and pleasant soundtrack. All three sisters received equal camera time as they chatted with each other. They were positive, quietly energized, and focused on their conversations. They were aware they were being video taped, and this inspired them to to smile often.

#### Cristin

Cristin (age 8, Caucasian, see Figure 17) is the youngest of three real-life sisters who appeared together as a team in two engaged RoboKids video segments and one nonengaged segment. During the school year, Cristin attends a weekly robotics club, and has studied for two West Virginia First Lego League robotics competitions. She was too young to qualify to compete the first year, but did compete the second year.

#### Engaged.

Within the engaged segments, Cristin was an engaged observer. She did **not** work on the ROBOLAB programming and never touched a computer. Instead, she sat in the middle of her two sisters as they each programmed on their computers. She was positive, undaunted at problems, supportive to Casey, and did assist with running the robots on the demonstration table. She did exhibit a great deal of intrinsic reward at successful problem-solving.

#### Nonengaged.

The nonengaged segment used a delicate, sweet, and pleasant soundtrack. All three sisters received equal camera time as they chatted with each other. They were positive, quietly energized, and focused on their conversations. They were aware they were being video taped, and this inspired them to smile often.

#### Devon

Devon (age 14, see Figure 18) and his brother Maurice are two African-American adolescents who appeared together as a team. Devon wore a spandex do-rag and baggy gym shorts worn low rise about his hips.

#### Engaged.

Devon was the rhythm section for the TBPD-BBB performance segment. He sat sideways, on top of a table and played the background rhythm to the chant that turned it into a mild rap. His manner was dark and remote. In a touch sensor segment that came near the close of the workshop, Devon was the advisor to his younger bother as Maurice worked through the issues of solving his robotics problems. He projected a coping type of support when his brother exhibited some frustration at his bot's misbehavior. Throughout, his manner, actions, and language tended to project an aloof, "cool" orientation.

#### Nonengaged.

Devon and his brother Maurice playfully sparred with each other for a bit and then located locales on a large wall map of the world. Devon maintained a withdrawn, rather droopyeyed aspect throughout the segment.

#### Maurice

Maurice (age 11, see Figure 19) and his brother Devon are two African-American adolescents who appeared together as a team. Maurice removed his spandex do-rag for the taping. He wore baggy gym shorts worn low rise about his hips.

### Engaged.

Maurice choreographed and performed a dance to the rhythm of the TBPD-BBB rhythm that his brother performed. His manner was concentrated upon his dance, and he ended it with a 'cool' gesture followed by a grin. In a touch sensor segment that came near the close of the workshop, Devon was the advisor to his younger bother as Maurice worked through the issues of solving his robotics problems. At times, his manner, actions, and language tended to project a sense of coolness. He was always animated and ready with an engaging smile. He did project some frustration at his robot's misbehavior.

#### Nonengaged.

Devon and his brother Maurice playfully sparred with each other for a bit and then located locals on a large wall map of the world. Maurice was animated throughout the segment, and played with his clothing or scratched himself quite often.

#### Elizabeth

Elizabeth (age 10, Caucasian, see Figure 20) appeared with team member Kathleen in two engaged and one nonengaged segments. She was always soft-spoken and precise in her movements.



Figure 19. RoboKid Maurice



Figure 20. RoboKid Elizabeth

Figure 21. RoboKid Kathleen



Figure 22. RoboKid Kyle

#### Engaged.

Elizabeth and her partner engaged in quiet problem-solving in close proximity of each other's personal space. They made reference to the TBPD-BBB cognitive strategy. In fact, the text to the strategy even projected on the video over their images. She solved the problem of the incorrectly attached wires, although her partner was the one who actually manipulated the robot.

#### Nonengaged.

Elizabeth and her partner are video taped talking to each other and watching other RoboKids working generically at computers.

#### Kathleen

Kathleen (age 10, Caucasian, see Figure 21) appeared with team member Elizabeth in two engaged and one nonengaged segment. She was always soft-spoken and precise in her movements. She has red hair and freckles and wears glasses

#### Engaged.

Kathleen and her partner engaged in quiet problem-solving in close proximity of each other's personal space. They made reference to the TBPD-BBB cognitive strategy. In fact, the text to the strategy even projected on the video over their images. She solved the problem of the incorrectly attached wires, although her partner was the one who actually manipulated the robot.

#### Nonengaged.

Kathleen and her partner are video taped talking to each other and watching other RoboKids working generically at computers.

#### Kyle

Kyle (age 11, Caucasian, see Figure 22) teamed with John Mark in two engaged segments and one nonengaged segment.

#### Engaged

Kyle was excellent at reiterating TBPD-BBB, and overtly using it to address his "badly behaving bot." He was serious at his tasks, engaged, and competent at a beginner's level. He is the active partner with the robot and the computer. He is excellent at his think alouds. He is also excellent at demonstrating intrinsic reinforcement at the robot's success.

Figure 23. John Mark



Figure 24. RoboKid Zak

### Nonengaged

Kyle and his partner stand together and look at the camera during their nonengaged segment. Although they say, "It better back up right this time," the robot is never shown on the screen or referred to. They also execute their success gestures, "Yes!." Their short periods of standing and talking are interwoven with the segment with Hispanic actors.

### John Mark

John Mark (age 12, Caucasian, see Figure 23) teamed with Kyle in two engaged segments and one nonengaged segment.

### Engaged

John Mark provided someone for Kyle to interact with and he reinforced Kyle's hypotheses. He is also excellent at demonstrating intrinsic reinforcement at the robot's success.

### Nonengaged

Kyle and his partner stand together and look at the camera during their nonengaged segment. Although they say, "It better back up right this time," the robot is never shown on the screen or referred to. They also execute their success gestures, "Yes!." Their short periods of standing and talking are interwoven with the Hispanic segment.

# Zak

Zak (age 13, Caucasian, see Figure 24) worked with partner Travis. As you can see in his picture, Zak was the funny guy. He acted this way in both his engaged and nonengaged segments.

# Engaged

Zak cut up, looked on, made funny gestures and over-emoted toward the robot. He did very little to contribute toward solving the programming challenge.

# Nonengaged

Zak spent most of his segment talking to the cameraman and laughing. He was happy, energetic, and entertaining.





Figure 27. RoboKid Juliana

#### Travis

Travis (age 13, Caucasian, see Figure 25) teamed with Zak.

#### Engaged

Travis was the serious, studious, competent teammate. No matter what antics Zak was up to, Travis remained focused, and communicated with Zak about the issues at hand. Travis was very involved in the problem-solving of getting his robot to succeed at the most difficult task of the workshop. In fact, the task Travis accomplished was more complicated than the Challenge assigned to workshop participants: training the robot to follow a curved path (see Figure 26).

# Nonengaged

Although he is not as consistently the focus of attention as his partner Zak, and although his humor is subtle, Travis does provide an enjoyable comic part. However, the camera effect, which uses an open iris on Travis' mouth to close iris transition to another scene with two other RoboKids is surprising and entertaining.



*Figure 26.* Travis and Zak examine their robot's performance as it begins to track a curved line.

#### Juliana

Juliana (age 20, Hispanic, see Figure 27) is the most mature and fashionable groomed of the RoboKids. You can see this by comparing her attire and accessories (earrings) to the other RoboKids. In addition, she is wearing tightly fitting clothes (scoop-necked stretch shirt and jeans). She and her team mate, Sebastian, are the only RoboKids who are not dressed in t-shirts.

Figure 28. RoboKid Sebastian

#### Engaged

Juliana appears as a dancer in the TBPD-BBB cognitive strategy sequence that starts the engaged RoboKids version of the workshop. She never appears again in any of the engaged videos. She never works with a robot, never works with a computer.

#### Nonengaged

Juliana is a major character in the nonengaged videos. She appears in three. One segment is dedicated to Juliana and Sebastian. The others intersperse nonengaged Juliana and Sebastian with other nonengaged RoboKids. The three videos used the same sequence of her talking to her brother Sebastian, reading from a piece of paper, laughing, and walking up a staircase. The dialog is too soft to follow the meaning, but it is obvious that she is an English secondlanguage speaker with a Spanish accent. She is positive, happy, and friendly during the segments.

#### Sebastian

Sebastian (age 18, Hispanic, see Figure 28) is Juliana's younger brother. He has a very thick Spanish accent. He and his team mate, Juliana, are the only RoboKids who are not dressed in t-shirts. He is wearing a polo shirt.

#### Engaged

Sebastian appears only in the TBPD-BBB cognitive strategy sequence that started the engaged RoboKids version of the workshop. He never appears again in any of the engaged videos. He never works with a robot, never works with a computer. During TBPD-BBB, he is the narrator, the chanter of the poem. He was in the United States to study English. His accent is so thick that, at times during the segment, the video producer overlaid the lyrics as text over the screen images. Sebastian sits in a chair throughout the TBPD-BBB and reads to the camera.

#### Nonengaged

Sebastian appears in three nonengaged video segments. One segment is dedicated to Juliana and Sebastian. The other two videos both used the same sequence of him talking to his sister Juliana when she shares something written on a piece of paper, interspersed with the Travis/Zak or Kyle/John Mark nonengaged segments. The two of them walk together up a flight of stairs, and he takes a drink from her bottle of soda. The dialog is too soft to follow the meaning, but it is obvious
that he is an English second-language speaker with a Spanish accent. He is positive, happy, and friendly during the segments. He looks very pleasant – more pleasant in the nonengaged than during the engaged.

## Equivalence Parameters

The nonengaged segments were edited so two sets of videos would take about the same amount of total time (time<sub>engaged</sub> =13 minutes 52 seconds, time<sub>noneg</sub>=13 minutes 55 seconds). All RoboKids appear in both engaged and nonengaged videos.

## Inspiration Lab Informal Event: Testing Inspiration Hypothesis Involving an Affective Inspiration Tool Within an Informal Event

The RoboKids affective inspiration tool was designed to use observational learning to enhance adolescents' self-efficacy and identification with role models for the targeted domain of introductory LEGO MINDSTORMS/ROBOLAB robotics (referred to as "robotics" hereafter).

## Research Hypotheses

The informal event inspiration lab tested the following hypotheses about the RoboKids tool and participant growth because of the RoboKids role models:

- 1. The RoboKids curriculum will increase participants' robotics self-efficacy.
- 2. Observational learning through RoboKids engaged in robotics tasks will engender higher robotics self-efficacy.
- 3. Observational learning through RoboKids engaged in robotics tasks will increase identification with role models.
- 4. Role model identification patterns that emerge through observational learning will be different for girls than for boys.

## Method

The informal event was conducted as a four-hour workshop on Oct. 15, 2005, at the Benedum Planetarium and Good Zoo at Oglebay Park in Wheeling, WV. Two workshop sessions were run. Participants registered for either the morning or afternoon session. Session attendees were randomly assigned to the either the engaged RoboKids role model or nonengaged RoboKids role model condition when they entered the workshop orientation room. Engaged and nonengaged workshops were designed to be identical (see Appendix D for workshop schedules), except for the version of the RoboKids video that participants watched. Participants watched the RoboKids video as a group. The videos were projected on a large screen. Seating in both conditions was identical with participants seated in a "U" at rectangular tables, two students to a table. The projector screen and presentation station were set up at the front of the room (the open end of the "U"). Each student used a dedicated computer, a computer mouse, and the ROBOLAB software to write programs to address the five robotics challenges. Each student had a dedicated infrared tower connected to the computer. Robots were shared, assigned to every two students, but students were not assigned or expected to work in pairs.

Two instructors were assigned to each condition, and a computer technician was on site to address any technical issues (there were no technical issues with student laptops). Although instructors made their presentations from the front of the room, they freely circulated among students and about the room during the workshop and assisted students when help or assistance was required. The director of the Oglebay Planetarium also attended one morning (engaged) and one afternoon (nonengaged) session.

#### Participants

Equipment supported 10 participants in each condition for a cap of 20 per workshop session and 40 for the set of two sessions. Participation of middle school students with little or no robotics experience was recruited during the first and second weeks of October through West Virginia newspapers (3), campus e-mail and web site for faculty and staff at Wheeling Jesuit University (3), brochures at an Oglebay event (2), word of mouth, mainly from Wheeling Jesuit University staff or faculty (5), and a flier e-mailed to all teachers who had participated in the InSTEP<sup>TM</sup> program at Wheeling Jesuit University's Center for Educational Technologies (26). The latter were primarily science teachers. Parents preregistered their children for a session and completed the informed consent forms approved by the Wheeling Jesuit University Institutional Review Board. The workshop was free. Registration caps were reached early during the second recruitment week. Of the 40 registered students, 35 actually attended the workshop (see Table 4). One boy with a severe learning disability began a workshop but was unable to complete his session. The 34 students who completed the workshops were middle school students in grades 5-8, ages 11-14. All but two participants reported white as their

ethnicity. Ten participants were female, and 24 were male. Although all participants followed the same schedule (see Appendix D) each participant worked individually.

## Instruments and Software

The Reese-Cummings LEGO MINDSTORMS Introductory Robotics Self-efficacy Scale and RoboKid Identification items were combined into one instrument (see Appendix C). The instructors administered the instrument three times—after the workshop orientation and introductions, midway through the workshop, and at the end of the workshop.

## Table 4.

Sex				
Grade			_	
	Age	Ethnicity	Engaged	Nonengaged
Female				
6				
	11	White	4	0
7	10			
	12	White	1	1
	13	White	0	2
8	10			
	13	White	1	1
Total Gir	Total Girls		6	4
Male				
5	40		_	_
_	10	White	3	3
6			_	_
	11	White	3	2
	11	Other	0	1
	12	White	0	2
7	40			
	12	Black	1	0
	12	White	1	2
8	40			
	13	White	2	3
	14	White	1	
Total Boys			11	13
Overall Total		17	17	

Participant Demographics	
--------------------------	--

## Procedure

Instructors met the participants in the lobby of the Good Zoo. Once all participants had arrived, instructors led the entire group to the lower-level classroom. Participants picked up their packet of materials when they entered the classroom. Materials were identified such that they alternated condition assignment. The packets and all packet materials were also labeled with participant identification numbers. Thus, the materials packet took care of random assignment and anonymity (participant names were not collected on any study materials). Staff introductions and workshop orientation were conducted for the entire group. Then two leaders took one condition to the upper level classroom. Condition assignment to rooms and instructors was rotated so that condition and treatment were assigned to both rooms and both sets of instructors.

Participants began the workshop by completing the self-efficacy/identification instrument. Then they received a training session in either the TBPD-BBB strategy (chanting it as a three-part round) or the components of the robot and ROBOLAB. Once both groups had completed these opening tasks, they went on to work through each of the five challenges. A script was used by both sets of instructors to introduce challenges. Both sets of instructors used the Robotics Academy ROBOLAB Video Trainer<sup>™</sup> to present instruction. Instructors conducted a debriefing at the conclusion of the workshop and played excerpts from the other condition's video set.

#### Results

All analyses were conducted using both versions 11.X and 13.X of the SPSS statistical package.

## *Self-efficacy for introductory LEGO MINDSTORMS and* ROBOLAB robotics.

Scales like self-efficacy must be reliable. That is, they must be comprised of items that can all be shown statistically to measure the same construct. A statistical test called the Cronbach's alpha is run on participant responses to the scale items to determine scale reliability. Alpha levels can range from 0-1. A score of .7 is normally considered a cut-off point for reliability. The Reese-Cummings LEGO MINDSTORMS Introductory Robotics Self-efficacy Scale created for determining introductory robotics self-efficacy was highly reliable across the three times the instrument was adminsitered during this study. All three administrations of the scale scored a Cronbach's alpha above .95 ( $\alpha_{\text{pretest}} = .98$ ,  $\alpha_{\text{medialtest}} = .95, \alpha_{\text{medialtest}} = .95, \alpha_{\text{posttest}} = .96$ ). A mixed methods repeated measures analysis with condition (engaged versus nonengaged) as the between groups variable and instruction (pretest, posttest) indicated that all participants made significant gains in self-efficacy over the course of the

intruction, F(1, 32)=126.67, p<0.01,  $\eta^2_{\text{partial}}$ =.80. This means that 80 percent of the variance in participant self-efficacy scores from the start of the workshop to the end can be attributed to the robotics instruction they received. Neither the main effect for condition nor the interaction between condition (engaged or nonengaged role models) and time were significant.

Participants could score each item on a scale from 0-100, for a maximum possible total of 2,400. A graph of percentage improvement over time is helpful to understanding the growth in self-efficacy caused by the fourhour COTF workshop (see Figure 29). On average, workshop participants who observed the engaged role models scored a 43 percent gain in self-efficacy. Those who observed the nonengaged role models made an average gain of 55 percent.

These scores mean that the COTF workshop was very effective in increasing participants' introductory robotics self-efficacy. The workshop preparation enabled all participants to perceive they could be pretty successful at solving the challenges and issues they encountered during the workshop.



*Figure 29.* Graph of the average growth in self-efficacy experienced by COTF robotics workshop participants by experimental condition. Participants could score each scale item from 0 (I can't do the task at all) to 100 (I can do the task perfectly). A score of 100 percent would mean that, on average, participants in that condition recorded a score of 100 for all 24 self-efficacy scale items.

#### Identification with RoboKids Role Models

The study included one identification item for each RoboKid role model (see Figure 10 and Appendix C) measured with a

Boys who observed RoboKids engaged in solving robotics challenges significantly increased their identification with the RoboKids.

#### Table 5.

Comparison of Boys' Average Pre/Post Scores for Identification with RoboKids: Over Time and Between Groups Observing Engaged and Non-engaged RoboKids.

	$\overline{X}_{pre}$	$\overline{X}_{post}$
Engaged	20.5	27.3*
Non-engaged	19.4	19.6
* <i>p</i> =0.01		



*Figure 31.* The Interaction Between Instruction (Time on X axis) and Condition Assignment (Engaged or Nonengaged RoboKids) for Boys. The y-axis is summed identification scores.

four-point Likert scale (0=not a bit like me, 1=not like me, 2=I don't know, 3=A little bit like me, 4=just like me). The total possible points are 52 (that is,  $13_{role models} X 4_{score}$ ). Graphing results by percentage of total score possible illustrates that the group that observed RoboKids engaged in solving robotics challenges increased its identification with the role models (see Figure 30). However, the significance of the increase is obscured unless we disaggregate the data through analysis of female and male participants as separate statistical models. Qualitative mathematics (graphing) of participant responses to selected RoboKids also helps to identify how the workshop participants responded to the RoboKids role models. In the case of the girls, it is actually necessary to analyze how female responses to particular RoboKids change over time.



*Figure 30.* Average growth in identification with RoboKids role models by condition as a percentage of total possible. 100 percent represents an average identification score of 4 (just like me) for all 13 role models.

### Boys.

A mixed methods repeated measures analysis for boys only with condition (engaged versus nonengaged) as the between groups variable and time (pretest, posttest) indicated a significant interaction (see Table 5 and Figure 31) between condition and growth in identification with the RoboKids role models, over time, F(1, 22)=7.7, p=0.01,  $\eta^2_{partial}=.26$ . This means that 26 percent of the variance in participants' identification with the RoboKids from the start of the workshop to the end can be attributed to the ordinal interaction between their condition assignment and time. This is a modest (medium) effect size. Boys who observed RoboKids engaged in solving robotics challenges significantly increased their identification with the RoboKids. Boys who observed nonengaged RoboKids evidenced only a small increase in identification. In fact, it is responsible for most of the change in time illustrated in Figures 31.

Figures 32 and 33 illustrate the changes for boys over time and allow a comparison across individual RoboKids between the boys observing the nonengaged role models and the boys observing the engaged role models. (See Figures 34 and 35 to compare girls.) Boys' identification with nonengaged RoboKids made very little growth over time. In contrast, boys' identification with engaged role models went up for 9 of the 13 RoboKids. Boys' identification with RoboKids Travis and Sebastian was high in both the engaged and nonengaged treatments.



Figure 32. Mean identification scores for boys observing nonengaged RoboKids.



Figure 33. Mean identification scores for boys observing engaged RoboKids.



Figure 34. Mean identification scores for girls observing nonengaged RoboKids.



Figure 35. Mean identification scores for girls observing engaged RoboKids.

#### Table 6.

Comparison of Girls' Average Pre/Post Scores for Identification with RoboKids: Over Time and Between Groups Observing Engaged and Nonengaged RoboKids.

Engaged	21	25	
Nonengaged	17	23	
	Grou	ıp	
	obset	rving	
	non-		
	<b>engaged</b> female		
	Robo	oKid	
	Grou	ıp	
	obset	rving	
	0000	0	
	enga	ged	
	enga fema	<b>ged</b> le	
	enga fema Robo	le oKid	

*Figure 36.* Definition of icons used in the graphs in this section for observations of female RoboKids.

## Girls.

The girls' data (see Figure 34 and Figure 35) tells a more complicated story. A mixed methods repeated measures analysis for girls only with condition (engaged versus nonengaged) as the between groups variable and time (pretest, posttest) showed no significant difference for main effects or interactions (see Table 6 for mean scores). The next four sections will compare average participant identification for RoboKids Emma, Casey, Zak, and Juliana between the girls observing RoboKids engaged in solving robotics challenges and girls observing RoboKids nonengaged in solving robotics challenges. Figures 36 and 37 define the illustrations used to represent condition assignments in the graphs that follow. Identification with the role model is measured with a five-point Likert scale (0=not a bit like me, 1=not like me, 2=I don't know, 3=A little bit like me, 4=just like me).

## Emma.

The engaged Emma led a team of three sisters who solved their robotics challenges. Girls who observed the engaged Emma reported increased identification with her  $(\overline{X}_{pre} = 1.8, \overline{X}_{post} = 2.8)$ . Those observing the nonengaged Emma reported decreased identification with her  $(\overline{X}_{pre} = 2.5, \overline{X}_{post} = 2.0)$ . This is a disordinal interaction<sup>2</sup> between robotics instruction and role model engagement in the targeted instructional task/goal (see Figure 38).

<sup>&</sup>lt;sup>2</sup> A 2 X 2 X 2 multimethod repeated measures analysis with gender and condition (observing engaged or nonengaged role models) as the two between subjects variables and instruction (pretest, posttest) as the within subjects variable over both male and female participants shows that the interaction condition and instruction for Emma is significant, F(1,30)=7.39, p=.01.  $\eta^2_{partial}=.20$ , a modest effect size indicating that the interaction accounts for 20 percent of the variance in the model.



*Figure 37.* Definition of icons used in the graphs in this section for observations of male RoboKids.



*Figure 38.* The interaction between instruction and RoboKid engagement for girls observing Emma.

## Casey.

The engaged Casey (see Figure 39) was unable to solve her robotics challenge. The girls observing the engaged Casey reported a decrease in identification with her ( $\overline{X}_{pre}$ =2.3 to  $\overline{X}_{post}$ =1.3). The girls observing the nonengaged RoboKid reported a constant identification with her at 1.5.



*Figure 39.* The interaction between instruction and RoboKid engagement for girls observing Casey.

## Zak.

Zak (see Figure 40) projected a consistently goofy, lighthearted character in both his engaged and nonengaged segments. Although he attended to solving the challenge during his engaged segment, he was more of the comic relief and an onlooker.



*Figure 40.* The interaction between instruction and RoboKid engagement for girls observing Zak.

There is a disordinal interaction between changes in girls' identification with Zak over the course of instruction and whether they are observing him within the context of role models engaged in solving robotics challenges. On average, girls observing the engaged Zak indicated a slight increase in identification (from  $\overline{X}_{pre}$ =1.6 to  $\overline{X}_{post}$ =1.8). On average, the girls watching the nonengaged Zak indicated a large growth in identification over the course of the workshop, from  $\overline{X}_{pre}$ =1.0 and  $\overline{X}_{post}$ =2.5.

## Juliana.

Across both conditions participating girls (see Figure 41) rated the pretest image of Juliana at about  $\overline{X}_{pre}$  =2.5. As the instruction progressed, girls watching Juliana nonengaged in robotics increased their identification with Juliana a bit more ( $\overline{X}_{post}$  =2.8). Girls expecting engaged role models decreased in level of identification with Juliana, dropping to  $\overline{X}_{post}$  =1.5.





Another way to visualize the changes in girls' identification with the RoboKids over the course of the workshop is to look at mean differences in girls' identification ratings for these four RoboKids role models. From Figure 42, it is easy to see that engaged girls' identification with Emma increased, and their identification with Casey and Juliana decreased. Additionally, the nonengaged girls' identification with Zak increased.



Figure 43. The Four RoboKids in their TBPD-BBB performance.



Figure 44. Devon as rhythm for TBPD-BBB.



Figure 45. Maurice and Juliana dancing in TBPD-BBB.



■ Nonengaged RoboKids □ Engaged RoboKids

Figure 42. Mean differences from pre-instruction to postinstruction for girls observing either engaged or nonengaged RoboKids.

## Ethnicity.

Self-efficacy research has found that ethnicity plays a strong role when learning environments are designed to provide vicarious success through role models. Shared ethnicity enhances initial identification. Remember that role model expertise will enhance identification with a role model when an observer gains task-related skills, knowledge, and coping (e.g., problem-solving) skills.

African-American RoboKids Devon and Maurice participated in the TBPD-BBB performance (the robotics cognitive strategy, see Figures 43-45) with Juliana (performance dancer) and Sebastian (performance chanter). Devon had been the drummer for the performance and Maurice danced. Both boys' performances in TBPD-BBB were heavily influenced by their cultural backgrounds and aspirations (e.g., Devon teased his bother about Maurice's aspiration to be a rapper).

Boys and girls observing engaged RoboKids reported a decline in their identification with both Devon and Maurice after observing the TBPD performance (see Table 7 and Figures 46 and 47). Mean medial scores for Maurice by boys and girls observing the engaged RoboKids were the lowest identification scores reported for any of the RoboKids. These medial scores for engaged Maurice and Devon were the only RoboKids medial scores that dropped. By the postinstruction the engaged Maurice average had almost regained its original level, and Devon's had surpassed the preinstruction rating. Participants observing nonengaged RoboKids did not exhibit this medial decline effect. A 3 X 2



*Figure 46.* The interaction between condition assignment and instruction for participant identification with RoboKid Devon.



*Figure 47.* The Interaction between Condition Assignment and Instruction for Participant Identification with RoboKid Maurice mixed methods repeated measures analysis with instruction (pre, mid, post) as the repeated measure and condition (engaged, nonengaged) as the between subjects measure indicated that the mid-instruction differences between students observing engaged and nonengaged RoboKids was statistically significant for Maurice,  $F_{interaction}(2,28)=5.0$ , p=0.01. An  $\eta^2_{partial}=0.26$  indicates a modest effect size, with the interaction between the instruction and condition assignment accounting for 26 percent of the variance in the model. The group observing engaged role models did not report identification declines for either Juliana (dancer) or Sebastian (chanter), who also appeared in the TBPD-BBB sequence.

## Table 7.

Effects of Ethnicity on Changes in Average Identification with African-American RoboKids over the Course of Instruction (Pre-instruction, Mid-instruction, Postinstruction)

	/						
	Devon				Maurice		
	Pre	Mid	Post	Pre	Mid	Post	
Noneng							
aged							
Female	0.8	0.8	1.3	1	1.0	1.3	
Male	1.3	1.6	1.6	1.2	1.6	1.2	
Total	1	1.2	1.4	1.1	1.3	1.2	
Engaged							
Female	0.7	1.0	2.0	1	0.3	1.5	
Male	1.5	1.3	1.9	1.7	0.7	1.6	
Total	1.1	1.1	2.0	1.4	.5	1.6	

## Conclusions/Discussion

The COTF robotics instruction (i.e., the RoboKids workshop curriculum) increased robotics self-efficacy for all participants. Domain-specific self-efficacy is a strong predictor of domain-specific academic achievement (Bandura, 1997). These results also suggest that workshop participants actually gained the knowledge of those introductory robotics skills, concepts, and cognitive strategies within the RoboKids curriculum. There was no significant difference, however, between the self-efficacy of the participants who observed engaged RoboKids and those who observed nonengaged RoboKids. This could be the result of a ceiling effect because RoboKids curriculum causes 49 percent increase in participant selfefficacy.

Boys' identification with observed role models is pragmatic and rigidly focused by contextually specific goals and tasks.

Once boys establish the relevance of a role model set, they tend not to invest additional effort to discriminate relative worth among individual role models within that set. of the workshop's instructional soundness. The 49 percent increase in average self-efficacy is strong evidence of effective instruction.

## Identity and Gender.

Role model identification patterns that emerged through observational learning were different for boys and girls. The gender interaction affected the specifics of how observational learning increased identification with role models.

Boys who observed the engaged RoboKids had a significantly greater increase in identification with their role models than did boys watching the nonengaged role models. Boys' identification with role models appeared to be pragmatic and driven by role model alignment with the boys' task or goal. Observing engaged, skilled RoboKids increased boys' identification with their role models. Observation of nonengaged RoboKids fostered little or no increase in boys' identification with the role model. Additionally, as their robotics skills, knowledge, and cognitive strategies grew, boys seemed to respond to the RoboKids as a set. Over time boys increased their sense of identification with most of the engaged role models. Over time boys observing nonengaged videos recorded decreased identification with most RoboKids as a set of role models.

Study participants were not primed to expect that watching the RoboKids would help them with their robotics challenges. Thus, boys drew their own inferences about any relevance of the videos to the robotics workshop or themselves. It appears that once the boys decided the RoboKids could be useful in goal attainment, the boys accepted the RoboKids as mentors as a group. Thus, boys' identification growth seemed to be pragmatically driven by specific context and goals. In this case identification growth was the context of the robotics workshop and its challenges. When role models were not related to the context, boys did not invest much attention toward potential benefits they could gain from the role model.

However, there is a caveat: It is possible that there were no RoboKids who corresponded with male-valued or media-inspired characteristics. The literature suggests that boys have an attraction to violent video games (Commission of Technology, 2000; Schoenberg, 2001). Table 1, derived from Margaret Honey's work (as cited in Schoenberg, 2001) suggests a male view of technology as product, weapon, control, power, exploitation, transcendence, speed, and effectiveness. With the exception of perhaps the message that might be communicated by Devon's do-rag, the RoboKids Boys will ignore observed role models irrelevant to their goals in the task at hand.

Girls can build identification with role models based on characteristics that transcend immediate context and goals.



Figure 48. Engaged RoboKid Juliana during TBPD-BBB.

Once girls establish an expectation that role models will contribute toward goals situated within the current context, girls will realign their identities with the strongest pragmatically beneficial role models. did not dress, posture, or project stances much beyond the environment or task at hand. Boys might also have responded to role models who projected global goals, but these nonengaged RoboKids did not seem to have projected the necessary characteristics.

Across both groups, the boys did indicate their highest identification score for the white males (highest identification with Travis) and their lowest initial identification score with the most mature and attractive girl (Juliana). The ratings for Juliana and Travis were consistent over the course of the instruction.

Results suggest that girls' identification with role models was not entirely motivated by immediate context or goal. When girls observed the nonengaged role models, there were aspects of the models that enhanced girls' identification. Using the descriptions of RoboKids video segment roles to inform analysis of the graphs suggests that girls increased their identification with the nonengaged role models when the role models were humorous (i.e., the Zak and Travis nonengaged roles). Girls also recorded an increase in identification with the two most mature nonengaged RoboKids (Juliana and Sebastian). In fact, the girls' average rating for nonengaged Juliana was the highest rating given in the nonengaged condition by either girls or boys.

The case of Juliana (see Figure 48) is important. Girls, especially adolescent girls, tend to construct their identification toward a media-driven image of attractive, cute, and "sexy" role models (Schoenberg, 2001a) rather than academically or technologically proficient ones. Girls' average pre and medial identification scores for Juliana were high and identical across both conditions. However, girls who observed engaged role models indicated their identification with Juliana decreased over the course of instruction. That is, when the instruction was completed and Juliana had not solved any robotics challenges, girls changed their mind about Juliana. For the girls watching role models who solved robotics challenges, an attractive and more mature female was no longer the most appropriate role model.

RoboKid Emma led the problem solving in her team, guiding her sister Casey through a solution to her scripting issue. The girls observing engaged role models decreased their identification with Casey and increased their identification with Emma. In fact, identification with engaged Emma was the second highest post-instruction identify score.

These results suggest that girls participating in a technology context could maintain and construct identification with observed role models for characteristics unconnected to the computer context at hand. However,

Gender Comparison 1. Boys tend to ignore role models irrelevant to their current goal while girls can identify with role models aligned to more global goals.

Gender Comparison 2. Boys tend to increase identification with all pragmatically relevant role models; girls increase identification with the most competent relevant role models.

Unfamiliar ethnic practices are greater hindrances to identification than racial characteristics. once girls established the expectation that role models are proficient and knowledgeable at a relevant task or goal, adolescent girls were selective about their identification with role models. They no longer looked to model characteristics marketed by external influences such as media. Instead, they examined the task and the individual competency of each role model and based their identifications accordingly.

Taken together, these results suggest a difference in how male and female adolescents responded to role models:

- Boys seemed to make pragmatic decisions based upon the immediate goal and task and ignored irrelevant models. Their decision was based upon the context. Once boys determined a set of role models was relevant, boys bought into the role models as a set. Girls seemed to be more global in determining role models. They attended to role models who exhibited valuable characteristics external to the immediate context. However, once these girls established a connection between role models and the current context, they disregarded previously valued characteristics that were external to the task at hand and pragmatically irrelevant (i.e., the decrease in the identification with engaged Juliana).
- 2. Girls were more discriminating about their identification with role models. While boys seemed to buy in across a set of role models, girls' identification with role models seemed to hinge more strongly on an individual role model's demonstration of pragmatically related competence.

## Identity and Ethnicity.

All but two of the study participants had reported their ethnicity as Caucasian (one African-American male and one identified as other). The middle school girls and boys observing engaged role models in this study decreased their identification with the male African-American RoboKids during the TBPD-BBB performance. The fact that the performance did not decrease participants' identification for the other two TBPD-BBB RoboKids suggests that the decrease was due to differences in the nature of the performance or of the kids themselves. It appears that Caucasian middle school-aged boys and girls do not identify with the dance style. Obviously, Maurice had dedicated a great deal of practice to the dance style in preparation for a future as a rapper. Later in the instructional sequence,



Results support COTF inspiration

*Figure 49.* Results from the RoboKids study support the systemic relationship among three dimensions within model of systemic inspiration growth.



*Figure 50.* Results from the RoboKids study suggest support for the systemic relationship among four dimensions within model of systemic inspiration growth.

observing Maurice and Devon solve their robotics challenges increased identification for both boys and girls. Racial characteristics are genetic (e.g., skin color). Ethnic characteristics are cultural. These results suggest that for Caucasian middle school youths living in the Northern Panhandle of West Virginia, (a) ethnic practice has a greater effect on identification valances than racial characteristics and (b) accumulation of skills, knowledge, and cognitive strategies can overcome ethnically engendered negative identification valances for observed role models. These results suggest that instructional technology tools developed according to RoboKids observational learning design have the power to expand both cognitive and affective horizons for youth who do not currently have access to culturally diverse role models. For example, the population of West Virginia is primarily Caucasian and not very diverse. Observational learning through instructional tools like RoboKids might help expand acceptance for culturally diverse practices and expertise.

## Support for the model of systemic inspiration growth.

The model of systemic inspiration growth predicts that its dimensions are mutually reinforcing. Thus, though identification with a role model may increase self-efficacy, increases in self-efficacy should increase identification (see Figure 49). Results from this study support the reciprocal relationship between self-efficacy and identify. Recall that in observational learning initial identification is driven by surface-level characteristics, such as gender and ethnicity (Bandura, 1997). Recall also that increase in self-efficacy because of observational learning has been found to increase the observer's identification with the role model as the observer gains skills, knowledge, and cognitive strategies- a larger set of recursive paths (or feedback loops). Domain knowledge was not measured directly; however, (a) every workshop participant who completed the study completed the challenges, (b) self-efficacy is a strong predictor of domain knowledge, and (c) within observational learning, growth in identification with a role model accompanies growth in domain knowledge. Thus, study results provide support for a third dimension, mental models within the system.

It requires some imagination for a learner to project identification with a role model initially viewed as dissimilar. Although RoboKids results logically suggest the place of imagination within this system (see Figure 50), this study did not measure imagination. Future work should derive measures for this dimension.

## Argumentation is the scientific practice of making claims, supporting those claims with evidence (data), and providing reasons (warrants) for how that evidence supports those claims though the use of the data.

## Argumentation Tools: Research-based Tool Features and the Inspiration DiSC Tool Interface

Science advances through both individual and collaborative thought and discourse (Kuhn, 1993). That discourse, scientific argumentation, lies at the core of science as an activity that is socially mediated. According to recommendations for best practice in science education science (i.e., National Research Council, 1996), the skill of scientific discourse is also central to the inquiry-based science education. Engagement in the practice of argumentation with their peers helps learners build strong mental models of targeted content. Authentic participation in authentic science practice helps learners construct accurate mental models of science. Although scientific discourse is a challenging concept and skill for both novices (Kuhn & Goh, 2005) and their teachers (Kuhn, 1993), computer-mediated instruction can scaffold learners' skills (Bell, 2004). COTF concentrated its efforts on the development of a tool to scaffold an introduction to argumentation for middle school learners. The tool would also serve to educate teachers with little or no training in scaffolding children's scientific discourse. A tool that scaffolds learners while also enhancing a teachers' knowledge and skills is termed educative (Davis & Krajcik, 2005). Although more complex models of argumentation exist, COTF specified its definition at the introductory level for middle school students encountering argumentation (concept and skill) for the first time (see Figure 51): Argumentation is the scientific practice of making claims, supporting those claims with evidence (data), and providing reasons (warrants) for how that evidence supports those claims though the use of the data (Driver et al., 2000; Kuhn, 1993; Kuhn & Goh, 2005; Nussbaum, 2004; Nussbaum et al., 2005). The term argumentation is often used in the literature. However, COTF prefers the nonconfrontational terms scientific discourse, or "science talk" (Ryan & Kolodner, 2004), for use with middle school students.



Figure 51. Introductory components of scientific discussion.



*Figure 52.* The rubric practice. Students view 10 successive video clips and rate the quality of argumentation after each clip.



*Figure 53.* Recognition. Students drag and drop argumentation components from the dialog boxes into the argumentation concept map on the bottom of the screen. Point totals are kept at the bottom, left-hand corner of the scientific discussion rectangle. This screen is designed as a concept map of scientific discussion and its components. Such a tool would be designed to enhance learners' mental models of the targeted content, of practice of science, and of scientists (for a more extensive discussion of argumentation and its effects on COTF inspiration model dimension, see Reese *et al.*, 2005).

## Discussion in a Scientific Context (DiSC) Tool Features

DiSC was designed as a web-based tool to provide opportunities for:

- Practice in recognition of argumentation components (Merrill et al., 1992).
- Production (construction) of argument components (Bell, 2004; Driver et al., 2000; Kuhn, 1993; Kuhn & Goh, 2005).
- Reflective analysis (Bell, 1997; Kuhn, 1993; Kuhn & Goh, 2005).

It was organized so that student support is scaffolded, and gradually faded (Bell, 2004; Collins *et al.*, 1989; Kuhn, 1993). It provides an authentic context, opportunities to reason to come to a conclusion, and opportunities for counterarguments. The tool is structured to encourage learners to generate as many reasons as possible and work cooperatively in teams rather than as adversaries (Nussbaum et al., 2005). Finally, the tool is structured to make students' thinking visible and concrete to individuals and groups as they progress through learning, practicing, and engaging in argumentation (Reese & Coffield, 2005).

## DiSC Inspiration Tool Interface

The DiSC tool consists of four interface modules:

- Log-in/Status checker: Identifies the student to the database, keeps track of student progress, includes first-time registration.
- Rubric practice (see Figure 52): Students watch short video examples of scientific discussion and use the DiSC rubric (see Appendix E) to evaluate the effectiveness of (a) the scientific discussion, (b) engagement, and (c) turn taking.
- Recognition (see Figure 53): This drag-and-drop "game" allows students to identify argument components (claim, evidence, reason) and provides self-correcting feedback. It shows the discussion team from the rubric practice videos. It plays video excerpts from the rubric and displays the excerpts in bubble dialog boxes projecting from each member as she or he speaks. It also



*Figure 54.* The DiSC tool argumentation practice module.

Inspiration Challenge hypothesis: Argumentation will enhance learner achievement along dimensions of the COTF model of systemic inspiration growth. displays the three introductory argumentation components as a concept map elaborated with drag-and-drop functionality. The dialog has been programmed to parse into argumentation components. Students drag each component into component boxes. The interface returns the component to the dialog box unless it is correct, in which case the student scores points. Points allocated are reduced for every successive attempt.

• Argumentation practice (see Figure 54): The DiSC tool is designed to be used in conjunction with a set of unit-specific four-item quizzes. Students take the quiz individually and then come to the DiSC tool as a team. The screen projects one screen for each quiz item. Each quiz item screen contains the quiz item and an open-ended answer explanation, called a topic summary. The topic summary is structured as an open-ended drag and drop. The interface turns the quiz item into a claim and asks the learner/team to provide warrants and evidence to support or reject the claim. Learners use the summary– or their own ideas– to provide evidence and reasons. This screen is organized into three steps:

Step 1. Read. Students read the quiz question and topic summary. They read the claim. Step 2. Collect. Students highlight sections of the summary and click an arrow to move them into the workspace. Or they can type their own responses into the workspace. The team labels the selected item as either evidence or reasons.

Step 3. Sort. Students click a button to move the workspace content into the "supports claim" column or the "opposes claim" column. There is no limit to the number of reasons and evidence that can be listed in the sorting boxes. Then the team decides whether it agrees with the claim, disagrees with the claim, or cannot agree on a consensus for the answer.

The interface saves the responses and advances to the next quiz question until the team has completed the four quiz questions.

## Inspiration Challenge: Hypothesis, Instruments, Design and Protocols

COTF was contracted to design a study that used a social tool to test an aspect of the model of systemic inspiration growth. The DiSC tool was designed as a social tool to enhance learners' mental models of targeted content, practice of science, and scientists. The tool was to be implemented within an Inspiration Challenge, and participants were to be drawn from the NASA Explorer Schools and COTF testbeds. The study was to use a NASA-approved product. COTF selected e-Mission: Operation Montserrat because it uses state-of-the-art educational technology (videoconferencing to deliver learning adventures simulated to model authentic science) and documented widespread appeal for the NASA Explorer Schools (Hernandez *et al.*, 2004).

## Hypothesis

The Inspiration DiSC Tool will enhance learner achievement along dimensions of the COTF model of systemic inspiration growth.

## Instruments

COTF selected, modified, and designed instruments to measure student growth along two dimensions of the COTF model of systemic inspiration growth (mental models and self-efficacy) and flow:

- 1. *Mental models* of the targeted science content.
- 2. *Mental models* of argumentation practice of the nature of science, scientific inquiry.
- 3. *Mental models* of Operation Montserrat-related science careers
- 4. *Self-efficacy:* academic, social, and argumentation at argumentation.
- 5. Learners' level of *flow*.

COTF designed five instruments to measure learner growth in mental models, self-efficacy, and flow (see Table 8):

- Pre/Post: Survey 1
- Pre/Post: Survey 2
- Pre/Post: Curriculum-Oriented Exam
- Posttest: Standards-based
- Experience Sampling Method (ESM) Instrument

The survey and the ESM instruments were developed or adapted from four sources:

• The seven-year Sloan Study of Youth and Social Development conducted by the Alfred P. Sloan

Working Family Center

(http://www.sloanworkingfamilies.org/) at the University of Chicago and the National Center for Research (http://www.norc.uchicago.edu/).

- Norm G. Lederman's (Lederman *et al.*, 2002) research and Views of Nature of Science questionnaire.
- Deanna Kuhn's (Kuhn, 1993) research about the nature of science.
- Albert Bandura's academic and social self-efficacy scales and item writing guidelines (Bandura, 2001).

Academic achievement items were developed using Daniel T. Hickey's (2004) multi-level assessment framework. A team from his lab at the University of Georgia developed the first iteration of the quizzes, exam, and test. A COTF team revised and refined the quizzes.

## Study Design

The Inspiration Challenge design was a pretest/posttest randomized experiment. Fifty teachers were randomly selected from a self-selected, volunteer population of NASA Explorer Schools. Prestudy attrition was addressed by replacement before random assignment. Half of the teachers were randomly assigned at the classroom level to use the online DiSC tool and training practice with their students. The other half was assigned to use an interface with the look and feel of the DiSC tool, but with no argumentation scaffolding.

Each teacher's class was assigned a teacher ID number. Each teacher was provided with a set of student ID numbers. Each teacher assigned student numbers and logged them on an ID sheet. Participating teachers who completed all study requirements received a stipend of \$200 per participating class.

## The Inspiration Challenge Competition.

All teachers who completed all study activities were eligible to compete with their class in the Inspiration Challenge competition. The competition was designed to motivate students to do their best while working through the unit and completing the study instruments. Teachers and their students were to prepare evidence along each of the five inspiration dimensions of how inspired they had been during the study. The most inspired treatment and control classes would each receive \$1,000 to be used for the purchase of science or mathematics technologies for their classroom.

Inspiration Challenge Instruments			
Instrument	Source		
and Inspiration Component or Dimension <sup>1</sup>			
Pre-/Post Survey 1			
Parent's education, race, native language	Adapted from Sloan <sup>2</sup>		
Plans for the future: Values, expectations,	Adapted from Sloan <sup>2</sup> : "Your Plans for the		
feelings	Future"		
Self-esteem and locus of control	Adapted from Sloan <sup>2</sup> : "Your Opinions"		
Perceived social presence	Adapted from Sloan <sup>2</sup> : "Your Opinions"		
Friends' values	Adapted from Sloan <sup>2</sup> : "Your Opinions"		
Educational plans	Adapted from Sloan <sup>2</sup> : "Your Plans for the Future"		
Academic motivation	Adapted from Sloan <sup>2</sup> : "About My Future—Self and Future Expectations"		
Mental Model: Nature of science	Adapted from Sloan <sup>2</sup> : "About My Future—Job Knowledge"		
Mental Model: Value of science	Adapted from Sloan <sup>2</sup> "About My Future—Job Knowledge"		
Mental Model: Science knowledge	Adapted from Sloan <sup>2</sup> : "About My Future—Job		
Pre-/Post Survey 2	Kilowicage		
Setterflearer: Academic	Adapted from Bandura <sup>3</sup>		
Self-officary: Social	Adapted from Bandura <sup>3</sup>		
Self-efficacy: Argumentation	Written by COTE (Reese and Kim) based upon		
sug graag. mgamematon	Bandura's self-efficacy guidelines <sup>3</sup>		
Mental Model: Operation Montserrat-related	Adapted from $Sloan^2$ written by COTE (Frank):		
science career knowledge	"About My Future—Job Knowledge"		
Mental Model: Nature of science	Adapted from Lederman and Kuhn <sup>4</sup> written by		
normal mount in active of science	COTE (Palak revised by Reese and Kim)		
Mental Model: Nature of argumentation	Reese and Kim		
Source of job knowledge for primary career	Adapted from Sloan <sup>2</sup> . "About My Future—Iob		
aspiration	Knowledge"		
Aspiration for NASA career	Adapted from Sloan <sup>2</sup> . "About My Future—Iob		
	Knowledge'		
Pre/Post: Curriculum-oriented Exam	Adapted from COTF Challenger Learning		
Mental Model	Center assessment instrument <sup>4</sup>		
Posttest: Standards-based Test	Items selected from publicly available national		
Mental Model	and state assessment items—assembled by the		
	University of Georgia multilevel assessment team <sup>5</sup>		
Experience Sampling Method Instrument	Adapted from Sloan study <sup>2</sup>		
Flow	reapted from broad study		

## *Table 8.* Inspiration Challenge Instruments

*Notes:* <sup>1</sup>inspiration dimensions are set in italics, <sup>2</sup>(Schneider, 1993), <sup>3</sup>(Bandura, 2001), <sup>4</sup>(Kuhn, 1993; Lederman *et al.*, 2002), <sup>5</sup>(Hickey *et al.*, 2004), <sup>6</sup>List of items and sources available upon request.

Entries would be judged by a panel of five COTF in-house judges along the five inspiration dimensions.

#### The Calendar of Events.

The five-week study was designed to begin on Sept. 26, 2005, and conclude during the first two weeks of November (see Appendix F : Inspiration Challenge Study Calendars: Calendar of Events). Individual teachers' ending date would be determined by the date his or her class completed the Operation Montserrat during the first week of November. Students were scheduled to complete all pretests/surveys, ESM training and baseline administrations (five of 30 ESMs), and their DiSC tool practice during week 1. ESMs were scheduled for daily administration throughout the study with ESM 30 completed during the Operation Montserrat e-Mission. In order to administrations of the ESM.

Instruction began on Monday of week 2, and Operation Montserrat lessons 1-3 were scheduled for the week. Teachers were to administer quiz 1 and follow the quiz with DiSC tool session 2.

Week 3 covered Operation Montserrat lessons 4-6. Teachers were to administer quiz 2 and follow the quiz with DiSC Tool session 2. Week 4 covered Operation Montserrat lessons 7-9. Teachers were to administer quiz 3 and follow the quiz with DiSC tool session 3. Week 5 covered Operation Montserrat lessons 10-12 and contained no DiSC tool practice or quiz. The final study week involved the e-Mission and the posttests/surveys.

## Implementation calendar and instructional scope and sequence.

The study was administered through a BlackBoard site. In addition to the overview provided by the calendar of events, the BlackBoard site contained an annotated calendar of all study components (see Appendix F: Monthly Implementation Calendars 1-7). The study also provided a detailed scope and sequence for the Operation Montserrat unit of study. The scope and sequence was linked to detailed daily lesson plans complete with timings, focus, readings, resources/extensions, and student assignments.

#### The Inspiration Challenge facilitators.

Each participating teacher was assigned to a COTF facilitator. Facilitators conducted most communication with teachers. The facilitation process was designed to provide e-mail support and a weekly, scheduled telephone conversation between a facilitator and each teacher. Some teachers



*Figure 55.* Fifty Inspiration Challenge shipping cartons were arrayed for packing by COTF staff. Each box was packed with all hard copy materials necessary to complete the study and return shipping supplies. COTF shipped each box to an Inspiration Challenge participating teacher.

required multiple telephone and e-mail communications every day. Facilitation was individualized according to teacher needs. The challenge began with five facilitators and one facilitation coordinator. This was reduced to four facilitators and a coordinator, with the fifth facilitator's teachers reassigned among the remaining four.

## Shipping coordinator co-leads

Two staff members led the COTF packaging and shipping of study materials during September (see Figure 55). Most of the CET staff assisted with assembly of the shipping materials. Coordinators prepared a check-off list. Materials included 1,225 ESM Scantron forms, 245 generic Scantron forms, 6 labeled return shipping boxes, student identification number labels for students, class list of student identification numbers for teacher, 30 sealed envelopes labeled 1-30 (each contained the timer setting for administering the ESM and directions for how to administer it), and a COTF Inspiration Challenge digital timer to be used when timing for the administration of the ESM.

## The mailing coordinator.

A COTF staff member scheduled and coordinated weekly pickup of completed tests, surveys, ESMs, and informed consent forms from participating teachers. The mailing coordinator logged and filed all incoming materials by teacher.

# The Operation Montserrat coordinator and technical support specialist.

The Challenger Learning Center co-lead flight director scheduled all Inspiration Challenge e-Missions and responded to teachers' questions about implementation of the Operation Montserrat instructional unit. Facilitators also addressed curricular questions. The Challenger support technical specialist consulted with school site staff and tested and facilitated all e-Mission videoconferencing.

## **Inspiration Challenge: Implementation**

On July 9, 2005, at the NASA Explorer Schools Sustainability Conference, teachers were solicited as volunteers for the challenge. Seventy teachers volunteered and submitted applications to participate in the study. A list of all volunteers was created, and each teacher was assigned an original identification number. A total of 50 possible participants and 5 first alternates were randomly selected from the 70 total volunteers through a drawing conducted by two COTF staff.

#### Teacher Commitment and Shipment of Materials

The first 50 selected were given a selection identification number from 1 to 50 by order of selection and a status of "active." The five alternates were given a selection identification letter "a–e" by order of selection and a status code of "alternate." The remaining 15 were given only a status code of "wait listed."

On Aug. 4, 2005, COTF sent letters of selection indicating active or alternate status to all teachers/volunteers. The letters requested an immediate confirmation of participation.

If active teachers responded with requests to be dropped from the study, status was updated to status code "dropped" and replaced with the first alternate status teachers. The alternate code was then updated to a status code of active/alternate and the alternate teacher was sent email notification of the change in status. As alternate or waitlisted teachers responded with requests to be dropped from the study, their status was also updated to "dropped."

On Aug. 30 teachers considered to have confirmed participation in the study were given a teacher identification number. At this time 47 of the original 50 teachers remained as active status and 4 selected alternate teachers were updated to a status of active/alternate. Two of the active teachers were leaving their school's NASA Explorer Schools team and requested to be replaced by the teacher who would be taking their place at their school. Challenge leadership approved these replacements.

On Sept. 2, 2005, the five facilitators began their work with study implementation. Their first task was to contact the 51 active teachers to obtain complete teacher contact information. COTF then mailed each teacher hard copies of the study's informed consent form, which had been previously approved by the Wheeling Jesuit University Institutional Review Board. This form had to be signed by both the teacher and his or her principal. The mailing also contained study requirements, the study's calendar of events (see Appendix F), and a questionnaire for technology requirements. The facilitators found many of the selected volunteers unresponsive to numerous attempts to contact and gather information. At this time several teachers requested to be dropped from the study. Unfortunately, three active teachers were employed at schools in the Hurricane Katrina disaster zone. COTF had to remove these teachers from the study because of school closings. However, COTF reserved a free e-Mission for each teacher to be conducted at the



Figure 56. Teachers used the smaller, return-labeled boxes from the COTF September shipment to return completed Scantron tests, surveys, and ESM sheets. Staff broke down the returned Inspiration Challenge shipping boxes and stored them for use in future inspiration studies.

teachers' pleasure once conditions were again favorable at school.

COTF sent a follow-up e-mail to each active teacher containing attachments duplicating the hard copy materials that had been sent via ground mail. The e-mail notified all active teachers that their informed consent forms had to be received by COTF by Sept. 16, 2005. Any teacher whose informed consent form was not received by Sept. 16 would be dropped from the study.

In addition, the e-mail and attachment materials were sent to all teachers on the alternate or wait list. The accompanying e-mail message stated that if any alternate teacher was still interested in study participation, the signed informed consent form would need to reach us by Sept. 16, 2005. COTF received four responses and consent forms from that e-mail.

COTF's goal was to conduct a study with 30-50 classrooms, and COTF wanted to begin the study as close to 50 as possible to cover any later attrition. As COTF approached its Sept. 16 deadline for mailing study materials, several active status teachers had still not returned consent forms. Leadership mailed out a first mailing of study materials (see Figures 55 and 56) to confirmed participants on Sept. 16.

Several teachers had requested permission to take multiple classes through the study. To replace teachers who had not sent their consent forms by the deadline, leadership allowed teachers who had made a timely return of their consent forms to enroll multiple classes in the study. After replacing eight unresponsive teachers with four active teachers willing to take multiple classes and replacing another four teachers with the wait listed/alternates who sent in a school consent form, COTF arrived at a final list of 50 teachers who would receive the challenge materials.

COTF sent out a second shipment on Sept. 19.Fifty boxes of materials were shipped. Leadership randomly assigned each of these 50 teachers to treatment or control conditions.

## Participation as of December 19

Of those 50 teachers who received materials, 6 have been withdrawn from the study. Of the 44 remaining classes, 41 have flown their missions. By Dec. 19, 22 classes had completed all of the study requirements, and several others were close to completion. It is a hopeful estimate that about 29 teachers completed the study with enough integrity for their data to be pure and usable for an overall data analysis. Many teachers submitted incomplete data sets. Four teachers



*Figure 57.* Plaques Awarded for "Best Research Partner" to the Seven Challenge Teachers Who Earned the Highest Scores on the Implementation Rubric. The white text section was inlaid on a walnut plaque.



*Figure 58.* The Plaque Awarded to the Inspiration Challenge Competition Winners. The white text section was inlaid on a walnut plaque.

did not return parent/student consent forms, which made their data unusable. Five teachers did not use the DiSC tool at all and approximately nine did not administer the DiSC Tool properly.

## The Implementation Rubric

Even with weekly, daily, or multiple daily interaction with Inspiration Challenge facilitators, many participating teachers' implementation of the challenge was idiosyncratic. The Inspiration Challenge implementation teams designed a rubric for use in statistical analysis to control for the quality of teachers' implementation of the challenge. Teachers were ranked on a score from 0-5 on several study dimensions. Staff decided to award plaques to teachers who had carefully followed research protocols. COTF is awarding plaques to the seven teachers who achieved the highest rubric scorings. The award is to recognize "Best Implementation by Educator Research Partners" (see Figure 57). Award winners are:

- Rhonda Harris, Florence Middle School.
- Danielle Hartkern, Central Park Middle School.
- Dene' Carter, W.C. Stripling Middle School.
- Sharon Sadler, Sycamore Hills Elementary.
- Crystal Canady, Mid Carolina Middle School.
- Joan Piper, Edwards Middle School.
- Steve Roth, Gifford C. Cole Middle School.

## Inspiration Challenge Competition

A team of five judges awarded the Inspiration Challenge award for "Most Inspired Class" (see Figure 58) to the classes of Sandra Watts and Danielle Hartkern. Each winning class will receive a \$1,000 award for purchase of technology equipment once COTF receives memorandums of understanding drawn up by Wheeling Jesuit University and signed by each winning teacher's administrator.

## Processing Data for Statistical Analysis

Estimating 44 participating teachers, 30 ESM forms, 7 test/survey forms, and 25 students per teacher, the COTF data processing staff processed, scanned, and archived 40,700 (see Figures 59-62) documents. Although the study was scheduled to end the second week of November, teachers were slow to return data once their students had participated in Operation Montserrat. At this writing, data continues to trickle in, but the COTF must move into the data analysis



*Figure 59* . Scanning the NASA ESM Instrument.



*Figure 60.* Scanning the NASA ESM.



*Figure 61.* A Section of Inspiration Challenge Data, Scanned and Ready for Archive.



*Figure 62*. Inspiration Challenge Data Archive.

phase of the study. The Inspiration Challenge data analysis team has just begun to assemble and clean the scanned data files in preparation for statistical analysis and a preliminary report of results. COTF will continue analysis under its 2006 contract to mine the richness of the data files

## COTF Reflections: One Year of Inspiration Design and Research

COTF has had the privilege of designing a theoretically and empirically grounded concept of inspiration composed of a system of dimensions and processes that support positive and productive life choices. It has created the first set of NASA inspiration tools. COTF has completed two studies to test these tools in authentic learning environments. Results of the first analysis not only provide empirical support for the model of systemic inspiration growth, they illuminate direction for the research agenda to follow. As other scholars and researchers join this and the other inspiration research agendas that will follow, and as results and tools disseminate within formal and informal learning environments, it is this positive vision of healthy, mindful, autotelic American youth:

- Who identify themselves as students who can learn science.
- Who have the efficacy to perceive that they CAN learn science, that they can prepare themselves for highly technical careers.
- Who imagine themselves as advanced learners and citizens making contributions in highly technical fields.
- Who build personal and shared repertoires of highly technical skills, concepts, and problem-solving strategies.
- Who create the rich new possibilities of tomorrow.

As the letters of collaboration and commendation that accompany this report attest, leaders in formal and informal education arenas are ready to support this quality work as it moves forward.

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## Appendix A: Letters of Support

Letters of support and collaboration

- Dr. David M. Merrill
- Dr. Tony Cook
- Dr. Yvonne Clearwater



C I T O Center for Instructional Technology and Outreach

> Dr. Charles A. Wood, Executive Director Center for Educational Technologies Wheeling Jesuit University 316 Washington Avenue Wheeling, West Virginia 26003

Dear Dr. Wood

Last week I had the opportunity to review the DiSC tool that was developed by **Debbie Denise Reese** and her colleagues. I wrote her a note in which I said "I found your instruction very well done and fun to use." She asked me to write to you directly and repeat my commendation of their work hence the purpose for this letter.

Let me elaborate my comment a bit. I have written about effective ways to teach concepts (Merrill, M.D., Tennyson, R. D. & Posey, Larry O. Teaching Concepts: An Instructional Design Guide 2<sup>nd</sup> Ed, Englewood Cliffs, NJ: Educational Technology Publications, 1992) and find that not much instruction follows the prescriptions which our research has shown are most effective for efficient and effective learning. I'm happy to say that the DiSC tool is a very good example of effective concept instruction for a difficult to teach concept. This team is to be commended for an outstanding piece of work.

Cordially

M. David Metrill Emeritus Professor Utah State University Professor in Residence Brigham Young University - Hawaii



State 4-H Headquarters 214 Duncan Hall Auburn University, AL 36849-5620 Telephone: 334.844.2233 FAX: 334.844.2252 E-mail: cookja1@auburn.edu

January 19, 2006

#### Charles A. Wood, Ph.D.

NASA-sponsored Classroom of the Future Center for Educational Technologies Wheeling Jesuit University 316 Washington Avenue Wheeling, WV 26003

#### **RE:** Inspiration Research

#### Dear Dr. Wood:

Our conversations on the above topic have been very interesting and very relevant to my own efforts in 4-H science and technology programming. My work with the aviation and space education community especially engages youth and leaders in experiences intended to inspire and motivate youth in science, technology, engineering and math (STEM). The work of the CET in regard to inspiration, self-efficacy, use of role models and mentors, and identity would help define what we believe happens and further evaluate the impact. I look forward to further interaction in this area and how it can benefit my specific work with NASA, Space Camp, Challenger Learning Centers, and others.

4-H programming in science, engineering, and technology (4-H SET) is growing and has taken on a higher level of importance as a mandate of USDA for youth programs. Our strategies will go beyond traditional programming and must include measures for accountability and proven impact. That 4-H programming is experiential in nature the intrinsic aspects of learning are important. The effect of programs on participant knowledge gain is important but even more important is their capacity and belief in their abilities to excel beyond what they had previously hoped for (self-efficacy).

I eagerly anticipate results and products of your research and instrument development and to how it might be used in 4-H. I will share your work with others in the 4-H community especially in the science, engineering, and technology areas. The work in aerospace, robotics, and other areas in 4-H could benefit a great deal from your inspiration research.

Sincerely,

John a. Cool

John A. (Tony) Cook, Ed.D. Extension 4-H Specialist

ALABAMA A&M AND AUBURN UNIVERSITIES, AND TUSKEGEE UNIVERSITY, COUNTY GOVERNING BODIES AND USDA COOPERATING


January 6, 2006

Dr. Charles A, Wood Executive Director, Center for Educational Technologies Wheeling Jesuit University 316 Washington Avenue ,Wheeling, WV 26003

Re: Prospects for Formal Collaboration with the COTF

#### Dear Dr. Wood,

After my good fortune earlier this year in finding kindred-collaborator potential in you and Dr. Meri Cummings, and discovering the excellence of the NASA-sponsored Classroom of the Future (COTF), I was pleased to have been recently introduced to Debbie Denise Reese, Ph.D., an Educational Researcher with the COTF.

I am greatly impressed by the highlights of methods, tools and results Debbie has shared with me from COTF's RoboKids research, a component of the Inspiration project she leads within COTF for NASA education's Technology and Products Office. It is a distinct honor to meet and converse with someone as bright, well informed – and on target – as Dr. Reese.

After several years of working in the field of NASA-sponsored robotics education -- as a means to stimulating students' interest and active, hands-on involvement in math, science and technology -I find that the direction of the RoboKids research aligns closely with many of what I consider to be the most critically needed areas of scientific inquiry, including:

- Why do young girls consistently and dramatically lose interest in math and science? And what can be done to ameliorate this decline?
- Why do girls fail to chose and engage in technological challenges? What are the current messages that they are integrating into their decision making?
- How do both girls and boys perceive, discriminate, identify with and begin to adopt winning strategies in novel and challenging learning situations?
- What are the most effective sources of inspiration and methods to inspire youth in STEM related endeavors?
- What are the most successful characteristics and strategies for mentoring and role models specifically in a virtual teaming, e-learning mode?

While we are still some distance from specifics, I am excited with the prospect of working in collaboration with Dr. Reese. We have opened a mutually enthusiastic discussion of options for both replication and extension of her original methodology. Of course, whatever we propose will need to be sanctioned by NASA management at my end.

Dr. Reese and I each bring valuable and complimentary skills, experience and perspectives to the table. While I have been engaged in the design, development and production end of e-education for the past several years, my roots are firmly in research and communications. My own doctoral training (University of California) focused heavily on research methodology and communications, and I have conducted and managed research projects for many years. In my role as the developer and director of the NASA Robotics Curriculum Clearinghouse (http://robotics.nasa.gov/rcc) I have built a nationwide network of educators who are involved – or desire to become involved – in robotics learning activities. A wide network of robo-educators could prove valuable to the COTF for both extended collaboration – as well as a possible resource of student research subjects.

Debbie and I will be continuing our conversation and hope that you will join us at some level of ideation toward creating a powerful and effective collaborative team.

Sincerely,

prome Charweter

Yvonne Clearwater, Ph.D. Project Manager and Producer NASA – Ames Research Center Moffett Field CA, 94035

<u>Yvonne.Clearwater@NASA.gov</u> Phone: 650-604-5937

Appendix B: Research-based Implications for Technology Tools Designed to Enhance Self-efficacy through Observational Learning, Generic Tool Features, and RoboKids <sup>3</sup> Features								
Category	Research Implications (after Bandura, 1997)	Tool Features	<b>RoboKids Features</b> <sup>4</sup>					
Characteristics of Model								
Knowledge, skills, cognitive strategies	-Role model should possess robotics knowledge, skills, and effective strategies. (implication 1) -Model skill level should be equal <b>or</b> <b>slightly</b> higher than learner. (implication 10)	-Train models so that they are just competent with the task challenges, but still have to work at solving them. -Train model in relevant problem- solving strategy	-Middle school-aged youths with beginner and intermediate-level skills train to use TBPD-BBB (see Table 1) to solve beginner-level robotics challenges.					
Salience and similarity	-Model must be similar to learner, especially age and gender. (implication 9) -Learners assume model similarity characteristics are predictive of task achievement. (implication 11)	-Recruit peer-aged role models. -Use male and female role models. -Match role model ethnicity/race to learners.	-13 youths recruited and trained as RoboKids: male (7) and female (5) -initially targeting primarily Caucasian learner population, also Hispanic and African-American with RoboKids: 9 Caucasians, 2 African-Americans, 2 Hispanics.					
Multiplicity/Diversified modeling	-Use more than one salient model. (implication 12/13)	-Use multiple role models solving similar tasks.	-Each skit uses two or more models in each of nine video segments. Multiple skits cover the same topic and application of TBPD-BBB.					

<sup>&</sup>lt;sup>3</sup> An affective tool for enhancing self-efficacy and identity for solving LEGO<sup>®</sup> MindStorms<sup>TM</sup>/ROBOLAB<sup>TM</sup> introductory robotics challenges. <sup>4</sup> Some features support more than one category.

Category	Research Implications (after Bandura, 1997)	Tool Features	<b>RoboKids Features</b> <sup>4</sup>	
Coping strategy Strategy	-Model must use strategies that help to cope and succeed. (implication 3)	-Identify and design problem-solving strategy. -Create mnemonic for delivery and practice of strategy.	-Identified and specified a programming problem-solving procedure. -Authored a multipart chant for the procedure: TBPD-BBB.	
Memorization/Practice	-Model must encode problem- solving/coping methodology in a way that can be encoded overtly and symbolically mnemonically. (implication 4) -Model should help learners to memorize and practice the problem- solving/coping methodology. (implication 5)	<ul> <li>Models perform mnemonic in memorable way that learners can repeat.</li> <li>Models think aloud using the components of strategy when they solve tasks.</li> <li>Soundtrack replays mnemonic as background when mentors are problem solving.</li> </ul>	<ul> <li>-Learners practice TBPD-BBB.</li> <li>-Actors dance and perform TBPD-BBB.</li> <li>-Actors use TBPD-BBB when they think aloud.</li> <li>-Soundtrack plays excerpts from TBPD-BBB when actors solve problems.</li> </ul>	
Generative	-The mnemonic must be generative rather than prescriptive. (implication 6)	-Strategy is generative. -Model solutions for multiple challenges.	-Encounter BBB problem and work through TBPD-BBB solution. -RoboKids become more calm as work through solving bugs and challenges	
Demonstrated control	<ul> <li>-Model coping behavior. (implication 14)</li> <li>-Model is in control while working through coping steps. (implication 15)</li> <li>1. Models display decreasing stress working through strategy</li> <li>2. Demonstrate strategies for mastering difficult situations</li> <li>3. Voice self-efficacy beliefs (Bandura, 1997, p. 100)</li> </ul>	<ul> <li>-Models are calm while solving task challenges.</li> <li>Gain confidence as work through solution steps.</li> <li>Show how apply strategy.</li> <li>Make self-affirmation statements.</li> </ul>	challenges. - During video segment lesser-skilled RoboKids rely on team members with greater competence for assistance. -State will use TDPB-BBB to solve problem.	

Category	Research Implications (after Bandura, 1997)	Tool Features	<b>RoboKids Features</b> <sup>4</sup>
Script			
Think aloud	-Model must think aloud while enacting solutions. (implication 7)	-Models think aloud as they demonstrate challenge solutions.	-RoboKids verbalize what they are thinking as they problem-solve and debug.
Subtasks	-Model must enact how to complete subtasks. (implication 6)	-Actively model steps of solution rather than just the culminating step.	-RoboKids encounter problem and think aloud as they work through steps to solve it.
Competence	-Effective model will express confidence throughout the session. (implication 2) -Model competence, especially for novice learners. (implications 16/17)	-Models are competent. -Models are confident.	-RoboKids model their confidence in working through problem-solving. If one RoboKid is demonstrating a lack of competence or confidence, a team member demonstrates confidence and competence.
Success and reward	- Model success and salient reward.	-Model achieves success and demonstrates receipt of reinforcing reward.	-RoboKids model intrinsic reward through idiosyncratic success gesture and exclamation.

## Appendix C. The Reese-Cummings LEGO<sup>®</sup> MINDSTORMS<sup>™</sup> Introductory Robotics Self-efficacy Scale and RoboKid Identification Instrument.

Note: There were three administrations of the RoboKids instrument. The first added an item to identify students' level of expertise. The third added a section to collect demographics. The version of the instrument included here is the third, containing the final demographics section.

LEGO<sup>®</sup> MINDSTORMS<sup>™</sup> Introductory Robotics Self-Efficacy Scale Debbie Denise Reese, Ph.D., and Meri Cummings, Ph.D.



Directions: Please give yourself a score from 0 to 100 for each task below.

Directions.	icase g	ive your				<b>101 C</b>	ich tasi	a below.		
0 Not at all	10	20	30	40	50 Maybe	60	70	80	90	100 Perfectly
Example: I ca	ın do a	cartwhe	el. <u>92</u>							
1. I can con	nect me	otors to	correct p	orts o	on the yell	ow RC2	K brick	•		
2. I can revi	se my p	orogram	if it is di	rectin	g my robo	ot to do	the wr	ong beh	avior	
3. I can mak	te my ro	obot go	in a strai	ght lir	ne					
4. I can fix r	ny robo	ot if it is	not built	t the v	way the pr	ogram i	s writte	en		
5. I can mak	ke my ro	obot sto	p at a da	rk line	e and reve	rse whe	n it see	s light		
6. I can tell	if my p	rogram	is directi	ng my	robot to	do the c	orrect	behavio	r	-
7. I can dese	cribe th	e task I	want my	robo	t to do					
8. I can deb	ug my 1	obot pr	ogram's	broke	n wires					
9. I can tell	if my ro	obot is b	ehaving	correc	ctly to acc	omplish	its tas	k	_	
10. I can fix t task.	he prol –	olem wh	nen my pi	rograi	n and rob	ot are d	esigned	d correct	ly but	are not doing the
11. I can dese	cribe th	e behav	iors I wa	nt my	robot to	do	_			
12. I can tell	if my ro	obot is b	ehaving	the w	ay the pro	gram di	rects it	to	_	
13. I can fix t goes strai	he prol ght	olem wh 	nen my pi	rograr	n directs t	he robo	t to re	verse on	hitting	g an object, but tl
14. I can see	the rob	ot's ligh	t reading	s						
15. I can figu	re out l	now to f	and a sho	ortcut	command	l when i	ny pro	gram ge	ts too l	long
16. I can tell	if my ro	obot is n	ot built t	he wa	ay the prog	gram is	written			
17. I can use	"HEL	<b>P"</b> to fig	gure out	how t	o progran	n the set	nsor co	onnectio	ns	
18. I can prog	gram m	ore that	n one wa	y to g	et my robe	ot to go	a certa	in dista	nce	
19. I can figu	re out v	which se	ensor to u	ise to	track a pa	.th	_			
20. I can adju	ıst my p	orogram	when I l	nave t	o switch s	ensor c	onnect	ions		
21. I can adju	ıst my l	ight sen	sor prog	am to	o work une	der a dif	ferent	lighting	condit	ion
22. I can run	10 prog	grams w	rith one r	obot	even thou	gh it ho	lds onl	y five pr	ogram	S
23. I can dese	cribe ho	ow all th	e sensors	s are p	orogramm	ed by w	atching	g the rob	ot's be	ehaviors.
24. I can get	my rob	ot to tra	ck a curv	red lin	ne					

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## How much like you is each person pictured below?

	R		
This person is:	This person is:	This person is:	This person is:
Just like me.	Just like me.	Just like me.	Just like me.
A little bit like me.			
I don't know.	I don't know.	I don't know.	I don't know.
Not like me.	Not like me.	Not like me.	Not like me.
Not a bit like me.			
			AT ALLENDATEST
This person is:	This person is:	This person is:	This person is:
Just like me.	U Just like me.	U Just like me.	Just like me.
A little bit like me.			
I don't know.	L l don't know.	U don't know.	I don't know.
Not like me.	Not like me.	Not like me.	Not like me.
Not a bit like me.			

## How much like you is each person pictured below?

HID STATE			
This person is:	This person is:	This person is:	This person is:
Just like me.	Just like me.	Just like me.	Just like me.
A little bit like me.			
l don't know.	I don't know.	I don't know.	I don't know.
Not like me.	Not like me.	Not like me.	Not like me.
Not a bit like me.			



(OVER)

Your current grade in school:

- 4th grade
- $\circ$  5th grade
- $\circ$  6th grade
- $\circ$  7th grade
- $\circ$  8th grade
- 9th grade
- 10th grade
- Other (write in below)

Your gender:

- Female
- Male

Your ethnicity (select one):

- o Asian
- 0 Black
- Hispanic
- Native American
- White
- Other (write in below)

Your age:

- 8 years
- $\circ$  9 years
- $\circ$  10 years
- 11 years
- 12 years
- 13 years
- 14 years
- 15 years
- 16 years

### Appendix D: Robotics Informal Event Schedule of Events for Treatment (RoboKids Engaged in Solving Robotics Challenges) and Control (RoboKids Not Engaged in Solving Robotics Challenges)

The workshop was run in the morning (9 a.m.-1 p.m.) and afternoon (1:30 p.m.-5:30 p.m.). Only the morning schedules are listed. The afternoon sessions paralleled the morning session's format.

#### October 15 - Robotics Informal Event Workshop - Morning Agenda (9 a.m. – 1 p.m.) Group: Engaged (treatment)

9:00 Welcome and Orientation – (plus group assignments, nametags and envelopes) – Videos, Surveys, and Robotics programming

9:05 SE Survey 1 & Role Model ID Survey 1

#### [Early finishers explore ROBOLAB program]

9:12 Intro to TBPD – Debbie: Chant plus process - go over form use & DVD videos 1-3: TBPD (1'51''); If we thought of it, the programmers probably thought of it first (22''); Robot Wiring (33''), Program Number (47'') [Total video 3'33'']

9:22 Intro to ROBOLAB – Video Trainer sequences: Tankbot briefing (4') and Forward (3')

9:30 Use ROBOLAB to program a straight line – *Challenge 1* – Students program a robot going straight for one second, load program, and test it.

- 9:40 Challenge 2 Program a square Video trainer sequence Point Turn (2'18")
- 9:43 Solve Challenge 2
- 9:53 DVD video 4 Dolan loop (3'40")
- 9:57 Continue Challenge 2
- 10:07 Challenge 3 Light/Dark Challenge
- 10:10 Light Sensor video using Video Trainer (4'20")
- 10:15 Solve Challenge 3
- 10:28 DVD Light Sensor video (1'34")
- 10:30 Bathroom/stretch break
- 10:35 Modifiers Video Trainer sequence (5'45")
- 10:45 Continue Challenge 3
- 10:51 SE Survey 2 & Role Model ID Survey 2

- 11:01 Introduce Challenge 4 Line tracker
- 11:03 DVD Line Tracker video (2'15")
- 11:07 Solve Challenge 4

#### [For kids who finish early, add a bonus line counter challenge with beeps]

- 12:00 Touch Sensor video using Video Trainer (3'30")
- 12:04 Introduce Challenge 5 Touch Sensor Challenge
- 12:07 Solve Touch sensor challenge
- 12:30 DVD Touch Sensor videos (2'17" and 1'48")
- 12:35 Continue Challenge 5
- 12:55 SE Survey 3 & Role Model ID Survey 3
- 1:00 Place your nametags in box at door. Thank you! Have a great day!!

#### October 15 - Robotics Informal Event Workshop - Morning Agenda (9 a.m. – 1 p.m.) Group: Not Engaged (control)

9:00 Welcome and Orientation – (plus group assignments, nametags and envelopes) – Videos, Surveys and Robotics programming

9:05 SE Survey 1 & Role Model ID Survey 1

#### [Early finishers explore ROBOLAB program]

9:12 Intro to TBPD – Debbie: Chant plus process - go over form use & DVD videos 1-2: TBPD NE (2'); If we thought of it NE (1'53") [Total video 3'53"]

9:22 Intro to ROBOLAB – Video Trainer sequences: Tankbot briefing (4') and Forward (3')

9:30 Use ROBOLAB to program a straight line – *Challenge 1* – Students program a robot going straight for one second, load program, and test it.

9:40 Challenge 2 - Program a square - Video trainer sequence Point Turn (2'18")

- 9:43 Solve Challenge 2
- 9:53 DVD video 3 Line Tracker NE (3'10")
- 9:57 Continue Challenge 2
- 10:07 Challenge 3 Light/Dark Challenge
- 10:10 Light Sensor video using Video Trainer (4'20")
- 10:15 Solve Challenge 3
- 10:27 DVD 4 Light Sensor & Program No. NE (2'37")
- 10:30 Bathroom/stretch break
- 10:35 SE Survey 2 & Role Model ID Survey 2
- 10:45 Modifiers Video Trainer sequence (5'45")
- 10:51 Continue Challenge 3

- 11:01 Introduce Challenge 4 Line tracker
- 11:03 DVD Video 5 Robot Wiring Sensor NE (2'05")
- 11:05 Solve Challenge 4

#### [For kids who finish early, add a bonus line counter challenge with beeps]

- 12:00 Touch Sensor video using Video Trainer (3'30'')
- 12:04 Introduce Challenge 5 Touch Sensor Challenge
- 12:07 Solve Touch sensor challenge
- 12:30 DVD Touch Sensor Bumper NE (2'00'')
- 12:32 Continue challenge 5
- 12:55 SE Survey 3 & Role Model ID Survey 3
- 1:00 Place your nametags in box at door. Thank you! Have a great day!!

## Appendix E: The DiSC Tool Rubric

The DiSC tool rubric is based upon research led by Dr. Daniel T. Hickey, conducted under contract for the Classroom of the Future under its cooperative agreement with NASA. Argumentation is the foundation for Hickey's (Hickey *et al.*, 2004) multilevel assessment research program.

# **Group Feedback Form**

## **Scientific Discussion**

10			2 🗆	3 🗆	4 🗆
No "reason" (rational or explanation) or "evidence" (r use of data, observation, or factual information).	10	Only a suppo	a reason is brought in rt of the claim.	Only evidence is brought in support of the claim.	Both evidence and support are brought in support of the claim.
Self (circle one): 1	2	3	4		
Group: (circle one): 1	2	3	4		

## Engagement

1□				2 🗆	3 🗆	4 🗆
Group is unfocused during scientific discussion.			Gron durii	up is somewhat focused ng scientific discussion.	Group is focused most of the time during scientific discussion.	Whole group is focused all the time during scientific discussion.
Self (circle one):	1	2	3	4		
Group: (circle one):	1	2	3	4		

## **Turn Taking**

1□			2 🗆				3 🗆	4 🗆
No teamwork. Nobody contributes to discussion, nobody takes turns during scientific discussion.Some teamwork some of the t (but maybe one individual talk too much or one doesn't talk enough).				vork some of the time one individual talks r one doesn't talk	A lot of teamv group member	vork, but not all rs participate.	Teamwork and participation are excellent; everyone has a voice; everyone's ideas are heard.	
Self (circle one):	1	2	3	4				
Group: (circle one):	1	2	3	4				

### Appendix F: The Inspiration Challenge Study Calendars

- Calendar of Events: Weekly overview of schedule for all curriculum materials, exam/quizzes/tests, DiSC tool administration, and surveys/ESM administrations.
- Operation Montserrat Scope and Sequence: Scope and sequence are linked to daily lesson plans complete with timings, focus, readings, resources/extensions, and student assignments.
- Monthly Implementation Calendars:
  - 1. September monthly view: All items are linked to annotation directions.
  - 2. Calendar annotation for September 29 control group.
  - 3. Calendar annotation for September 29 ESM administration.
  - 4. Calendar annotation: directions for Monday "Box and Mail"–for teachers to box up study materials in prelabeled boxes to COTF and take them to their school office for COTF's scheduled FedEx pick-ups.
  - 5. October implementation calendar: All items are linked to annotation directions.
  - 6. November implementation calendar: All items are linked to annotation directions.
  - 7. Directions for administration of posttest: Standards-based test.



## Calendar of Events for the Inspiration Challenge Study

	Curriculum Materials	Exam/Quizzes/Tests <sup>1</sup>	ΤοοΙ	Surveys <sup>1</sup>
Week I September 26 -30	Teacher Phone Orientation to the Inspiration Study	Pretest: <ul> <li>Curriculum-Oriented Exam</li> </ul>	Discussion Tool practice.     (online)	<ul> <li>ESM<sup>2</sup> practice (#1, #2, #3, #4, #5)</li> <li>Pre-Inspiration Survey 1</li> <li>Pre-Inspiration Survey 2</li> </ul>
Week II October 3 – 7	<ul> <li>Lesson 1: Introduction to e-Mission</li> <li>Lesson 2: Applying for e-Mission</li> <li>Lesson 3: Analysis of Yellowstone</li> </ul>	• Quiz #1	Discussion Tool Session 1     (use after Quiz #1, online)	• ESM (#6, #7, #8, #9, #10, #11)
Week III October 10 – 14	<ul> <li>Lesson 4: Volcanoes</li> <li>Lesson 5: Mt. Pinatubo</li> <li>Lesson 6: Volcano Tracking</li> </ul>	• Quiz #2	Discussion Tool Session 2     (use after Quiz #2, online)	• ESM (#12, #13, #14, #15, #16, #17)
Week IV October 17 – 21	<ul> <li>Lesson 7: Hurricanes</li> <li>Lesson 8: Hurricane Georges</li> <li>Lesson 9: Hurricane Tracking</li> </ul>	• Quiz #3	Discussion Tool Session 3     (use after Quiz #3, online)	• ESM (#18, #19, #20, #21, #22, #23)
Week V October 24 – 28	<ul> <li>Lesson 10: Montserrat</li> <li>Lesson 11: Risk Analysis of Montserrat</li> <li>Lesson 12: Prepare for e-Mission</li> </ul>			• ESM (#24, #25, #26, #27, #28, #29)
Final October 31	Lesson 13: e-Mission	<ul> <li>Posttests (all students take two tests after the e-Mission):</li> <li>Curriculum-Oriented Exam</li> <li>Standards-Oriented Test</li> </ul>		<ul> <li>ESM (#30-completed during e-Mission)</li> <li>Post-Inspiration Survey 1</li> <li>Post-Inspiration Survey 2</li> </ul>

<sup>&</sup>lt;sup>1</sup> We will schedule mail pick-ups from your school office for Mondays beginning October 3 and ending November 14. You will use supplied mailers to package materials for mailing. <sup>2</sup> ESM means "Experience Sampling Method." To administer the ESM, you will set a timer (supplied by us) to a prespecified time. When the timer rings, you will immediately distribute an ESM Scantron form. Your students will use the ESM to record how they thought and felt about their experience when the timer rang. Once students have practiced answering the ESM questions (week I) completing the ESM will take your students two to three minutes.

#### Scope and Sequence

Click on underlined text to open that resource

Week 2: Mission Briefing							
Lesson (click to view)	Focus	Readings	Resources / Extensions	Student Assignment			
1	Introduction to the e- Mission	<u>Join Us</u> <u>Earth System Science</u> <u>Application Process</u>		<ul> <li>Review <u>Application</u></li> <li><u>Process</u></li> </ul>			

Week 2: Forest Fires							
Lesson (click to view)	Focus	Readings	Resources / Extensions	Student Assignment			
2	Applying for the Mission	<u>Application Process</u> <u>Science Interests Inventory</u> <u>Letter of Commitment</u>		<ul> <li>Students form</li> <li>Emergency Response</li> <li>Teams</li> <li>ERTs complete Letter of</li> <li>Commitment</li> <li>View resume</li> <li>requirements</li> </ul>			
<u>3A</u>	Analysis of Yellowstone / Application	Resume     How Forest Fires Work     Fire Management     Fire's Role		<ul> <li>View <u>resume</u> requirements</li> </ul>			
<u>3B</u>	Analysis of Yellowstone / Application	How Forest Fires Work     Fire Management     Fire's Role     Case Study: Yellowstone Fires					

Week 3: Volcanoes							
Lesson (click to view)	Focus	Readings	Resources / Extensions	Student Assignment			
<u>4</u>	Volcanoes!	Your Task Volcanic Dangers How Volcanoes Work The good, the bad					
<u>5</u>	Volcano Case Studies	<u>Case Study 1: Mt. Peleé</u> <u>Case Study 2: Mt. St. Helens</u> <u>Case Study 3: Mt. Pinatubo</u>					
<u>6</u>	Volcano Tracking	<ul> <li><u>Volcano Monitoring Instructions</u></li> <li><u>Volcano Practice Data</u></li> <li><u>Volcano Graphs</u></li> </ul>		<ul> <li>Students practice for mission day</li> </ul>			

Week 4: Hurricanes							
Lesson (click to view)	Focus	Readings	Resources / Extensions	Student Assignment			
		◆ Your Task					

7	Hurricanes!	Hurricane Dangers How Hurricanes Work Getting Prepared	
<u>8</u>	Hurricane Case Studies	<u>Case Study 1: Hurricane</u> <u>Katrina</u> <u>Case Study 2: Hurricane</u> <u>Georges</u>	
<u>9</u>	Hurricane Tracking	Hurricane Tracking Instructions     Hurricane Practice     Hurricane Tracking Map	<ul> <li>Students practice for mission day</li> </ul>

Week 5: Mission Prep							
Lesson (click to view)	Focus	Readings	Resources / Extensions	Student Assignment			
<u>10</u>	Montserrat	<u>Your Task</u> <u>Newspaper Article</u> <u>Montserrat Fast Facts</u>					
<u>11</u>	(optional) Risk Analysis of Montserrat/ Begin Pre- Mission Prep	<u>Situation Report</u>	➡ <u>Maps</u>	Divide into mission teams.			
<u>12</u>	Prepare for the e-Mission	<u>Overview of Teams</u> <u>Mission Prep Materials for each</u> <u>team</u> <u>Situation Report</u>		<ul> <li>Discuss communication flow and team members' roles</li> </ul>			
<u>13</u>	Run the MIssion						

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## Calendar: View by Month

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VIEW DAY	VIEW WEEK	VIEW MONTH VIEW	WYEAR					
I September, 2005								
SUN	MON	TUE	WED	THU	FRI	SAT		
				1	2	3		
4	<u>5</u>	<u>6</u>	Z	<u>8</u>	<u>9</u>	10		
11	12	<u>13</u>	14	<u>15</u>	<u>16</u> <u>Consent-Tea</u>	17		
<u>18</u>	<u>19</u> Parent/Stud	20	21	22 Assign IDs	23	24		
25	26 ESM 1 Pre-Inspira	27 ESM 2 Pre-Survey	28 ESM 3 Pre-test: E	29 DISC Tool P ESM 4	<u>30</u> <u>ESM 5</u>			

OK

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## Calendar View Event

## **DISC Tool Practice**

DateThursday, September 29, 2005Start Time08:00 AMEnd Time05:00 PMCategory

#### Objective: To introduce your students to the D.I.S.C. tool.

#### Materials.

- You will need computer set-ups for the entire class. Group each team of four students to one computer that is connected to the Internet.
- You will need to use Internet Explorer with the most recent updates.
- MAC users must use Internet Explorer. Safari will not work.
- You will need to have Flash 6.0 or higher installed on the computers. (This is a free download <a href="http://www.macromedia.com/shockwave/download/download.cgi?P1\_Prod\_Version=ShockwaveFlash">http://www.macromedia.com/shockwave/download/download.cgi?P1\_Prod\_Version=ShockwaveFlash</a>).
- Turn off the pop-up windows blocker.

#### Procedure.

- Group students in teams of 4. They will be in these same teams throughout the study.
- Place each team at a computer with an Internet connection. Your students will work in their teams of four to use the DISC Discussion tool online (<u>http://inspirea.cet.edu</u>).
- Teams will need to create a login by clicking in the rounded rectangle at the left ("Don't have a D.I.S.C. Tool login? Signing up is easy, click here.")
- To create a login, students will select your ID number from the drop-down list. They will create a team name. They should write this name down to remember it. They will need it every time they login. Then students each insert their own four-digit ID numbers to the member ID number fields and click 'Create Team." Then they return to the login page and login.
- Once they have logged in, direct your students to complete the section labeled "Week 1: Practice."
- Here students will practice using the tool to help them to discuss their answers to a quiz question. They will
  read a quiz question and a topic summary addressing that question.
- They will also read a claim.
- Then they will decide individually whether or not they agree with the claim.
- Then they will decide, **as a group**, whether to support or oppose the claim, record their answer, and go on to the next question.
- They will answer four questions during the week 1 practice session.



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### Calendar View Event

## ESM 4

DateThursday, September 29, 2005Start Time08:00 AMEnd Time05:00 PMCategory

Open ESM envelope 4 at the start of the period. Inside, you will find an ESM sheet that tells you to set the CET timer for a certain time. Set the timer. When the timer rings, immediately distribute the ESM Scantron sheets. Write your ID number on the board. Write the ESM number 4 on the board. You should have already distributed to each student a student ID number. Direct students to use that student ID number. Direct your students to write (a) their four-digit ID number, (b) your ID number, and (c) the ESM number 4 on the Scantron form and fill in the corresponding rectangles. Tell students to record what they thought and felt when the timer beeped. Place the completed ESM sheets in the box for mail pick-up from your main office on October 3.

OK

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## Calendar View Event

## Box & Mail

DateMonday, October 03, 2005Start Time08:00 AMEnd Time05:00 PMCategory

Box all completed forms and Scantron sheets for mailing. Take them to your main office first thing Monday morning, October 3.

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Calendar: View by Month

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VIEW DAY	VIEW WEEK	VIEW MONTH VIEW	W YEAR					
I October, 2005								
SUN	MON	TUE	WED	THU	FRI	SAT		
						1		
2	<u>3</u> ▼ Box & Mail ESM 6	<u>4</u> <u>ESM 8</u> <u>ESM 7</u>	<u>5</u> ESM 9	<u>6</u> ESM 10	<u>7</u> ESM 11 Quiz 1/DISC	<u>8</u>		
<u>9</u>	<u>10</u> ESM 12	<u>11</u> <u>Box &amp; Mail</u> <u>ESM 13</u>	<u>12</u> ESM 14 ESM 15	<u>13</u> ESM 16	<u>14</u> ESM 17 Quiz 2/DISC	<u>15</u>		
<u>16</u>	<u>17</u> <u>Box &amp; Mail</u> <u>ESM 18</u>	<u>18</u> ESM 19	<u>19</u> ESM 20	20 ESM 21 ESM 22	21 ESM 23 Quiz 3/DISC	22		
23	2 <u>4</u> ESM 2 <u>4</u> Box & Mail	25 ESM 25	26 Begin Opera ESM 26	27 ESM 27	28 ESM 28 ESM 29	29		
30	<u>31</u> <u>Box &amp; Mail</u> ESM <u>30 - Fl</u>							

OK

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Calendar: View by Month

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VIEW DAY	VIEW WEEK		W YEAR				
November, 2005 III							
SUN	MON	TUE	WED	THU	FRI	SAT	
		1 Post-Inspir	2 Post-Survey	<u>3</u> <u>Post-test:</u>	<u>4</u> <u>Post-test:</u>	5	
<u>6</u>	7 Box & Mail	<u>8</u>	<u>9</u>	10	11	12	
13	<u>14</u> Box & Mail	<u>15</u>	<u>16</u>	17	<u>18</u>	<u>19</u>	
20	21 Competition	22	<u>23</u>	24	<u>25</u>	26	
27	<u>28</u>	<u>29</u>	<u>30</u>				

OK

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## Calendar View Event

## Post-test: Standards-based Test.

DateFriday, November 04, 2005Start Time08:00 AMEnd Time05:00 PMCategory

Post-test: Standards-based Test. Complete Post-test: Standards-based Test AFTER your e-Mission.

Have your students take the Post-test: Standards-based Test online or using the print-based materials.

Online:

Provide the online link for your students (Go to Online Surveys/Tests menu button on the left). Give them your Teacher ID number and your BlackBoard password to enter the test or survey site. Direct them to enter their student ID number when prompted.

Print-Based:

Distribute one generic Scantron form and one Post-test: Standards-based test to each student. Help students to follow the directions on the front page of the survey. **Student should use a number "2" pencil to mark their answers on the Scantron sheet**. They must <u>not</u> mark their answers on the survey. Collect the completed scantron sheets and surveys. Check to see that students have correctly filled in their student ID numbers, teacher ID number, and the form number. The form number is 7.

Place the scantron forms in the shipping box for shipping from your school's mail office on Monday, November 7 or 14 (depending on you e-Mission date).

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