Project Evaluation Final Report

March 1, 2010

Silicon Prairie Initiative for Robotics in Information Technology

SPIRIT

Funded by the National Science Foundation as Project #0525111
within Innovative Technology Experiences for Students and Teachers (ITEST)

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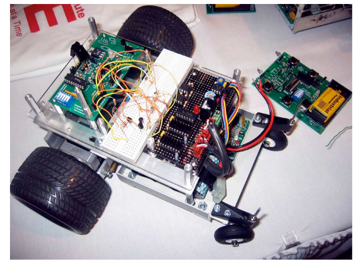
Executive Summary
The SPIRIT Project – Progress, Challenges, and Next Steps

Introduction:



The following is an executive summary of the final report for the activities and results of the SPIRIT Project, as funded by the NSF-ITEST program (NSF #0525111). The SPIRIT project was essentially a teacher professional development effort that sought to help middle school mathematics and science teachers to learn how to teach science, technology, engineering and mathematics (STEM) concepts using educational robotics. This first SPIRIT project led to a later second phase project, called SPIRIT 2.0 that is now using these trained, creative, and enthusiastic teachers in the development of a cyberinfrastructure-based curriculum to assist in the teaching of STEM concepts using educational robotics. This second SPIRIT effort is starting its third of five years of effort (NSF DRK12 #0733228) and is a direct outcome of the ITEST project. The SPIRIT project has also resulted in a new educational robotics platform, called the CEENBoT™ , which recently received NSF Phase I production support for a University of Nebraska startup company (NSF SBIR# 0945280). This executive summary discusses the SPIRIT professional development project as initially funded by ITEST, and how it is transitioning to an expanded curriculum and robotic platform development effort.

A Summary of the SPIRIT ITEST Activities and Results:

- The SPIRIT-ITEST teacher professional development effort was successful in providing extended training for 163 middle school mathematics and science teachers in educational robotics, representing 155% of the targeted proposal participation of 105 teachers.

- The SPIRIT-ITEST professional development project led to a second curriculum development project, called SPIRIT 2.0 (funded by the DRK12) which is now creating an educational robotics curriculum for middle school students, building upon the earlier SPIRIT work.

- The SPIRIT-ITEST professional development effort with teachers resulted in a total of 120 highly creative robotics lessons that have now been professionally edited, illustrated, and are now accessible on the project website.

- The SPIRIT-ITEST project lead to a new flexible, inexpensive, educational robotics platform, called the CEENBoT™ (Computer and Electronics Engineering Robot), which is now being produced by a University of Nebraska startup company (CEENBoT™ INC.). This company was awarded a NSF SBIR grant, for initial refinements in the CEENBoT™ production.

- Surveys related to the SPIRIT professional development effort documented positive changes in teacher perceptions of their instructional competence in educational robotics, engineering design, electronics, cooperative learning, and problem-based learning.

- Criterion-referenced test data of students involved with SPIRIT teachers, although limited for project interpretation (due to the way these tests are administered by schools) were relatively encouraging. Of the 29 groupings of students examined (N = 1058), a total of 21 classes scored above their school averages on the related criterion referenced tests, and a total of 23 groups scored above district averages.

- Using more consistent attitude and content assessments, results were encouraging for a short duration pilot test (4 hours) using a controlled time series design, with students participating in a pilot test of individual SPIRIT lessons and activities ($N = 141$). A dependent t-test showed a significant increase in STEM attitudes ($t(123) = 6.92$, $p < .0001$, $d = .62$). A similar t-test for content topics showed a slight increase in scores (pre $M = 16.57$, post $M = 16.81$); however, the content-related increases were not significant ($t(131) = .91$, $p = .36$). In comparison, the control group analyses indicated no significant increases in either category.

- Three longer duration pilot tests showed more mixed content and attitude results. Three classes were involved in piloting eight SPIRIT lessons over a full semester, including a middle school math class ($N=12$), a middle school science class ($N=18$), and an engineering topics class ($N=7$). The math class showed improvement on the content assessment (Pre $M=13.25$, $S=3.98$; Post $M=15.00$, $S=3.02$; $t(11) = 2.83$, $p = .016$) as well as the attitude assessment (Pre $M=127.5$, $S=23.6$; Post $M=140.3$, $S=17.61$; $t(10) = 3.23$, $p = .010$). However, the other two classes did not show significant improvement on either assessment.

<u>SPIRIT ITEST Challenges (Now addressed in SPIRIT 2.0)</u>:

- It was difficult to examine academic success using existing district criterion referenced tests, within the classrooms of the SPIRIT teachers, particularly when they undertook a relatively mixed set of lessons. In SPIRIT 2.0, this challenge has led to a more structured pilot testing and field-testing effort, with more focused pretest and posttest assessments.

- The establishment of student comparison groups was difficult in the SPIRIT project, although a comparison group of 141 students was successfully established. Few teachers and parents wanted to be part of a traditional "control group". To address this comparison challenge, classrooms willing to be in the control group (and take the pretest-posttest assessments) were provided with a large educational robotics event, following the posttest.

- The use of educational robotics in STEM instruction can be seen as a significant financial investment by school districts, involving a need for new robotics equipment. In response to this challenge, the SPIRIT project is refining an inexpensive, flexible, and open source robotics platform that can use scrounged parts, as well as off the shelf parts, called the CEENBoT™. This platform is attempting to lower the costs for school robotics use.

- The SPIRIT project is facing the challenge of producing and repairing CEENBoT™s, as well as providing technical support, on a rapidly expanding scale. To assist in robot production and repair, a University of Nebraska startup company (CEENBoT INC.) has been established.

Internet Site(s):

SPIRIT Education Components of the Website: http://www.ceen.unomaha.edu/TekBots/SPIRIT2/
SPIRIT Cyberinfrastructure Prototype: http://spirit.unomaha.edu/
SPIRIT Video Clip Sample: http://www.ceen.unomaha.edu/TekBots/Shared/Video/jumbotron07/
SPIRIT General Website: http://www.ceen.unomaha.edu/TekBots/

Silicon Prairie Initiative for Robotics in Information Technology (SPIRIT)

Final Report Narrative

Report Purpose:

This document is the final project report for the SPIRIT project, as of February 28, 2010. It is submitted as a stand-alone evaluation report attached to the NSF FastLane system. Parts of this report have also been entered into the FastLane system, through a copy and paste process. The SPIRIT report represents the work of many professionals engaged with the project and provides a summary for the past activities and results of the project, as well as the details for a Phase II effort of the project as funded by a follow-up SPIRIT 2.0-DRK12 grant (NSF #0733228), which expands the SPIRIT-ITEST effort into formal curriculum development.

"If you want to go quickly, go alone. If you want to go far then go to together" African Proverb

Project Focus:

The SPIRIT Project has continued to evolve from the SPIRIT-ITEST project (NSF #0525111), which represented an initial teacher professional development effort, to a further curriculum development effort, that expanded the base of experienced teachers, and funded formally in a SPIRIT 2.0-DRK12 grant (NSF #0733228). Both efforts are consistent with the standards-based learning discussed by many professional organizations, related to science, technology, engineering and mathematics instruction (ISTE, 1999; ITEA 2000; NCTM, 2000; NAS, 1996), within a relatively new context of educational robotics.

The teacher professional development efforts sought to use teacher professional development as a driver to transform the culture of mathematics and science instruction, as well as to empower student interest and achievement through revitalized, inquiry-based activities using robotics. The SPIRIT teacher professional development effort recognized that effective teacher professional development is a key variable for educational reform in mathematics and science (Loucks-Horsley et al., 2003; Richardson, 1994) and middle school grades are often where some of the most important general mathematics and science instruction is undertaken (Adams et al., 2000). SPIRIT's vision for this teacher professional development was to develop an effective teacher professional development model to support the integration of educational robotics into the middle school; to train middle school science and mathematics teachers in engineering design principles by the use of educational robotics; to help teachers plan for the integration of educational robotics into regular science and mathematics instruction; to try out lessons that they developed in their classrooms; and to try to increase student success by better reaching all of their students, in any demographic category.

As an extension of the professional development effort undertaken in the SPIRIT project, a second phase of the project, called SPIRIT 2.0 was conceptualized to build upon the creative synergy of these teachers, and to create a middle school educational robotics curriculum by 2013. The curriculum will comprise a set of instructional modules organized into flexible, Internet-accessible lessons and lesson support materials. This SPIRIT curriculum is targeting the instruction of specific topics or "touch points" in science, technology, engineering, and mathematics (STEM). A total of 163 teachers that have now been trained in SPIRIT summer institutes, workshops, and graduate courses, are routinely contributing lesson and classroom ideas to the SPIRIT 2.0 curriculum development efforts. Thus, the focus of the new curriculum effort consists of: 1) to develop a Grades 5-8 educational robotics curriculum that will enhance the student learning of STEM concepts; 2) to refine curriculum in an extended development process, using peer editing, expert review, pilot testing, and field-testing; 3) to integrate a series of assessments into the curriculum; 4) to extend the newly developed CEENBoT™ platform with technical enhancements, hardware tutorials, software guidelines, and a Graphical Programming Interface; 5) to create a cyberinfrastructure support environment, including a flexible sequencing of all curriculum materials; and 6) to scale the use of the curriculum, by two national workshops (in person and via distance learning).

Review of Intellectual Merit and Broader Impacts:

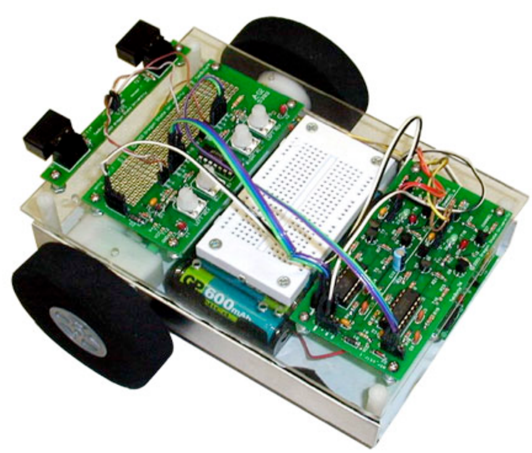
As the SPIRIT project progressed to this final reporting stage for its ITEST teacher professional development efforts and as it now transitions to a DRK12 curriculum development effort, the SPIRIT staff has worked hard to maintain both the intellectual merit and the broader impacts of the project, as originally described in the proposal. Those two important considerations are now reviewed.

The **intellectual merit** of the project is represented by the professional development model undertaken within the SPIRIT project (funded by ITEST), and the ability to now work closely with these teachers as a source of creative ideas and lessons to support an evolving educational robotics curriculum. The intellectual merit of the project is also represented by the new CEENBoT™ robotics platform, that was initially conceptualized in the SPIRIT project, and that is now being refined with teacher input, from the teachers who participated in the SPIRIT professional development. Further, this teacher input has led to a SPIRIT cyberinfrastructure strategy for the flexible delivery of lessons to teachers using the Internet. This further curriculum development effort of the SPIRIT project (now supported by DR-12) is creating web-based mechanisms for teachers to select compatible lesson components by grade level, STEM topic and national standards, as well as the use of an electronic "On-Call Technician" that will be able to eventually diagnose CEENBoT™ malfunctions and eventually guide teachers in repair and maintenance strategies. The SPIRIT project has also led to several relationships with school districts that have agreed to pilot test and field test the evolving curriculum resources.

The **broader impacts of the project** have been to operationalize an educational robotics professional development model that is replicable by school districts nationally. The use of a less expensive, more flexible, and more realistic robotics platform, than is available in the commercial setting, allows for a broader participation by schools in educational robotics. Further, by helping these SPIRIT teachers (who have participated in extensive educational robotics professional development) to also systematically contribute to an evolving educational curriculum, they can become local, regional, and potentially even national, "role-models" for the use of educational robotics in STEM instruction. This consistently expanding network of SPIRIT teachers is also becoming a significant source of experience, guidance, and encouragement to other STEM teachers seeking to use robotics in the classroom, for innovative instruction. The ideas of these SPIRIT project teachers have already been directly integrated in the evolving curriculum model, that includes teacher lessons, resources, assessments, technical tutorials, teacher professional development guidance, and a comprehensive cyberinfrastructure support environment. Lesson prototypes conceptualized in this SPIRIT-ITEST project have led directly to a further focus on expanded curriculum development, as additionally funded by the DRK12 program in SPIRIT 2.0. These new educational materials, and the teachers already trained and using them, will also support a greater general awareness and appreciation of engineering and technology (representing the T&E of STEM), as these two disciplines connect to innovative science and mathematics instruction, and as well as to help support the general benefits of engineering and technology to society.

The Initial TekBot® Platform:

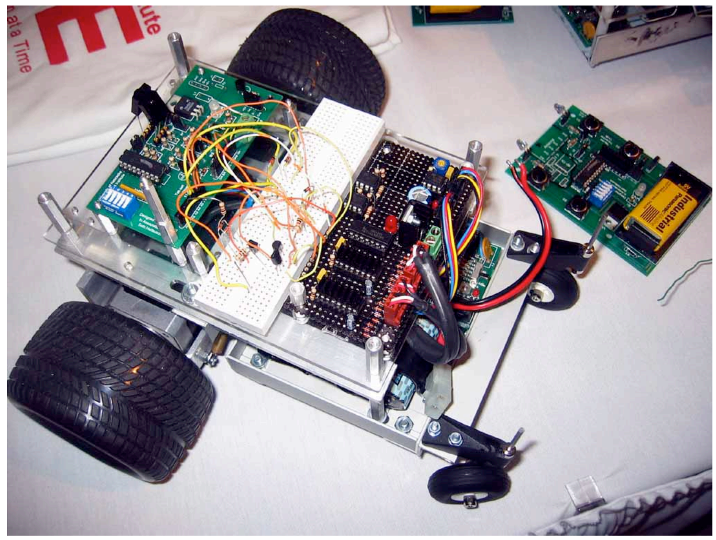
One of the keys to the instructional promise for educational robotics is the potential engagement and motivation of students with the robotics platform itself. Successful middle school curriculum often needs a motivating context (Adams et al., 2000; Greenwald, 2000), and robotics can be a motivating topic for students (Heer et al., 2003). This SPIRIT ITEST Project was initiated with the TekBot® educational robotics platform, which is a flexible, hands-on platform for learning developed by Oregon



State University. The TekBot® is a useful educational tool to provide a motivational student context for STEM learning. This mobile robotics platform can demonstrate a number of STEM concepts within an engineering environment, including microprocessors, mechanics, wireless communications and control, and sensors. It also has the benefit of being able to use limited "scrounged components" that one might find around the local electronics store, hobby outlet, or surplus parts store. However, we quickly evolved into creating our own SPIRIT educational robotics platform called the CEENBoT™ due to limitations with the TekBot® platform, and its extended handling by middle school students and teachers.

The New CEENBoT™ Platform:

Our work in the SPIRIT project has led us to develop a new educational platform that was similar to the TekBot®, but significantly enhanced and expanded, as well as more readily modified by students, called the CEENBoT™. This platform was more compatible with the rough handling by middle school and high school students. The versatility of the platform allows for a greater diversity of learning environments including in-school, afterschool, at-home and university settings.



Relative to the VEX® and the LEGO® robot, which are advanced consumer toys with simple "drag and drop" programming software and limited exposure to electronics engineering design, the CEENBoT™ offers a more modifiable platform with non-proprietary off-the-shelf (OTS) electronic hobbyist components for creative learning, involving a diversity of possible activities from hardware implementation, experimentation and software language development.

Relative to the TekBot® learning platform (developed by Oregon State University), the SPIRIT Project's CEENBoT™ offers a more robust platform for learning that is more durable and rugged for extended activities, is less prone to accidental damage, and comes with a larger prototyping board to help students to design possible enhancements. The CEENBoT™ also uses more rugged motors and steering components.

The CEENBoT™ was developed by engineering faculty and students at the University of Nebraska's Department of Computer and Electronics Engineering, building upon feedback from SPIRIT Teachers in K-12, and working closely with the faculty of the University of Nebraska at Omaha's College of Education, which has helped to synthesize suggestions related to the CEENBoT's™ current migration into the K-12 environments.

Participants

1. What people have worked on your project?

The following people represent the leadership team for the SPIRIT project:

PI: Dr. Bing Chen, Computer and Electronics Engineering (CEEN), Peter Kiewit Institute
CoPI: Dr. Neal Grandgenett, Teacher Education, University of Nebraska at Omaha
CoPI: Dr. Elliott Ostler, Teacher Education, University of Nebraska at Omaha
Senior: Dr. Bob Goeman, Teacher Education, University of Nebraska at Omaha
Senior: Mr. Dennis Deyen, Engineer and CTO, CEENBoT™ INC
Senior: Mr. Roger Sash, Computer and Electronics Engineering, Peter Kiewit Institute
Senior: Ms. Alisa Gilmore, Computer and Electronics Engineering, Peter Kiewit Institute
Senior: Mr. Herb Detloff, Computer and Electronics Engineering, Peter Kiewit Institute
Senior: Mr. Steve Eggerling, Computer and Electronics Engineering, Peter Kiewit Institute
Senior: Mr. Bill Schnase, Teacher Education, University of Nebraska at Omaha
Senior: Ms. Deb Duran, Computer and Electronics Engineering, Peter Kiewit Institute
Senior: Mr. Ken Townsend, Computer and Electronics Engineering, Peter Kiewit Institute
Senior: Mr. Jim Harrington, Mathematics Supervisor, Omaha Public Schools
Senior: Mr. Chris Schaben, Science Supervisor, Omaha Public Schools
Senior: Mr. Steve Hamersky, Physics and Technology Specialist, Omaha Catholic Schools
Senior: Dr. Gwen Nugent, Educational Researcher, University of Nebraska at Lincoln
Senior: Mr. Bill Schnase, Teacher Education, University of Nebraska at Omaha
Senior: Mr. Jim Wolfe, Teacher Education, University of Nebraska at Omaha
Senior: Dr. Paul Clark, Teacher Education, University of Nebraska at Omaha
Senior: Dr. Mike Timms, Measurement and Evaluation, Walnut Creek, California

In addition to the Project Leadership Team, a total of 163 teachers have now been fully trained in the SPIRIT project and many of these teachers have been actively involved in the SPIRIT curriculum development activities. This total represents 155% of the amount of teachers targeted in the initial grant proposal. Of the 163 teachers trained to date, a total of 41% are male and 59% are female. The project has been very pleased with its female teacher participation, since one of the long-term aims of the project has been to increase the number of female role models in STEM.

2. What other organizations have been involved as partners?

The Omaha Public Schools (OPS) remains a strong K12 partner in the SPIRIT Project, and contributed significantly to the teacher professional development planning of the SPIRIT-ITEST effort. OPS enrolls approximately 50,000 students in urban neighborhoods and is an ideal partner in the SPIRIT 2.0 DRK12 curriculum development efforts and the related pilot testing and field testing the educational robotics curriculum. Nearly 80% of the state's African American students, 60% of the state’s Hispanic students, and 35% of the state’s Native American students are enrolled in OPS. At least 40 languages are spoken within the OPS district.

In addition to OPS, the SPIRIT project has established a close relationship with the Metropolitan Omaha Education Consortium (MOEC), which also includes OPS, for later curriculum pilot testing and field-testing to occur in the SPIRIT 2.0 efforts. MOEC is a collaborative organization involving the University of Nebraska at Omaha, the twelve metropolitan area school districts, and two educational service units. The MOEC consortium involves nearly 100,000 students, and is a catalyst for identifying high priority issues common to member organizations. MOEC has offered to help communicate with area school districts and to help to identify potential pilot testing and field-testing sites within their consortium, as the SPIRIT 2.0 project becomes ready to test and refine the new curriculum.

Educational Service Unit #3 in Omaha, Nebraska has also become a valuable partner in the SPIRIT project in teacher recruitment and in providing a general awareness of the project within MOEC. ESU#3 has also been a key partner in helping us to begin to establish various control and comparison groups for our evolving curriculum pilot testing and field-testing strategies. Some initial efforts at pilot testing have already been undertaken and more are planned as part of the SPIRIT 2.0 curriculum refinement efforts. In this pilot testing effort to date, which has used a time series design (explained later in the report), ESU#3 asked a designated mix of teachers to have their students take the project's pretests and posttests in a specific period of time (without using the robotics materials). Then after the posttests were completed, the SPIRIT project held a three to four hour robotics event at ESU#3 for all the participating students and teachers in the comparison group, where some specific SPIRIT lessons and activities are piloted. This provided a convenient set of student comparison data, while also providing some instructional benefits for control students, after the comparison group data was received. We are also planning a large Summer 2010 Robotics Institute, where the SPIRIT lessons will be further pilot tested, in the curriculum refinement efforts of SPIRIT 2.0.

3. Have you had other collaborators or contacts?

The Peter Kiewit Institute (PKI) remained a strong collaborator throughout the ITEST professional development funding and continues as a strong partner now into the SPIRIT 2.0 curriculum development funding. PKI facilities include two academic colleges, the College of Information Science and Technology (University of Nebraska at Omaha) and the College of Engineering (University of Nebraska-Lincoln) of which the Department of Computer and Electronics Engineering is a member. With 2,500 total students engaged in IT in programs leading to a Ph.D., the PKI forms a powerful educational entity with considerable regional outreach and has strong corporate support, approaching $250 million. In addition, through its Technology Development Corporation, PKI is affiliated with the Scott Technology Center, which is a technology park within the PKI complex.

As envisioned in the initial ITEST proposal, the UNO College of Education took an aggressive educational leadership role in the teacher professional development effort in SPIRIT. That leadership is now transitioning into coordination of the curriculum development efforts for the SPIRIT 2.0 project and the related DRK12 funding. In many ways, this represents an important sustainability step for the ITEST project, since the SPIRIT educational effort continues to grow and evolve under this leadership. The College of Education is well suited for this management role and project sustainability, and has undertaken successful curriculum and teacher professional development projects for the past fifteen years beginning with NSF funding as a Center of Excellence in Research, Teaching and Learning (1995-2000). Additional leadership was also undertaken in a NSF Urban Systemic Program (2000-2005). The UNO College of Education has also received national awards for its curriculum work, including the Great City Schools Leadership Award (2004) and the NASA Mission Home Award (1995).

In this last year of ITEST no-cost extension funding, the SPIRIT project has also established a nice working relationship with the Nebraska Advanced Manufacturing Coalition (NAMC) and their STEM outreach project, called "Dream It - Do It". In this new collaborative effort, the NAMC is already funding a large set of CEENBoT™s for seven different rural school districts, and expects to fund more schools. Lead teachers from each of these first seven districts are now being trained (again at NAMC expense), and will undertake selected SPIRIT lessons and activities, in support of their classroom educational robotics integration, as well as our curriculum pilot testing and field-testing efforts. A brochure announcing this important partnership, as well as information about the NAMC and its business and industry representation, is included in the appendix of this report.

Project Activities and Findings

1. Describe the major research and education activities of the project:

Technical Research in SPIRIT:

While undertaking the SPIRIT educational robotics efforts in ITEST, our team found that there were some significant limitations to the educational platform that we were originally using, that of the TekBot® from Oregon State University. Although realistic from a computer and electronics engineering perspective and able to indeed add scrounged electronic parts, the TekBot® was far too brittle for the rough handling of middle school students, and the small size of the TekBot® made adding new components difficult (such as a robotics arm). During the 2nd year of the ITEST project, we designed our own educational robotics platform called the CEENBoT™ (Computer and Electronics Engineering Robot) and we are continuing to refine the CEENBoT™ as part of the continued SPIRIT 2.0 effort.

There has been significant research and design progress on the enhancements to the CEENBoT™ educational robotics platform and its technical options, during the last year of the ITEST teacher professional development effort, and now into the DRK12 curriculum design efforts. The CEENBoT™ represents the development of a more rugged and flexible platform for student experimentation and enhancement. It can include different chassis features (wheels, supports, etc.) as well as different microprocessors and sensors. It also now includes an open source Graphical Programming Interface (GPI), and soon will have an integrated Global Positioning System (GPS). In addition, work is underway to establish a more rigorous production process for the CEENBoT™ and to refine the educational robotics technical tutorials, schematic diagrams, and instructional videos/clips associated with building the CEENBoT™. These technical resources, like the educational lessons, will eventually be deliverable to teachers within the flexible online retrieval environment that helps teachers to select the technical documents that are the most relevant to their educational context and to their classroom goals. The full progress of the technical research on the robotics platform started in ITEST and now continuing in DRK12 is presented within the results section of this report. A sample technical tutorial is also provided in the appendix of this report. It is important to note that the technical research surfaced in the ITEST efforts as a result of significant problems with the TekBot® rather than as an initial goal in the project. However, we feel that the transition to the CEENBoT™ and its continued development is an important and very positive outcome of SPIRIT to date. The prototype of the CEENBoT™ platform has been widely embraced and there is a waiting list of delivery orders.

A third-generation CEENBoT™, being called internally the "CEENBoT-K2™", will have significant improvements over the current CEENBoT™ and will better meet the needs of the K-12 environment. This includes a new Lithium Ion battery supply with longer run times through a more reliable and energy efficient circuit design, compatibility with LegoBot sensors, icon driven programming options, LabVIEW compatibility, interchangeability of the ARM family of microprocessor platforms, an enhanced graphical programming interface, and simpler assembly options in kit form. The CEENBoT-K2 system should be available for delivery to schools in the early fall of 2010.

Modular Lesson Development and Cyberinfrastructure:

As mentioned earlier, the SPIRIT cyberinfrastructure is being designed around a unique modular and flexible approach to lesson retrieval for teachers related to educational robotics. This cyberinfrastructure was initially conceptualized by teachers undertaking SPIRIT-ITEST professional development, and is now being refined in the SPIRIT 2.0 curriculum development efforts as funded by DRK12. In the SPIRIT cyberinfrastructure, the Science, Technology, Engineering, and Mathematics (STEM) disciplines are being integrated through the instructional use of robotics that strongly support the learning of STEM concepts that are already taught at the middle school level. Thus, the SPIRIT robotics curriculum is being mapped to curriculum "touch points" where teachers can use robotics to illustrate middle school STEM concepts, such as an algebra teacher teaching the concept of slope while investigating the steepness of a ramp that a robot can successfully transverse. A total of 120 lessons (along with support materials) have now been fully developed and are resident in the SPIRIT cyberinfrastructure system, which is continuing to be refined. This new cyberinfrastructure system, as well as the lessons and materials stored within it to date, are more fully described later in the results section of the report. A core set of lessons relate to introductory algebra and middle school science, and many any of the lessons involve a variety of integrated STEM concepts. Lesson development will continue into the SPIRIT 2.0-DRK12 efforts, and lesson pilot testing is also beginning as part of the new curriculum development efforts. STEM topics are also being added and expanded as the current SPIRIT lessons are further tested and modified for efficiency within the cyberinfrastructure environment.

The SPIRIT lessons are using a modular design created by the education team (referred to as the AEIOU method) that allows for the lesson components to be interchangeable and selected by teachers based on individual lesson needs. The AEIOU components include A-Asking Questions, E - Exploring Concepts, I - Instructing Concepts, O - Organizing Learning, and U - Understanding Learning (or assessment). With this AEIOU strategy, a well-established base of critical and well done lesson components will allow for a flexible retrieval of lessons and lesson components, as desired by a teacher using the curriculum. The AEIOU method allows a user to select individual components of lessons within a five-part model of lesson plan construction, so that each component can stand alone, or can be easily removed from a lesson if desired by a teacher, or can even be replaced with a component of the same type, for a slightly modified lesson. A sample lesson is included in the appendix. The AEIOU lesson components are further detailed in the following description.

SPIRIT Lesson Format:

A – Asking questions: This component is designed to facilitate an initial classroom interchange of questions and ideas. An ***A*** component may include a prompt-type question in an engineering or scientific format as a model of good questioning. These ***A*** components may also include video clips, graphs, scenarios, and other hooks to empower students to become curious and ask questions.

E – Exploring concepts: This component helps students to study, experiment, conjecture, and to instructionally play with the robotics equipment in the context of the questions that were asked in the ***A*** component.

I – Instructing: This component is the only static component of the lesson plan and is designed to instruct students in the formal core processes of the STEM topic that they are studying. All ***I*** components are designed to service a broad range of grade levels by separating topics into vertically articulated units: *recognizable* terms, *conceptual* terms, *mathematical* terms, *process* terms, and *applicable* terms. For example, beginners might explore a topic like slope through *recognizable* terms such as "steepness" whereas advanced students might touch on the *application* of slope by exploring changes in slope based upon what they see the robot do during ramp or various movement experiments.

O – Organizing learning: This component is designed to allow students to participate in a guided practice environment where they might create graphs, develop charts, solve problems, and make decisions based upon what they have learned from the ***I*** components as well as what they have observed from their questions and explorations in the ***A*** and ***E*** phases.

U – Understanding: This component is designed around effective ways to assess how well the various ***I*** components have been addressed for students. The ***U*** components include a number of unique assessment instruments that range from short quizzes, games, to tests and worksheets, to projects, to interpretive writing.

The AEIOU lesson components are also being "tagged" and arranged within an electronic database of similar components to fit the needs of an individual instructional topic, or each ***I*** component. For instance, for a given instructional topic such as *slope*, there may be many of each of the other vowel components that are tagged to fit that particular ***I***. A teacher may chose, at their discretion, from among those components that best fit their needs, guided by the interactive website. Once the individual components have been selected by the teacher, the website will further help the teacher to organize the components into a cohesive set of lessons including all of the ancillary documentation (i.e., worksheets, web links, assessment instruments, etc.) and then print this set of individualized curriculum materials.

The editing process for lessons has been very systematic and extensive. Each lesson is carefully edited, by use of a review team that includes a peer teacher, a content specialist, a professor of learning research, and a technical writer. A diagram flowchart of the lesson writing and editing process is included in the appendix.

Professional Development with Teachers:

As part of the original SPIRIT-ITEST teacher professional development efforts and that now forms a foundation for more extensive curriculum development in the DR K12 project, survey research was conducted with 97 teachers that attended the three years of the initial SPIRIT professional development efforts, as well as 21 teachers that attended a fourth year of professional development in Columbus, Nebraska. The fourth year of professional development at Columbus was undertaken at no cost to NSF, at Central Community College, due to a grant that they received from the Nebraska Department of Education. Another 45 teachers participated in a SPIRIT related graduate class at UNO. Thus, a total of 163 teachers have now participated in either an extended summer workshop or in a project-related graduate course.

The purpose of the initial teacher professional development sessions were to introduce the teachers to engineering principles and basic electronics, as well as to show them how to construct the TekBot® (in Years 1 and 2 of ITEST funding) or the CEENBoT™ (Year 3 of ITEST funding) and to generate lessons ideas for incorporating educational robotics into their own STEM instructional responsibilities. Topics covered included problem based learning; the educational advantages of STEM integration; the discipline of engineering; a comparison of the scientific method to the engineering process; the engineering design process; engineering design tools; and the use of an engineering notebook. Other more technical topics covered included assembly of the TekBot® or CEENBoT™ itself; electrical circuits; motors and electrical components (such as resistors and capacitors). The results of these professional development activities, related to teacher perceptions, are provided in the results section of the report.

Data Collection with SPIRIT-ITEST Students and Comparison Groups:

The SPIRIT-ITEST project collected a range of initial data with students, to help to examine whether the educational robotics lessons that the teachers were doing in their classrooms, was having any impact on student achievement. The SPIRIT 2.0-DRK12 Project is refining and expanding this student data collection effort as a curriculum pilot testing and field-testing process, building upon what was learned in the SPIRIT-ITEST project.

The student data collection and analysis undertaken within the SPIRIT-ITEST project consisted of the following, which was in addition to the teacher survey data. The results and discussions of these data analyses are included in the results section. The data collection activities included: 1) data on student criterion referenced test scores in mathematics and science (N=1058); 2) content and attitude test data on short duration SPIRIT lesson testing of three to four hours (N=141); and 3) content and attitude data from three courses that adopted the SPIRIT robotics activities into a full semester course. Each of these analyses used a control or comparison group, but could not be randomly assigned, due to district restrictions. The results of these SPIRIT-ITEST analyses are further discussed in the results section of the report. In addition, these results have also been published in several refereed articles, also detailed at the end of the report.

Types of Student Data Collected in the SPIRIT – ITEST Project

Type of Student Data Collected	N =	Comparison Group	Results *(explained in results)*
Criterion Referenced Test (CRT) Scores (Compared the CRT scores for students in a teacher's class with school/district)	N=1058	School and district mean Scores for the same CRTs	Although encouraging, CRT scores for impact analysis was limited, leading to other strategies.
Short Duration Pilot – Content/Attitudes (Used content and attitude tests before and after a 4 hour robotics intervention)	N = 141	Students were own comparison group in a time series design	Significant attitude improvement for STEM was found. No content improvement was found.
Math Class Pilot – Content/Attitudes (Examined a full semester mathematics class and eight SPIRIT lessons)	N = 12	Students were compared to earlier comparison group	Significant STEM attitude and content increases were found, with particular content increase in math.
Science Class Pilot – Content/Attitudes (Examined a full semester science class and eight SPIRIT lessons)	N = 18	Students were compared to earlier comparison group	Results indicated no significant improvement on either the content or attitude assessment instruments.
Engineering Pilot – Content/Attitudes (Examined a full semester 9th grade engineering class and eight lessons)	N = 7	Compared to control data from the time series design.	Results indicated no significant improvement on either the content or attitude assessment instruments.

Further Data Collection with SPIRIT-DRK12 Students (Expanding ITEST efforts):

The student data collection and analysis continues as the SPIRIT-ITEST project transitions now into the SPIRIT 2.0-DRK12 project. Building upon what was learned in the SPIRIT-ITEST project, the SPIRIT 2.0 project is now gearing up for more extensive educational robotics lesson pilot testing. During November of 2009, the SPIRIT Project received an updated IRB approval (IRB 443-09 EX) to undertake more refined pilot testing of selected lessons within several schools of the Metropolitan Omaha Education Consortium (MOEC), which is a diverse set of 12 school districts within the Omaha metropolitan area, representing more than 100,000 students. The pilot testing of a group of individual lessons (with 8-10 hours of instruction) will begin in selected MOEC schools during the spring semester of 2010 and will involve more than 150 middle school students. The pilot testing will then be expanded into an even larger first field-test (with 30 or more hours of instruction) at three summer camps in the summer of 2010, with 75 students, and into the fall of 2010, with an additional 100 students.

As the SPIRIT pilot testing is expanded, we are building upon what we have learned in the initial ITEST effort. The lessons that have been targeted for further pilot testing and field-testing will focus directly on core STEM topics already being taught within the typical school curriculum. This pilot testing process, expected to continue during the next three years of the SPIRIT 2.0 project, will seek teacher volunteers each semester, within MOEC to pilot test at least three educational robotics lessons with students in their classes. The students will take a pretest and posttest on core robotics-related STEM concepts, as well as an attitude assessment on science, technology, engineering, and mathematics (STEM) interests. The educational robotics lessons will then be refined based upon this feedback. The assessment instruments are from a partnership with the NSF ITEST GEAR-Tech-21 (NSF #0833403) project and have been previously tested for reliability and validity. They are described further in the results section, and represent focused collaboration between the two ITEST projects.

In support of the SPIRIT-ITEST student comparison group process, in 2009 we established a set of classrooms that took the assessment instruments as a pretest-posttest baseline, with no robotics activities to get foundational data for no intervention. This group then took the assessment again after a short educational robotics intervention of about four hours. These "control groups" took the assessments a total of three times, which included taking the assessments one to two weeks apart, and then a third administration of the assessment, after the four-hour mini-intervention, to reward the students and their schools for their comparison group participation. The four-hour intervention essentially piloted SPIRIT lesson components as well as introduced students to educational robotics in a fun, hands-on setting, in which the whole school could participate. This "event" also allowed the project to retrieve data on the effectiveness for the four-hour intervention to potentially impact the STEM content and attitudes of the students. The results of these mini-intervention sessions are described in the results section of this report. This successful SPIRIT-ITEST control group strategy will be continued into SPIRIT 2.0-DRK12 curriculum refinement efforts.

Beyond being a reward for the data retrieval process, the series of short-term four-hour mini-interventions were also conducted with the intent to briefly introduce youth to robotics through the use of hands-on experimentation. While we did not expect such a short duration post-control group session to have lasting conceptual learning, we did expect that this introductory experience might provide some initial excitement for youth about robotics and perhaps even increase their interest in robotics. It also functioned as a recruitment process for further control group sessions. As the pilot and field-testing expands in SPIRIT 2.0 – DRK12, the content and attitude assessments of these longer duration groups will be contrasted with this expanding comparison group of students who do not receive any robotics instruction between the pretests and posttest assessments.

Further SPIRIT Pilot Testing and Field Testing Procedures Plans:

We have learned a lot in SPIRIT-ITEST about working with teachers and students, which have allowed us to strategically evolve from local teacher professional development to national level curriculum development and refinement. As the SPIRIT 2.0 project gears up for further pilot testing of educational robotics lessons, we are refining our procedures for pilot testing. In this newest data collection effort planned, teachers from the Metropolitan Omaha Education Consortium who have previously attended a summer SPIRIT Educational Robotics Institute will be asked to volunteer for the lesson pilot testing process, by use of an e-mail to the list of these 163 project teachers. If a teacher is interested, they will send a return e-mail to the SPIRIT project stating their interest, experiences, and general background, which will be reviewed by the research team.

If selected to participate by the research team for further pilot testing, the SPIRIT teachers will be invited to a follow-up Saturday morning meeting, describing the lesson pilot testing process. If they agree to participate after this overview session, the teachers will sign a consent form for pilot testing. Their principal will also sign their consent form. Teachers will be asked to pilot three educational robotics lessons of their choice, from the database of educational robotics lessons (http://www.ceen.unomaha.edu/TekBots/SPIRIT2/). They will also distribute consent forms to their students, to be signed by parents and returned to the teacher, and then to the researcher. Once the student consent process is completed, they will give their students two pretests on STEM content and attitudes. They will then pilot the selected educational robotics lessons with their students. Upon the conclusion of the lesson piloting, teachers will then give students a content and attitude posttest, using the same assessment instruments as before. Finally, teachers will complete a short survey feedback form after the pilot testing process to provide lesson refinement suggestions, as well as return the student pretests and posttests. Upon return of this feedback survey and the student pretests, posttests, and consent forms, the participating teachers will receive a university voucher for $100 to sign, which will initiate project payment for their participation in this lesson evaluation activity.

For the pilot testing procedures for the students, they will be given a consent form by teachers to be signed by parents, to participate in lesson piloting, conducted by the teacher in their regular classroom. The consent form describes that the educational robotics lessons will be relatively short in duration, interesting to students, and that the lessons will map to standard educational content already within the students' curriculum. The consent form will also provide background information on the assessments to be given to the students. These short assessments represent another 60 minutes of student time. Field testing efforts for the complete SPIRIT curriculum will also be undertaken, primarily in 2011, but with several smaller field tests in 2010, and will involve a larger sequence of SPIRIT lessons, integrated over several weeks, and when possible, over a whole semester.

The student assessment instruments that are now being used in the SPIRIT project are well-developed instruments, and represent some significant improvements over earlier instruments used in the SPIRIT-ITEST project. They have been developed in collaborative work with the GEAR-Tech-21 ITEST Project, under the direction of Dr. Bradley Barker (NSF #0833403). The content assessment test is an instrument with 39 short multiple-choice questions related to mathematics and science that might be found in a robotics context. The attitude instrument is a 33-question Likert-scaled instrument that asks students their attitudes about mathematics, science, and learning. Both assessments are well known nationally, and have been previously used and validated within a variety of educational settings, summer camps, and after-school programs including previous work within the MOEC area schools (Barker, Nugent, Grandgenett, Hampton, 2008).

In this new data collection effort planned, the participating teachers will remove any student names, on all the assessments, before sending them to the SPIRIT project researchers. They will instead us a numeric ID for the names, such as Student 1, Student 2, etc. However, consent forms will continue to retain the student names when they are sent to the researchers. Thus, consent will be able to be verified by name, but student assessment data will not have any names attached to this information. The field-testing process will be initiated during the next year, starting with Lewis and Clark Middle School. This high minority school has agreed to fully integrate the SPIRIT curriculum into selected classes.

Online Course Development:

An outcome of the SPIRIT-ITEST project was also to initiate an online approach to teacher professional development, as represented by an online graduate course. The online course focuses on teaching educational robotics to interested STEM teachers across the nation and for the offering of graduate credit, as a way to extend and sustain the SPIRIT teacher professional development initially conceptualized for the ITEST grant. The first pilot offering of the online course was done as a face-to-face offering during the summer of 2008, and the second offering was a blended course format (some instruction done in person and some done online) during the spring of 2009. The next course offering is planned in the spring of 2010 and will also be a blended format. The course is entitled "TED 8010 Seminar in Education: STEM Robotics" and is a three credit hour graduate course designed for any level of elementary, middle, or high school teacher. The blended format includes three Saturday sessions as well as eight on-line sessions and includes building a CEENBoT™ from a kit as well helping teachers to develop a set of educational lessons for their own classroom use. The Spring 2010 session will try holding classes on several evenings, instead of Saturdays, with less in-person instruction. Eventually, the course will be taught completely online, so that it can be offered nationwide, to teachers interested in taking the course, as well as for supporting their learning about the use of educational robotics in the classroom.

During this graduate course experience, students are expected to think about teaching, learning and curriculum writing in creative ways, focusing on not only improving student learning, but also on sparking student interest. Another activity in the course is for participants to identify a compatible selection of SPIRIT lessons and to use them with learners. The course is a model for future course offerings within a national context, which also might involve community colleges. For example, a community college instructor in another state could teach several sessions locally (supporting CEENBoT™ construction) and a UNO College of Education professor could teach the on-line sessions (supporting curriculum development). The enrolled teacher could get graduate credit from UNO, and the community college instructor could receive an instructional stipend for assisting with robot construction in the course. Finally, this course model will strive to help educators to better understand what it takes to teach with the robots, the advantages of such instruction, as well as the challenges faced for such STEM learning environments.

2. Describe the major findings resulting from these activities:

Robotics Platform Results to Date:

As described earlier, the work in the SPIRIT-ITEST project has led us to successfully develop a new educational platform called the CEENBoT™. The initial teacher professional efforts with Oregon State's TekBot® found that the platform was too fragile for use by middle school and high school students, and that it had structural limitations in the ability to add onto the platform. A prototype of the new CEENBoT™ educational platform was used with teachers during Year 3 of the ITEST grant and is continuing to evolve during the DRK12 curriculum development efforts. The CEENBoT™ is more compatible and flexible for the inquiry-based use and rough handling of students. The versatility of the platform also allows for a diversity of classroom and independent learning environments including in-school, afterschool, at-home and university instruction. The CEENBoT™ offers a modifiable platform with non-proprietary off-the-shelf (OTS) electronic hobbyist components for supporting a diversity of possible user-enhancement activities ranging from hardware implementation, operational investigations, design experimentation and software language development. The CEENBoT™ already has been designed so far to include features such as high-quality precision motors, strong suspension for traversing uneven terrain, a quick-change power supply, interchangeable drive tires, flexible remote control capability, large prototyping board for enhancement support, peripheral interfaces for communication, and various programming options. The operational production of the CEENBoT™ is also striving for the ability to deliver either kits to educators, or partially completed or fully completed robots. Peripherals for the CEENBoT™ are in various stages of development, and include add-on components involving GPS, laser diodes, alternate wireless controls, anon-board video camera, robotic arms, graphical programming and C++ interfaces, and eventually, feature compatibility with Microsoft Robotics Studio.

In the SPIRIT project's continued efforts at refining the CEENBoT™ platform, we are striving for the development of a reliable robotics educational platform that is ready to be produced at a very low cost, and that can be supported by a cyberinfrastructure-based curriculum. This is a challenging undertaking, but our progress has been steady, and our foundational work in the ITEST project has served us well in conceptualizing the platform. Technical issues continue to be identified and addressed as the CEENBoT™ is introduced into grades 5-12 classrooms and to the Electronics and Engineering coursework at the University of Nebraska's Department of Computer and Electronics Engineering, as well as at partner institutions of the Rose-Hulman Institute of Technology, Tulsa University and Howard University, who are each beginning to experiment with the CEENBoT™ and to work with us to enhance its educational efficiency and classroom utility.

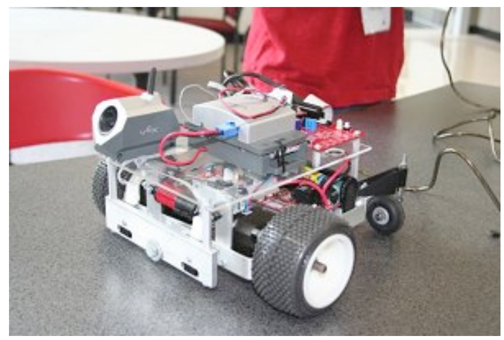
A number of improvements in software and hardware have been achieved during the ITEST funding, or are fully underway now in the DRK12 funding to eventually support the CEENBoT™ for national distribution. These CEENBoT™ platform achievements and further plans include the following accomplishments.

1. We have made progress during ITEST in the energy efficiency of the CEENBoT™ and we are continuing to perform energy requirement analyses to determine the best energy

strategies specific to the educational market through a cost benefit analysis. A short charge cycle and a long usage cycle are required for many instructional uses in grades 5-12 and for university classrooms as well as for outdoor use, where some robot activities, including GPS mapping, may take several hours to complete.

2. We are steadily reducing manufacturing costs (currently near $200 per kit) to eventually be below $100. Schools in SPIRIT's educational arena are very cost sensitive and reducing the product cost while providing a quality product will help leverage CEENBoT™ production, distribution and utility for educators. A thorough cost analysis is being undertaken each quarter, as we transition from ITEST to a DRK12 curriculum focus.

3. We have applied Design for Manufacturability (DFM) and Design for Testability (DFT) engineering concepts to ensure product reliability and customer satisfaction for both CEENBoT™ kits and completed units. The kits are being designed for ease of assembly in the classroom. A programmable CEENBoT™, useable by both technical and non-technical educators will employ self-diagnostics and a factory default setting to allow the teachers to quickly diagnose hardware, software or programming issues in the classroom or remotely through an Internet connection. Providing the educators with empowerment tools to answer most of their own questions will also help engage students in this useful learning activity.



4. During Year 3 of the ITEST funding, we researched new trends in the educational robotics field and this has informed our future improvements in sensor, microprocessor, DSP, video, RF, battery, programming and language technologies. We are enhancing the CEENBoT™ to also have connector capability with existing LEGO Mindstorm accessories, in case users want to combine accessory features of these two platforms.

5. We are improving the CEENBoT™ chassis to make it as economical as possible, with a targeted $20 cost, in contrast to the current chassis cost of $130 and exploring motor options to further lower cost and power consumption as well as to increase speed.

6. We are starting to promote environmental awareness in mobile robotics by defining a possible standard for energy consumption and environmental impact. A standard defining the environmental impact of mobile robotics does not currently exist. Definition of a useful CEENBoT™ standard has made significant progress, and will eventually address: battery and gear box spill containment, noise levels, energy efficiency and environmental impact from turf and foliage damage. A portion of this standard will also address programmable energy level peripherals by allowing for different power level settings (e.g., sleep mode, wake on external event, wake on pre-programmed time event, etc). One of our technical goals is to provide future products that are 100% RoHS compliant, for disposal to comply with the US EPA Design for the Environment (DfE) guidelines. Designing a product to fall within the US EPA DfE program may enable more educator use and interests, as no other mobile robotic platform is a DfE partner (Design for the Environment, 2009).

7. We are working to make the CEENBoT™ compatible with graphing calculators. Our SPIRIT-ITEST Teachers have recommended compatibility with the graphing calculators found frequently in schools and STEM coursework. Graphing calculators are also now allowed for use on the PSAT, SAT, and ACT College entrance exams and AP tests and are quite commonplace for use in grades 6-12 and university coursework. The project's technical team is planning for this capability, and it is becoming an evolving design priority. The education team has already developed initial prototype programming sequences based upon the Norland Research Smallbot (Norland Research Calculator, 2007) and the Texas Instruments TI-8x series graphing calculators. CEENBoT™ design will now also include ARM7 (upgradable to ARM9) microprocessors that will be able to interface with common graphing calculators. Graphing calculator compatibility would allow the CEENBoT™ to physically illustrate various functional relationships often shown just visually on the calculator, such as having the robot drive in a path illustrating a sin curve. Controlling a CEENBoT™ with a graphing calculator opens up the educational use of the CEENBoT™ to a vast number of teachers and students, who are already using graphing calculators in their STEM coursework.

8. We are also examining the potential of smart phone compatibility with the CEENBoT™. Several school districts have already approached us about the use of smart phones with the CEENBoT™ and the Department of Homeland Security has shown interest in funding some of our evolving research. Microsoft has already developed a WiMo robotics model to meet this objective using a Microsoft smartphone. For the CEENBoT™, utilizing an existing platform like a smartphone, provides inexpensive educational access to GPS, megapixel cameras and custom programmability, allowing the educators and students to utilize a wireless off-the-shelf controller like a cellular phone. The SPIRIT technical team is researching these possibilities and the education team is looking at possible classroom applications.

9. We are working to make the CEENBoT™ as environmentally friendly as possible and we are very sensitive to the need for environmentally friendly features. Two rapidly changing technologies that we are addressing are battery chemistries and RF communication protocols. The existing CEENBoT™ platform, initially developed by University of Nebraska students, uses Nickel Cadmium (NiCd) batteries. NiCd battery technology has some drawbacks including memory effect due to crystal growth from overcharging, and disposal considerations

when the battery is no longer useful. For example, for every 1,000 CEENBoT™'s utilizing a 9-ounce NiCd battery pack it would require the disposal of 562 pounds of battery waste. NiCd battery collection and recycling are required under US Federal Law (Material Safety Data, 2007). Other dominant battery technologies being considered instead for the CEENBoT™ include: Nickel Metal Hydride, Lithium Polymer and Lithium Ion. These batteries are less toxic to the environment as they do not contain the heavy metal Cadmium. We are proud of this new "green technology" refinement of CEENBoT™ battery use.

10. We are looking for ways to help SPIRIT educators and students to diagnose technical problems that arise with the CEENBoT™. Two methods for robot diagnosis are currently being considered: self-diagnostics available to the end user and remote diagnostics via an Internet connection. Self-diagnostics will strive to provide a clear understanding of the functionality of the device and provide results that are easy to understand. An example is to provide vocal feedback when something changes (i.e., battery charger is plugged in and the robot responds vocally with "charging battery"). The Internet connectivity will allow remote diagnostics or an "On-Call Technician" to inspect the states of the device without requiring an end user to send the product back for repair analysis. Providing Internet connectivity to the robot will also allow software updates to keep the product current as new peripherals emerge.

11. Finally, we are developing strategies for the delivery of partially completed or fully completed kits to educators as desired. We are also looking at various ways to package, bar code, and distribute the robots more efficiently to teachers. We are producing the related documentation for these efforts and options as necessary. Our fundamental desire is to make the CEENBoT™ as flexible, engaging, useful, and efficient for educators as possible, in support of an overall goal of enhancing student STEM education.

Graphical Programming Interface Results to Date:

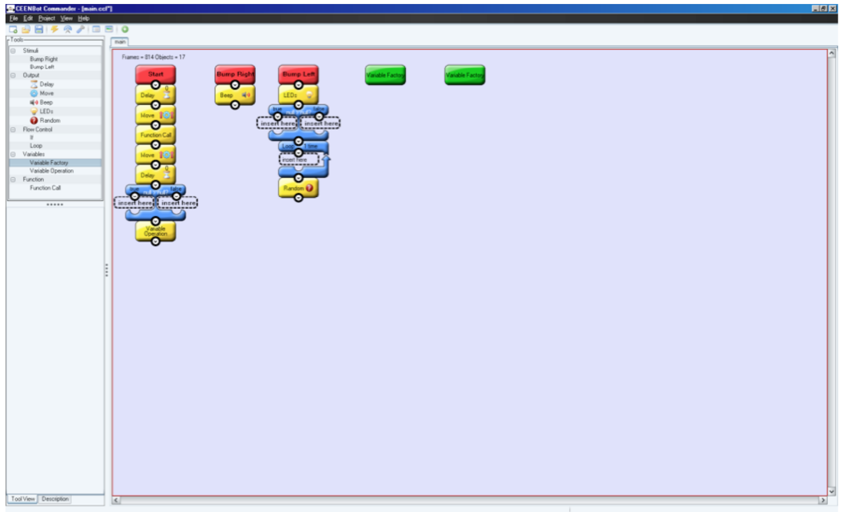
The need for a Graphical Programming Interface (GPI) for the CEENBoT™ was identified by several of the SPIRIT teachers attending the ITEST professional development workshops. This programming enhancement was considered to be helpful with middle school student use. Work started on the GPI during the recent no-cost extension year of ITEST, and continues for the new SPIRIT 2.0 – DRK12 efforts. The GPI is about 80% complete and is in a testing and refinement mode. It will be compatible with Windows and Mac computers, as well as a microprocessor-based GPI control board for the CEENBoT™ which will coordinate external controls with a capability to converse in different programming languages starting from "drag and drop" as well as C, Java and Assembly. It will allow for the addition of new sensors and other hardware modules. The GPI is unique in that it will simultaneously connect the various sensors and modules to the base platform while also allowing for multiple programming languages to be used that are appropriate to the level and language of interest of the schools.

The CEENBoT™ Graphical Programming Interface (GPI) project essentially encompasses the goal of providing a seamless, user-friendly interface for programming the CEENBoT™ robotics platform. The GPI project, led by Computer and Electronics Engineering (CEEN) faculty member Alisa Gilmore, has realized several key milestones this last year, including the design and prototype of an in-house GPI software application called "The CEENBoT™ Commander". The CEENBoT™ Commander is the tool that will be used by students to create programs for the CEENBoT™. It features a graphical interface which students can use to create flow-chart like programs that are capable of being compiled and uploaded onto the CEENBoT™. Special care is taken to emphasize interface simplicity and to ensure that students cannot destroy their program accidently.

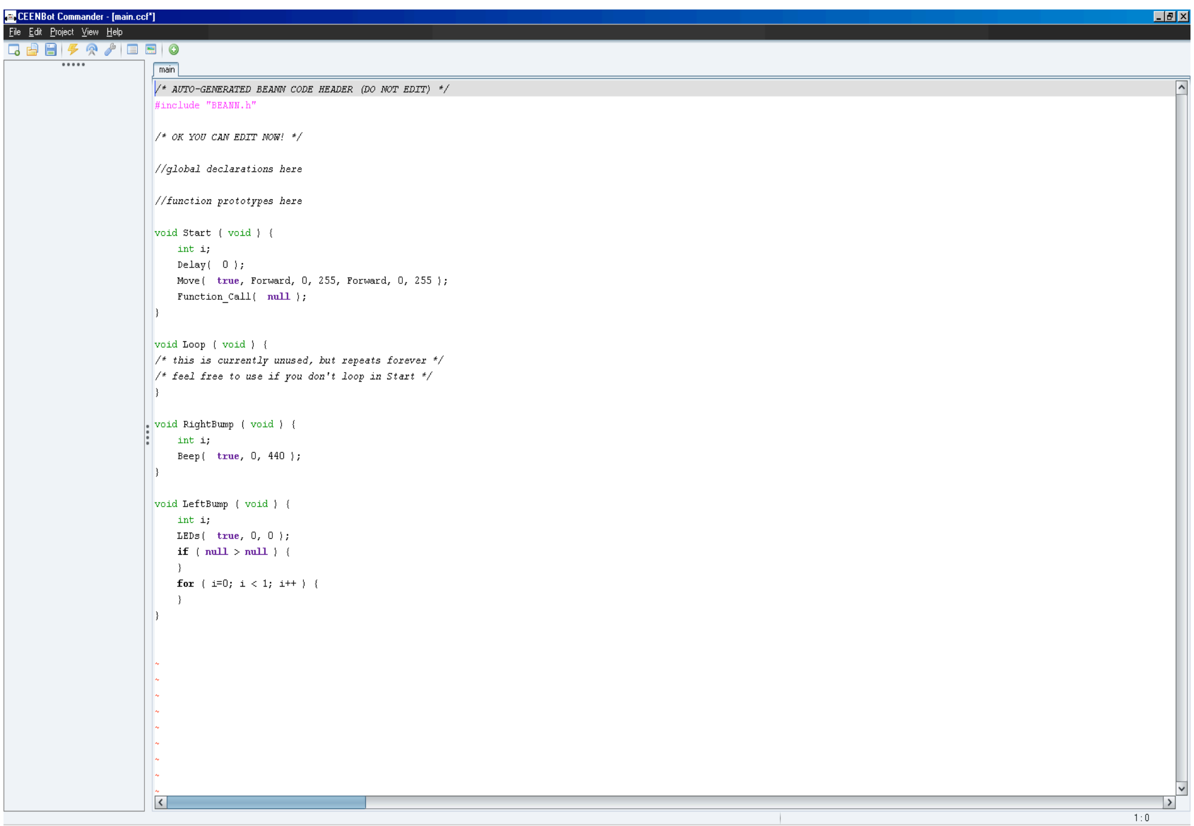
The CEENBoT™ Commander is a Java-based Integrated Development Environment using a customized and designed graphical programming language developed by the technical team and some University of Nebraska Computer and Electronics Engineering students. It offers a way to graphically and textually edit CEENBoT™ programs from a Windows or Macintosh based PC. The CEENBoT™ Commander software repository is accessible for beta pilot versions at: http://ceenbot.cet.unomaha.edu/. From this site the current test versions of the software can be downloaded and freely used, and some SPIRIT teachers are already doing so.

The narrative that follows shows the current status of the CEENBoT™ Commander, prototyped in the summer of 2009. The software was designed to interface with an ARM7-type microcontroller, the centerpiece of the CEENBoT™ hardware re-design, currently in progress. The example graphic provided is the CEENBoT™ Commander Splash Screen.

The CEENBoT™ Commander Integrated Development Environment (IDE) will allow users to drag and drop programming elements for creating stimulus-based robot program logic flow, using intuitive block elements. The following elements are currently supported with others planned: Stimuli (Bump Right, Bump Left), Output (Delay, Move, Beep, LEDs, Random), Flow Control (If, Loop), and the creation of designated Variables and Functions.



In order to provide a bridge between the CEENBoT™ Commander's simple graphical block programming and the more formal C-language programming, an option also exists to view textually, the behind-the-scenes C-code generated by the graphical program. This feature adds rich educational value to the platform in that while it allows inexperienced programmers to quickly create programs for the CEENBoT™ with no prior programming experience, the C-code view then helps them to learn how the program would be written in C as they progress in programming knowledge and skills.



Manufacturing Plans and Marketing Results to Date:

Providing enough CEENBoTs™ to meet teacher demand evolved to be a very significant concern that surfaced in the later two years of the SPIRIT-ITEST project. In various conversations with administrators in the University of Nebraska system, it was identified that the production of robots could be better supported by establishing a University of Nebraska start-up company to produce the educational robot platform, and was named CEENBoT™ INC., and has been endorsed by the University of Nebraska. The new university startup company is seeking a sole source provider agreement with the University of Nebraska to provide educational robots to the SPIRIT project at the University of Nebraska. Additional personnel have been retained to provide engineering technical support to meet existing project orders and to streamline procurement and manufacturing capability. A NSF SBIR Phase I grant (NSF #0945280) was also awarded in November of 2009 that will assist CEENBoT™ INC. in these early formative stages, and to help the company produce the first set of robots.

Mr. Dennis Deyen has been recently appointed Chief Technology Officer of CEENBoT™ Inc. Mr. Deyen has 23 years of expertise in the management of embedded product design and switchgear design for the transmission and distribution of power. He has provided consulting services for the development and production of custom MRI antennas for GE magnetic resonance machines as well as embedded RF solutions. He has a B.S. in Electronics Engineering Technology from the University of Nebraska and has recently completed a 6-month Management Training course with Best Care EAP and the Small Business Entrepreneur Program from the Kauffman Foundation. Mr. Deyen provides management leadership in the areas of compliance engineering, reliability, design for manufacturability, design for testability and ISO9001 procedures development, providing cost-effective solutions in lean manufacturing.

Significant school district demand for the CEENBoT™ is already being experienced by the SPIRIT project within the local Nebraska area, and we are gearing up to be able to meet demand on a national scale, which looks challenging but feasible. Manufacturing efficiencies are being explored to reduce the time to prepare both kits and assembled robots. Consultants are reviewing current practices and we are undertaking improvements in preparation for ramping up production to meet the demand of various educational, university and private constituencies. In the interim period, retired faculty and staff are being used to assist in producing the initial parts during the transformation to greater levels of automation.

Another company with a national potential for outreach and support of distribution of the CEENBoT™, is HobbyTown USA and we are continuing discussions with this organization. They are already assisting our cost cutting efforts by finding lower costs for screws, bolts, nuts and other attachment items. Given our experience with middle school students and school district involvement to date, HobbyTown USA is also interested in perhaps distributing the CEENBoT™ in kit form to educators and other customers across the nation. We are now looking further at the viability of this potential partnership and other similar ones.

Current demand and market research, including industry review, education conferences, in-depth interviews and trade references have indicated that the CEENBoT™ market consists of four segments: K12 schools, colleges and universities, after-school programs (for-profit and not-for-profit) and the private hobbyist industry. The potential educational market includes:

1. Elementary and middle schools
2. High schools
3. ECE (Electrical & Computer Engineering) colleges
4. Community colleges and trade schools
5. After-school clubs and summer camps
6. Hobbyists

Potential future educational distribution possibilities beyond U.S. K16 institutions include Department of Defense (DOD) schools (elementary, middle and high schools), after-school organizations (Girl Scouts, Boy Scouts, Girls Inc.), corporate-backed schools, robotic competitions and corporate education. These various groups particularly include organizations interested in developing their youths' STEM skills and talents by offering hands-on, educational robots for enhancing their students' educational needs. Another distribution and outreach possibility is ECE departments that wish to attract and retain high school students interested in engineering fields and careers. Thus, the student profile being targeted for CEENBoT™ initially incorporates grades 5-16 with a long-term goal of grades K-16. The SPIRIT-ITEST project has also formed a partnership with the 4H Robotics and GIS/GPS Project (NSF ITEST #0833403) in which the robots eventually to be used in that project for 4H distribution will be CEENBoTs.

To meet teacher educational robotics needs, specific educational market responses with benchmarking will be further developed. Middle school, high school and community college success will be determined by engagement in integrated STEM learning as evidenced by pilot testing and field-testing at all levels. Evidence at the university level will include student interest in engineering disciplines and as measuring increases in student retention and numbers of graduates. After-school program success will be examined with student enrollment numbers, student interest perceptions and ongoing participation in further programs. Finally, hobbyists that might work with a young person at home will be interviewed, targeting a platform that is customizable, competition-quality, and fun for building in that setting. Success in both after-school and home settings will also be examined by youth focus groups and the numbers of kits distributed, while targeting better youth STEM experiences in these settings. The estimations of the long-term distribution of the CEENBoT™ in these settings include the following.

Estimated Educational Market Size and Yearly CEENBoT™ Sales Potential

Educational Market	Estimated Market Size	Yearly Unit Sales Potential
U.S. Middle Schools[1]	27,000 Schools	5 per School
U.S. High Schools[1]	30,000 Schools	5 per School
U.S. Electronics and Computer Engineering Colleges	500 Colleges	100 ECE students / College
U.S. Community Colleges[2]	1,065 Colleges	30 Tech students / School
After-school Programs	5,000 Programs	5 per Program
Hobbyist Market[3]	25,700 Hobbyists	25,700 Hobbyists
Total Market Potential		417,650 Units

[1]publicschoolreview.com; [2]nces.ed.gov/programs/coe/2008/analysis/sa04.asp
[3]ibisworld.com/industry/retail.aspx?indid=1080&chid=1

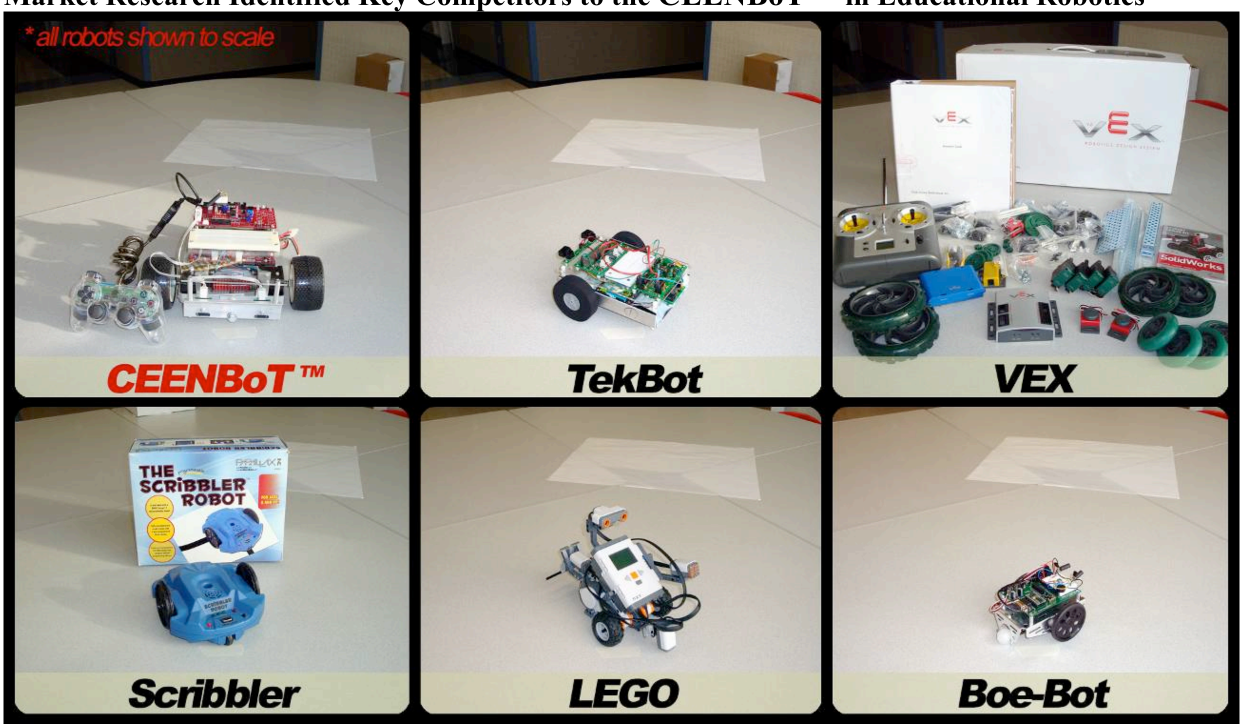
Estimated CEENBoT™ educational market penetration within 5 Years

Educational Market	Penetration Percentage	Anticipated Yearly Sales
U.S. Middle Schools	1%	1,300 Units
U.S. High Schools	0.5%	700 Units
U.S. Electronics and Computer Engineering Colleges	1%	700 Units
U.S. Community Colleges / Trade Schools	0.3%	100 Units
After-school Programs	1.6%	400 Units
Hobbyist Market	2%	400 Units
Est. Market Potential	**0.9% Composite**	**3,600 Units**
Est. Annual Sales @ $200/Unit (3,600 total) + $50/module (9,300 total)		**$1,185,000**

Some significant barriers to educational market expansion of course exist, and we are considering these barriers. These barriers include: minimal awareness of the CEENBoT™; strong competition (sales channels, existing orders, strategic relationships, established distribution chains, use through sponsored competitions); limited school budgets with small allowances for new products; and, complicated sales processes and long sales cycles.

In addition to the CEENBoT™, the SPIRIT-ITEST project's initial efforts at market research has indicated that there are five other educational robotic platforms which are already available and which are currently available for comparison purposes: TekBot, VEX, Scribbler, LEGO and Boe-Bot. Three of these platforms are suitable for a younger middle school audience, but do not provide a high level of programming capability (VEX, LEGO and Scribbler). These platforms instead provide a very limited icon driven programming environment. They also do not provide electronics design experiences or software design within the educational setting of typical school environments. The TekBot and Boe-Bot provide some programming capabilities in terms of relevant hardware and software experiences. However, the Boe-Bot comes already preassembled in some form with no soldering or electronics work. The TekBot comes closest to the CEENBoT™ in its capabilities of C programming, sensor additions, soldering and construction, and platform modifications, but is relatively fragile for middle school and high school students.

Market Research Identified Key Competitors to the CEENBoT™ in Educational Robotics



Also, extending the TekBot platform beyond introductory courses would be very challenging to schools due to a small prototyping area for electronics circuits, a less than precise drive motor system, the lack of a quick connect battery system and in general, the somewhat flimsy superstructure. A poor superstructure (as found in our initial SPIRIT-ITEST use) is particularly problematic for educators, since robotics in elementary, middle school, and high school classrooms get bounced around and roughly handled by students quite frequently. A comparison of these educational robotic platforms with the CEENBoT™ is shown below.

Advantages of the SPIRIT CEENBoT™ Educational Robotics Platform						
Feature	**CEENBoT**	**LEGO**	**TekBot**	**Boe-Bot**	**Scribbler**	**VEX**
Capacity for self-design hardware modifications	Very High	None	High	Medium	Low	High
Can be used in ECE course sequences including upper division?	Yes	No	Yes *(limited)*	No	No	No
Microprocessor Design and Programming?	Yes	No	Yes	Yes	Limited *(K-8 only)*	No
Graphical programming interface (multiple languages)?	Yes	No *(GUI only)*	Yes	No	No *(GUI only)*	No *(GUI only)*
Capacity for additional sensors (e.g., GPS, video, Wi-Fi)?	Yes	No	Yes *(limited)*	Yes *(limited)*	No	Yes *(limited)*
Parts from readily available sources? *(e.g., RadioShack)*	Yes	No	Yes	Yes	No	Yes
Low cost for basic unit? (<$250)	Yes *($175)*	No	Yes *(<$120)*	Yes *(<$160)*	Yes	Yes
Outdoor robustness?	Yes	No	No	No	Yes *(limited)*	No
Soldering skills, circuit design, and electronics design?	Yes	No	Yes	No	No	No
Capacity for middle-high school classrooms / clubs / after school?	Yes	Yes *(limited)*	Yes	Yes	No	Yes
Maps to K-12 STEM Disciplines with cyberinfrastructure?	Yes	No *(K-8 only)*	No	No	No *(K-8 only)*	No

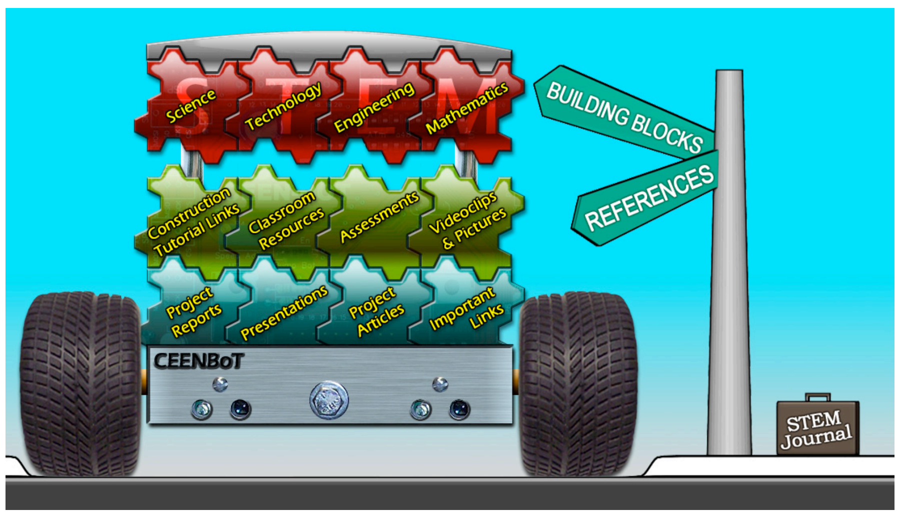
Thus, our educational market research has shown that for the successful distribution of the CEENBoT™ to schools, we must be able to satisfy five key attributes: 1) to efficiently manufacture, market, and distribute CEENBoT™ robots, 2) to build and strengthen relationships with strategic customers and educational partners, 3) to cut costs and strengthen financial positions, 4) to build and strengthen distribution channels with schools, and 5) to improve and adapt the CEENBoT™ and the SPIRIT cyberinfrastructure to meet educator needs.

SPIRIT Lesson Results to Date:

The SPIRIT-ITEST professional development effort included a component where trained teachers developed lessons for their classrooms. These developed lessons are now being further refined in the DRK12 efforts. As of February 2010, a total of 120 fully completed

AEIOU Lessons, representing all four STEM areas have been developed, edited, and posted to the SPIRIT website. Nearly 70 other lessons are in various stages of lesson development, editing, and refinement. The posted lessons are interdisciplinary and involve interrelated STEM concepts, as consistent with educational robotics. The lesson writers have diligently went through many rough and previously drafted lesson ideas and found "the best of the best". Additional writing efforts have also concentrated on the instructional component (I) of the modular lessons to be sure the concept instructional base has been well developed. Along side of the full curriculum lessons, thirteen games to explore CEENBoT™ movements have also been created, edited and posted. Lessons currently available to teachers piloting the lessons include: Science – 49 completed lessons (and 31 different I components), Technology – 8 completed lessons (and 12 different I components), Engineering – 10 lessons (and 7 different I components), and Mathematics – 43 completed lessons (and 27 different I components), and 10 other miscellaneous lessons. The writing of mathematics lessons has been particularly emphasized, with a special focus on introductory algebra. All lessons can be viewed under their primary headings at the SPIRIT lesson website of:

http://www.ceen.unomaha.edu/TekBots/SPIRIT2/

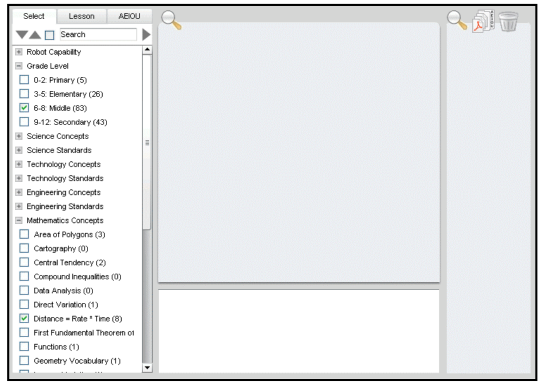


This website also includes a variety of password protected draft lessons, in various stages of development, under the Science, Technology, Engineering, and Mathematics, as well as construction tutorial links, classroom resources, student assessments, videoclips and pictures, project reports, presentations, project articles, and important links. These sections of the website will all be further populated as the SPIRIT curriculum continues to grow and evolve.

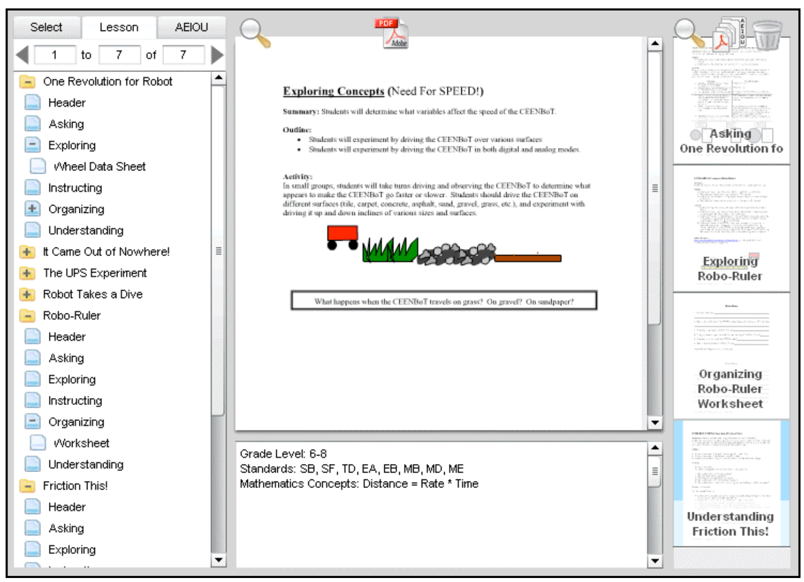
Cyberinfrastructure Results to Date

Although the SPIRIT-ITEST project focused on teacher professional development, the follow-up work on the teacher's educational robotics lessons and the curriculum efforts in the SPIRIT 2.0-DRK12 led to a cyberinfrastructure support mechanism for these lessons. This lesson delivery system continues to evolve in ways that support the teacher lesson development and usage. To date, the cyberinfrastructure includes a working database structure, lesson query methods, and lesson uploading and tagging tools. The increased number of lessons and lesson tags has motivated a few enhancements to the user interface as well as ways to clear all tag selections, search all tags, and view search results by pages. The cyberinfrastructure prototype is now able to handle thousands of lessons with tag counts that are typically two orders of magnitude higher in ways that are efficient and intuitive, making for a more effective educator experience in locating SPIRIT lessons.

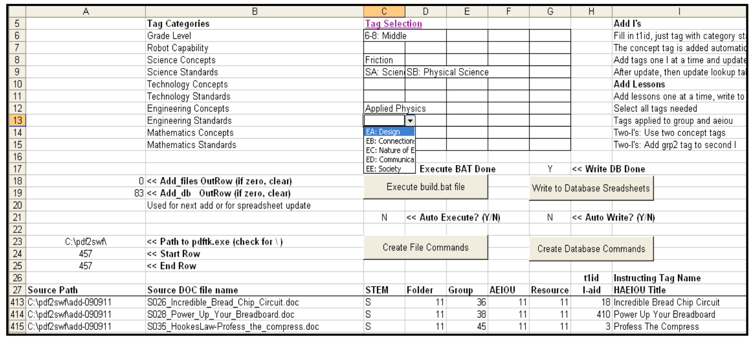
As described previously, SPIRIT instructional components are divided into five categories: Asking, Exploring, Instructing, Organizing, and Understanding (AEIOU). Component categories are stored individually as files and are accessed through a system of hierarchical tagging. An online database stores category and tagging information that is displayed under the "Select" tab. The teacher first opens a tag category under the "Select" tab such as Robot Capability, Grade Level, or Science, Technology, Engineering, or Mathematics (STEM) Concepts or Standards, and makes selections within the tag categories. The teacher can then view component information based upon the originating "Lesson" or based upon the "AEIOU" component type using the associated tabs.



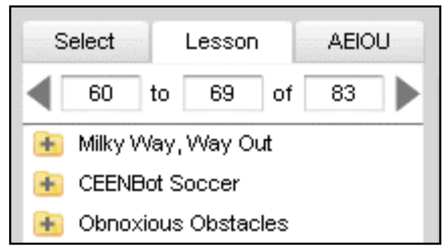
Under the Lesson tab, folder icons are displayed for each originating lesson grouping. The lesson folders can be opened to show the lesson components and resources. The large center window displays the associated page when the user clicks on a lesson component or resource. The text area below the center pane displays the standards-based tag information for the component. The teacher user can then drag and drop the displayed item from the center window to the far right window to mix-and-match lesson components and resources, and thus create a customized lesson grouping which can be printed as output in a Portable Document Format (PDF) file by clicking the lesson group PDF icon at the top of the far right pane.



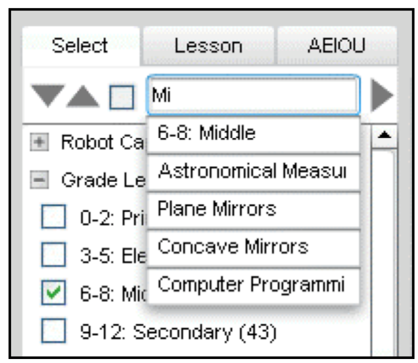
Recent developments in the SPIRIT-ITEST no cost extension have also implemented more efficient protocols for managing the expanding number of lessons in the database. The database structure and query commands were redesigned to optimize the time for search and selection. The entry of lessons permits that the AEIOU components be split into separate files and individually tagged which can be very labor intensive. A spreadsheet support tool was developed where the lesson information is entered, then spreadsheet macro programs create the file manipulation and renaming commands. The spreadsheet tool also provides for the entry of tag information and creates the database commands for lesson grouping and tagging. The spreadsheet tool has been an efficient way to prototype the process of lesson entry into the server file system and database.



A navigation bar was also added under the "Select" tab to help teachers locate and choose among the increased number of tag categories and tags. Teachers can open or close all tag categories, clear all selections and can do contextual searching for lesson tags. A navigation bar was also added to the "Lesson" and "AEIOU" tabs which displays the lessons in pages showing the first and last lesson number on the page and the total number of lessons based on the chosen tag selection.



The SPIRIT cyberinfrastructure prototype thus provides a means for the educator to locate lesson components and resources using transparent filtering and intuitive interactions. As the number of lessons has increased, the user interface has been extended in ways that maintain a simple user interaction model. The database structure and query commands were also redesigned to quickly return results.



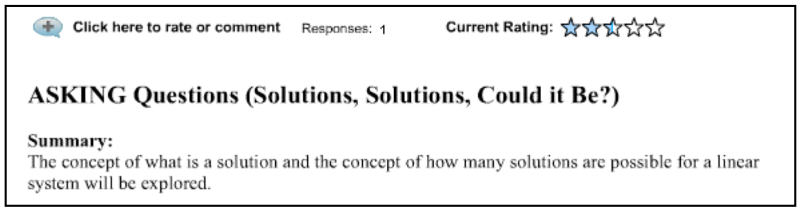
The SPIRIT cyberinfrastructure prototype can be viewed at: http://spirit.unomaha.edu

The educators that have started using the cyberinfrastructure prototype have made some initial comments on database feedback forms and in person, indicating a need for a tutorial on basic usage and operation. In response, a help button was also added that links to an animated demonstration of how to search and view lesson components and build custom lessons. The SPIRIT project is continuing to routinely get feedback from users to refine the cyberinfrastructure operations.

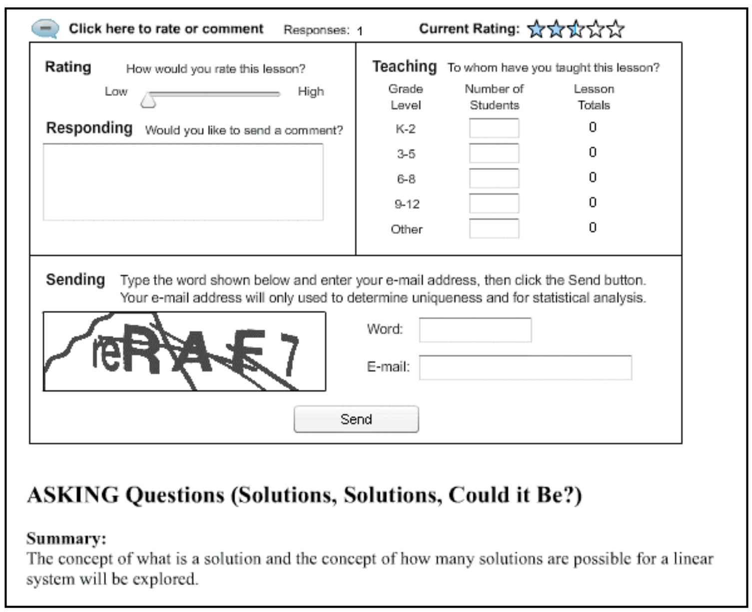
Extensions to the cyberinfrastructure database being considered for the near future include grouping lessons by word frequency analysis, usage statistics, and user evaluation. All extensions could be used in developing alternative lesson search methods that could use software suggestions to teachers rather than topic selection. Word frequency analysis involves pre-scanning the lessons and recording in the database all words with a relatively low frequency and which lessons contain those words. The word list could be used as an alternative or extended set of tags for lesson selection. Usage statistics could involve recording the clicks and drags of how the cyberinfrastructure is being used and which tags and lessons are being selected and what components are being included in custom lessons. User lesson evaluation could also collect user ratings for each lesson component through an evaluation form. The usage statistics and educator evaluations could be used to rank the lessons by instructional popularity which could be added to the lesson search options so that the most popular lessons could be located for educator use and less popular lessons could be reviewed, edited, or perhaps eventually removed. Our cyberinfrastructure team is now considering these potential enhancements.

A new area in development of the SPIRIT cyberinfrastructure centers on the teacher evaluation and implementation of lessons in the database. While searching, reading, and selecting lessons, a teacher will be able to post an evaluation or comment on the entire lesson or an individual lesson component. When a teacher uses a lesson in their classroom they can also return to the cyberinfrastructure interface to rate or comment on the lesson. The lesson author or editor can review the ratings and comments and make changes and updates to the lesson or the database.

When first viewing a lesson or component, only the top line of the rating form is visible which shows the number of responses and the average rating in filled stars. Clicking on the comment icon (plus sign) will then reveal the entire form along with the lesson that allows the teacher to rate the lesson.



The data collected on the form includes an overall rating of the lesson, a comment about the lesson, and the number of students that have worked with the lesson by grade level. The rating information is added to the overall average rating and appropriate comments may be added to the lesson display after the lesson author or editor has reviewed the comments. The numbers of students that have interacted with the lesson can also serve as additional lesson evaluation information. A "CAPTCHA" word and an e-mail address must be entered to send the form. The "CAPTCHA" word will help secure the form from automated attacks and the e-mail address will help define the uniqueness of the respondent and give some indication about the number of respondents.



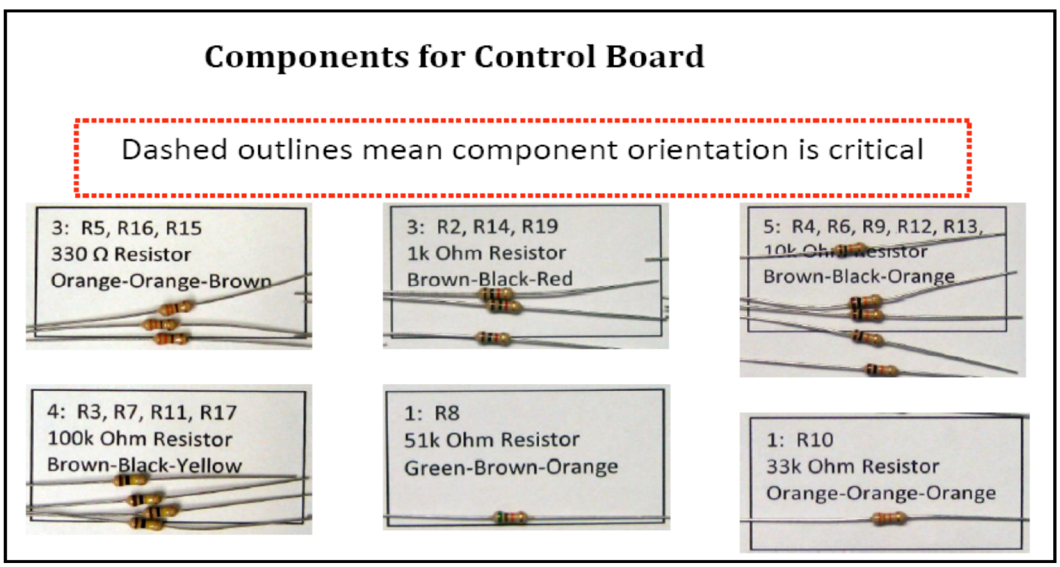
The cyberinfrastructure stores the form data in the database along with the other lesson search criteria allowing the collected data to assist in lesson display and selection. Database search results can be modified based on the evaluation data so that the most popular lessons are displayed first, for example. Other types of lesson suggestions will include all lessons highly rated by an individual respondent or other lessons in the same subject or content category used by an individual teacher respondent. The appropriate comments that are included with the lesson display will also support the refinement and further development of the lessons and concepts in the classroom environment.

Construction Tutorial Development Results:

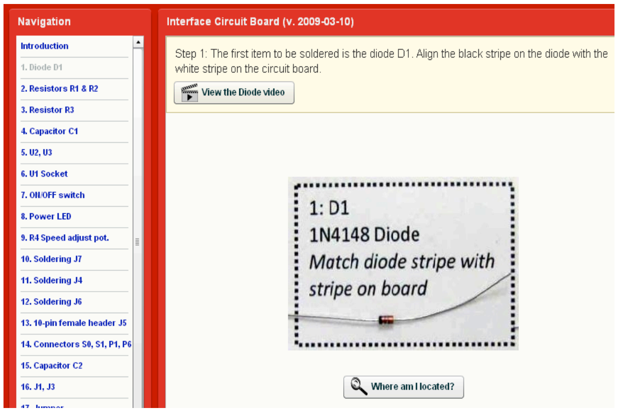
There has been significant progress on robot construction tutorials throughout the SPIRIT-ITEST project to support the use of the CEENBoT™ in the classroom. These tutorials are found on the general website by clicking on the prominent CEENBoT™ tutorial banner (http://www.ceen.unomaha.edu/TekBots/), where constructional materials are accessible.

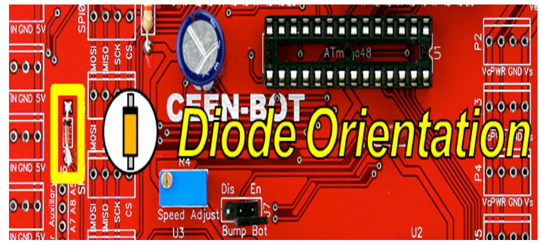
The construction tutorials are divided into modules corresponding to the different circuit boards in the robot and the assembly of all the pieces into the final CEENBoT™. Each module takes about one to four hours to complete depending on the experience of the student.

The instructions have evolved from a narrative description of how to assemble the parts to an interactive Flash presentation where each step is described on an individual slide. Narrative is kept to a minimum and embedded video clips and clickable assistance is provided. Parts for each board are identified separately. The first step of each module is to place the parts onto a "parts map." This helps ensure that the components are placed correctly.
The interactive instructions guide the educator or student through the placement of each component. The steps are listed in a table on the left side of the screen. This ensures that none of the steps are omitted and that the correct sequence is used. The main part of the instruction shows the part as it is seen on the parts map with a short description of what needs to be done. Many of the steps include a link to a video-clip to help with specific constructions.



If the student or educator is unsure of where the component is located, he or she can click the *"Where am I located"* link button to see a magnified photo of the location of the component on the board. The step-by-step instructions have resulted in significant improvements in the CEENBoT™ assembly process. Much less educator time is needed to explain how to perform the construction process and the individual steps have eliminated most of the problems of placing components in the wrong location.





Graduate Course Results to Date:

As mentioned, to help with teacher training, the SPIRIT project is also striving to develop a graduate course for educational robotics, where teachers will eventually be able to enroll online for graduate credit nationwide. This class focuses on the critical integration, articulation, and differentiation aspects of Science, Technology, Engineering, and Mathematics (STEM). The purpose of this course is to prepare graduate students to incorporate the research and practices of STEM education, especially within the context of educational robotics, at the elementary, middle and secondary levels. The dynamic nature of advancements in the core areas of STEM and educational robotics require that teachers be able to share current developments in a rapidly advancing technological environment, and thus, the course is striving to prepare teachers of STEM coursework to meet the challenges of their educational profession in a changing world. Four overarching course themes include: Understanding the importance of STEM education, the use of robotics in the curriculum, designing and implementing immersive learning environments, and encouraging curiosity and problem solving. The class meets currently in a hybrid fashion including a traditional classroom environment with a mix of online collaboration and learning. Eventually, it will be offered fully online to interested teachers around the country. The course has been offered twice to date in smaller prototype formats (N=21) and received some encouraging evaluations from the participating teachers. Using a 5-point scale, ranging from a score of 1 (which represented strongly agree) to a score of 5 (which represented strongly disagree) the course participants responded that they were "satisfied with the amount I learned in the course" (mean of 1.69); "this course was well organized" (1.82), and that "this course helped me to think in new ways" (1.25).

Teacher Training Results to Date:

In pursuit of its curriculum development effort and as of February 2010, a total 119 teachers have now been trained in extended summer workshops and another 44 teachers have been trained in graduate courses and credit-based independent study options. These 163 teachers also developed lessons and curriculum materials for their own classroom, which became some of the raw material for further SPIRIT lesson development and for related educational materials that have been indexed within the SPIRIT database and website (such as an engineering notebook), after significant refinement and editing by the SPIRIT team.

To date, a total of 67% of the trained teachers have been female and 5% have been minority teachers. The female participation has been encouraging, since the SPIRIT project has been especially interested in getting the participation of women teachers. An extensive teacher survey was given at the beginning of the training workshops and then again at the end. The beginning survey asked for basic biographical information, professional qualifications, teaching experience, and professional development. A series of questions also measured perceptions about project-based learning (PBL) and science, technology, engineering and mathematics (STEM). Another set of questions was designed to measure participants' evolving experiences and expectations with the SPIRIT project. The ending survey repeated the PBL and STEM questions and asked three specific open-ended questions about the teachers' experiences of the professional development experience that they had just completed. Responses to the open-ended questions were reviewed and coded into categories. Reliability of the subscale for perceptions about PBL was measured using ten items. Cronbach's Alpha for the PBL scale was .75, which is a moderate level of reliability. Reliability of the subscale for perceptions about STEM was measured using only 10 of the 13 items administered, as three items did not perform well and were adversely affecting reliability of the scale. Using just the 10 acceptable items, Cronbach's Alpha was .75, which is an acceptable level of reliability.

SPIRIT training has now been undertaken in a total of four summers, three summers related to the initial ITEST Project which involved a total of 97 teachers, and one summer replicating the SPIRIT model with a small state funded grant, involving 22 teachers. Training in the first three years (2006-2008) took place at the Peter Kiewit Institute in Omaha, Nebraska and training in 2009, was conducted at Central Community College in Columbus, Nebraska. The 2009 Columbus training was also trying to see if the training could be replicated at a community college, if given some relatively basic help from the SPIRIT education and technical teams. This 2009 training effort was paid for by a small grant from the Nebraska Department of Education (requiring no NSF funding), and closely followed the model established with NSF funds, and was an attempt at working toward sustainability of the summer training institutes.

For the 97 teachers trained in previous summers (2006-2008) the results of the teacher survey were relatively encouraging from year to year. The questions that evaluated participants' perceptions of PBL and STEM education asked teachers to rate their agreement to a variety of statements using a five-point scale ranging from "strongly disagree" to "strongly agree." For analysis purposes, and to reflect the ordinal level of data within the assessment instrument, the scale presentation was transformed to a numeric scale of 1 to 4. Dr. Mike Timms, the managing director of the NSF Center for the Assessment and Evaluation of Student Learning (CAESL) suggested this modified analysis approach. Stronger agreement (higher scores) on the scale indicated that teachers had greater familiarity with PBL and STEM, and that they valued them as beneficial to their students. There were distinct changes in how experienced teachers felt on a number of aspects of the content and teaching covered.

The following summarizes the perceptions of the teachers from the four teacher training institutes that have been conducted to date in the SPIRIT project, three funded by the initial ITEST project (2006-2008) in Omaha, Nebraska, and the later one funded by the Nebraska Department of Education (2009) at the community college in Columbus, Nebraska. The later workshop represents a replication process and a step toward sustainability of the teacher training, where the community colleges might undertake the educational robotics teacher training with guidance from the SPIRIT team. It was felt that community colleges would be a good source for host professional development sites with the potential expansion of educational robotics support across the nation.

The initial teacher training results from the first three Omaha workshops follow. The first cohort of teachers' ratings on five of the seven factors that were components of the workshops increased one category on the four-category scale. In engineering, electronics, and robotics, teachers moved from expressing, on average, no experience to feeling that they have a low amount of experience as a result of the workshops. On their average ratings for computers and project based learning, they moved up from low to medium. In the 2nd cohort, participating teachers' perceptions of their experience also rose, but only on two topics. The changes occurred in engineering and robotics, two of the major themes of the workshop. In the 3rd cohort, teachers' perceptions of their experience changed the most, which was likely attributable to the fact that there was a greater proportion of beginning teachers in the group (i.e., teachers with 2 years or less experience), so their room for growth was greater. In all cohorts, teachers' perceptions changed the most in the specific topics that were a particular focus of the workshop trainings, which primarily included engineering, electronics and robotics.

Changes in Teacher Perceptions from SPIRIT Trainings (Cohorts 1-3)

	Cohort 1 (2006)			**Cohort 2 (2007)**			**Cohort 3 (2008)**		
General Experience in	**Before**	**After**	**Change**	**Before**	**After**	**Change**	**Before**	**After**	**Change**
Engineering	1	2	1	1	2	1	1	3	2
Electronics	1	2	1	2	2	0	1	3	2
Robotics	1	2	1	1	3	2	1	3	2
Programming	2	2	0	2	2	0	1	2	1
Computers	2	3	1	3	3	0	2	3	1
Cooperative Learning	3	3	0	3	3	0	2	3	1
PBL	2	3	1	3	3	0	2	3	1

The teachers in the sustainability replication trained at Central Community College were also asked to rate their level of experience in the seven topics that were covered in the workshop training. In three of the seven categories, (Engineering, Robotics and Cooperative Learning) teachers' most common rating (mode) increased one category. These results were similar to those observed in the second year of the previous SPIRIT project, but not as high as those seen in the first and third years.

Changes in teacher perceptions (Replication Cohort 4 – 2009)			
General Experience in…	**Before**	**After**	**Change**
Engineering	2	3	1
Electronics	2	2	0
Robotics	1	2	1
Programming	2	2	0
Computers	3	3	0
Cooperative Learning	3	4	1
PBL	2	2	0

In further analysis at the community college replication site, the mean scale score for teachers on the PBL scale rose from 2.7 at the start of the workshop to 3.1 at the end, which was a statistically significant increase ($p<.001$, $t=4.23$, $df=17$) although it was not a full category increase. Similarly, the mean scale score for teachers on the STEM scale rose from 3.0 at the start of the workshop to 3.4 at the end, which was also statistically significant increase ($p<.001$, $t=4.04$, $df=17$), even though it was also not a full category increase.

In all four of the summer professional development workshops, teachers made many positive comments in open-ended survey questions about how they had been impressed by and learned from the hands-on laboratory sessions in the workshop. More than a quarter of the comments were about the building of the robots. Participants in all years felt that the workshop in general, as well as the session on developing lesson plan ideas and sharing them, would be very helpful with planning instruction for their students. Teachers also commented that they had gained a better appreciation of engineering in general and the course and career opportunities that could be open to their students. Teachers also commented favorably about the diversity of experience of the workshop presenters and the enthusiasm that they brought to the topics they facilitated. Also, they liked the opportunity to work with other teachers and felt that the sessions gave them "concrete examples for applying in the classroom."

In all four cohorts, the comments about potential improvements to the workshops primarily related to spending more time on various topics, in particular on the construction of the robot and the associated electrical theory and electronics. Approximately one-half of improvement suggestions were about improving the content of sessions, the time devoted to particular sessions, and the presentation strategy. Teachers found the content of the workshop challenging both in learning about electronics and engineering, and in developing some of the skill subsets needed like soldering.

Student Criterion Referenced Test (CRT) results:

As an initial preparation for more formal pilot and field-testing of the SPIRIT activities, the project leadership worked closely with the Omaha Public Schools to investigate possible patterns within the student criterion-referenced test scores of the students taught by the SPIRIT teachers. A total of 29 groupings of these mathematics and science test scores (representing

N=1058 students) have been examined to date and have been compared with school and district averages. Some groupings at the 7th and 8th grade levels represented multiple classes of a teacher. Of the 29 groupings of students examined, represented by their teacher's participation in a SPIRIT workshop, a total of 21 groupings (72.4%) scored above their school averages on the related criterion referenced tests in mathematics and science, and a total of 23 groups (79.3%) scored above their district averages. The limitations of using district developed criterion referenced test scores were quickly apparent within this analysis, and a significant limitation was identified, in that these assessments might be taken, or even retaken, at various times in the school year. Thus, although this very limited evidence cannot directly support any possible cause and effect conclusions, it was still encouraging, since many of these SPIRIT groupings are taken from some of the traditionally poorest performing schools in the Omaha Public School system. The SPIRIT leadership team selected teachers are now engaging in more carefully controlled pilot tests and field tests where more consistent assessments are used.

SPIRIT Student Criterion-Referenced Test Score Comparisons (2008 and 2009 Scores)					
Group, Grade, N = (CRT Number) *Total N = 1058*	**CRT SPIRIT**	**CRT School**	***SPIRIT above?***	**CRT District**	***SPIRIT above?***
Group 1: 5th, N=22 (Math)	**89.4%**	92.3%	Below	88.9%	**Above**
Group 2: 5th, N=22 (Science)	**90.7%**	77.8%	**Above**	75.3%	**Above**
Group 3: 5th, N=19 (Math)	**94.7%**	87.5%	**Above**	81.1%	**Above**
Group 4: 5th, N=22 (Math)	**90.9%**	92.3%	Below	81.2%	**Above**
Group 5: 5th, N=23 (Math)	**100.0%**	85.9%	**Above**	81.2%	**Above**
Group 6: 5th, N=8 (Math)	**87.5%**	86.1%	**Above**	81.2%	**Above**
Group 7: 5th, N=19 (Science)	**100.0%**	88.8%	**Above**	88.9%	**Above**
Group 8: 5th, N=22 (Science)	**100.0%**	96.9%	**Above**	88.8%	**Above**
Group 9: 5th, N=23 (Science)	**100.0%**	95.8%	**Above**	88.9%	**Above**
Group 10: 5th, N=8 (Science)	**87.5%**	91.7%	Below	88.9%	Below
Group 11: 6th, N=14 (Math)	**85.7%**	78.0%	**Above**	75.3%	**Above**
Group 12: 6th, N=16 (Math)	**62.5%**	78.0%	Below	75.3%	Below
Group 13: 6th, N=16 (Science)	**87.5%**	51.2%	**Above**	75.3%	**Above**
Group 14: 6th, N=25 (Math)	**88.0%**	91.4%	Below	73.5%	**Above**
Group 15: 6th, N=9 (Math)	**66.7%**	64.7%	**Above**	73.5%	Below
Group 16: 7th, N=74 (Science)	**78.8%**	68.6%	**Above**	68.6%	**Above**
Group 17: 7th, N=95 (Math)	**85.1%**	83.9%	**Above**	84.5%	**Above**
Group 18: 7th, N=26 (Math)	**93.4%**	83.9%	**Above**	84.5%	**Above**
Group 19: 7th, N=100 (Science)	**79.6%**	76.9%	**Above**	68.6%	**Above**
Group 20: 8th, N=76 (Math)	**87.5%**	86.1%	**Above**	84.5%	**Above**
Group 21: 8th, N=46 (Math)	**97.0%**	86.1%	**Above**	84.5%	**Above**
Group 22: 8th, N=79 (Math)	**89.4%**	86.1%	**Above**	84.5%	**Above**
Group 23: 8th, N=28 (Math)	**99.4%**	86.1%	**Above**	84.5%	**Above**
Group 24: 8th, N=14 (Math)	**94.9%**	86.1%	**Above**	84.5%	**Above**
Group 25: 8th, N=13 (Math)	**75.0%**	83.9%	Below	84.5%	Below
Group 26: 8th, N=11 (Math)	**57.7%**	83.9%	Below	84.5%	Below
Group 27: 8th, N=19 (Science)	**56.2%**	68.6%	Below	68.6%	Below
Group 28: 8th, N=118 (Science)	**78.8%**	76.9%	**Above**	68.6%	**Above**
Group 29: 8th, N=112 (Science)	**77.8%**	76.9%	**Above**	68.6%	**Above**

The Research Limitations of District Criterion Referenced Tests:

In our initial investigations of student criterion-referenced test data, and in preparation for further curriculum-related pilot tests and field tests, we have found that the use of existing criterion-referenced test scores are substantially limited in their ability to measure student achievement within this project's context. From our data analysis, it is apparent to us that district criterion-referenced test score limitations include the following:

a) Limitations Related to CRT Teacher Administration: Because teachers can have their students retake the CRTs as desired, there is a significant testing difference in how teachers complete this retake process, and thus the scores don't compare reliably across classes, even within a specific school or district.

b) Limitations Related to District CRT Variation: The Nebraska (and other state) CRTs vary widely across districts, and thus, it is difficult to use these instruments across districts for effective pilot testing and field-testing efforts that mix schools or districts.

c) Limitations Related to District CRT Timing: The timing of the CRTs also vary widely from teacher to teacher, and district to district, making the variable timeline of a pre-test to post-test schedule a significant limitation.

Thus, for pilot and field-testing of the evolving SPIRIT curriculum, we have decided to use a different strategy for looking at academic performance that is more reliable across districts and teachers. Conveniently, a sister project that we are closely collaborating with, the 4-H Robotics and GIS/GPS Scale-Up Project (NSF #0833403) has developed four instruments that we will now be using (and have started to use in limited ways already) that include a STEM content test, a STEM attitudes/interests test, a 21st century skills reflection, and a longitudinal coursework instrument. The content and attitude tests have already been refined, and the 21st Century Workplace and Longitudinal Instruments are currently being validated. We are also working closely with the 4-H Robotics Project in the sharing of data collection strategies and assessments, which essentially map nicely to both projects, since some districts are integrating educational robotics both during the school day (focus of SPIRIT) and in after school programs and summer camps (focus of 4H Robotics). This cooperation between our two NSF projects is permitting a much better comparison across interventions and is more promising for curriculum pilot and field-testing. A more detailed description of the four instruments now follows:

1) STEM Concepts Test: This content focused instrument is a 37-item, paper-and-pencil, multiple-choice assessment, covering a variety of STEM topics including computer programming, mathematics, geospatial concepts and engineering/robotics. The assessment is based on a previous 24-item robotics assessment instrument that demonstrated a Cronbach's alpha reliability coefficient of 0.86 (Barker & Ansorge, 2007). Two experts from Carnegie Mellon University's Robotics Academy and two engineers from the University of Nebraska at Lincoln Department of Biological Systems Engineering Department validated the assessment instrument's content. The overall Cronbach's alpha reliability coefficient of 0.798 is currently reported for this instrument. New versions of the test are also being conceptualized and created.

2) Student Attitudes/Interests Test: This instrument was modeled after the Motivated Strategies for Learning Questionnaire (Pintrich, et al., 1991). The questionnaire focuses on the following eight constructs: task values/attitudes for science, mathematics, robotics and GPS/GIS, problem solving/critical thinking, teamwork cooperative learning/teamwork, self-

efficacy in robotics and self-efficacy in GPS/GIS. The task value for science includes questions like "It is important to me to learn how to conduct a scientific investigation." The mathematics task value construct includes questions like "It is important for me to learn how to make accurate measurements to help solve mathematical problems." The robotics construct asks questions like "It is important for me to learn about robotics." The GPS/GIS construct includes questions like "It is important for me to learn about GPS." In addition, problem solving skills (i.e. "I try new methods to solve a problem when one does not work") and teamwork constructs (i.e. "I like being part of a team that is trying to solve a problem") are also included. Finally the instrument examined self-efficacy in robotics and GPS/GIS concepts. The overall Cronbach's alpha reliability coefficient of 0.94 was reported as an average for previous administrations of the post attitudinal instrument. The SPIRIT project will also soon be adding GPS activities, so these additions make this new instrument particularly relevant.

3) 21st Century Workplace Skills Reflection: This instrument, which is currently undergoing validation and refinement, includes 21 questions that ask students about common workplace skills such as speaking, writing, and listening, within a STEM context. This newer assessment instrument has already been requested by several educators involved in both the SPIRIT and 4-H Robotics projects.

4) Longitudinal Instrument: This instrument is designed to ask students about their interests in high school STEM coursework, and why they are interested in such coursework, within a set of questions in each of seven short reflection sections. The instrument is being designed so that it can also be used to track students within a particular school or district, to see if students take more STEM coursework, after experiencing a course, club, or summer camp with educational robotics.

In addition to the four key instruments described above, two short lesson feedback surveys are also being used in the SPIRIT curriculum refinement process, to receive formative feedback from teachers and students who pilot particular SPIRIT lessons and activities, and then provide revision suggestions to potentially improve the lessons. These feedback forms ask teachers and students how they liked the lessons, what they believe they learned in the lessons, and how the lessons might be improved. Finally, the State of Nebraska has also developed an online career planning assessment for middle school and high school students that will be used in selected pilot testing and field-testing efforts for the evolving SPIRIT curriculum, as a way to eventually include student career interest in later analyses.

Status of Initial Pilot Testing, Field Testing and Test Site Agreements:

Since our SPIRIT efforts are now moving into selected pilot testing of lessons and the initial field-testing of lesson sets and various curriculum components, we continue to steadily expand and refine the curriculum. We have initiated work with area school districts to assist in the pilot and field-testing process, as well as to provide control groups of students (who will not be using educational robotics) to permit comparisons. We are also working toward larger field testing efforts, where large groups of lessons would be tested over a longer duration (such as a summer session or full semester) and involve larger numbers of sequenced lessons. These pilot testing and field-testing agreements have evolved steadily, and include the following progress:

1) We have received Institutional Review Board approval from the University of Nebraska Medical Center for permission to undertake pilot testing and field-testing with 12 different area school districts within the Metropolitan Omaha Education Consortium (MOEC). This includes an excellent diversity of students and educational settings. The IRB approval number is: 443-09 EX.

2) We have already successfully conducted small short duration pilot test sessions of three-hour durations, with 141 students, at Educational Service Unit #3, an educational support facility serving the MOEC schools. These results have been encouraging, particularly related to student STEM attitudes (described in next section).

3) We have arranged to have Lewis and Clark Middle School (Omaha Public Schools) undertake a large-scale SPIRIT robotics field test during 2010. This will involve 70 students in science and technology innovation classes over the duration of one semester. They will undertake a well-sequenced set of 10 educational robotics lessons that also includes the building and testing of CEENBoT™ robots. Lewis and Clark Middle School is also interested in further pilot testing and field-testing of the curriculum within summer camps. That possibility is now being considered in joint planning meetings.

4) We have organized three summer camps of four days duration each that will also undertake smaller field-tests of various sets of SPIRIT lessons, and that will be held at Educational Service Unit #3 in Nebraska. It will include 60 students and each camp will field-test a set of sequenced lessons and activities from the curriculum.

5) We are successfully arranging further control group sessions for this upcoming year. As a reward for district participation in the control group process, we are also scheduling a three-hour robotics event for students and teachers at each school district control group site, which would involve a set of robotics exploration stations that would be staffed by our team members (SPIRIT educators and engineers). This event would be conducted after the control group data is received. At a designated time period before the participation session, the teachers have the involved students take the STEM content and STEM attitude instruments. The teachers then bring those completed pretest instruments to the session, and take another set of tests before the event begins, to capture control group comparison information.

In summary, we have already had initiated agreements with the following organizations to assist in pilot testing and field-testing. Other districts and organizations are now also expressing an interest in contributing to this process. The willingness for educational organizations to collaborate in the pilot testing and field-testing process is in itself encouraging, as this demonstrates the educational value and reputation that they already see in the SPIRIT curriculum.

a) The Metropolitan Omaha Education Consortium (11 school districts) – *Pilot Testing*
b) The Omaha Public Schools Alternative Schools – *Pilot Testing*
c) Educational Service Unit #5 (representing 17 rural districts) – *Pilot Testing*
d) The Papillion-LaVista Schools – *Pilot Testing*

e) The Ralston Public Schools – *Pilot Testing*
f) The Gretna Public Schools – *Pilot Testing*
g) The Westside Community Schools – *Pilot Testing*
h) Lewis and Clark Middle School – *Field-Testing*
i) Educational Service Unit #3 (representing 15 urban districts) – *Field-Testing*

Pilot Test Results to Date:

Pilot testing during this last year of the SPIRIT project encompassed two types of pilot testing formats, which included a short-term intervention of roughly three hours in duration and three longer interventions that lasted for one semester, with about 1 to 2 lessons per week over a 16-week period. The short-term intervention undertook samples of three short lessons, while the longer intervention undertook eight well-sequenced lessons. Each intervention was facilitated by a previously well-trained SPIRIT teacher.

<u>Short-Duration Pilot Test</u>:

A total of 141 students participated in the short-term pilot testing process for SPIRIT. These students were involved in three tests of individual SPIRIT lessons, lesson components, or robotics related activities. The lessons focused on: 1) algebraic slope, using robots to move up ramps, 2) the chemistry of batteries, moving a robot that was connected to different battery types, and 3) the physics of movement, by examining the movement of different robots. This short intervention activity was also collaborated closely with the Nebraska 4-H Robotics team who participated in some of the pilot activities. That partner grant project will soon be transitioning to the CEENBoT™ robot as their operational robotics platform.

The short-term intervention (pilot test) data was retrieved in a time series design process that included a first set of pretests (given about a week before the pilot activities), a second set of pretests (given right before the pilot activities), and a final set of posttests (given right after the pilot activities). The pilot activities lasted about 3 hours with students. The participating students were recruited through the Nebraska's Educational Service Units (ESU), a set of 19 state-funded educational support organizations. The ESUs sent e-mails to schools and curriculum leaders in the Omaha area inviting their participation in the research. Schools were asked to try to target a mix of student abilities, interests, gender, and ethnicities to reflect the school's general population of students. They were asked to avoid having only interested or high ability students participate. The resulting group of 141 students was 74% male, 20% minority, and had a mean age of 11.39 years.

The content learning instrument used in the pilot testing process was from the 4-H Robotics Project and was a 37-item, paper-and-pencil, multiple-choice assessment, covering mathematics (including fractions and ratios), geospatial concepts (coordinate estimation based on location), engineering (such as gears and sensors), and computer programming (such as looping and multi-tasking). Two experts from Carnegie Mellon University's Robotics Academy and two engineers from the University of Nebraska at Lincoln Biological Systems Engineering Department had previously helped to validate the assessment instrument's content. The same instrument was used as the pre- and post-test, and a Cronbach's alpha reliability coefficient of .80 was reported for the administration of the posttest.

The attitude instrument given to the participating students, consisted of 33 Likert scale items, and was also from the 4-H Robotics Project. It was modeled after the Motivated

Strategies for Learning Questionnaire (Pintrich, Smith, Garcia, & McKeachie, 1991) and included two subsections focusing on motivation and the use of learning strategies. The overall Cronbach alpha reliability of this instrument computed earlier by the 4-H Robotics team was .95, with individual scale alphas running from .64 to .88.

Pre-post learning results. Data was analyzed by Dr. Gwen Nugent, of the University of Nebraska Center for Research on Children, Youth, Families, and Schools. A dependent t-test showed that although there was a slight increase in content test scores (Pre $M = 16.57$, post $M = 16.81$), the increase was not significant ($t(131) = .91$, $p = .36$). Thus, these results indicated that the short-term pilot testing intervention focusing on relatively short duration lessons and lesson components did not significantly impact learning on the content instrument.

Pre-post attitudinal results. The attitudinal data sets from the short-term intervention were also analyzed by Dr. Nugent. A dependent t-test comparing overall attitude scores showed that there was a significant increase in attitudes for the youth experiencing the short-term intervention ($t(123) = 6.92$, $p < .0001$, $d = .62$). The mean attitude score increased from 4.09 (pre) to 4.34 (post). To provide more insight into these increases additional dependent t-tests were run for each of the attitude scale scores. All of the scales showed a significant increase. The time series non-intervention phase (acting as a control) indicated no significant increases.

Attitudinal Measure (5-pt. scales)	Means		t (121)	Effect size d	Significance
	Pre	Post			
Task Value					
Science	4.06	4.33	6.69	.61	.0001
Mathematics	4.26	4.43	3.80	.35	.0001
Robotics	4.38	4.55	3.38	.31	.001
GPS/GIS	4.03	4.27	4.25	.39	.0001
Self-efficacy					
Robotics	3.81	4.33	7.94	.72	.0001
GPS/GIS	4.02	4.40	6.04	.55	.0001
Problem Approach	4.00	4.26	6.07	.55	.0001
Teamwork	4.23	4.40	3.70	.34	.0001

Although the short-term pilot test intervention had no impact on student learning, we really did not expect this result for such short duration interventions, particularly since these shorter interventions were mainly about curriculum improvement, as well as building student awareness and interest. It would appear that three hours of robotics activities, no matter how interesting, engaging, and well facilitated, will probably not provide enough time to cover topics with sufficient depth and structure to promote student understanding as identified on this instrument. Students are of course introduced to certain educational robotics and STEM topics during these short duration events, as integrated into the activities, but the time constraints would not seem to allow for a full exploration of concepts and processes necessary to promote learning.

While the short-term pilot testing intervention did not have a direct impact on student learning as measured by the content assessment, it did impact student attitudes, as measured by that assessment. Students' attitudes towards science, mathematics, and technology all increased from pre to post, as well as their self-efficacy with robotics. This attitude improvement result is likely also due to the fact that the activities in the short-term pilot testing interventions were specifically selected and designed to be highly engaging and motivating, with limited cognitive load. As previously discussed, the short-term nature of the pilot interventions also meant that the individual activities for this instructional setting could not contain extensive mathematics and science background material and the needed calculations to perform the tasks on this short intervention timeline. Similarly, the short duration activities could not illustrate the complete scientific inquiry or engineering design processes, which may have led to a relatively superficial content focus for these shorter pilot tests. This emphasis on the affective, as opposed to cognitive, domain appeared to contribute to the more positive views of youth in the short-term pilot intervention.

Short-term robotics interventions will continue to help us to pilot test selected elements of the SPIRIT curriculum, and also appear to be a successful way to impacting student STEM attitudes and getting students excited about robotics in general. The shorter duration pilot tests also allow us to get direct feedback for lesson improvement, using short feedback forms given to both the students and educators on how the pilot activity went, and how it could be improved. Two sample feedback forms that we currently use are included in the report appendix.

Shorter duration pilot tests also help to provide a nice reward strategy for the schools and districts that are willing to act as control group settings for us, since we can then offer them a short duration robotics event in return for piloting shorter duration lessons, that would be provided after the control group data is collected. This later robotics event may also perhaps serve a motivational role to encourage both youth and educators to seek out additional opportunities to explore educational robotics in greater detail.

Longer Duration Pilot Tests:

Three SPIRIT teachers were asked to undertake longer duration pilot tests with selected lessons of the SPIRIT curriculum over a full semester. In this process, the teachers selected eight or more lessons that would be most aligned with their curriculum. Lessons were piloted approximately every two weeks or so, and aligned with the current content responsibilities of the course. The pilot classes were generally small, due to requests from the participating school districts. Three teachers and three different classes were involved, including a middle school mathematics class (N=12), a middle school innovations science class (N=18), and a high school special engineering topics seminar (N=7). Lessons were all carefully selected, sequenced and aligned with the curriculum. Control groups were very difficult to establish in this field-testing effort. Since the same age student had participated in the short duration pilot tests (N=141), and those pilot tests had used a time series design (pre-pre-post) with a no intervention phase, that data was used as a very limited comparison group. The same content and attitude instruments (as described earlier) were also used in all the groups being examined.

The middle school mathematics teacher selected eight lessons that aligned generally with topics in introductory algebra, and undertook a one to two hour educational robotics lesson about every two weeks. The 12 participating students took the content and attitude instruments at the beginning and at the end of the semester. A total of seven males and five females participated. Using a dependent t-test, the students' scores were examined for both the content and attitude instruments. For the content instrument, a dependent t-test showed that there was a slight but significant increase in content test scores, and particularly mathematics questions (Pre M=13.25, S=3.98; Post M=15.00, S=3.02), which was significant ($t\ (11) = 2.83$, $p = .016$). For the attitude assessment, another dependent t-test was also used. The attitude scores also showed a significant increase (Pre M=127.5, S=23.6; Post M=140.3, S=17.61), which was significant ($t\ (10) = 3.23$, $p = .010$).

The middle school innovations science teacher selected eight lessons that aligned generally with topics in engineering and technology invention, and also piloted a one to two hour educational robotics lesson about every two weeks. The 18 participating students took the content and attitude instruments at the beginning and at the end of the semester. A total of ten males and eight females participated. Using a dependent t-test, the students' scores were examined for both the content and attitude instruments. For the content instrument, a dependent t-test showed that there was no observed increase in content test scores (Pre M=14.0, S=3.43; Post M=14.5, S=3.36), and was not significant (t (17) = 0.67, p = .509). For the attitude assessment, another dependent t-test was also used. The attitude scores also showed no significant increase (Pre M=130.0, S=13.9; Post M=132.1, S=9.96), and was again not significant (t (16) = 0.73, p = .471).

The high school engineering seminar teacher selected eight lessons that aligned generally with topics in engineering design, and also piloted a one to two hour educational robotics lesson about every two weeks. The 7 participating students also took the content and attitude instruments at the beginning and at the end of the semester. These students were ninth graders and represented a total of seven males participated in the all male seminar class. Using a dependent t-test, the students' scores were examined for both the content and attitude instruments. For the content instrument, a dependent t-test also showed that there was no observed increase in content test scores (Pre M=18.8, S=3.23; Post M=19.1, S=3.71), and was not significant (t (6) = 0.31, p = .766). For the attitude assessment, another dependent t-test was also used. The attitude scores also showed no significant increase (Pre M=130.3, S=8.9; Post M=136.6, S=12.7), and was again, not significant (t (6) = 1.04, p = .338).

Some Pilot Test Interpretations:

In some ways, the longer duration pilot tests had similar results to the shorter duration pilot testing effort, and illustrated that it is easier to increase student attitudes in this context than it is to increase student content knowledge. In fact, increasing student content knowledge was found to be quite challenging in this context, with only a small but significant increase in the class of the middle school mathematics teacher, while the other two longer pilot tests, and the short duration pilot test group all experienced no content increases, as measured by the content test. However, attitude improvement was somewhat more encouraging, with attitudes improving in the shorter duration pilot tests (N=141) as well as the middle school mathematics teacher longer pilot test (N=12). The attitude results also tended to be slightly improved in the other sections, but not to a level of statistical significance.

One study limitation that became obvious in the pilot and field-testing process is that the content testing process needs to be better aligned with the specific content being taught. The SPIRIT team is now undertaking revisions to the content test, and preparing several versions of the test, with more specialized questions focused on particular coursework threads, such as introductory algebra.

Artwork Added to the Curriculum:

Feedback results from teachers and students in the initial pilot testing process has also suggested that we add more “fun and engaging” visuals to the lessons and curriculum activities. The project thus found a professional graphics design artist from a local television station that was very interested in working (inexpensively) to add some interesting “cartoons illustrations” to various lessons. As part of the lesson writing process, the SPIRIT lesson writers now include an idea for a cartoon that illustrates a STEM concept in their lesson. This illustration idea is then noted at the start of the draft lesson and labeled “Cartoon Idea.” with the illustration to be added at a future date. To illustrate the lesson, Mr. Dan Wondra, the Omaha-based graphic designer at a local television station, then creates the cartoons needed. His work is both creative and impressive with some excellent and thoughtful illustrations of STEM concepts, in a kind of “editorial cartoon” style.

The cartoons include a personable CEENBoT™ that is sometimes illustrated as a female robot, and sometimes illustrated as a male robot. The cartoons are also designed to give the reader a clever and engaging visual “hint” about the STEM concept for the lesson. Humor is also provided and integrated into the cartoon visuals. Teachers and students replying to lesson feedback forms, as well as in anecdotal comments, have really embraced the cartoon illustrations, and the initial feedback in the pilot sessions has been very positive about this element when it is included. In addition to creating the cartoons for the lessons, Mr. Wondra has also created the designs for the t-shirts as part of the CEENBoT™ Showcase events, making his contributions truly an integral part of the SPIRIT project and its evolving curriculum components.

SPIRIT 2009 and 2010 Showcase Events:

In support of further partnerships with area school districts, businesses, and other partners that are so critical to helping us to refine the SPIRIT curriculum and the CEENBoT™ platform, the project held a showcase event on March 28th of 2009 and a second showcase event on January 30th, 2010. A total of 113 students from grades K-12 attended the first event along with teachers and many parents. A total of 26 schools (and 34 teachers) were represented in this inaugural event. The second event had more than 400 students participate and was held at the Strategic Air and Space Museum in Ashland, Nebraska. The Governor of Nebraska gave the opening welcome speech. Students in both showcase events participated in various robot challenges and made presentations related to robotics, and provided ideas on how they could extend or use the CEENBoT™. Teachers also presented on how educational robotics overlapped with their current curriculum goals and where such activities might further assist with student STEM achievement. There was news coverage by television stations and state newspapers. Some sponsors from business also contributed prizes to students at both showcase events. Business partners included Lockheed Martin, Union Pacific, Omaha Public Power

District, and Cox Communications. College students from both the University of Nebraska at Lincoln engineering programs and the University of Nebraska at Omaha College of Education programs helped to run the event. All student participants in the Expo received t-shirts and a robotic bug donated by the business partners, and many schools received a CEENBoT™ kit and an Electronic Snap Circuit Kit that was also donated.


Many middle/high school students, teachers, and parents attended this Saturday

Due to the success of the first inaugural 2009 Robotics Showcase, the second event on January 30th, 2010 was extremely well attended. This second showcase was a statewide event, and we partnered with the 4-H Robotics Project. The second event was called the Nebraska Robotics Expo, and will eventually, become a regional, and then a national event. We have developed strong collaborative partnerships in support of this large-scale and now annual effort, that includes the Boys and Girls Clubs Inc., the University of Nebraska System, the Peter Kiewit Institute, the Strategic Air and Space Museum, the Nebraska 4-H, and the NASA Space Grant. The further events will feature a CEENBoT™ showcase program on the SPIRIT side as well as a FIRST LEGO League qualifying competition on the 4H Robotics Project side. Working closely with the 4-H Robotics Project on the Robotics Expo, we are also attempting to examine student learning and attitudes, related to these shared events, using pretest/posttest content and attitudes tests, as well a new 21st century skills survey. Finally, we also conducted qualitative interviews to help to investigate the effect of the competition on the attitudes of girls towards STEM education coursework.

Overall, we fully expect to continue to utilize these sorts of showcase events, and to steadily expand them, as a way for teachers to share their classroom strategies and materials related to SPIRIT, and as a way for their students to get further excited about educational robotics. These events also provide a nice catalyst to further partnerships, and a provide a convenient way to engage with industry partners to enhance their collaboration, as well as to increase their understanding of what teachers and schools are trying to accomplish within the SPIRIT project and STEM education. We hope to eventually make this annual showcase event a truly national event. We believe that it can enrich both our partnerships, and our SPIRIT curriculum, by bringing even more teachers, schools, partners and creative energy into the SPIRIT project.

Student Participation in Robotics Construction:

Since one of the goals of the project related to the newer CEENBoT™ platform is to develop a more compatible robot for student construction, students have been regularly invited to build the CEENBoT™ at either their schools, or at summer and Saturday sessions at the Peter Kiewit Institute. In many ways, these student-constructions have been technical "dry runs" to see if middle and high school students can successfully construct the robot, and if they needed additional assistance within that process. The CEENBoT™ and its various versions have now had more than 100 students build the robot in these various settings. The students sometimes build the robot right along with the teachers. In fact, anecdotal observations have indicated that students were even a bit faster with the robot construction than teachers. This was an encouraging observation, as well as a useful editing contribution, since the students also found several edits to the construction directions that the teachers had missed.

3. Describe the opportunities for training and development provided by your project:

The project team has had a great opportunity to engage in very collaborative teacher training on educational robotics. The engineering experts have worked closely with education and curriculum experts in their technical instruction, and in turn, the educational experts have coordinated closely with engineers in their pedagogical instruction. The result has been an excellent group synergy and set of teacher training activities, where the exchange of ideas, suggestions, and formative review has systematically continued on both the technical and educational objectives. This has resulted in a natural and ongoing professional development process for both the engineering/technical team members and the education team members that have directly supported the SPIRIT curriculum development process, as well as the further development of the CEENBoT™ platform itself.

The SPIRIT project has also continued to refine the professional development efforts for area middle school teachers and a total of 163 teachers have now participated in extended training of 10 days or more. We have also engaged in shorter duration sessions (of several hours or a day), at the request of various school districts as well as provided one-half day awareness workshops for teachers and students related to how educational robotics can help to teach STEM concepts. To date, the SPIRIT project has trained 97 teachers in summer extended workshops at PKI (2006-2008), 22 teachers at a summer workshop in Columbus, Nebraska (2009), and 44 teachers in graduate classes (2007-2009). The Columbus, Nebraska training and the graduate class training were completed at no cost to NSF. More than 200 teachers have also participated in shorter duration training events, again, at little or no cost to NSF. These trained teachers are now providing an excellent source of the pilot testing of individual SPIRIT lessons (already underway), and more extensive field-testing to be initiated in 2010.

All project training included having teacher participants systematically look at their local curricula and the national, state, and district standards to determine the best integration or “touch points” for new robotics activities in their specific coursework. The project website contains several resource documents for each teacher in this endeavor, such as standards lists, integration suggestions, samples of student misconceptions, and a variety of other curriculum support documents, such as a spreadsheet of potential curriculum "touch points" for integration into various school curriculums.

4. Describe the outreach activities your project has undertaken:

Outreach and teacher engagement has been critical to the SPIRIT project as we have worked systematically to integrate teacher training, curriculum development, pilot testing, and curriculum refinement activities. Faculty and staff from the College of Education have frequently observed and videotaped SPIRIT lessons in action, and have worked closely with teachers who are pilot testing lessons, and who have agreed to do larger field-testing this next year. Engineering students and faculty from Peter Kiewit Institute have also been routinely invited to come to the schools to observe and participate in the CEENBoT™ construction activities. Outreach activities have also included local science and engineering fairs and as well as the now annual SPIRIT Showcase, in which SPIRIT teachers and their students participate in various collaborative and competitive activities, and give presentations on their efforts (see pictures and overview in the report Appendix).

The Omaha Public Schools and the Metropolitan Omaha Education Consortium (12 area school districts) have indicated that the SPIRIT efforts dovetail very well with the existing science and mathematics curriculum in these schools. Special attention has been paid by this initiative to aligning with the national science, mathematics, and technology standards, since these standards have been of particular interest to MOEC and OPS, and form a foundation to the evolving SPIRIT curriculum. Many area teachers and administrators have sent thank-you notes that praise that the design and format of the teacher training efforts and outreach, as well as the SPIRIT lessons and its evolving cyberinfrastructure. SPIRIT teachers are also continuing to write STEM lessons and to contribute STEM lesson ideas based upon educational robotics, which integrate various skills and knowledge gained from their previous SPIRIT training activities, and that align with their own district's vision for innovative and engaging STEM learning for all students.

The SPIRIT project has also begun a systematic outreach to various educational service units in the area, which are support consortiums for area school districts. Four educational service units (located in Kearney, Beatrice, Omaha, and Millard) have already requested to host awareness and exploration sessions for their teachers, to participate in pilot testing efforts, and have also agreed to provide control group data from some of their students in the area, as well as to help to retrieve perceptions data from students participating in the awareness sessions. Other educational service units in Nebraska, as well as several Area Education Agencies in Iowa have also indicated an interest to work with us in the future. In addition, four community colleges: Central Community College in Columbus, Nebraska; Western Nebraska Community College in Scottsbluff, Nebraska; Iowa Western Community College in Council Bluffs Iowa; and Northeast Nebraska Community College in Norfolk, Nebraska have all worked initially with the SPIRIT project to host a SPIRIT training or awareness session. This evolving link to community colleges is a new and exciting outreach partnership that we see as having significant potential to help with systematic SPIRIT growth and sustainability.

There is also a growing interest by university Electrical and Computer Engineering (ECE) departments in the use of the CEENBoT™ as an educational platform that promises to invigorate our existing programs and to again help to support SPIRIT sustainability. This will eventually help to form partnerships around the country where university ECE departments and local K12 schools work together to use and extend the SPIRIT robotics curriculum. Several university partnerships are already underway. For example, Tulsa University's ECE department has had positive experiences with robots in the past and is now very interested in the possible adoption of the CEENBoT™ to fit the needs of their university-level ECE department. Rose-Hulman Institute of Technology (one of the most progressive ECE departments in the United States) is another example and is interested in reviewing the attributes of the CEENBoT™ in comparison to other platforms currently used in their program. The Missouri School of Science and Technology's ECE department (formerly the University of Missouri-Rolla) also has an interest in providing the educational robotics platform to their entering freshman class in a manner similar to what the University of Nebraska is doing here in Omaha at the Peter Kiewit Institute. Finally, Howard University's ECE chairperson sees the CEENBoT™ as a means to reach out to their minority students by penetrating the local K-12 environment surrounding Howard University in Washington D.C. In further support of extended university collaborations, the national ECE chairs group has also proposed that the SPIRIT project promote the CEENBoT™ at the next annual meeting during March 11-14th, 2010. Dr. Chen (SPIRIT Project PI) was recently elected to be the incoming Secretary-Treasurer of the Electrical and Computer Engineering Department Heads Association (ECEDHA) and will eventually move up to president of the organization in 2012. Two of his projected themes at that time will be to increase student diversity by an all out national penetration into the K-12 space and an increasing voice within education and working with the political leaders of the U.S. to support K-16 STEM education in a focused manner. This leadership position provides a great opportunity to further extend the SPIRIT project into a truly national presence.

Publications and Products

1. Journal manuscripts and other publications

The following publications have been related to activities associated with the SPIRIT project, or are derived from foundational research efforts. Some publications were undertaken in collaboration with the 4H Robotics and GIS/GPS project. Additional publications are in the planning process, and will be submitted soon.

Harris, J., Hofer M., Grandgenett, N.F. (In Press). Testing a TPACK-based technology integration assessment rubric. To be published in the *Proceedings of the 2010 Society for Information Technology in Education*, San Diego, California, March 29, 2010.

Nugent, G., Barker, B., Grandgenett, N., & Adamchuk, V.G. (In Press). Impact of robotics and geospatial technologies interventions on youth STEM learning and attitudes. To be published in *The Journal of Research in Technology Education*, Spring, 2010.

Harris, J., Hofer M., Grandgenett, N.F. (In Press). Instructional Planning Using Curriculum-Based Activity Type Taxonomies. To be published in the *Journal of Technology and Teacher Education*, Spring, 2010.

Barker, B., Grandgenett, N., Nugent, N., Adamchuk, V. (In Press). Robots, GPS/GIS, and programming technologies: The power of "digital manipulatives" in youth extension experiences. To be published in the *Journal of Extension*, Spring, 2010.

Grandgenett, N. F., Harris, J., Hofer, M. (2009). Grounded technology integration in mathematics. *Learning and Leading with Technology*, 37(3), pp. 24-26, November, 2009.

Gilmore, A., Sash, R., Grandgenett, N., Chen, B. (2009). Using robotics to equip K12 teachers: The Silicon Prairie Initiative for Robotics in Information Technology (SPIRIT). Published in the *Proceedings of the 2009 American Society of Engineering Education Annual Conference*, Austin, Texas, June, 2009.

Adamchuk, V.G., Nugent, B. Barker, and N. Grandgenett (2009). The use of robotics, GPS and GIS technologies to encourage STEM-oriented learning in youth. *Proceedings of the 2009 Midwest Section Conference of the American Society for Engineering Education*, in Lincoln, Nebraska, 16-18 September 2009, D. Schulte, ed. Washington, DC: ASEE.

Barker, B., Grandgenett, N., Nugent, G., Adamchuk, V.G. (2009). Scaling-up an educational robotics intervention for informal learning environments. Published in the *Proceedings of The World Conference on Educational Multimedia, Hypermedia & Telecommunications 2009*, pp. 3231-3236, Chesapeake, VA: AACE.

Barker, B., Nugent, G., Grandgenett, N., Adamchuk, V.G. (2009). Synchronous educational robotics intervention for informal learning environments. Published in the *proceedings of The World Conference on Educational Multimedia, Hypermedia & Telecommunications 2009*, pp. 3237-3242, Chesapeake, VA: AACE.

Nugent, G., Barker, B., Toland, M., Grandgenett, N., Hampton, A. & Adamchuk V. (2009). Measuring the impact of robotics and geospatial technologies on youth science, technology, engineering, and mathematics attitudes. Published in the *Proceedings of the World Conference on Educational Multimedia, Hypermedia, and Telecommunications* (pp. 3331-3340). Chesapeake, VA: Association for the Advancement of Computing in Education

Barker, B., Grandgenett, N. & Nugent, G. (2009). A new model of 4-H volunteer development in science, engineering, and technology programs. *Journal of Extension*. [On-line], 47(2) Article 2IAW4. Available at http://www.joe.org/joe/2009april/iw4.php.

Nugent, G., Barker, B., Grandgenett, N. & Adamchuk, V. (2009). The use of digital manipulatives in K-12: Robotics, GPS/GIS and programming. *In the Proceedings of Frontiers in Education's 39th Annual Conference*, 2009, FIE '09.

Ostler, E., Goeman, B., Grandgenett, N., Wolfe, J.B. (2009). From robotics to semiotics: Using robots and graphing calculators to provide context for traditional algebra skills. Published in the proceedings of The Society for Information Technology and Teacher Education (SITE) annual conference, March 2-6, Charleston, South Carolina.

Grandgenett, N.F. (2008). Perhaps a matter of imagination: TPACK in mathematics education. Published as Chapter 6 in *The Handbook of Technological Pedagogical Content Knowledge for Teaching for Educators*, Matt Koehler & Punya Mishra, Editors. An American Association of Colleges for Teacher Education (AACTE) publication, New York, New York: Routledge Publishing.

Barker, B.S., Nugent, G., Grandgenett, N.F., Hampton, A. (2008). Examining Robotics in the Learning of Science, Engineering and Technology Topics and the Related Student Attitudes. *Journal for Youth Development: Bridging Research and Practice*, Volume 2, Number 3, online at http://www.nae4ha.org/directory/jyd/jyd_article.aspx?id=f5a34e58-1cd3-4994-981d-b81fa406cd74.

Barker, B.S., Nugent, G., Grandgenett, N.F. (2008). Examining 4-H Robotics and Geospatial Technologies in the Learning of Science, Technology, Engineering, and Mathematics Topics. Publication in the *Journal of Extension*, Volume 46, Number 3, online at http://www.joe.org/joe/2008june/rb7.shtml.

Nugent, G., Barker, B., & Grandgenett, N. (2008). The effect of 4-H robotics and geospatial technologies on science, technology, engineering, and mathematics learning and attitudes. *In Proceedings of World Conference on Educational Multimedia, Hypermedia, and Telecommunications, 2008,* (pp. 447-452). Chesapeake, VA: AACE.

2. Products of the SPIRIT grant

The products related to SPIRIT are directly related to the foundational curriculum elements developed by the project that will support a middle school curriculum strategy for educational robotics. These evolving products can be examined at the general SPIRIT Education website *(http://www.ceen.unomaha.edu/TekBots/SPIRIT2/)* and include the following:

Teacher Lessons and Lesson Ideas: A large number of edited, refined, and tested teacher lessons (120 as of February 28, 2010) have been posted to the SPIRIT website and the related cyberinfrastructure database. A total of nearly 70 other lessons are in various states of development for eventual postings and further refinement. Teachers also use the website as a place to share ideas and exchange evolving lesson prototypes.

Technical Tutorials and Video clips: The project is generating an extensive number of technical tutorials (print and video) that help teachers to build and test their CEENBoT™. These tutorials are both interactive on the web, as well as available by downloadable PDF.

Lesson and Teacher Resources: A variety of lesson resources such as an "Engineering Notebook", “Robot Games”, and other resources, such as a list of “Misconceptions in Science” are being created and posted by SPIRIT teachers as possible prototypes for use by other teachers.

Evaluation Instruments: An initial set of evaluation instruments have been created to look at teacher and student change as related to their STEM knowledge, skills, and attitudes. Student assessment development has been undertaken collaboratively with the 4-H Robotics and GIS/GPS project, as mentioned earlier.

Reports, Articles, and Presentations: The many outreach presentations for the SPIRIT project, as well as selected reports, article manuscripts, and other overview documents are also posted on the SPIRIT website.

3. Internet Site(s):

As mentioned in other report sections, the SPIRIT project has generated a system of websites with a great number of archival documents, lessons, instruments, and movie clips. Here are a few of the key website URLs:

Curriculum Information
SPIRIT Education Components of the Website:
http://www.ceen.unomaha.edu/TekBots/SPIRIT2/

General Project Information
SPIRIT General Website:
http://www.ceen.unomaha.edu/TekBots/

Cyberinfrastructure Information
SPIRIT Cyberinfrastructure Prototype:
http://spirit.unomaha.edu/

Videoclip Sample Information
SPIRIT Video Clip Sample: (sample / others on website)
http://www.ceen.unomaha.edu/TekBots/Shared/Video/jumbotron07/

Contributions

1. Contributions within the principal discipline(s) of the project:

The SPIRIT project is aggressively pursuing sustainability and expansion, and is dedicated to providing a solid contribution to the discipline(s) of STEM Education. The contributions of the project to date are essentially the following.

Contribution 1: The project has conceptualized the structure of an educational robotics "touch point" curriculum for middle schools that will enhance the student learning of STEM concepts using a flexible CEENBoT™ robotics platform. A total of more than 120 lessons have been developed, edited, and posted, and are now in final form. A total of 70 more lessons are in various stages of development. Some of these lessons can also be modified further for use in an elementary or high school classroom as well.

Contribution 2: The project has continued an educational research agenda to help determine the instructional effectiveness of the lessons in an extended development process, using peer editing, expert review, pilot testing, and field-testing strategies. The individual lesson pilot testing process is fully underway, and the field-testing process starts in 2010 with selected schools. Pilot testing and field-testing of the evolving SPIRIT curriculum received IRB approval in 2009.

Contribution 3: The project has collaborated with another NSF project (4-H Robotics and GPS/GIS) to contribute to a series of interactive and focused assessments to help teachers determine what STEM concepts students are learning and their resultant attitudes. The initial versions of several of these instruments have already been developed and validated.

Contribution 4: The project has extended the TekBot® learning platform into a newly developed CEENBoT™ educational robotics platform for use with the curriculum, including detailed technical enhancements, hardware tutorials, software guidelines, a GPI interface, and a flexible hardware and software system that permits creative enhancements by a student or teacher.

Contribution 5: The project has created a cyberinfrastructure support environment that includes a flexible sequencing of lessons, materials, assessments, technical information, and online diagnostics. Progress has continued in the development of this technically challenging interface, and the cyberinfrastructure continues to be expanded and refined.

Contribution 6: The project has conceptualized a teacher training strategy that can be scaled nationally, where local community colleges, local educational service units, and university computer electronics and engineering departments, might assist with technical aspects of robotics construction, while the corresponding educational training is offered via distance education, or in local colleges of education. An online graduate course has been developed and is continuing to be refined to help teachers to more efficiently learn to use educational robotics in the instruction of their STEM disciplines.

Contribution 7: The SPIRIT project has continued to produce and publish articles related to the use of robotics and educational technology in the systematic instruction of science, technology, engineering and mathematics. A mix of articles have been published that involve both the theoretical base, results of the project itself, and implications for teachers, as well as educators in other environments, such as after-school programs and summer camps. Some articles have been published in collaboration with the 4H Robotics and GIS/GPS Project.

Contribution 8: The project has successfully initiated a university start-up business to produce and service the CEENBoT™ that is called CEENBoT™ INC. This commercial element of the SPIRIT effort was needed in order to supply teachers and schools with the needed robots for their classroom on a continual basis, and to service the robots as needed. This university startup company, CEENBoT™ INC., successfully competed for NSF SBIR Phase I funding, and was awarded $150,000 of startup funds during late 2009. This new production company effort (as a funded university start-up company) also represents a new model of blending university and business approaches, to better support teachers and schools in their use of educational robots.

The project is also continuing to make presentations at national conferences, and is routinely submitting and scheduling conference presentations and papers. Professional engineering conferences are also being included in the formal dissemination of the SPIRIT curriculum strategies and project results. The SPIRIT project has already made presentations at annual meetings of the International Technology in Education Association (ITEA), the American Evaluation Association (AEA), the Advanced Technologies in Education (ATE) conference, the Association of Mathematics Teacher Educator's (AMTE) conference and the Society for Information Technology and Teacher Education (SITE) conference. Further presentations are scheduled for the American Educational Research Association (AERA) annual conference and the Association for the Advancement of Computing in Education Educational Media conference (Ed-Media).

The SPIRIT project has also successfully established a systematic teacher professional development model for middle school teachers. Middle schools, high schools and community colleges in nearby states are also now showing an interest in further collaborations for extending the model. In particular, educational institutions within the three additional states of Iowa, North Dakota, and South Dakota have expressed an interest in participating in the program. This interest may eventually result in having these states host educational robotics workshops for teachers, particularly at a community college in the area. The SPIRIT project leadership has also been in close contact with the Midwest Center for Information Technology (funded by the

NSF Advanced Technologies in Education program), which includes ten leading community colleges in a four-state region (Nebraska, Iowa, South Dakota and North Dakota). These discussions are continuing, and we are excited about expanding steadily into other states, and other levels of formal education, such as the community college level. In addition, several community colleges are also becoming interested in working closely with our SPIRIT project for undertaking their own educational robotics initiatives. We even recently assisted Central Community College in Nebraska in writing a NSF Advanced Technology in Education (ATE) proposal that was successfully funded, and that will include educational robotics and lesson development activities on site at that community college, and that will use our lesson cyberinfrastructure.

2. Contributions to other disciplines of science and engineering:

The information technology related activities of the SPIRIT have the potential to initiate new strategies for the use of the cyberinfrastructure in the delivery of discipline related content information via the Internet. This would include fields such as English, History and Literature. The SPIRIT project is striving for a high quality, inexpensive, flexible, and cyberinfrastructure-supported educational robotics curriculum that can in turn help scaffold student thinking and promote the curiosity needed for sustained inquiry, as described in *How People Learn* by the National Research Council (1999). We are proud of our progress toward this challenging goal, and that the many demonstrations of our cyberinfrastructure at national conferences and at teacher presentations have been generally well received.

The educational robotics curriculum will permit teachers to choose their level of classroom engagement in the construction of the CEENBoT™, with options ranging from a bag of parts to fully completed robots. By 2012, we anticipate a fully developed series of curriculum lessons and units, which will include written, audio, animation, and video components. The initial lessons are being completed and indexed, building an Internet-accessible database system in which teachers can tailor and personalize their own curriculum enhancements. Teachers can choose from a set of web forms that ask for relevant parameters, such as grade levels, content topics, or desired mathematics and science standards, to assist the database in generating the tailored curriculum sequence. The curriculum generated can then be printed or stored by a teacher for later use. In addition to the curriculum, a software-based "On-Call Technician" is in development, and will eventually provide classrooms with an interactive method for diagnosing potential problems with their robots, by connecting the CEENBoT™ to an Internet connected computer, that remotely accesses servers at the Peter Kiewit Institute (PKI) in Omaha, Nebraska.

In further support of the SPIRIT project and the sustainability of this educational robotics initiative, the Computer and Electronics Engineering faculty are establishing a new research program in educational robotics within the department that could eventually establish it as a national center for educational robotics research and development. Exploring advanced uses of the graphing calculator as a robot control device is just one example of a very specific project that is already being undertaken by such a new research and development effort. Another example might be the creation of the CEENBoT™ avatar for computers to teach programming concepts or gaming/logic to solve maze and resource problems (like finding a lost astronaut within a battery resource limit. This research will use a K-20 context that would involve Ph.D. students looking at optimal control and gaming theory. Connections to artificial intelligence, stereoscopic vision, proximity sensors, on board sonar and high-level digital signal processing, would all be topics that would be potentially considered by the researchers, as well as other topics not yet identified.

The SPIRIT effort has led to some excellent university-level engineering contributions, as well as our K12 education efforts mentioned previously. The CEENBoT™ is currently being used in university level engineering coursework at the Peter Kiewit institute, providing a nice synergy between university and K12 education. For example, the CEENBoT™ is used in a Computer and Electronics Engineering Fundamentals course (CEEN 1030). This is the first undergraduate engineering course taken by students in the first semester of their freshman year. As a part of a lab component, students receive the CEENBoT™ in kit form: bare circuit boards, electronic components, mechanical components, nuts, bolts, screws, motors, etc. Students solder components onto the four circuit boards and assemble the mechanical parts to produce a working robot. They also further use the CEENBoT™ in the Microprocessor Applications course (CEEN 1060). This further course studies assembly language, microprocessor system architecture, and C programming. As an example of an embedded system, the CEENBoT™ is used to introduce system level C programming. Students also use their assembly skills to construct a microcontroller PCB with an LCD display. The microcontroller is then programmed using the C language for motor control and sensor inputs. Other programming assignments introduce port access and peripheral initialization. In the Electrical Circuits I course (CEEN 2130), students are challenged to design the circuitry required to disable CEENBoT™ operation when the lights in the lab are extinguished. A second task is assigned to design the circuitry necessary for the control of DC servo-motors. Finally, in CEEN 2220 Electronic Circuits I, university students undertake a CEENBoT™ challenge of taking a design modification to the prototype stage, and examining device bias and switching characteristic and modeling, project management topics, and fundamental control theory.

Some contributions are also being made to community college STEM instruction. At Metropolitan Community College (MCC) in Omaha, Nebraska, the CEENBoT™ is being used in basic algebra instruction. For example, in a lesson focusing on graphing on the Cartesian coordinate system in MCC's developmental Algebra course, the CEENBoT™ is used to increase the engagement of the students and to connect algebra to real life applications in robot navigation. Using a remote controlled CEENBoT™ as an instructional platform, students drive on a rectangular floor grid and discover various introductory concepts, such as slope, that are covered in the textbook and that are illustrated in robot movement. Topics covered in the algebra and robot activity include: ordered (x,y) pairs, x-intercept and y-intercept, quadrant designations (I, II, III, & IV), algebraic slope, and symmetry with respect to the axes and origin. The community college instructors involved in these robotics lessons have found that the classroom treatment of straight lines and slope is generally much more successful when it follows the use of an introductory educational robotics exercise using the mobile robot in this manner. Furthermore, the student conversation in the course frequently turns to the CEENBoT™ itself, how it was constructed, how it operates, and the underlying principles and concepts embodied in robotics in general.

On the College of Education side of the SPIRIT efforts, the project educators have initiated work to establish an online journal called The Journal for Science, Technology, Engineering, and Mathematics for Classroom Teachers. It will be a resource designed primarily for classroom teachers with a goal of creating awareness, discussion, and the sharing of innovative ideas for STEM Education. The journal has had several manuscript submissions and the editorial board is working to produce a first issue. This online journal will eventually provide a nice educational and peer-reviewed venue for teachers to contribute their educational robotics ideas to the professional literature.

In further support of the SPIRIT educational research needed for the sustainability of the SPIRIT project, the University of Nebraska at Omaha College of Education has established the Office of STEM Education, which will further support SPIRIT as one of its key initiatives. The Office of STEM Education was designed to facilitate a unified and long-range effort on improving STEM education, in projects such as SPIRIT. The Office and its members are focused on many aspects of STEM education that relate closely to SPIRIT, including improving teacher training for STEM teachers, increasing the number and diversity of STEM teachers, providing innovative STEM curriculum, and researching STEM interventions. The philosophy of this office is to particularly concentrate on supporting the educational research needed to assist in innovative STEM instruction and in supporting STEM teachers. The SPIRIT project is an excellent example of combining science, technology, engineering, and mathematics in the school curriculum, and the UNO Office of STEM Education is excited about supporting the SPIRIT project on a long-term basis.

As the SPIRIT project expands its educational robotics efforts, there are expected to be significant long-range contributions to science, technology, engineering and mathematics education. Several examples are becoming apparent at this time for our potential long-range contributions. First, our new evolving robotics platform (the CEENBoT™) will be a flexible, inexpensive and engaging teaching and learning platform. Second, we are developing the foundation of an excellent "touch point" cyberinfrastructure-based curriculum to be used with this platform, including prototype lessons, teacher resources and technical tutorials. Finally, we are creating a professional development model for helping teachers to learn about educational robotics and its potential use in STEM teaching and learning.

3. Contributions to the development of human resources:

This SPIRIT project has been striving to contribute to the need for encouraging more women and underrepresented minority groups to consider engineering as a profession. One or more training sessions in each teacher training institute has been dedicated to this topic, and we have initiated discussions with teachers related to this important national issue and the resultant poor U.S. engineering enrollments, to help our teachers become more aware of the gathering national "storm" in engineering education and global competition.

We are continuing to address minor human resource challenges in our writing process, as we carefully undertake collaborative lesson writing within the SPIRIT project. As described earlier in the report, we employ current classroom teachers to help write lesson drafts that support the SPIRIT curriculum. These practicing teachers are a valuable human resource and we have been impressed with both their creativity and energy. However, they are inexperienced writers of a professional level curriculum, and we are carefully editing and refining teacher lessons and resources. Our lesson development and editing process, representing a relatively dynamic human resource model, is illustrated in the report appendix. To assist with achieving as strong as lessons as possible for the SPIRIT curriculum, the writing team produces lessons around instructional (I's) components in STEM categories that have been previously developed and checked by a content team. The practicing teachers then work from these core components, assisted by expert curriculum writers. The SPIRIT curriculum team continues to strive for educational excellence in all products produced, and only the most refined and promising lessons are edited, illustrated, and posted to the system. Lessons are also posted to the SPIRIT curriculum in two different ways. The first way is the "complete lesson" format where teachers can come and download AEIOU lessons as they are originally. The second way is in the "interactive database" format. In this way, teachers can mix and match what components they feel would best meet their individual curriculum needs.

To keep this extensive human resource effort of writing SPIRIT lessons as organized as possible we have established a lesson development tracking system online so that the SPIRIT leadership can see what status different lessons are in within the curriculum pipeline, as well as what lessons are being populated. This human resource model related to teacher curriculum development will eventually be submitted to a journal such as *Learning and Leading with Technology*, to help to document this successful model in the professional literature.

As the SPIRIT project continues to evolve, grow, and expand, we believe that we are also developing an extended team of experienced teacher consultants who have significant expertise in curriculum development, as it relates to educational robotics and the instruction of STEM concepts. The SPIRIT project team, and the many collaborative partners that we have engaged, have not only become a valuable resource to the curriculum writing process being undertaken in this project, but will also eventually become an important source of experience and expertise, as we assist other educators around the country, to benefit from the SPIRIT lessons and the related curricular resources.

4. Contributions to the physical, institutional, or information resources that form the infrastructure for research and education:

The project is developing strategies to help map engineering activities to traditional STEM coursework and the needed STEM outcomes as identified by the public schools. The SPIRIT project has also collaborated closely with the 4-H Robotics Project to refine several shared prototype instruments to help quantify STEM related achievement by students within an engineering and educational robotics context. It is anticipated that school districts will be able to use these instruments to help demonstrate STEM achievement for their students when using selected educational robotics lessons.

The SPIRIT Project is developing a series of lessons and educational resources (such as worksheets and movie clips) that interested teachers can use within their own classrooms, to help engage students in educational robotics within traditional mathematics and science classes. Thus, these educational robotics lessons and lesson ideas can form a support structure for classroom innovation, where STEM connections can make concept learning more interesting and more realistic. A sample SPIRIT lesson is included in the report appendix.

Working closely with educational researchers at other institutions, such as Iowa State University and the College of William and Mary, the SPIRIT project is also contributing to cutting-edge educational research being undertaken related to Technology Pedagogical Content Knowledge (TPACK). The use of educational robotics to help teachers to increase their TPACK, in both in-service and pre-service settings, is very promising and the SPIRIT education team has already contributed to published articles in this new educational research area, and even contributed a chapter in the TPACK Handbook, published by the American Association of Colleges for Teacher Education (AACTE). Other collaborative articles related to TPACK and SPIRIT have been published or accepted for publication in journals such as the *Journal of Technology and Teacher Education, the Journal for Youth Development, and Learning and Leading with Technology.*

As described earlier, to support the use of educational robotics by teachers, the SPIRIT project has also developed a university start-up company to help produce, distribute and support the CEENBoT™. Mr. Dennis Deyen, a well-respected and well-experienced engineer and businessman, has been appointed Chief Technology Officer of CEENBoT™ INC. The company will produce CEENBoT™ kits for teachers, and is seeking a sole source provider agreement with the University of Nebraska to provide the educational robots, add-on kits, and parts needed, for the national sustainability of the SPIRIT project. Additional personnel have been retained in the company to provide engineering technical support, and to meet existing project orders as well as to streamline procurement and manufacturing capabilities. A NSF SBIR Phase I grant was awarded in November of 2009 that will assist CEENBoT™ INC. in its early formative stages. This commercialization effort, was written into the SPIRIT grant proposal, and is in direct support of SPIRIT sustainability, while also supporting university, K-12 schools, and business partnerships, that we see as promising for the continued and long-term support of STEM education by the SPIRIT project.

5. Contributions to other aspects of public welfare beyond science and engineering, such as commercial technology, the economy, cost-efficient environmental protection, or solutions to social problems.

As mentioned earlier, the SPIRIT project is developing and refining various lessons, delivery structures, instruments and protocols to help support and investigate the impact of educational robotics lessons on student STEM achievement. There is also a focused effort within the curriculum development process, by all involved, to help to ensure that the CEENBoT™ materials represent a relatively "green" technology, and that these materials also help students to understand efficient and ethical energy use, as well as appropriate ways to get rid of electronics waste materials, such as batteries. We are also considering various project development ideas that might further connect with ethically responsible engineering.

The SPIRIT project is also now undertaking a new model of commercialization that will permit a low cost engineering strategy for many schools that might not be able to afford expensive robotics kits. Educational robotics can be an expensive STEM endeavor for many schools, and we hope that the CEENBoT™ will eventually be a very cost-effective alternative for these schools if they wish to have their students participate in educational robotics activities. This "SPIRIT alternative" will help schools to make their STEM coursework more affordable, by access to a low cost, engaging, and flexible educational robotics platform, which also includes a convenient curriculum support structure. Thus, we hope to make the SPIRIT project and the CEENBoT™ a useful and cost-effective alternative for schools, who might not otherwise be able to have their students participate in this exciting context for STEM education.

Objectives and Scope

1. Provide a brief summary of the work to be performed during the next year of support if changed from the original proposal:

[No] Objectives and scope remain unchanged from the original proposal.

Project Examples and Illustrations

A detailed appendix of SPIRIT project samples is also available. Further samples of the project work can be found at http://www.ceen.unomaha.edu/TekBots/SPIRIT2/ or requested.

SPIRIT Report Appendix

Samples of SPIRIT Work
(February 2010)

SPIRIT Samples

SPIRIT/GearTech 21 Robotics Collaborative Assessments

SPIRIT Websites and Samples

SPIRIT Education Components of the Website:
http://www.ceen.unomaha.edu/TekBots/SPIRIT2/
SPIRIT Cyberinfrastructure Prototype:
http://spirit.unomaha.edu/spirit9/index.html
SPIRIT General Website:
http://www.ceen.unomaha.edu/TekBots/
SPIRIT Video Clip Sample: (sample / others on website)
http://www.ceen.unomaha.edu/TekBots/Shared/Video/jumbotron07/

SSW 1. *NSF ITEST (SPIRIT 1.0) & NSF K12 Discovery Learning Projects (SPIRIT 2.0)*

SPIRIT: Silicon Prairie Initiative for Robotics in IT

Principal Investigator(s)
Bing Chen
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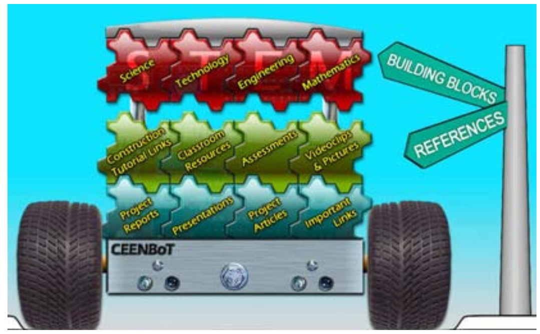
Website
http://www.ceen.unomaha.edu/TekBots/SPIRIT2



The "Silicon Prairie Initiative for Robotics in IT" (SPIRIT), a collaboration between the University of Nebraska and area schools, was a three-year Comprehensive NSF ITEST Project for Students and Teachers, that has expanded into a NSF Discovery K12 Learning Project. SPIRIT targets science and mathematics teachers in grades 7-8, each of whom receives extended professional development and follow-up support in developing in-school curricular activities related to educational robotics. More than 9,000 students have participated through in-school and summer programs. The centerpiece of the project is a university level CEENBoT (TM) learning platform that has been adapted to the middle school level. This platform can be used to demonstrate basic applications in wireless, video and signal processing, sensors, video displays, electronics, control systems, embedded systems, digital logic and introductory programming. The curriculum being developed in the project employs CEENBoTs as a fundamental strategy for problem-based instructional activities. It is adaptable, expandable and cost-effective, providing learning experiences that can extend into high school and college. Results are being disseminated through publications and presentations, teacher workshops, displays prepared for school districts and collaborations with other universities using robotics platforms. An interactive, dynamic website has been created with modules and tutorials, uploadable programs, videoclips and links to robotics research. As of December 2009, a total 173 teachers have been trained in extended workshops and graduate courses and more than 120 Internet-based lessons have been created. Teacher surveys and assessments have documented teacher significant growth in problem-based learning, robotics, electronics, and engineering design.

SSW 2. SPIRIT In Action (Pictures)

Students working with the engineering process to come up with a design to better the TekBot

Students working with the engineering process to come up with a design to better the TekBot

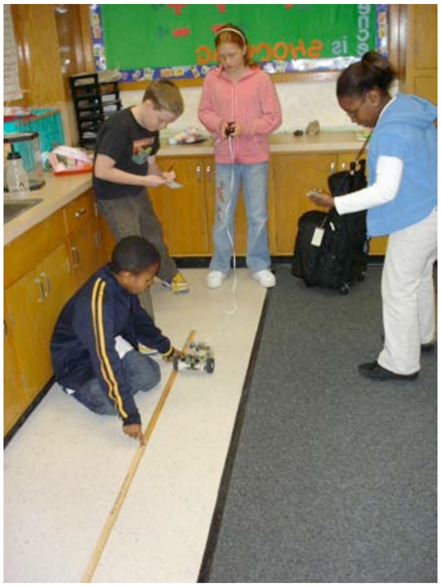
Teachers learning how to use the electronics equipment before they build the TekBot.

Teachers in deep concentration as they build their robots.

Teachers learning to drive their Robots and having a bit of an impromptu robotic Sumo competition.

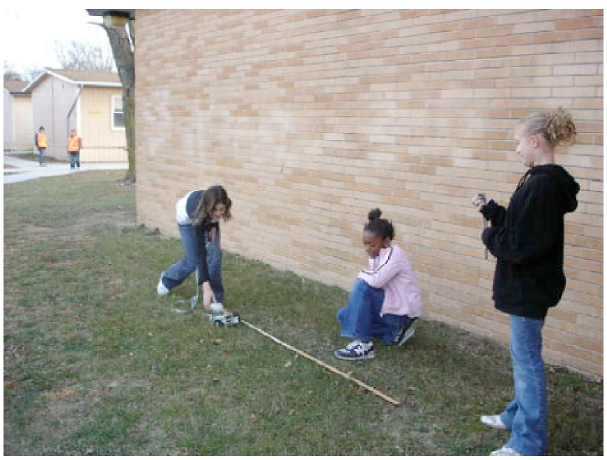
A teacher works on adding some resistors to a circuit board.

Three students investigate how the circumference of the wheel is related to the distance traveled.



Students investigate the formula for distance = rate x time.

Students investigate the relationship between the circumference of the wheels and the distance traveled upon various wheel rotations.



Students investigate the how the various surfaces, including grass impacts the overall speed of the TekBot.

Summary of Robotics Showcase:

- ✓ Over 100 students from grades K-12 attended the event on Saturday, March 28th along with teachers and many parents
- ✓ 26 schools participated in the inaugural event
- ✓ News coverage by WOWT and the Omaha World Herald
- ✓ Sponsors included OPPD, Cox Communications, Lockheed Martin and Union Pacific

Ed Hollingsworth, UP gives a few opening remarks

- ✓ Presentations were conducted by Cox and Lockheed Martin and proved to be a great success and very popular with students, teachers and parents

Sponsors Cox Communications (left) and Lockheed Martin (right) offered hands-on activities and learning opportunities to participants. Omaha Public Power District and Union Pacific also helped sponsor the 2009 SPIRIT Robotics Showcase.

- ✓ IEEE student organization contributed to building road courses and manning the food booth
- ✓ All students received t-shirts and a Cricket Robot

- ✓ All participating schools received CEENBoTs and/or Electronic Snap Circuit kits, thus infusing their classrooms with new materials related to engineering with the promise of exposure to more K-12 aged students
- ✓ When asked if they would like to be engineers someday all the students enthusiastically responded “YES”
- ✓ CEEN freshman seminar students served as judges and guides providing them with a service learning experience
- ✓ CEEN Laboratories (including the KUKA robot lab) and Computer Science Robotics Laboratory demonstrations were conducted
- ✓ All the events were well synchronized and went off without a single hitch thanks to our organizer, Deborah Duran

Plans for next year:

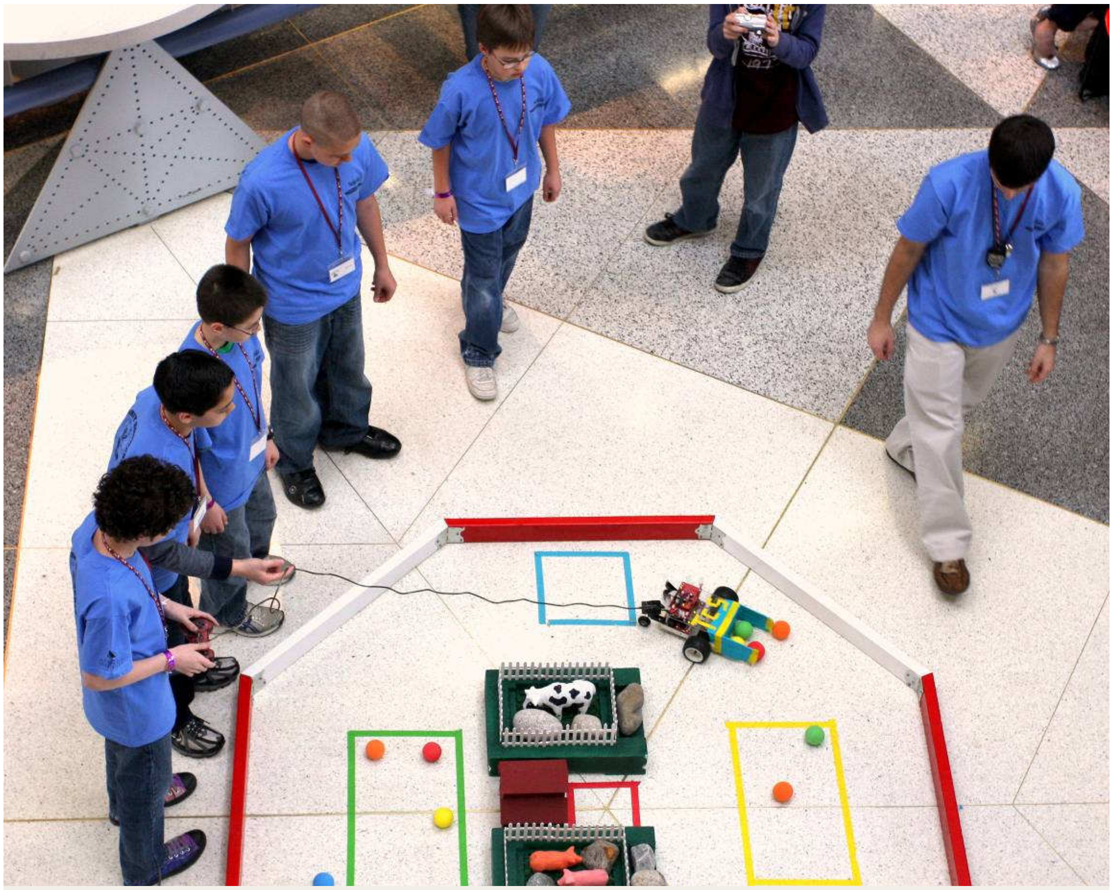
- Due to the success of the inaugural 2009 Robotics Showcase, planning has begun for 2010
- As the CEENBoT adds a microprocessor board with the promise of programming experiences along with new sensors (proximity, video, microphones, light sensing), new events will be added to the Showcase
- Additional schools will be added to the Showcase to expose greater numbers of students to the promise of engineering as a career destination
- Increase the number of corporations providing presentations on their technology as an outreach to the community
- Continue the infusion of engineering tools into more classrooms until there is a continuity of exposure throughout the K-12 period
- Utilize the Showcase as an opportunity for teachers to share their classroom materials related to engineering with one another and to interact with industry sponsors to enhance their understanding of engineering design and philosophy

SPIRIT Robotics Showcase 2009 Photos

Original CEENBoT™ designers Dan Norman and Ben Barenz with PI Dr. Bing Chen holding the CEENBoT™.

Middle school participant holding his CEENBoT™.

Many middle/high school students, teachers, and parents attended this Saturday event.



A middle school CEENBoT™ team powers through the ball maze.

The Benson High School CEENBoT™ team pilots the ball maze wirelessly.

The Tera Heights all-girls TekBot® team navigates the road-obstacle course.

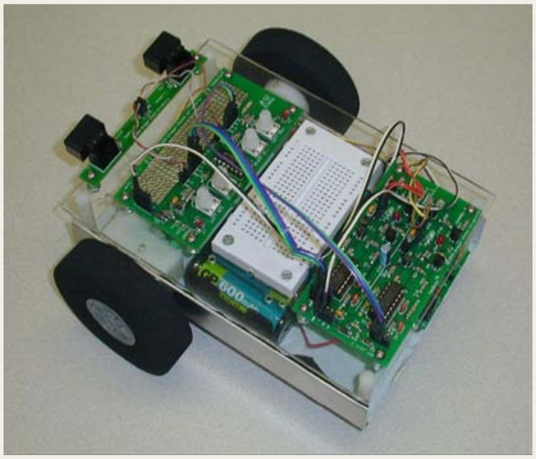
An all-girls middle-school TekBot® team pushes to score in the final seconds.

Demonstrations of the KUKA Industrial robot (left) and other CEEN student-built robots (right) were offered to participants and to the public.

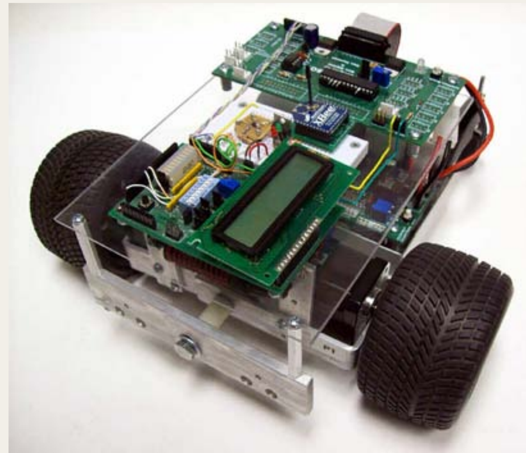
Artist Dan Wondra was on hand to do caricature sketches of participants.

SSW 4. Comparison of CEENBoT and TekBot attributes

TekBot™



CEENBoT™



Attributes of the TekBot developed by Oregon State University: 5” by 7” footprint

- DC motors with plastic gear train and foam wheels
- Compact design
- Prototype board for use by college students at both Oregon State University and University of Nebraska (to 2007)

Attributes of the CEENBoT developed by the University of Nebraska (CEEN): 6” by 8” footprint

- High-quality stepper motors for precision control
- Full suspension for traversing uneven terrain
- Larger capacity, quick-change power supply
- Interchangeable rubber drive tires
- Remotely controllable using the popular Sony PlayStation® controller
- Large prototype board for projects and more reliable connectors
- Serial-to-peripheral interface (SPI) to allow communication between multiple multiprocessors
- Amenable to K-16 educational space to meet needs at multiple levels

Features Under Development

- GPI and C++ interfaces
- Platform can accommodate GPS, laser diode, alternate wireless controls, different microprocessor systems, on-board video camera, and a robotic arm
- Compatible with Microsoft Robotics Studio
- Available in a number of configurations from kits to completed modules

SPIRIT Writing Team and Database Flowchart

Team 1: Lesson Draft Writers
Responsibility: Selecting topics from the list of algebra concepts, these writers create 2 or 3 page draft lessons. Each draft lesson includes: *(include a sample lesson)*

1) AEIOU **"text"** database version
- Each of the 5 AEIOU boxes
- Uses unique title of lesson
- Submit to database

2) AEIOU **"word"** display version
- A lesson in nicer word format
- Same title as above
- Suggested picture(s)
- Suggested diagram(s)
- Suggested chart(s)
- Suggested worksheet(s)

Algebra Course Topics
- Algebraic expressions
- Signed numbers
- Operations on signed numbers
- Reciprocals and zero
- Removing grouping symbols
- Adding like terms
- Linear equations
- Word problems
- Inequalities
- Absolute value
- Exponents
- The distributive rule
- Factoring polynomials.
- Binomials and trinomials
- Factoring trinomials
- The difference of two squares
- Algebraic fractions
- Negative exponents
- Operations on algebraic fractions
- Equations with fractions
- Radicals
- Simplifying radicals
- Multiplying and dividing radicals
- Rational exponents
- Complex numbers
- Rectangular coordinates
- The Pythagorean distance formula
- The equation of a straight line
- The slope of a straight line
- Simultaneous linear equations
- Quadratic equations
- Variation

Leadership Team: This group monitors the two writing teams and continues to refine the database system and process.

"AIEOU Display" Database
Function: Displays lessons well
This database includes the more nicely displayed MSWord version of the lesson (or if necessary a pdf version). This database does not have switchable parts, but simply includes brief complete lessons, for when the user simply wants to display those versions, and perhaps to order them.

Text and Word versions of the developed lesson are linked by a unique title…

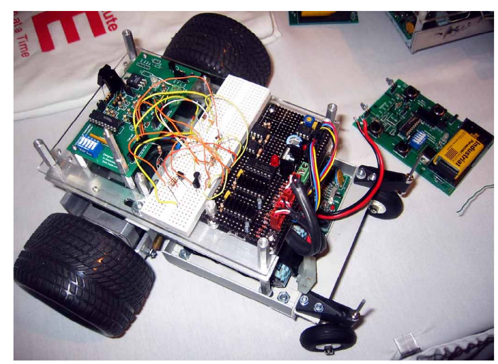
"AEIOU Pieces" Database
Function: Can swap pieces
This database (or part of the system) includes some lessons or topics where switching pieces make sense. In other words, for topics where multiple lessons have been submitted (such as slope), the user can mix and match AEIOU pieces of the lesson if desired for a separate text printout.

Functionality Notes:
*1) For the **AEIOU Display Database,** a user can display nice looking, brief lessons in Word or pdf format that interest them on a particular algebra topic. If desired, a filter will suggest topics and lessons.*

*2) For the **AEIOU Pieces Database**, which works with selected lesson topics, the user is allowed to mix and match of component parts. For this database, the display is simple text, and it can be copied and pasted into other documents by the user as desired.*

Note: All team members will be selected by application process, mailed out to all class and SPIRIT participants.

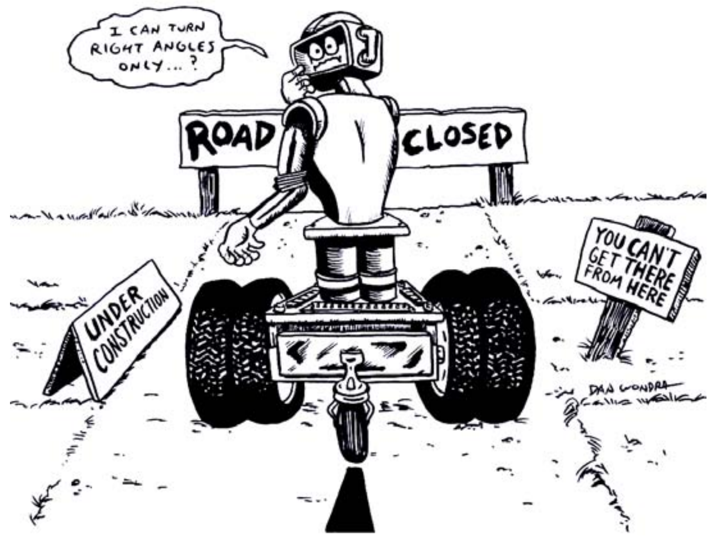
Team 2: Lesson Editors
Responsibility: This group of team members carefully review the lessons and make editorial suggestions and fill in the missing pieces as they can. They will also review how the display works with the database components and how it appears to work.



SSW 6. SPIRIT 2.0 Lesson:
The Power Steering Is Out?!

============================== Lesson Header==============================

Lesson Title: The Power Steering Is Out?!
Draft Date: July 17, 2008, 2008
Author (Writer): Derrick A. Nero
Instructional Topic: Mathematics, Slope
$m = rise / run$ and $m = (y_2 - y_1) / (x_2 - x_1)$
Grade Level: Middle



Content (what is taught):

- Use of coordinate planes and points
- Application of the mathematical formula $m = (y_2 - y_1) / (x_2 - x_1)$ or $m = rise / run$
- Measurement

Context (how it is taught):

- Coordinate points are identified and recorded
- The CEENBoT is driven from one coordinate point to another using the driving criteria, *Driving Citeria*: Travel only horizontally or vertically and make only one 90º turn.

Activity Description:
In this lesson, students investigate how the slope of a line connecting two coordinate points is calculated. Students will select "locations" on a coordinate plane marked on the floor. Each student will record his/her "location" as a coordinate point. Pairs of students will be randomly selected to "travel" to one another's "location" using the CEENBoT and the *driving criteria*. All students will record the horizontal and vertical distances traveled by the CEENBoT. The student pair will then travel in a straight path from one "location" to the other and will measure the path using a meter stick. Finally, students will calculate the slope of each pairing using the formula $m = rise / run$ or $m = (y_2 - y_1) / (x_2 - x_1)$.

Standards:

Science
A1, A2

Engineering
A1, B1

Technology
A3

Mathematics
A1, A3, D1, D2, E1, E3

Materials List:
CEENBoT
Student Data Sheet
Notebook
Masking tape
Meter sticks

ASKING Questions (The Power Steering Is Out?!)

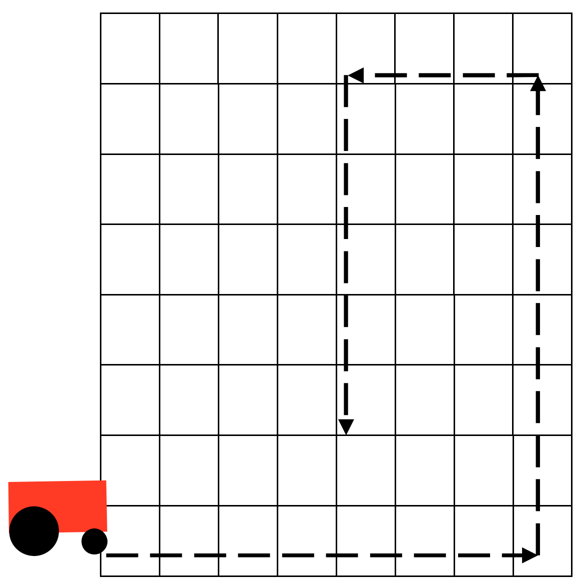
Summary:
Students determine the best route to travel from one location to another.

Outline:

- Demonstrate the CEENBoT traveling on the coordinate plane that is marked on the floor.
- Drive the CEENBoT from one location to the other using many 90º turns.
- *Driving Criteria:* Drive the CEENBoT from one location to the other using only one 90º turn.

Activity:
The teacher will demonstrate driving the CEENBoT on the coordinate plane from one location to another. As students become interested, ask these questions:

Questions	Answers
How many routes can be used to travel to either location?	Numerous routes (with no constraints) can be used to travel to either location.
How many routes can be used to travel to either location, using the *driving criteria*?	Two routes (with the second being the opposite of the first) can be used to travel to either location using the *driving criteria*.
What is the quickest route from one location to the other?	A straight path is the quickest route from one location to the other.

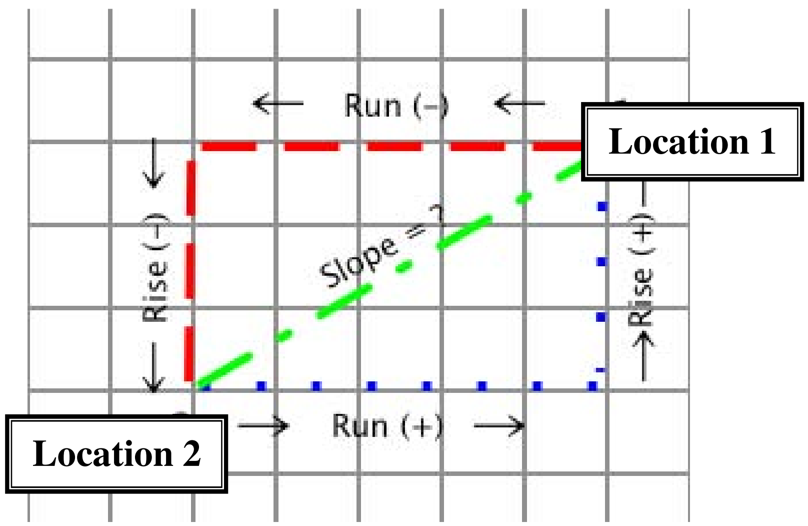


EXPLORING Concepts (The Power Steering Is Out?!)

Summary:
Students investigate the relationship between the horizontal, vertical, and diagonal distances traveled from one point to another, and describe the slope between points using rise and run.

Outline:

- Students will drive the CEENBoT on a coordinate plane that is marked on the floor.
- Student pairs will drive the CEENBoT from one location to another using only 90º turns.
- *Driving Criteria:* Drive the CEENBoT from one location to the other using only one 90º turn.
- Student pairs will drive the CEENBoT from one location to another using the driving criteria..
- Students will predict the number of units from the starting location to the 90-degree turn (Run).
- Students will predict the number of units from the 90-degree turn to the ending location (Rise).
- Students will predict the straight path distance from one location to the other (Distance).



Activity:
In this lesson, students investigate how the slope of a line connecting two coordinate points is visualized. Students will select "locations" on a coordinate plane marked on the floor. Each student will name their "location" as a coordinate point. Pairs of students will be randomly selected to "travel" to one another's "location" using the CEENBoT and the *driving criteria*. Students will name the horizontal and vertical distances traveled by the CEENBoT including the positive and negative sign on the value. The student pair will then travel in a straight path from one "location" to the other, and will describe the distance and features of the path and compare it to the path when using the *driving criteria*.

To provide formative assessments of the exploration, ask yourself or your students these questions:

1. Did students consider the direction, therefore the negative or positive sign of the value?
2. Did students predict the distances traveled to be identical between locations? both directions?
3. How did students predict the straight path distance from one location to the other (i.e., math computation or estimate)?

INSTRUCTING Concepts (The Power Steering Is Out?!)

Putting Slope in recognizable terms: Other words for slope are: steepness, pitch, grade, angle of elevation, angle of inclination/declination, and ***rise*** *over* ***run***.

Putting Slope in *Conceptual* terms: Slope is a relationship between two rates (related rates) or a comparison of two distances (remember that rate is just a *distance* divided by a measure of time, r = d/t): the distance the bot travels in the ***y*** direction varies (or changes) as a ***factor*** (***m***) of the distance the bot travels in the ***x*** direction. So, some number (***m***) times ***x*** gives us ***y***. Therefore, m (dist. Of x) = (dist. Of y). If we solve for the variable m by dividing both sides of the equation by (dist. Of x), we get a related rate (slope). This is also called ***rise*** over ***run***.

Putting Slope in *Mathematical* terms: We could also call the distance traveled in the ***y*** direction the *change* in *distance* of ***y*** or the difference in the ***y***-coordinate values of two points. We could call the distance traveled in the ***x*** direction the *change* in *distance* of ***x*** or the difference in the ***x***-coordinate values of the same two points. This gives us a formula: $M = \frac{\Delta y}{\Delta x}$ (difference in y values over the difference in x values or, delta ***y*** divided by delta ***x***). When we get to *calculus*, we simplify by saying, $m = \frac{dy}{dx}$.

Putting Slope in *Process* terms: Algebraic computation of slope: $m = \frac{y_2 - y_1}{x_2 - x_1}$. Provide examples of calculating slope between points. Be sure to include examples and explanation of negative value slopes.

Putting Slope in Applicable terms: Randomly angle the bot, drive it for three seconds from a given point, measure the ***vertical*** and ***horizontal*** components, and define the slope.

ORGANIZING Learning (The Power Steering Is Out?!)

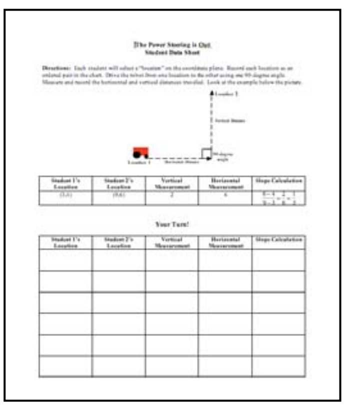
Summary:
Students investigate the relationship between the horizontal, vertical, and diagonal distances traveled from one point to another, and calculate the slope between points using the slope formula or rise and run.

Outline:

- Student pairs will drive the CEENBoT from one location to another using the driving criteria.
- *Driving Criteria:* Drive the CEENBoT from one location to the other using only one 90º turn.
- Collect data as student pairs travel to one another's locations
- Data includes the coordinate points, and horizontal (run), vertical (rise), and diagonal distances.
- Fractions should be expressed in reduced form.

Activity:
In this lesson, students calculate the slope of a line connecting two coordinate points. Students will select "locations" on a coordinate plane marked on the floor. Each student will record his/her "location" as a coordinate point. Pairs of students will be randomly selected to "travel" to one another's "location" using the CEENBoT and *driving criteria*. All students will record the horizontal and vertical distances traveled by the CEENBoT. The student pair will then travel in a straight path from one "location" to the other and will measure the distance of the path using a meter stick. Finally, students will calculate the slope of each pairing using the formula $m = rise / run$ or $m = (y_2 - y_1) / (x_2 - x_1)$.

Student Worksheet


The Power Steering is Out
Student Data Sheet

Your Turn!

Student 1's Location	Student 2's Location	Vertical Measurement	Horizontal Measurement	Slope Calculation

UNDERSTANDING Learning (The Power Steering Is Out?!)

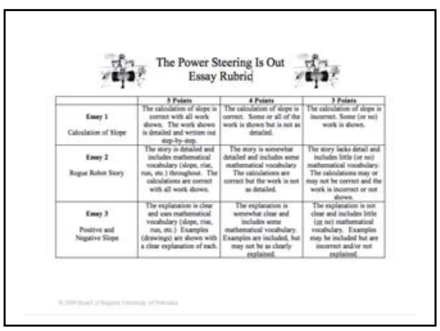
Summary:
Students write essays about the application of $m = rise / run$ or $m = (y_2 - y_1) / (x_2 - x_1)$.

Outline:
- Formative assessment questions asked during the learning activity about slope and its meaning.
- Summative assessment essay questions about slope and its application.

Activity:
Formative Assessment
As students are engaged in learning activities ask yourself or your students these types of questions:
1. Were the students able to apply either formula for slope?
2. Can students explain the meaning of slope?

Summative Assessment
Students will complete the following essay questions about the distance-rate-time formula:
1. Calculate the slope of the line formed by the student's home and the local shopping mall.
2. Write a story involving the path of a rogue robot determined to find its creator and how detectives found it based on its known locations.
3. Describe how you can tell the positive or negative value of slope by looking at the location of two points on a coordinate plane.

Student Worksheet

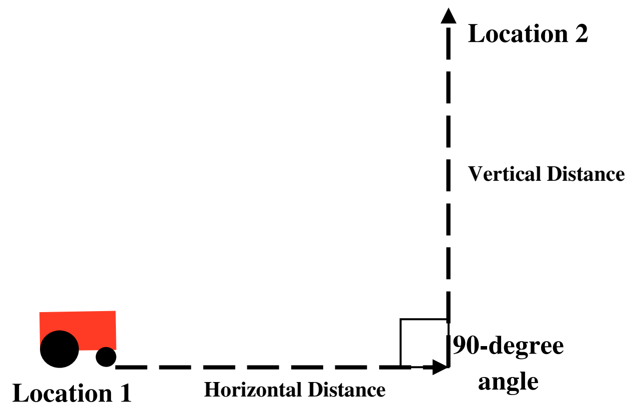


The Power Steering Is Out
Essay Rubric

	5 Points	4 Points	3 Points
Essay 1 Calculation of Slope	The calculation of slope is correct with all work shown. The work shown is detailed and written out step-by-step.	The calculation of slope is correct. Some or all of the work is shown but is not as detailed.	The calculation of slope is incorrect. Some (or no) work is shown.
Essay 2 Rogue Robot Story	The story is detailed and includes mathematical vocabulary (slope, rise, run, etc.) throughout. The calculations are correct with all work shown.	The story is somewhat detailed and includes some mathematical vocabulary. The calculations are correct but the work is not as detailed.	The story lacks detail and includes little (or no) mathematical vocabulary. The calculations may or may not be correct and the work is incorrect or not shown.
Essay 3 Positive and Negative Slope	The explanation is clear and uses mathematical vocabulary (slope, rise, run, etc.) Examples (drawings) are shown with a clear explanation of each.	The explanation is somewhat clear and includes some mathematical vocabulary. Examples are included, but may not be as clearly explained.	The explanation is not clear and includes little (or no) mathematical vocabulary. Examples may be included but are incorrect and/or not explained.

The Power Steering is Out?!
Student Data Sheet

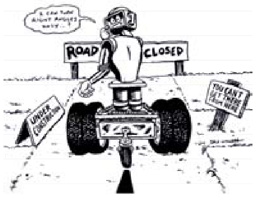
Directions: Each student will select a "location" on the coordinate plane. Record each location as an ordered pair in the chart. Drive the robot from one location to the other using one 90-degree angle. Measure and record the horizontal and vertical distances traveled. Look at the example below the picture.



Student 1's Location	Student 2's Location	Vertical Measurement	Horizontal Measurement	Diagonal Measurement	Slope Calculation
(1, 2)	(4, 6)	4	3	5	$\frac{6-2}{4-1} = \frac{4}{3} = 1.33$

Your Turn!

Student 1's Location	Student 2's Location	Vertical Measurement	Horizontal Measurement	Diagonal Measurement	Slope Calculation



The Power Steering Is Out

Essay Rubric

	5 Points	4 Points	3 Points
Essay 1 Calculation of Slope	The calculation of slope is correct with all work shown. The work shown is detailed and written out step-by-step.	The calculation of slope is correct. Some or all of the work is shown but is not as detailed.	The calculation of slope is incorrect. Some (or no) work is shown.
Essay 2 Rogue Robot Story	The story is detailed and includes mathematical vocabulary (slope, rise, run, etc.) throughout. The calculations are correct with all work shown.	The story is somewhat detailed and includes some mathematical vocabulary The calculations are correct but the work is not as detailed.	The story lacks detail and includes little (or no) mathematical vocabulary. The calculations may or may not be correct and the work is incorrect or not shown.
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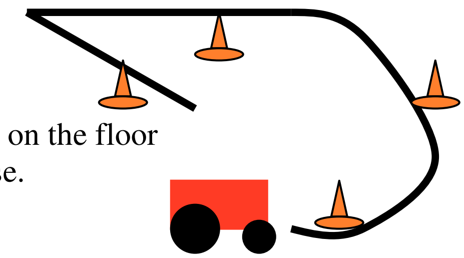
SSW 7. Sample CEENBoT Game

Descriptive Game Name: BUMP BOT NAVIGATION
Author: Betsy Rall, Matt Bills, Jennifer Higgins, Brian Moeller

Game Brief Description: In this game, students will operate their CEENBoT in Bump-Bot mode through a course. The students will activate the sensors at the front of the CEENBoT to cause it to change directions in order to successfully get through the course.

Game Area Picture/Diagram and Materials: A CEENBoT course should be created on the floor with tape and cones (or other obstacles). The course should contain corners and curves that necessitate the turning of the CEENBoT.



- A CEENBoT for each competitor
- Cones and/or other obstacles
- Tape or other material that would provide an outline of the course on the floor
- Stopwatch for timing the CEENBoT as it drives through the course.

Rules:
1. Students will play in pairs. One person will 'drive' while the other uses the stopwatch to time and keep track of penalties.

2. The 'driver' may use any part of his or her body to activate the sensors at the front of the CEENBoT and cause it to change direction while traveling through the course.

3. Any redirection of the robot using anything other than the sensors will result in a 20 second penalty. This penalty will be added to the total time.

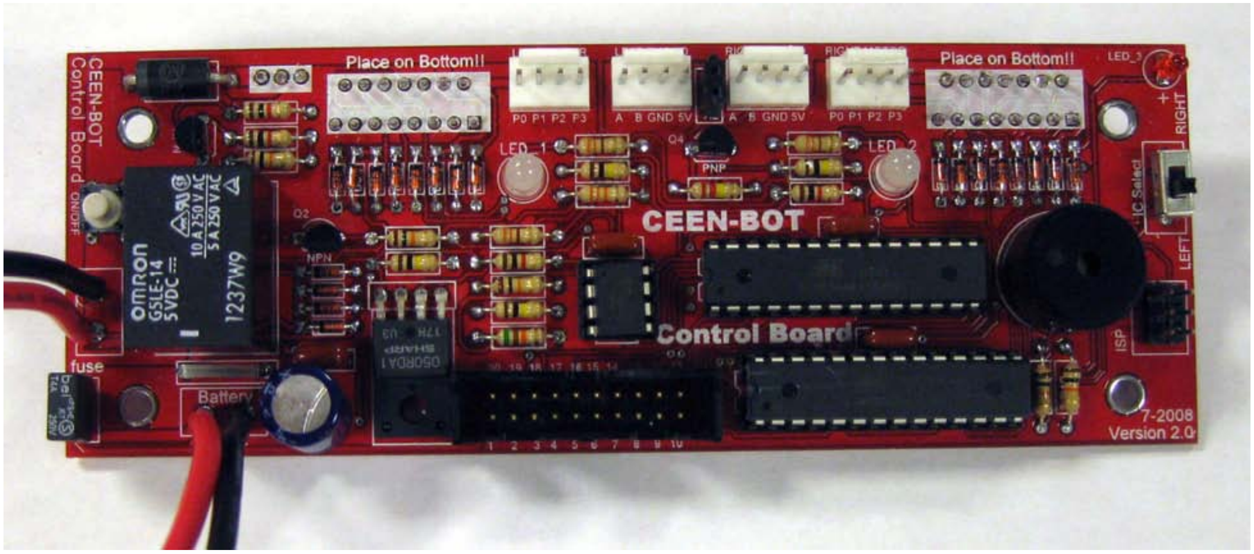
4. Additional penalties can be decided upon before going through the course (i.e. If the CEENBoT knocks down an obstacle while going through the course, a certain number of seconds could be added to the total time.)

Scoring:
Each student will complete the course using the CEENBoT in Bump-Bot mode.

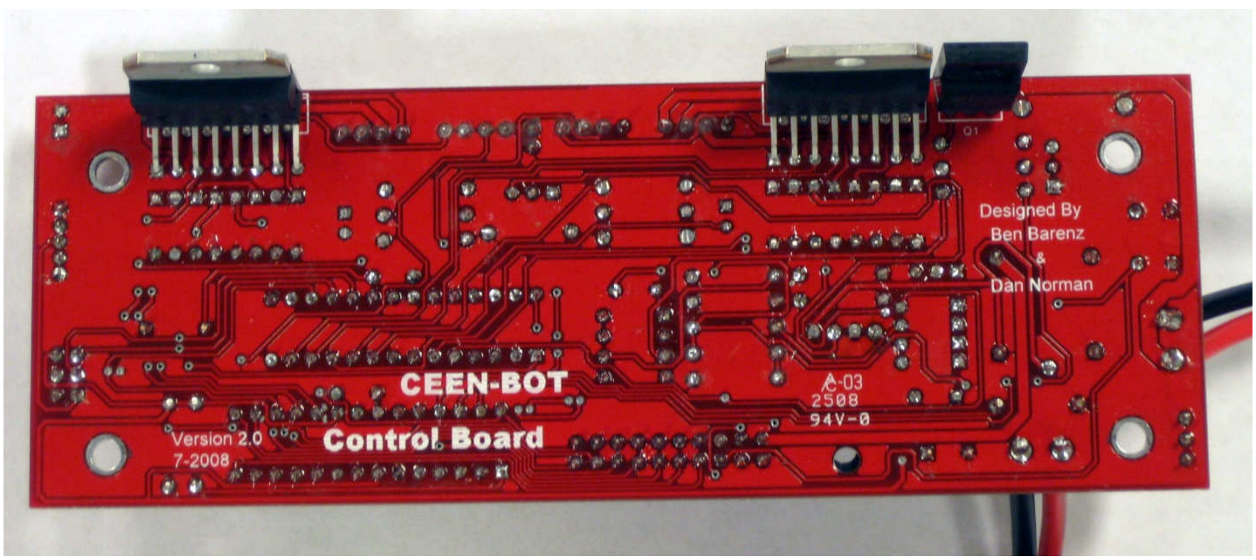
Game Suggestions:
1. Have each pair of students create a course and test it using a CEENBoT. Make any necessary modifications to the course before the competition starts. For example, when students test the course, they might find areas that need to be widened, etc.
2. Let each student have a second-chance at the course and take the better time or an average of both times.

Learning within the Game:
Students should gain some creative experience in creating a course. Students should also gain some insight into geometry when directing the CEENBoT. Students should gain an understanding of how the CEENBoT moves in Bump-Bot mode.

SSW 8. Technical Tutorial: Control Board



Top View



Bottom View

Open the bag of parts for the Control board and sort them onto the Parts Map. Do this before you solder any components to minimize the chance of misreading a component's id and soldering it into the wrong location. Solder the components in the order shown on the parts map. The order is basically that the lowest profile items are soldered first. The dashed outlines on the parts map indicate components that must be oriented a specific way. **Do not solder the integrated circuit on the board. It is placed into a socket.**

The techniques for soldering many of these components are the same as was done for the Interface board. References to video clips in that tutorial are given if you wish to review the procedure.

1. The first items to be soldered are resistors R5, R16, and R17. Orientation does not matter for resistors. (Video 2)

2. Next are resistors R2, R9, R14 and R20. Brown-Black-Red

3. Resistors R4, R6, R12, R13, R15.

4. R3, R7, R11, AND R18

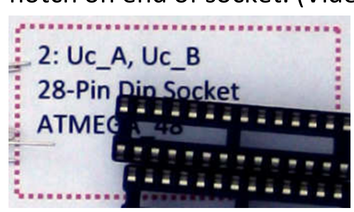
5. R8

6. R10

7. R19

8. Diodes D0-D3, D5-D20. Align the black stripe on the diode with the white stripe on the circuit board. . (Video 1)

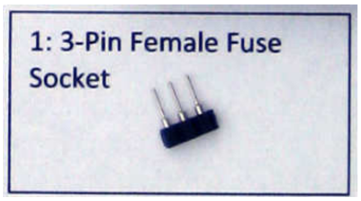
9. Uc_A and Uc_B Sockets. Align u shaped notch on end of socket. (Video 15)



10. Uc_A and Uc_B Sockets. Align u shaped notch on end of socket.

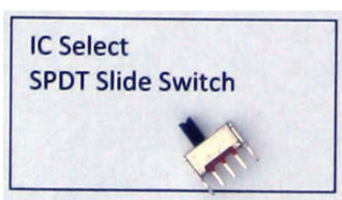
11. Switch 1

12. Fuse socket. Use machined female sockets.

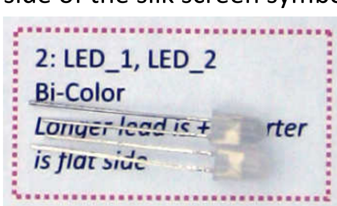


13. Solder the two 3-pin male header (Video 14)

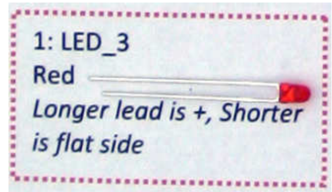
14. SPDT Switch



15. Bi Color LED Longer lead is +, shorter lead is negation and is placed by the flat side of the silk screen symbol.



16. Red LED_3. Longer lead is +, shorter lead is negation and is placed by the flat side of the silk screen symbol.



17. Q2, Q3. Match shape with silk screen. These look just like Q4. Read the numbers printed on them to make sure you have the correct devices.

18. Q4. Match shape with silk screen. These look just like Q2 and Q3. Read the numbers printed on them to make sure you have the correct devices.

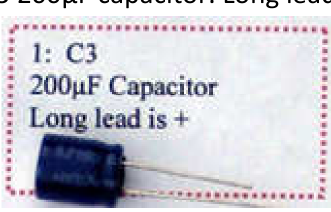
19. 0.1 µF Capacitors. Orientation not important.

20. D1 1N5402 Diode. Align the black stripe on the diode with the white stripe on the circuit board.

21. 4-pin male connector. Left Motor, Right Motor. Photo shows 4 – we will only use 2. *Plastic lip matches with stripe on board*.

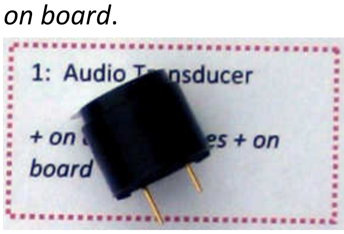
22. 5 Volt Regulator. Flat side against circuit board.

23. C3 200µF capacitor. Long lead is



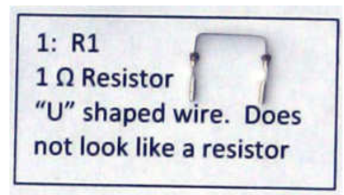
+.

24. Audio Transducer. *+ on case matches + on board*.



25. 20-Pin Male Ribbon Cable Connector. *Single slot to center of board*.

26. R1. 1 Ω Resistor. “U” shaped wire. Does not look like a resistor.

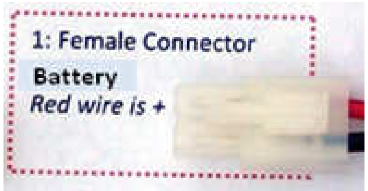


27. SPDT Relay. Pins will allow it to fit only one way.

28. Male Connector. Battery. *Red wire is +*. Strip about 1/8” of insulation off wires. The male connector has two prongs inside the plastic case.

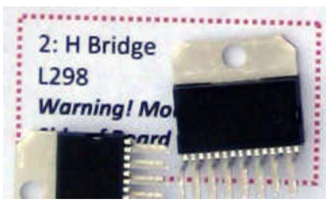
29. Female Connector. Charger. *Red wire is +*. Strip about 1/8” of insulation off wires. The female connector has two

sockets inside the plastic case.



WARNING The following parts are mounted on the bottom side of the board. Look at the photo.

30. H Bridge. L298. ***Warning! Mount on Back Side of Board***

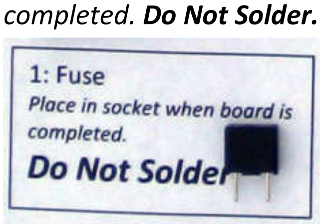


31. Q1. TIP-127FP. Place flat side to outside of board. ***Warning! Mount on Back Side of Board.***

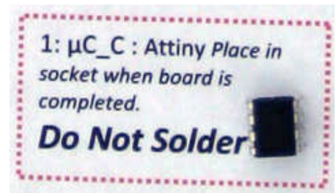
____

The following components are not soldered. They are placed in sockets. They may not be in your parts bag in which case they will be given to you after you have completed soldering.

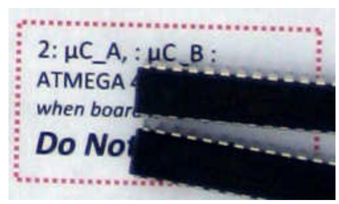
32. Fuse. *Place in socket when board is completed.* ***Do Not Solder.***



33. µC_C : Attiny *Place in socket when board is completed.****Do Not Solder.*** (Video 19)



34. µC_A, : µC_B : ATMEGA 48 *Place in socket when board is completed.****Do Not Solder***. (Video 19)

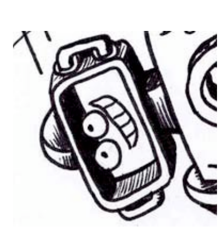


Engineering Notebook

Engineering Notebook Number ____ ____ ____

First Name ______________________

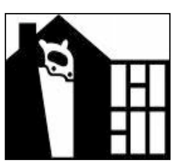
Last Name ______________________



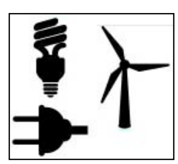
Your Picture Here


Medical


Manufacturing


Construction


Agricultural


Energy & Power


Transportation


Information & Communication

Rules

Be Safe

- Follow Lab Safety Rules
- Think before you act
- Hand objects – never throw

Be on Time

- Coming to class
- Handing in work

Follow Instructions

- Use the Social Skill by looking at the person/task, saying o.k. and doing the task immediately
- Keep Following Instructions the entire class time

Cooperate

- Use appropriate voice levels
- Respect partners – share, take turns, help, but do your own work
- Respect guests and guest teachers
- Be mature - monitor your own behavior
- Use your Social Skills

Safety Rules

1) Wear safety glasses at all times while using tools and equipment.
2) Keep all loose clothing and long hair tied back.
3) Use tools, materials and equipment for their designed purpose.
4) Do not talk to a person operating equipment.
5) Keep your work area clean and clear.

~Safety is EVERYONES' responsibility~

Partner/Group Reminders

- When someone talks, the other(s) listen.
- Allow everyone time to talk.
- Use only positive voice tones and comments – use your manners!
- Keep voices at low levels.
- Walk your chairs to the group area.
- Practice your Employability Skills. (see back cover)

Daily Instructions

1) Put belongings on shelf (zip trapper) and bring Assignment Notebook (handbag).
2) Use restroom/get a drink/get forms signed, etc.
3) Read and follow instructions on message board.
4) Read make up work if you have been absent.
5) Pick up Engineering Notebook and immediately follow message board instructions.
6) Sit down, put Name Badge on. If needed pick up computer - if needed, carefully wash/put safety glasses on (try to keep lenses scratch free).
7) Take inventory and report anything missing or damaged items. Use tools and materials only for the assignment – do not waste materials.
8) Sit with your knees under the workstation, facing the center. If it is more than a step – get up and walk.
9) Talk only with your workstation partner at a low level.

Closure Instructions

1) Make Assignment Notebook entry.
2) Restart/shut down – push computer under shelf or put away.
3) Return everything to its proper place.
4) Take inventory. Report any missing or damaged items.
5) Brush workstation dust/etc. into waste can – wipe down if needed.
6) Bookmark Engineering Notebook page with Name Badge.
7) Sit with your knees under your workstation facing the center and wait to be dismissed.

Lab Reminders

- To ask a question, use call lights so you can continue to work – on no call light days, a teacher will come around.
- Keep work area clean and clear. Keep computer pushed under shelf when working on products.
- When using computer nothing touches the screen and only your fingers touch the keyboard. Move computer by the base.
- Use only your period drawer and keep your hands off others' work.
- While waiting in line to use equipment, stand three feet back – behind line – no more than two people in line.
- Sand and file over a waste can.

Notes/Sketches/Questions/Thoughts

What is the Purpose of this Notebook?
This Engineering Notebook will be used to record your progress, ideas, notes, sketches questions, and thoughts. It is your evidence of the work you have completed.

This notebook has all the information you need to be successful in class. It will be kept in the classroom. If you need to take it home, you will need to ________________________________ ____.

Why an Engineering Notebook?
Engineers use an Engineering Notebook to record ideas, inventions, experimentation records, observations, and all work details. Careful attention to how they keep their Engineering Notebook can have a positive impact on the patent outcome of a pending discovery, invention, or innovation.

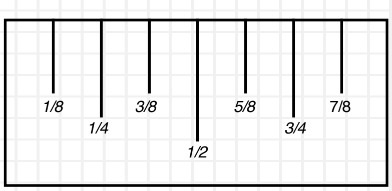
How do I keep an Engineering Notebook?

1. Write NEATLY - anyone should be able to read it.
2. Write down EVERYTHING AS IT HAPPENS.
   - If it is not documented, it did not happen
   - If you write it the next day, it did not happen.
3. Use BOTH sides of a page.

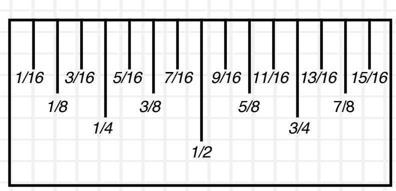
4. Date each entry in chronological order.
5. Clearly separate each day's entry by drawing a line under the entry.
6. Entries should include enough information so someone else could successfully duplicate your work.
   - Label figures and sketches. Keep sketches up-to-date – make changes as they happen.
   - Use complete sentences – a complete sentence is a complete thought that begins with capitalization and ends with a form of punctuation.

7. Draw a single line through any errors and enter the correct information nearby . . . it is o.k. to erase sketches
8. Never leave blank spaces - simply "X" out any blank spots.
9. Never, under any circumstances, remove pages from your notebook.
10. If you add pages, tape or glue it onto a page in your notebook. Clearly label and date it.

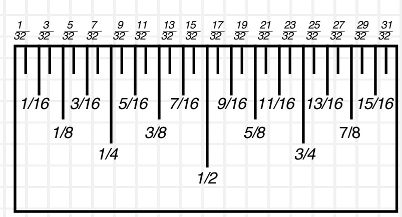
Reading a Ruler
If you have not memorized what each line on the ruler measures, use the rulers below to help you measure.



8 Division Ruler



16 Division Ruler



32 Division Ruler

Notes/Sketches/Questions/Thoughts

Date:

Design Brief
Name Badge

Situation/Challenge

In work environments, people need to wear name badges. This may be for identity, security or just so someone can call you by your name. In this class, you will change partners many times. You will be required to wear a name badge, so we can learn each other's names. This badge will remain in the room and be stored in your Engineering Notebook.

Criteria and Constraints

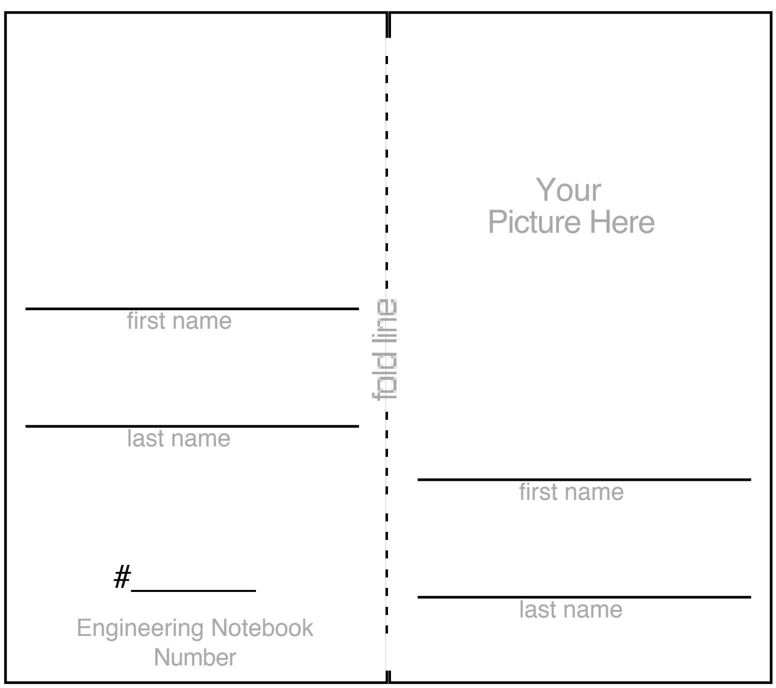
- Follow the procedure to complete your name badge.
- You may only use the material and tools listed.

Tools, Materials, Equipment

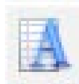
- computer
- printer
- laminator
- laminating pouch
- scissors
- badge clip

Procedure

1. Follow this procedure to make your name badge.
2. Identify the problem by re-reading the situation/challenge.
3. You will not be doing any Research for this situation/challenge.
4. The possible solutions have already been Developed for you.
5. The best solution was Selected for you.
6. Construct your name badge by following the steps below.
   a. On the desktop of your computer open the **name badge** template. If it asks, click on OPEN A COPY. It will look like the graphic below:



Next Page

b. Begin with the area below the words "Your Picture Here."
c. Click on the  tool - click above the line and type your **first** name.
d. Click on this name and move it to the correct location.
e. Click the  tool - now click on your name - make your **first** name as big as possible but still fits on the line by changing the <u>size of the text</u> - under FORMAT
f. You may need to make your text box larger by clicking on one of the boxes and dragging it out.
g. Move name close to the line.
h. Do the same for your last name.
i. Now do the other side of the name badge.
j. Type your three-digit Engineering Notebook number, change the text size and move it into place.
k. Have your partner do the steps above.
l. Turn on call light (light switch located at your workstation) and have it checked.
m. Print the document.
n. Cut out name badge and fold in half along "dashed" line.
o. Locate your picture and cut it out along the outside edge.
p. Return scissors and recycle paper waste in the blue recycle bins.
q. Open laminator pouch, place folded name badge - picture UP - towards punched hole.
r. Place picture (right side up) on top of picture box and carefully close the laminating pouch.
s. Place "**closed side**" of laminating pouch into laminator - push gently until the machine rollers take the pouch - it will roll out the back.
t. Return to workstation and attach the badge clip to your laminated name badge.

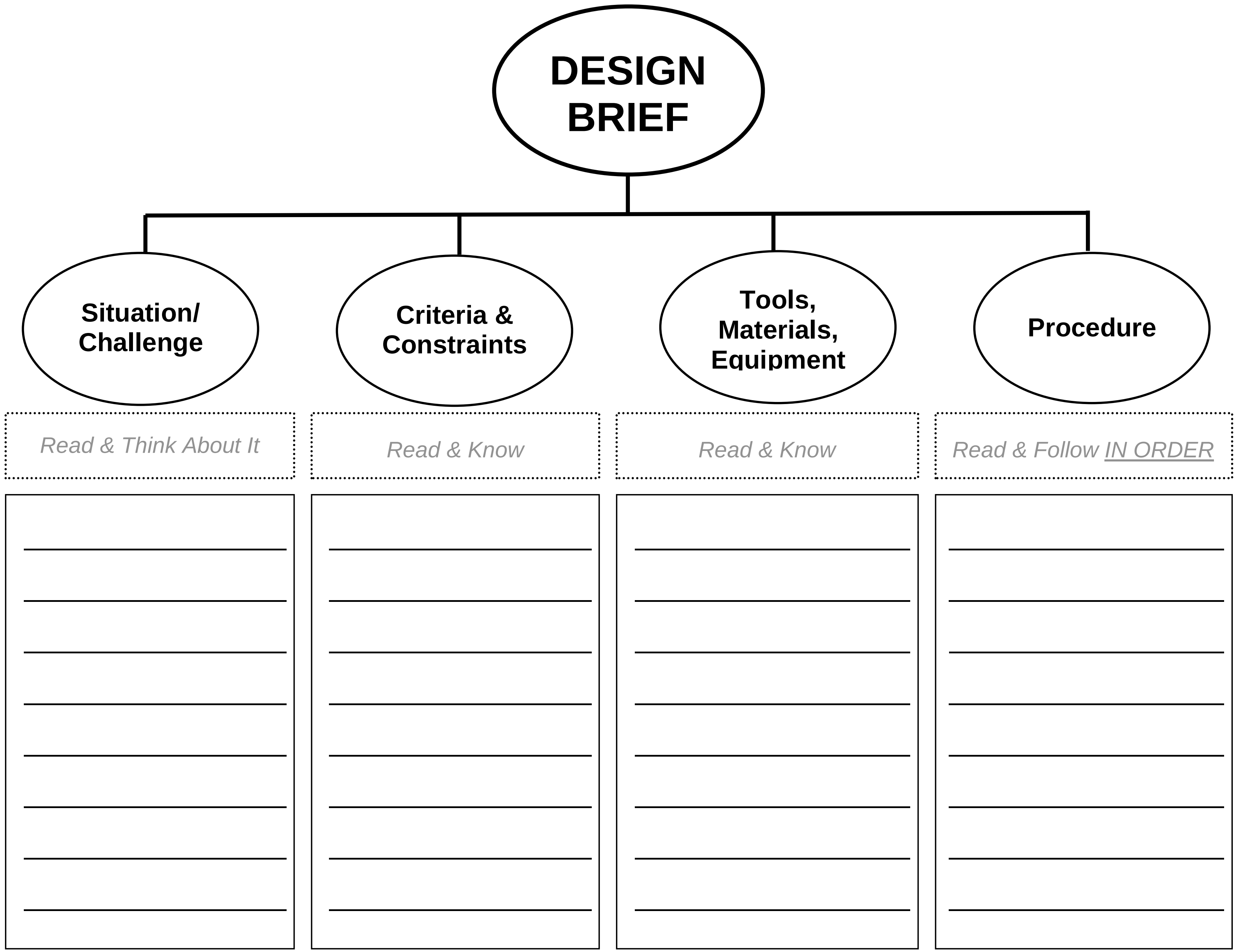
7. <u>Test</u> and Evaluate as well as <u>Communicate</u> who you are by clipping your name badge on your shirt. In this class we will wear our name badge where our heart is located.
8. You will not <u>Redesign</u> or Improve this product. Close your document without saving it.
9. Turn to page 2 in your Engineering notebook and draw a line under your last entry. Then, under the line, enter today's date.
10. CHOOSE either website below or do both.
    a. Begin by opening up the Internet on your computer.
    b. In your Engineering Notebook, after today's date, practice sketching. Your sketches do not have to be very big, but you want to be able to add details to it.
        - Go to bruceblitz.com - select Cartooning Tips - start by selecting the past tip CARTOON LION - sketch it using the steps. Now choose any of the tips and sketch them.
        - Practice basic sketching skills at: http://web.mit.edu/2.009/www/resources/sketchingTutorials.html
          When the page loads, begin by selecting one of the sketching skills. Follow along with the video sketching in your Engineering Notebook. If you finish one go to the next.

<u>Assessment</u>

This assignment will be recorded when it is completed correctly. You will receive and "X" to indicate you completed it.

If the computers or printer are not working – a copy of this Design Brief will be provided and you will use the graphic in your Engineering Notebook. Follow the Design brief through step 5 and substitute the paragraph below for steps 5a to 5m.

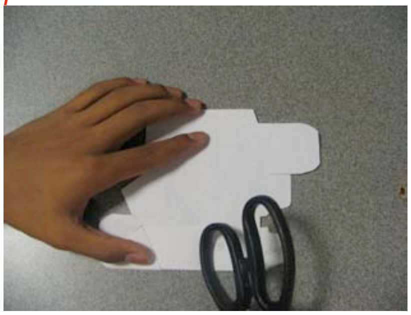
On the graphic, write your **first** and **last** name as large as possible on the lines. Do this on both sides of the name badge. Then write your three-digit Engineering Notebook number on the line. Turn on your call light and have it checked. Now go back to step 5n, and follow the procedure.


DESIGN BRIEF
Situation/ Challenge
Criteria & Constraints
Tools, Materials, Equipment
Procedure
Read & Think About It
Read & Know
Read & Know
Read & Follow IN ORDER

Design Brief
Flat to 3D

Situation/Challenge
This challenge will help you understand how a flat, 2-Dimensional image can become a 3-Dimensional object. It will also give you background information for solving future challenges. Your challenge is to label a flat image and make it into a 3-Dimensional object.

Criteria & Constraints
- Scissors may only be used for cutting the paper.
- Use the handle of your scissors and go over the fold lines – this will give you nice creases. *See picture below on how to do this.*



- Use very little glue.
- Recycle all paper scraps.
- Complete this design brief by due date.

Tools, Materials, Equipment
- Computer
- *Technology: Design and Applications* textbook
- Scissors – an extra pair of scissors for your partner are located at the Tools, Materials, Equipment area in your zone
- Pencil
- Very little glue

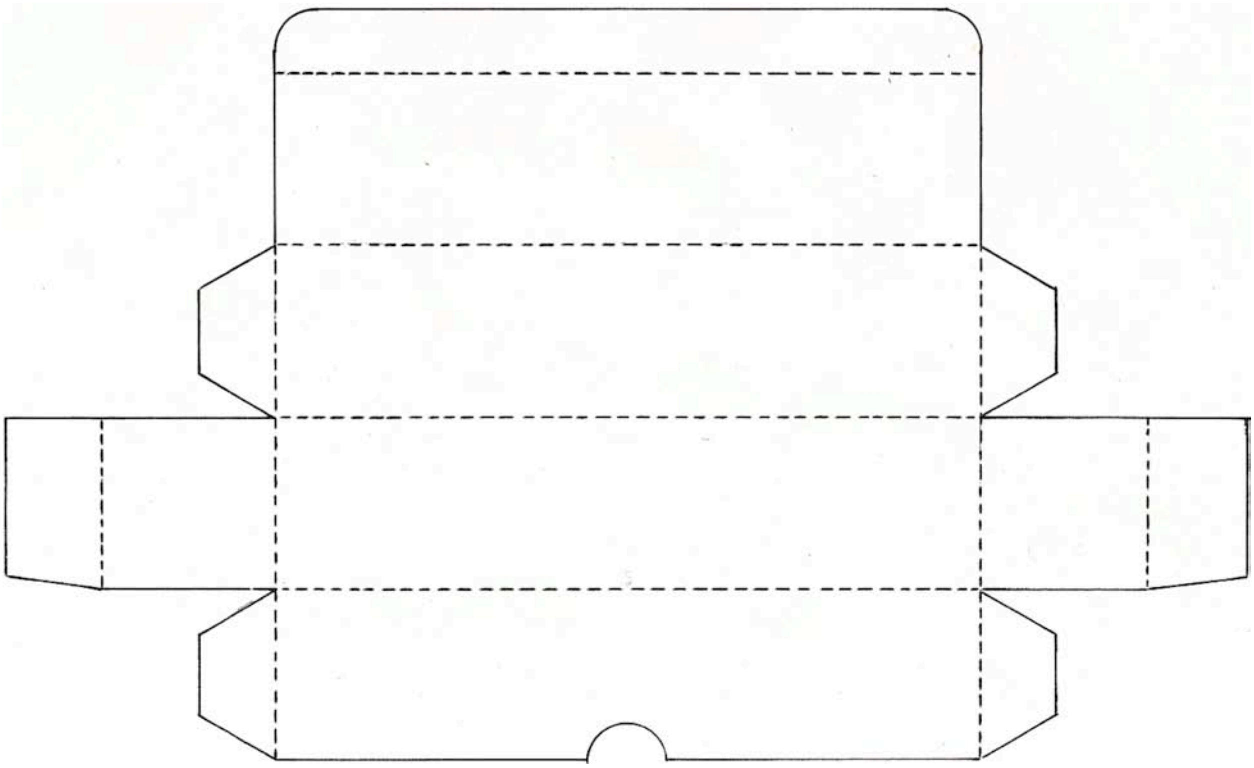
Procedure
1. **Identify** the problem by re-reading the situation/challenge. In your Engineering Notebook, restate the problem in your own words using a complete sentence.
2. **Research** –
   a. From your Technology Textbook (index), look up the answer to this question – What is an isometric drawing? Think . . . How can I put this answer this in my own words? Write your answer in a complete sentence in your Engineering Notebook.
3. The possible solutions have already been **Develop**ed for you.
4. **Select** one of the "boxes" from the Appendix C section (C-1, C-2, C-3, C-4) of your Engineering Notebook.
5. **Construct** your box by following the steps below . . .
   a. Study the isometric (3D) and flat (2D) drawings
   b. Label the views (top-front-side-right-left, etc.) on the isometric drawing
   c. Label the views on the flat drawing – be sure to label the flaps
   d. On the bottom view of the flat drawing, write your name and Engineering Notebook number
   e. Cut your box out of your Engineering Notebook along the dashed lines
   f. Cut out your box along the solid lines

g. Fold and unfold along each dashed lines – use scissor handle to crease lines
h. Fold and shape the box to look like the isometric drawing
i. Using very little glue – glue flaps but do not glue the box shut

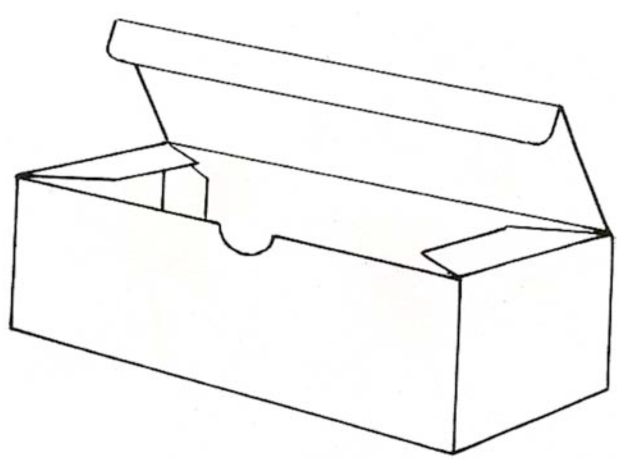
6. **Test and Evaluate** your box by comparing it to the criteria and constraints.
7. **Communicate** the solution by showing the folded box to your partner – point to and name each of the sides.
8. You will not **Redesign** or improve this product.
9. When you are finished, in your Engineering Notebook, sketch a 3D object at your workstation.
10. Now sketch what it would like if it were flat.
11. Select another box and repeat steps 5 through 7.
12. You will now design your own box.
    a. Think of a PRODUCT and how it could be packaged.
    b. Write the name of your product in your Engineering Notebook.
    c. Sketch 3 creative ideas as to how you would package this product.
    d. From your sketches, select the most creative box and circle it.
    e. Make a more detailed 3-Dimensional sketch of this box/package.
    f. Now locate a piece of scrap paper and draw the same box/package flat – include flaps and dashed lines for folding.
    g. Cut out your box along the solid lines.
    h. Fold and unfold along each dashed lines – use scissor handle to crease lines.
    i. Fold and shape the box to look like the isometric drawing.
    j. Using very little glue – glue flaps but do not glue the box shut.
13. Now look at other ways to turn Flat images into 3-Dimensional images. Type in one or both of the following addresses:

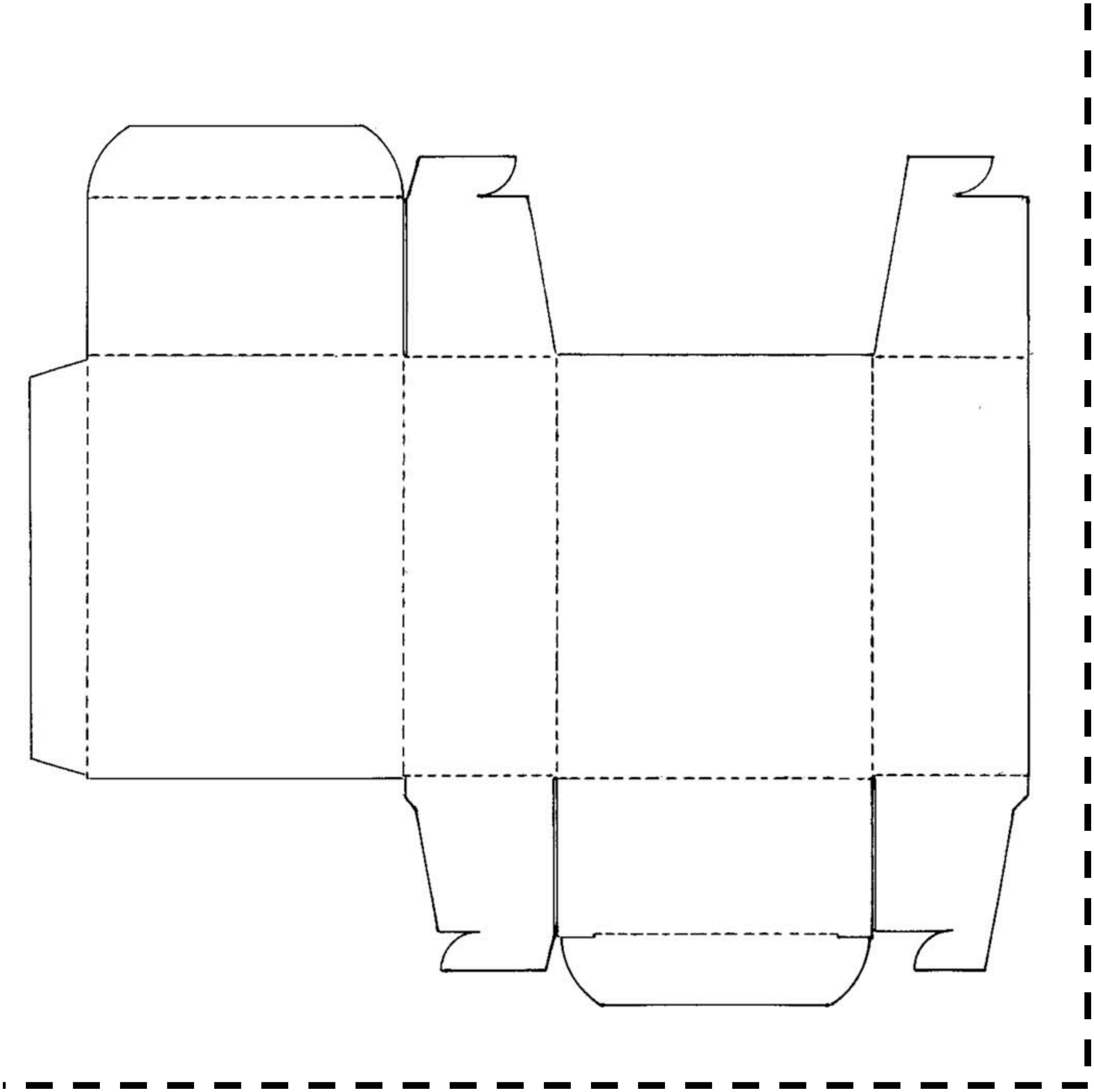
    http://www.papertoys.com/
    http://cp.c-ij.com/english/3D-papercraft/index.html – click on Download to view

    a. Look at all the 3D object you can make at home, or you could come in and print one after school to make at home.
    b. You might want to write these addresses in your Assignment Notebook.

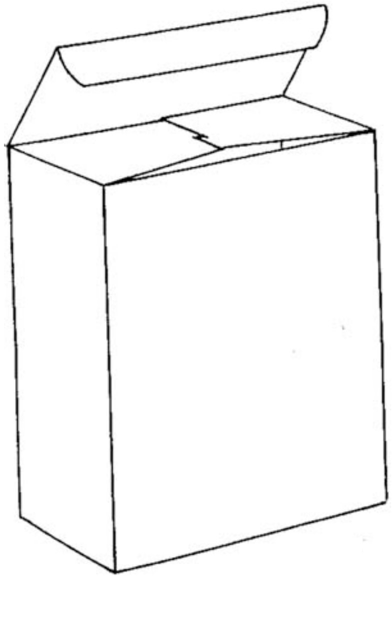


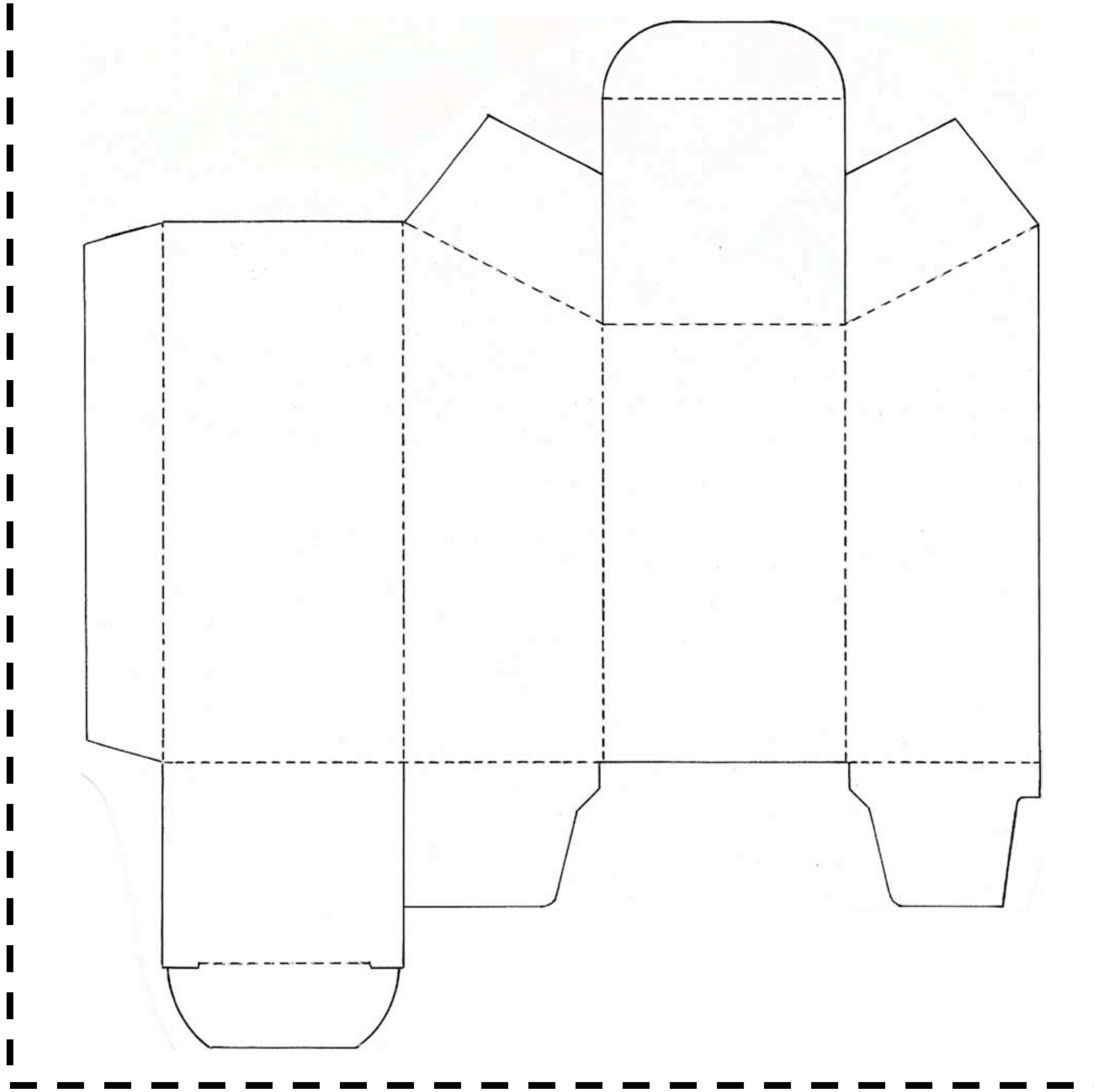
Cut out along dashed line



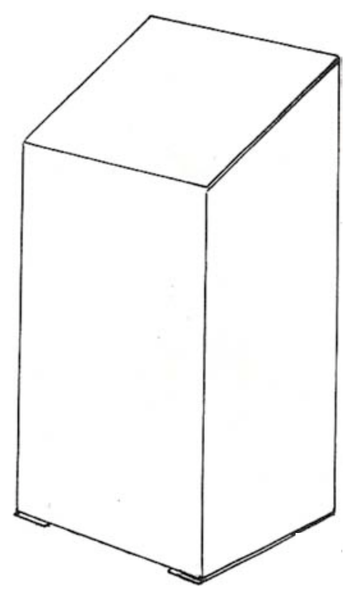


Cut out along dashed line





Cut out along dashed line



Design Process
Putting Together the Pieces

Directions: Engineers use the Design Process to solve problems. You too can use this process to solve problems, situations and challenges. This activity will help you learn the steps of the process and know happens during each step.

Remove this page by cutting along the dashed lines. Cut out the “half” circles. Now, turn to Appendix D-2. With your partner, match the description on the “half” circles to the correct circle in the Design Process. When you feel you have matched the design process with the correct description, make double stick tape and tape it in place.

remove along this line

Could it be better? How?

prototype model

restate the problem in your own words

use research and creativity to sketch/describe several ideas

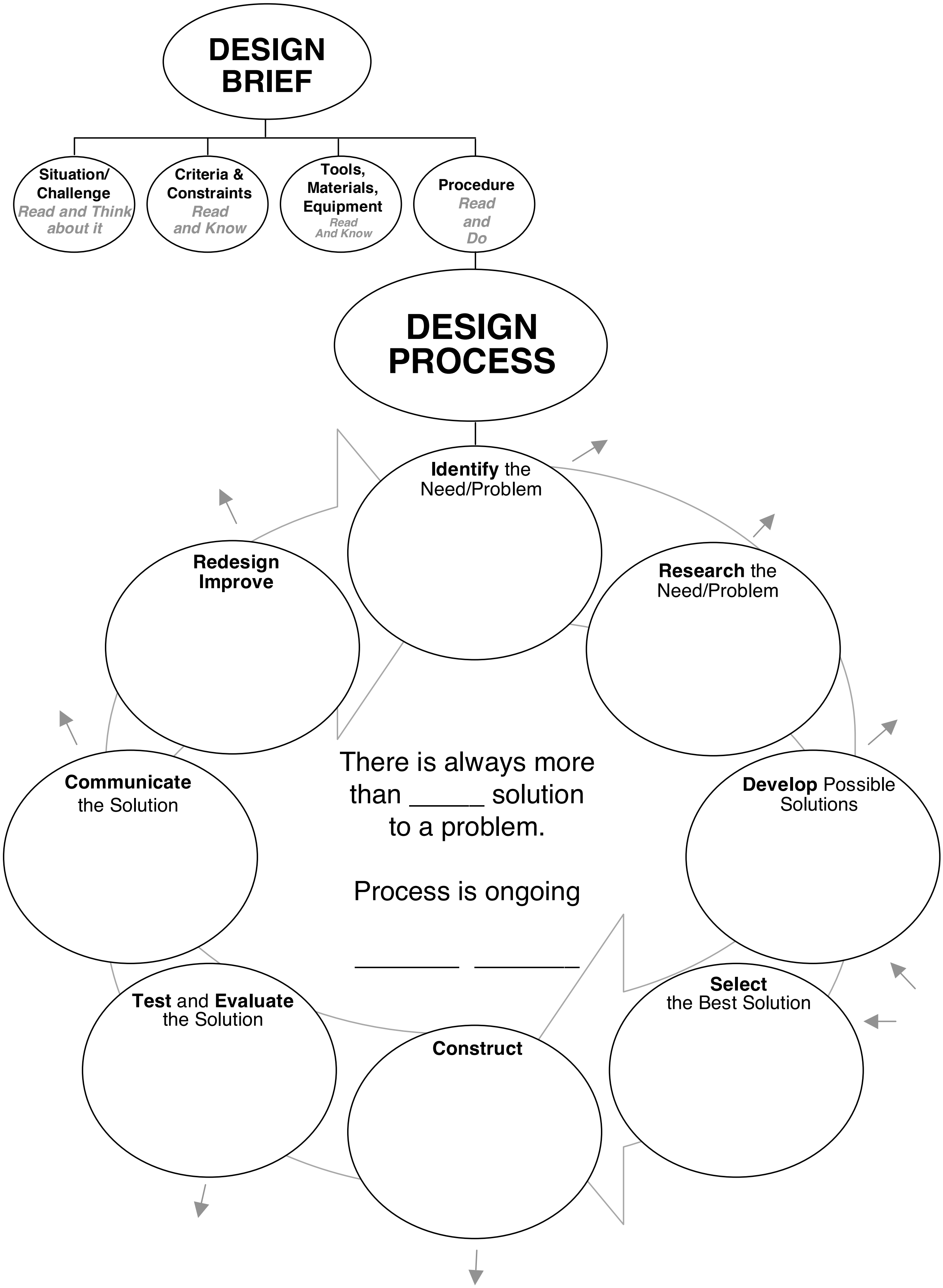
use creativity to tell your solution

books – internet databases experiences

best solves the problem – meets criteria & constraints

Does it solve the problem/work? Meet criteria?

Appendix D - 1


DESIGN BRIEF
Situation/ Challenge
Read and Think about it
Criteria & Constraints
Read and Know
Tools, Materials, Equipment
Read And Know
Procedure
Read and Do
DESIGN PROCESS
Identify the Need/Problem
Research the Need/Problem
Develop Possible Solutions
Select the Best Solution
Construct
Test and Evaluate the Solution
Communicate the Solution
Redesign Improve
There is always more than _____ solution to a problem.
Process is ongoing
_______ _______

Engineering & Technology Notes

Why Study Engineering and Technology?

Technological Literacy

Technological Device
YOUR EXAMPLE

Tech Device:

Problem it solves:

Problem it creates:

Technology is:

Product

Process

Science is . . .

Technology is . . .

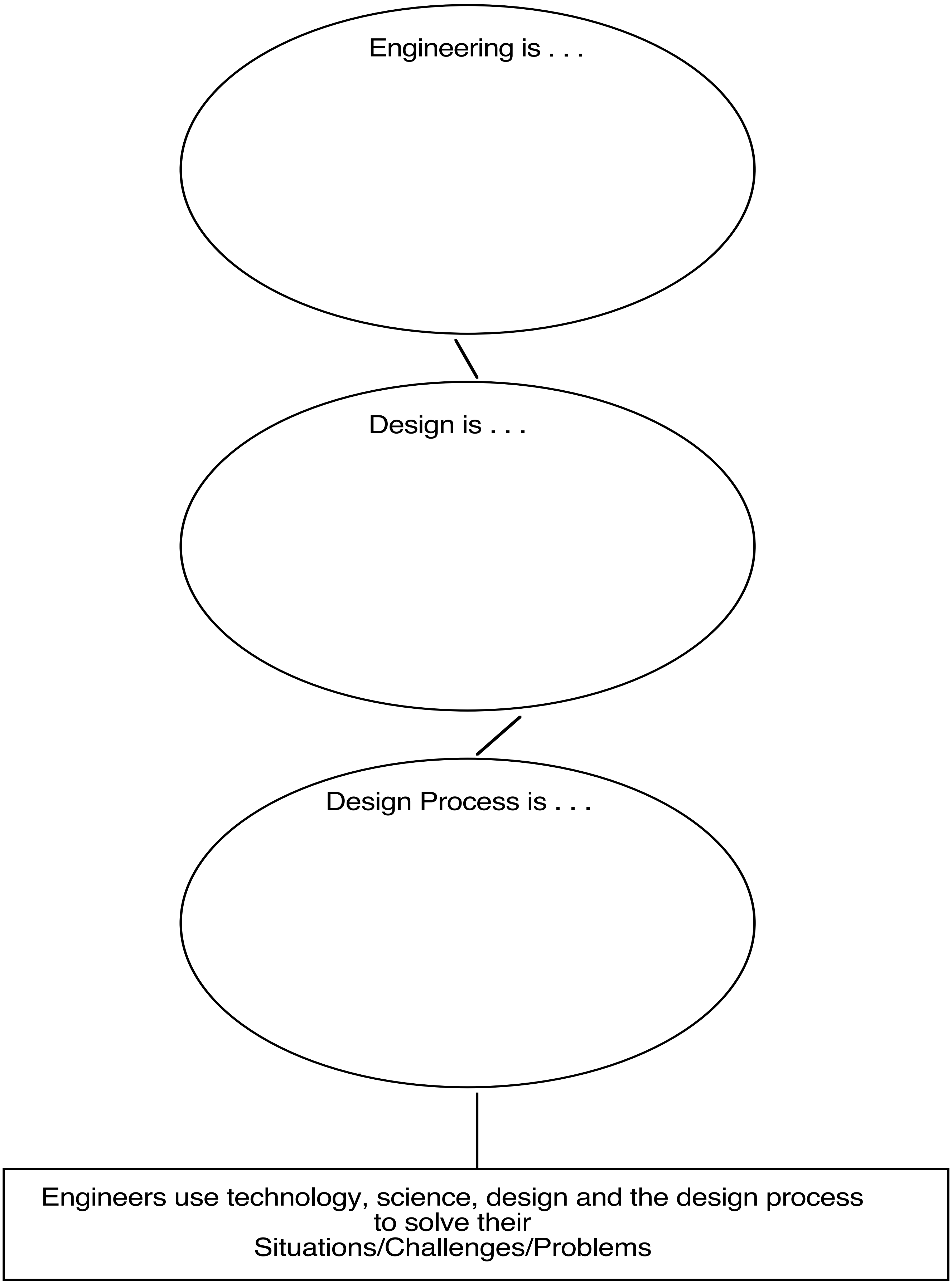
Technological Device

Technology is developed three different ways

Invention

Innovation

Serendipity


Engineering is . . .
Design is . . .
Design Process is . . .
Engineers use technology, science, design and the design process
to solve their
Situations/Challenges/Problems

r e m o v e a l o n g t h i s l i n e

Design Brief
Product of Technology Poster

Name: ___________________________________ Eng. Ntbk. # _________ DUE: _______

Challenge/Situation

Inventions, Innovations, and Serendipities have satisfied our wants and needs. They have been developed throughout time effecting our past, the present and some cases our future. Your challenge is to create a poster about an existing product of technology using the criteria and constraints below. **EXAMPLES of posters can be found on the billboards in the lab.**

Criteria/Constraints

1. This poster will be done entirely out of class time. You may come to the lab after school, use the media center or you may do this at home.
2. Be on the **FRONT** of **one** 8.5" x 11" sheet of paper.
3. Organized - neat - shows effort. Looks like a poster not a report.
4. Have the **name** of the invention, innovation, or serendipity – see procedure below.
5. A **picture/graphic** of the invention, innovation, or serendipity.
6. State **why** it is an invention, innovation, or serendipity.
7. **Who** invented, innovated or discovered (serendipity) it.
8. **When** it was invented, innovated or discovered.
9. Based on your research, state an interesting **fact** about your invention, innovation, or serendipity.
10. **Cite** the resource(s) used for your research. Give the entire Internet address or book title, author, year published and page number.
11. This sheet attached lightly taped or stapled to back of poster:
12. Handed in by due date.

Tools/Materials/Equipment

Books, computer, printer, markers/crayons/pencils, paper, scissors, glue, tape – whatever you have around the house to be creative.

Procedure

1. **Identify** the problem by re-reading the situation/challenge.
2. **Research** the problem by finding possible products of technology that match the criteria/constraints – **you may not use any of the examples given in class or food.** HINT: if you cannot find all the criteria/constraints, pick another product.
3. **Develop** possible solutions by making a list of possible products found in your research.
4. **Select** the product that best fits the criteria and constraints.
5. **Construct** your poster by using the criteria/constraints as a checklist.
6. **Test** and evaluate your poster by looking at your criteria/constraint. Put a check by the number if you did that criteria/constraint.
7. **Communicate** the solution by handing in your poster **after** you do the next step.
8. **Redesign** or improve your poster by making any corrections to the poster to meet the criteria/constraints you do not have a check beside.

Assessment is based on following the criteria/constraints

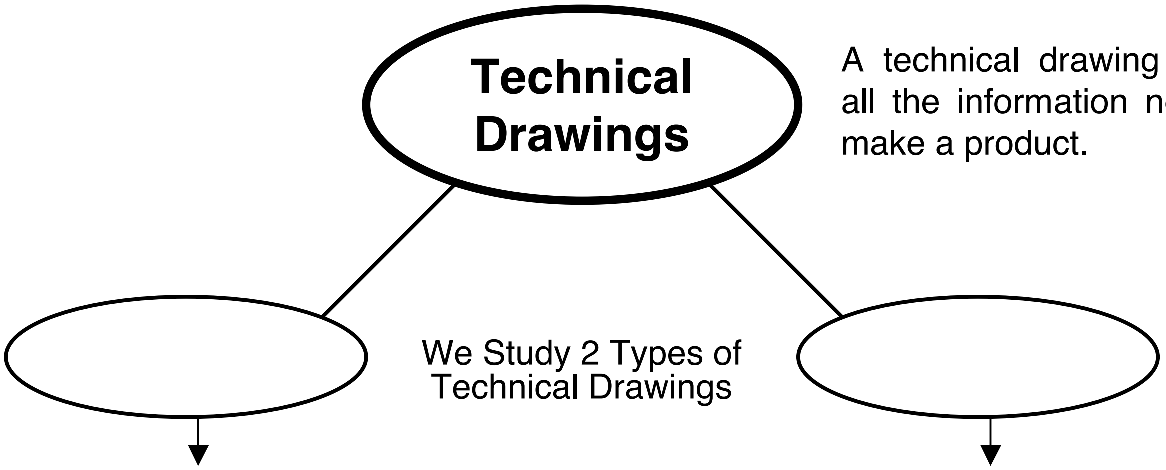
Points earned

12 = A   11 = B   10 = C   9 = D   8 and below = not passing

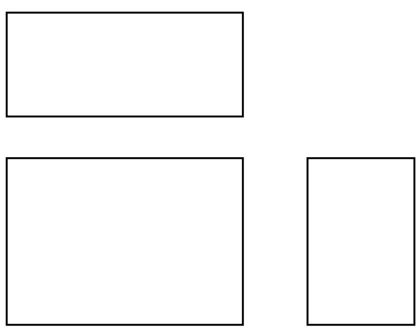
Remember you can correct/do your work and hand it back in. FINAL DUE DATE: _______

Corrected on: _______ New Score Earned: _______

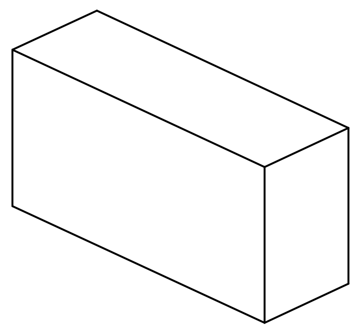
“A _______________ is worth a thousand words.”

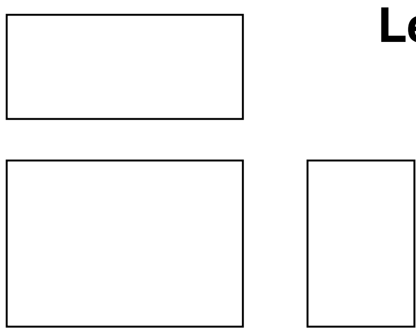


A technical drawing includes all the information needed to make a product.



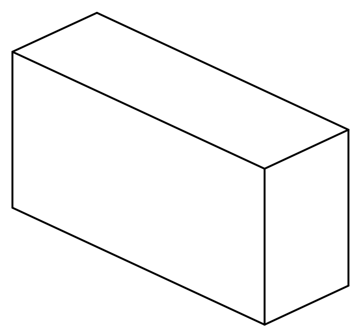
The 3 Views

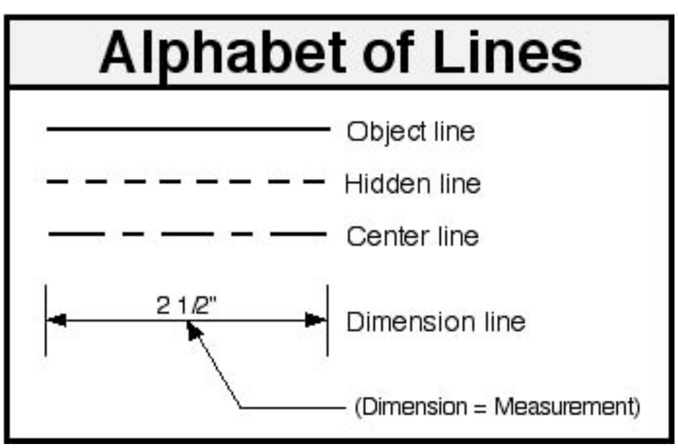




Length, Height, Width

X =
Y =
Z =





Scale: ______________________________

Proportion: __________________________

Stock: ______________________________

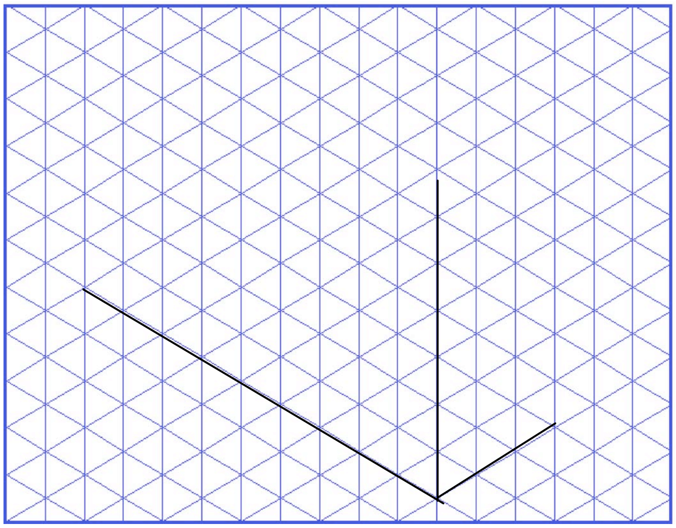
Object line: __________________________

Hidden line: _________________________

Center line: __________________________

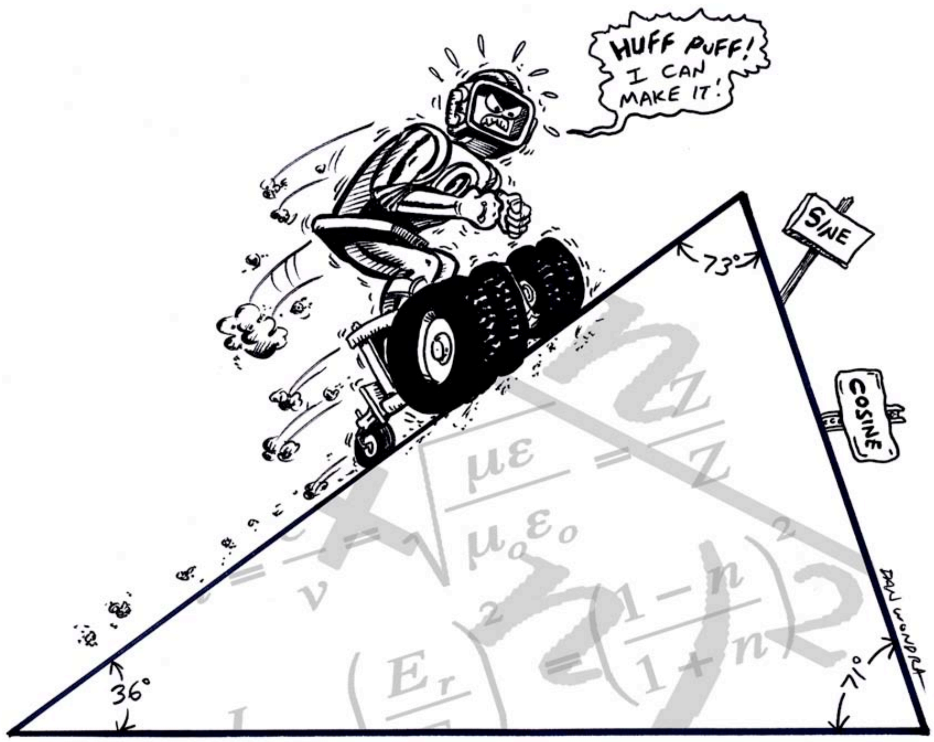
Dimension: __________________________

Isometric Graph Paper



Steps to making an Isometric Drawing:

1. Study the drawing
2. Lightly Sketch X axis
3. Lightly Sketch Y axis
4. Lightly Sketch Z axis
5. Lightly Sketch basic geometric shape in front view
6. Lightly Sketch in top and side views
7. Lightly Sketch in details beginning with front view
8. Erase lines not needed
9. Darken object lines



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The PETER KIEWIT INSTITUTE

INFORMATION SCIENCE, TECHNOLOGY & ENGINEERING

SSW 10: Robot General Lesson Ideas				
As generated by SPIRIT teachers (October, 2008)				
Context				
Moving TekBot	**TekBot Const.**	**Eng Notebook**	**Concept**	**Lesson Idea**
1			Angles	If you can change the angle of direction of the TekBot, what do you have to do to stay within an obstacle course? How about declination or inclination? (ramps)
1			Angles	How many degrees can the TekBot turn within a specific limited space?
1			Angles	How does the TekBot handle ramp angles? Calculate TekBot speed at different angles.
1			Area/Perimeter	Move TekBot in shapes and then solve for A or P, based on TekBot path measurements.
1			Area/Perimeter	Student moves robot to form shape with pregiven area or perimeter.
	1		Astronomy	Compare TekBot to Mars Rover in its construction.
		1	Astronomy	Research Mars and moon robots
		1	Astronomy	Show how robots are used in space today.
1			Basic Facts	Move TekBot around flash cards and students answer the question.
1			Basic Facts	Put answers to math basic facts on floor. Partners drive TekBot to answer the problem.
1	1		Batteries	How batteries function in a TekBot
1	1		Batteries	Measure how long different types of batteries last.
1			Batteries	Use fully charged vs. not fully charged batteries to see effect on TekBot performance.
	1		Bridge engineering	Understanding the design of bridges and have TekBot traverse bridge.
	1		Bridge Engineering	Examine the weight limits of a bridge and test with a TekBot moving across the bridge.
1	1	1	Cell Biology	Can you make a comparison chart of cell structures to that of TekBot components?
1			Cell Biology	How do TekBot circuits compare with cell communication?
1		1	Chemical Reaction	How long will the battery go before depletion? Rechargeable versus disposable can connect to slope.
1			Chemical Reaction	Observe batteries with different levels of charge and observe different reactions (movement of TekBot) How long does a battery type last?
	1	1	Chemical Reaction	What happens when a resistor is overloaded? Also, how do capacitors work? (the metals used, etc.). Documentation of results of tests.
			Circuit and Ohm's Law	How does the TekBot represent the equation V=IxR? Also, find I = instead of V, etc., solving for each variable.
	1		Circuits	Use design process to solve problems related to circuits.
	1		Circuits	Building a circuit out of popsicle sticks and tin foil which models a TekBot circuit.
	1		Circuits	Drawing open/closed circuits as they might exist on the TekBots.

Context				
Moving TekBot	TekBot Const.	Eng Notebook	Concept	Lesson Idea
1			Circumference	TekBots move around in circles and measure the circumference of those circles.
1			Circumference	Have the TekBot create several different type circles with students outlining the circle.
	1		Circumference	Using a shoebox full of wheels, how do different sizes impact TekBot motion?
1	1		Consumer decision: Honda vs. Hummer	Is a TekBot like a Honda or a Hummer? Compare mass, force needed, etc. to make a consumer decision. Futuristic applications.
1		1	Coordinate Axis	Graphing movement as TekBot moves on a large grid.
1			d = r x t Algebra Equation	Can you explain how different equations represent TekBot motion?
1	1	1	Decimals	What is the force being applied by the TekBot?
1	1		Decimals	Can you explain how the TekBot is moving using mathematics? Conversions, etc.
1			Decimals	How close can you measure TekBot movement? For example, to the nearest centimeter, etc.
	1		Decimals	If I was an engineer for this TekBot how much would it cost to build it?
1			Definition of Life	Is the TekBot alive? Does it move, seek shelter, seek food, etc.
1			Definition of Life	What defines life? Is the TekBot living? Why or why not?
1	1	1	Design	If you were to design a robot that made you breakfast, what would it need to do?
		1	Design Process	Illustrating it as you complete and create TekBot enhancements.
		1	Design Process	Design your own TekBot with a different purpose.
		1	Design Process	Figure out how to improve TekBot and make suggestions.
		1	Dialectic Notebook	Can you explain your TekBot experiment? Your objectives? Your mistakes? Have handout made to have students use layout for labs.
1			Dinosaur	Velcro a dinosaur on the TekBot. Create a game to review dinosaur information.
	1		Dinosaurs	Create mobile dinosaurs using the TekBot
		1	Dinosaurs	Compare/contrast TekBots to computers (old and future), then to cars; things must evolve/become better!
1			Division	Apply r*t=d to find speed (r=d/t) when discussing motion.
1			Division	Use it to show differences in sizes and scale.
	1	1	Electricity	How does the TekBot use resistors? How about capacitors?
	1	1	Electricity	How does a particular circuit work on the TekBot?
	1		Electricity	Your instructor has disabled your TekBot, how do you find what is wrong?

Context				
Moving TekBot	TekBot Const.	Eng Notebook	Concept	Lesson Idea
	1		Electricity	Can you create a simple circuit using tinfoil, popsicle sticks, LED, and battery?
	1		Electricity/ Positive-Negative	What stops the flow of electricity? What happens when you hook things up wrong in a particular part of the TekBot?
1	1	1	Engineering as a Career	Can you create a KWL chart to discuss the topic of engineering?
		1	Engineering Fields	What types of things need to have an engineer design them?
1	1	1	Engineering Problem Solving	Can you find a group solution to a particular TekBot situation/task?
	1		Following Directions	Can you give multistep directions to follow in moving the TekBot?
1			Force	TekBot pushes things on different surfaces.
1			Force	Experiment with adding weight to the TekBot and observe performance.
1			Force	Show how different forces make it move differently, and use vectors to illustrate the forces.
1	1		Formulas	Can you explain TekBot speed mathematically (velocity)? Can you explain its acceleration?
1			Formulas	Can you move the TekBot to show D = R x T ? How about S = D/T?
	1	1	Formulas	Can you measuring friction using different surfaces?
1			Fractions	Changing fractions to percentage in how far a TekBot is moving on a path.
		1	Fractions	Converting % to fractions and look at the percent grade of a ramp.
1	1	1	Friction	Can you illustrate Newton's Laws with a TekBot?
1		1	Friction	Can you calculate rate of ascent for varying inclines?
1			Friction	Can you use different weights and surfaces to test friction?
			Function of robots in society	What qualifies something as a robot? Can they be made more "human"?
1			Geometric Shapes	Can you create different geometric shapes by attaching yarn to the TekBot and moving it around a grid?
1	1	1	Graphing	Can you represent TekBot movement on a coordinate axis?
1	1	1	Graphing	Can you represent the various components of the TekBot using a Venn Diagram?
1			Graphing	Can you show the results of TekBot speed/change variables on a graph?
1			Graphing	Can you locate the positions of the TekBot based on ordered pairs?
1			Graphing	Can you set up a race track and graph distance vs. time of the TekBot?

Context				
Moving TekBot	TekBot Const.	Eng Notebook	Concept	Lesson Idea
1			Graphing	Is it possible to move the TekBot in a truly straight line? (add seconds for segments off the line). Graph segments or average time to travel course.
1			Graphing	Can you plot the diagonal distance of the TekBot using a grid and the distance formula? If the robot picks the points of its own path?
	1		Historical Research	See how robots have changed, compare/contrast robots of the past, present and future.
		1	Historical Research	Timeline of the invention of silicon chips.
		1	Historical Research	Research the development of motor technology.
	1		iMovie	How to construct the TekBot using step by step directions.
	1		iMovie	Create a tutorial where students show how electronics tools should be used safely.
		1	Innovation vs.. Invention	Are their real world applications of our TekBot?
1	1	1	Inquiry	What if the TekBot could be "super sized"? How could it move better? (e.g. larger wheels, larger batteries.)
1	1		Inquiry	How can robots work to help in today's industry?
	1		Inquiry	Why do you need a resistor? Allow students to demonstrate the answer.
		1	Inquiry	What questions would a person new to robotics have about your TekBot? Give them a TekBot and have them record questions, etc.
1			Integers	Movement on a big number line to use the TekBot to show integers.
1			Integers	Use with coordinate graphs to show negative and positive numbers.
	1		Inventions	How would you change a TekBot. What purpose would it have to help mankind?
		1	Inventions	Design new attachments for the TekBot.
1	1	1	Lab Safety	In what ways could you inadvertently damage the TekBot. How might it damage you inadvertently?
		1	Lab Safety	Why do we need lab safety when working with the TekBot? Examples?
1			Lesson Set	How can a TekBot be used to explain integers to a younger student?
1	1	1	Life	Is the TekBot alive? Why, why not.
	1		Magnetism	Explain how a motor works with a TekBot.
	1		Magnets	Study how magnets work inside a motor with a TekBot.
1			Mass	How much mass can the TekBot transport?
1			Math Facts	Move TekBot on a number line to do basic facts.
1			Mean, Median, Mode	How do different TekBots materials impact its performance?
1			Mean, Median, Mode	What is the average time a TekBot can traverse a maze? Calculate measures of central tendency.

Context				
Moving TekBot	TekBot Const.	Eng Notebook	Concept	Lesson Idea
1		1	Mean, Medium, Mode	Calculate and graph central tendency of races, obstacle courses, etc. Record construction times.
1			Mean, Medium, Mode	Navigate maze--determine class mean, median
1		1	Measurement and Unit conversions	Is mph appropriate unit of measure? What's a better unit? Create chart of different units. (convert weight unites)
1	1	1	Metric Measurement	Distance measurement size of TekBot, parts sizes documentation of sizes
1			Metric Measurement	Have TekBot navigate maze measuring metric, and mass-grams.
1			Metric measurement	Measure mass of different parts of the TekBot. Measuring distance traveled on track.
	1		Metric Measurement	Unit conversions while building
1			Metric System	Converting and measuring in metric a TekBot moves across the floor.
1			Metric System	Measuring distance and compare metric to standard measurements.
1			Metric System	Measure distance around room as TekBot travels.
	1		Metric System	Measuring weighted components of the TekBot.
1			Microbiology	Using a moving TekBot to simulate the spread of viruses or bacteria.
		1	Microbiology	Compare and contrast a TekBot with a cell, could lead to other cells.
1		1	Mode, Median, Mean	Using TekBot to make trial runs of distance and time and record the results. Discuss mean, median, mode.
	1		Motors-How They Work	How do motors work, parts, functions.
1			Newton's Law of Motion	Have different weighted objects in front of TekBot to illustrate Laws of Motion.
1			Newton's Law of Motion	Find Newton's 2nd law of Motion by placing different masses on the TekBots and measuring speed.
1		1	Newton's Laws	
1		1	Newton's Laws	F=ma Add weight to the TekBot to find change in velocity and acceleration.
1		1	Newton's Laws	Moving-gravity; Notebook-definitions processes of Newton's Laws
1			Newton's Laws	What happens when we change the direction of a wheel--what happens when an object disturbs the laws of motion.
1			Newton's Laws	Explore F=ma Add mass to TekBot and measure speed and acceleration.
1		1	Newton's Laws (Part A)	Definitions and formulas along with drawings in the notebook. Simulation tests.
1			Newton's Laws (Part B)	use the actual TekBot to experiment and incorporate these formulas. Record findings in notebook.

Context				
Moving TekBot	TekBot Const.	Eng Notebook	Concept	Lesson Idea
1			Newton's Laws of Motion	Inertia (First Law) use and object with and without a seatbelt. F=MA (2nd Law)--play with the mass to see the effect. (3rd Law) Action/Reaction--more vs. less mass--run TekBot into things.
1			Newton's Laws of Motion	Looking at how there must be an energy source to run something, including TekBots.
1			Note taking Documentation	Learning how important note taking is. Teaching combination note taking.
1	1	1	Operations	If you have x dollars and you need to get y number of parts to fix your TekBot, how and what could you purchase to complete your task?
		1	Outline Notes	Document procedure in outline form.
	1		Parts of a Circle	Calculate ratios of different types of wheels. Different calculations of diameter, radius, pi
1	1	1	Percent	Efficiency, drag. Hypothesis-engineering changes create percent of change in performance
1	1		Percent	Track percentage completion. Mass percentages of components.
1			Percent	Analyze percent difference, percent change.
1			Percent	Use for a completion of a maze (% finished).
1			Percentage	Find the percentage of total distance traveled. Find the percentage of ramps used with slope.
1		1	Podcasting Technology	Give oral directions for another to follow around an obstacle course.
1			Polygon	Move in the shape of a polygon and see if TekBot turn radius is sufficient.
1			Polygons	Creating shapes with the TekBot movement and recording with marker.
		1	Polynomials	Solving formulas of the TekBot as it moves in parabolic paths.
		1	Polynomials	Use with algebra and find resistance and describe paths of the TekBot.
1	1		Positive-Negative	Moving TekBot simulating number line. Positive, negative--electricity lesson
1			Positive-Negative	"Mobile counter" -- number line along baseboard with TekBot
	1	1	Positive-Negative	Conduction-Positive/Negative junctions, resistors, Forward Advancement-reverse for +/- number calculations. Documentation of connections
	1		Positive-Negative	Show what happens if you change the battery, balancing of protons/neutrons
		1	Positive-Negative	Use the diode to show the positive flow.
1	1	1	Problem Solving	"Your job is to get the TekBot to do this…." Generate a list of inquiry--"I wonder what would happen if…"
1	1	1	Problem Solving	How can you document and why. Quality control., trouble shooting. What mathematical knowledge required to build/operate TekBot?
	1	1	Problem Solving	Using the dialectic method for engineering log book

Context				
Moving TekBot	TekBot Const.	Eng Notebook	Concept	Lesson Idea
		1	Problem Solving	How do I solve this? What could this be used for? What's the best solution?
		1	Problem Solving	What do you do if it doesn't work. Brainstorm ways to test TekBot.
1			Rational & Real Numbers	Divide the circumference of circular paths by diameter for students to discover the value of Pi.
1			Ratios, torque, Problem Solving, Inquiry	Alter gear ratios and show/test relationships.
		1	Real Numbers	Experiment with different formulas and illustrate the Real number system.
	1		Recognizing Electronic Components	Lesson on resistor colors and their values.
1	1	1	Reflection	What math skills are required to build your TekBot? Can you identify all that you used?
1	1		Scale	Compare original wheels to larger/smaller wheels
1			Scale	Problem solving-changing
	1		Scale	How to scale the parts to fit the construction.
		1	Scale	Compare a TekBot to a real car and include a scale diagram. How does a tire to body scale change between a real car to a TekBot.
		1	Scale	Have students estimate size conversions relative to different payloads.
1	1	1	Science Ethics	What are the ethics of creating. So does the ethics of applications
1	1	1	Scientific Method	Examine how a trailer impacts TekBot performance.
	1		Scientific Method	Order of operations for construction. Trial and errors.
		1	Scientific Method	Compare scientific method to engineering method.
		1	Scientific Method	Give a problem and think of ways we could use the TekBot to help solve that problem.
1	1	1	Simple Machines	What simple machine is used to move the robot, building the robot. Create a Venn diagram of how they are common/different.
	1		Simple Machines	How do simple machines work?
		1	Simple Machines	What are the simple machines? How are these making the TekBot move more easily?
		1	Simple Machines	How things work.
1	1	1	Slope	Capacitors/resistors, linear slope vs. exponential slope
1			Slope	Set up a ramp at different algebraic slopes and observe TekBot movement up the ramp
1			Slope	Figure out the slope of the a ramp and its impact on TekBot

Context				
Moving TekBot	TekBot Const.	Eng Notebook	Concept	Lesson Idea
1			Slope of a line	Using ramp--how slope affects movement of car. (incorporate friction)
1			Sound	Adjust the pitch and volume with differing resistors, etc.
1			Sound	Drive across different materials and compare the sounds they make.
1			Sound	Measuring sound waves, comparing to electrical waves, using the context of the TekBot.
1		1	Sound (Doppler Effect)	Attach a noise maker to TekBot and have students cover their eyes. Students can describe the path of the TekBot as the operator moves it around the room.
1			Speed	Graphing different speeds dragging different weights with TekBots (charts/spreadsheet applicable also)
		1	STEM Careers	S.T.E.M. career research criteria, including salary, education, and daily work load.
1	1		Systems of Equations	Measuring friction
1			Systems of Equations	Use the TekBot to visually demonstrate "solution," to a system by physically showing intersections.
	1	1	Technical Drawing	Drawing a diagram of the TekBot construction process.
		1	Technical Drawing	Design TekBot accessories using technical drawing.
		1	Technical Drawing	Use to CAD-measure components and make a scale drawing.
		1	Technical Drawing	Learning to draw TekBot circuits and how it completes a circuit.
1	1	1	Technology & Society	Brainstorm the ways robots are being used in society.
1			Technology & Society	1. Mars rover 2. Bomb Squad 3. Vacuum cleaner and pool cleaner.
		1	Technology & Society	Have a discussion on how to improve the TekBot to also discuss about engineers.
	1	1	Technology in Society	Have an engineer come and explain the parts of a TekBot.
		1	Technology in society	Discussion about how technology is used in society.
		1	Technology System	Where Robots fit in a system. Mind mapping. Kids Spiration & Inspiration Software
1			Terrains	Varied terrains and observing how the TekBot responds
1			Time	measure time from point A to Point B as TekBot travels.
1			Time	Estimate time for distance traveled with a TekBot.
1			Time	Drive TekBot around polygons outlined on floor and measure times and compare for shapes.
1			Time	Races--measure the amount of time to travel a race path.

Context				
Moving TekBot	TekBot Const.	Eng Notebook	Concept	Lesson Idea
	1	1	Transistor	Demonstrate what it is' give examples outside of TekBot constraints.
	1		Transistor	How does a transistor affect your machine?
	1		Use of electronic components	Using VOM to test components and understand usage for them.
1	1	1	Using Formulas	Solving any physics equation after finding path with the TekBot.
		1	Variables	Solve problems involving circumference, power, velocity, etc.
1			Velocity	run the TekBot and measure number of revolutions per time and how far it goes per time.
		1	Velocity	Velocity of TekBot, math terms in notebook.
1			Velocity, Algebra, Problem Solving	In 60 seconds what is the largest square you can make?
1			Velocity, Distance	Mapping a room.
1			Video Technology	Create a video through the viewpoint of the TekBot. Use garage band, etc. to create feelings, etc. in the film.
1	1	1	Voltage	Use of multimeters
	1		Voltage	Test resistors V=IxR Experiment with multimeter.
	1		Voltage	measuring voltage using batteries--increase voltage
	1		Voltage	How does the TekBot change using different size batteries
1			Weather	Examine road conditions and performance of the TekBots on different roads.
1			Weather	How does weather affect the TekBot?
	1		Weather	Compare TekBot performance at different temperatures.

To Inspire Tech Kids, Inspire Tech Teachers

Teachers build robots in Nebraska, fix marine problems in California

The Silicon Kids:
Fourth In A Five-Part Series

BY JULIE VALLONE
FOR INVESTOR'S BUSINESS DAILY

Listen up class; here's your lesson for the day: If you want inspire the next generation of tech professionals, start with their middle school science and math teachers.

Studies show declining interest among college students in computer science, engineering and related fields. Many fear the U.S. will face a shortage of skilled tech workers.

Thus, a growing number of university educators and business executives say it's crucial to start early by getting kids interested in tech before they reach high school.

Math and science teachers want to do just that, but they often lack the out-of-classroom experience needed to show their students how their math homework or science experiments actually relate to rewarding careers in technology.

People such as Bing Chen, head of the Computer & Electronics Engineering Department at the University of Nebraska, are trying to change that. After visiting area high schools, he found that not enough was being done to expose students to his field.

"When I would meet high school students interested in engineering, there weren't very many of them, and they weren't particularly well prepared," he said. "It struck me that we needed to give younger students some introduction to engineering principles and a look at engineering as a possible career path before they reach high school."

So Chen and his colleagues created the Silicon Prairie Initiative on Robotics in IT, or Spirit, program for teachers and students. This past summer, the university invited 32 middle school teachers from Omaha, Neb., schools to participate in a two-week, hands-on engineering workshop.

Its agenda was drawn from the school's undergraduate engineering curriculum. Teachers learned engineering principles by building a small robot from scratch — using math, science and information technology, or IT.

"Frankly, our math and science teachers are not given many opportunities to explore engineering," Chen said. "Our workshop was designed to give them exposure and build skill sets in this area."

First Session Was Experiment

The Spirit program also includes summer workshops and school activities for kids, as another means of drawing young people to the field.

Chen says the program, in its first year, received a positive response from the teachers.

"This summer's program was experimental; we really didn't know what to expect," he said. "We found we had quite a diverse mix of teachers attending our workshop, with ages ranging from grandparents to very young teachers just starting out. They were all excited when they left."

Now that the teachers are back in the classroom, Chen says, they're able to incorporate what they learned into their lesson plans, and they're better able to identify which young people have the potential to be engineers.

For the National Middle School Aerospace Scholars, or Namas, program administered by San Jacinto College in Pasadena, Texas, robot building is also on the agenda.

The school, which enjoys a close relationship with the NASA-Johnson Space Center in nearby Houston, invites 150 teachers from eight states to attend year-round workshops where they learn about the aerospace industry.

"We need to attract young people to the aeronautics field, and believe we can hook them using the excitement of space and robotics," said math professor Sharon Sledge, one of the program coordinators. "We can also help the teachers get more students involved in math and science by building what they've learned into their curriculums."

As part of the workshop, teachers tour NASA, experience flight simulations used by the astronauts, learn about what it takes to launch a spaceship and talk to astronauts and others who work at NASA.

"We want to send the message that it takes more than astronauts to have a space program," Sledge said. "The teachers meet people from a variety of fields, so they understand that you can be a marketing or accounting major and still work for NASA. They learn that many NASA employees are everyday people."

Includes Videoconferencing

The program also helps teachers incorporate what they're learning into their curriculum, and lets them communicate with their students back in their classrooms through videoconferencing, Sledge says.

Farther west, on California's Central Coast, science and math teachers are getting a taste of in-the-field scientific inquiry through the Marine Biotechnology & Bioinformatics program at Moss Landing Marine Laboratories, part of California State University, Monterey Bay. At workshops during the summer and throughout the year, teachers learn how to investigate marine problems by gathering field samples, working in a professional marine lab environment, and using biotech gear to manage and analyze data.

School teachers build robots at a U. of Nebraska-Lincoln tech workshop.

Teachers are also given help in integrating their experiences into their curriculums. Like all the programs here, the program receives funding from the National Science Foundation, among other sources.

"We talked to teachers when we were designing the program, and they said they wanted help bringing interesting experiences to students in the classroom," said Simona Bartl, program coordinator and adjunct professor at CSU. "Only a few had experience doing actual research and being in the lab with scientists. Most had gone through science (teacher) education programs, where they're just not exposed to these aspects of the field."

The marine research workshops are designed to give teachers experience they can take back to the classroom, share with their students and inspire them to consider careers in marine science.

"Some of the best teachers we've encountered once worked in the science field and later went into teaching," Bartl said. "They have a lot of creative ideas about how to make science come to life in that classroom. With our program, we hope to give the other teachers, and the general public, a better understanding of what science is and what scientists do. We also want to show them how science is linked to the environment, public policy and other aspects of our lives."

Coming Friday: Some New York middle and high school students are learning how to use state-of-the-art forensic technology and research to investigate mock crime scenes. The curriculum looks less like a science class and more like an episode of the popular CBS crime show, "CSI."

Reaching the Millennium Generation

Bing Chen believes the best way to get students interested in engineering is to ignite their creative urges.

That's why the Department of Computer Electronics and Engineering has used the TekBot® as the glue between courses since 2004, said Chen, the department's chairperson. Now he is introducing the TekBot® to potential students as well.

The TekBot® is a 9-inch by 5-inch robot. Each student in the department receives a TekBot® at the beginning of his or her freshman year. Students use concepts from their engineering courses—and their imaginations—to customize a basic robot each semester through their senior year.

Need more power? Install a new motor. Want to control the robot while watching television? Build an infrared remote control. A group of juniors even programmed their robots to play laser tag.

"The TekBot® is a fun learning platform," junior Dan Norman said. "Once you put a microprocessor on there, you can put on all sorts of other applications."

Chen said the TekBot® was one way to keep students excited about engineering and apply their coursework to a tangible product. The curriculum was developed at Oregon State University.

After observing how popular the TekBot® was among college students, Chen realized that robotics could be an effective tool to get younger students interested in engineering. He recently received a $1.17 million grant from the National Science Foundation to bring TekBots® to middle school classrooms, particularly in low-income areas. Each TekBot® costs $100.

The pilot project will begin this fall in the Omaha Public Schools.

"Part of the problem in getting students interested in engineering is that K-12 education includes math and science curriculum but not engineering," Chen said. "What are fundamental engineering principles? Why should teachers encourage their students to considering engineering as a profession?"

He wants teenagers to understand that engineers developed many of the electronic gadgets they use daily, such as MP3 players, cellular phones and plasma screen televisions.

"We want them to understand that engineering applies knowledge to benefit society," Chen said.

The teachers participating in the TekBot® pilot program are critical to the program's success, he said. In July, the department hosted a two-week workshop to train 30 Nebraska middle school teachers to build a TekBot® and develop lesson plans, many of which reinforce basic math and science skills. After the workshop, participants will meet monthly to share their progress and get new lesson ideas.

Jennie Premer, who teaches seventh grade

TekBot® continued on page 6

Photo by Tom Slocum

Photo by Ashley Washburn

David Shabram, a teacher at Westside Middle School, cuts a wire that he soldered onto the motor terminals of his TekBot®. Inset: Bing Chen

TekBot® continued from page 5

at McMillan Magnet Center, said she would use the TekBot® to reinforce mathematical standards.

"It gives students an immediate visual on how, for instance, slope works," Premer said.

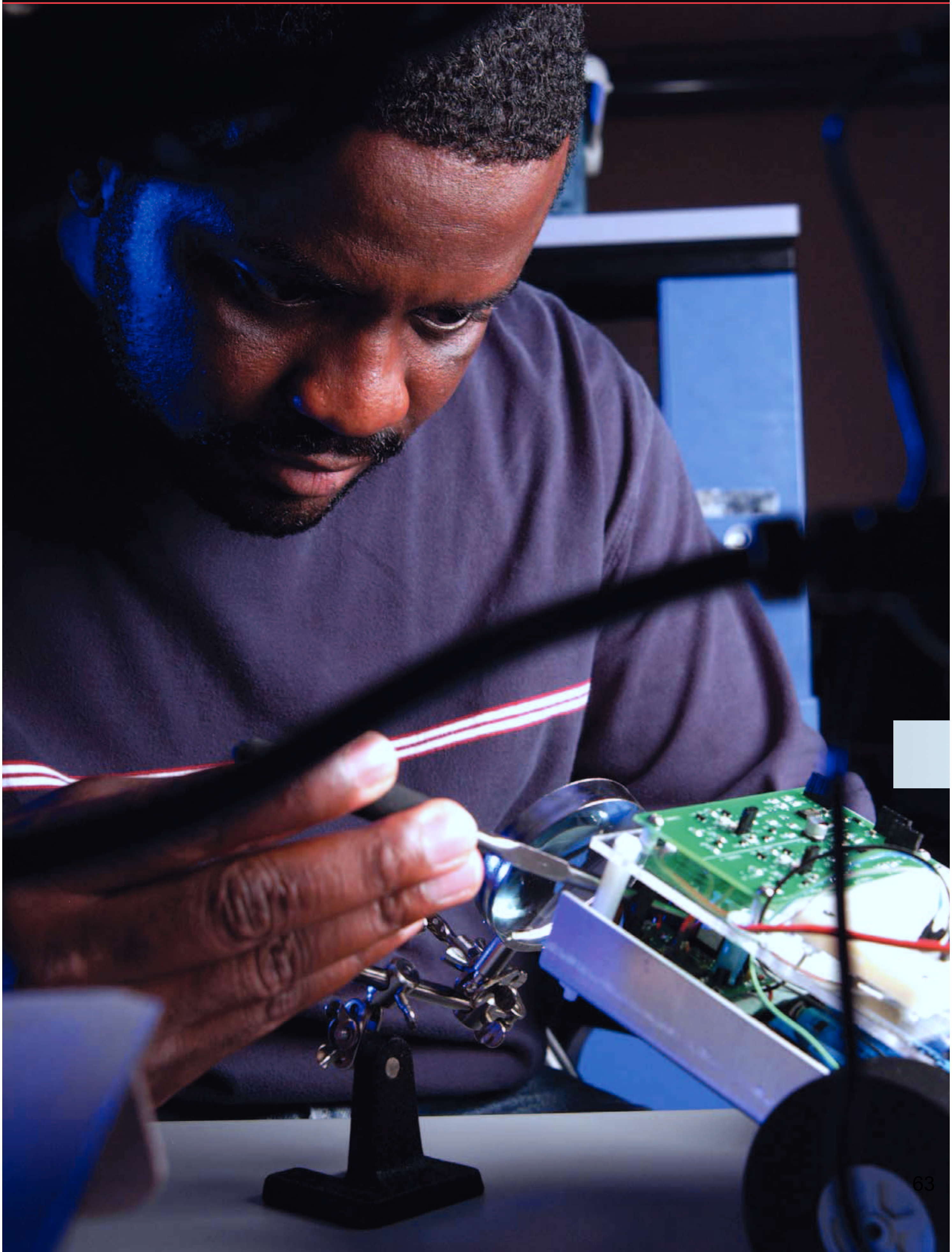
Chen said the workshop was an intense course in circuitry, soldering and the societal impact of robots. For many teachers, the workshop was the first time they'd experimented with welding and circuitry.

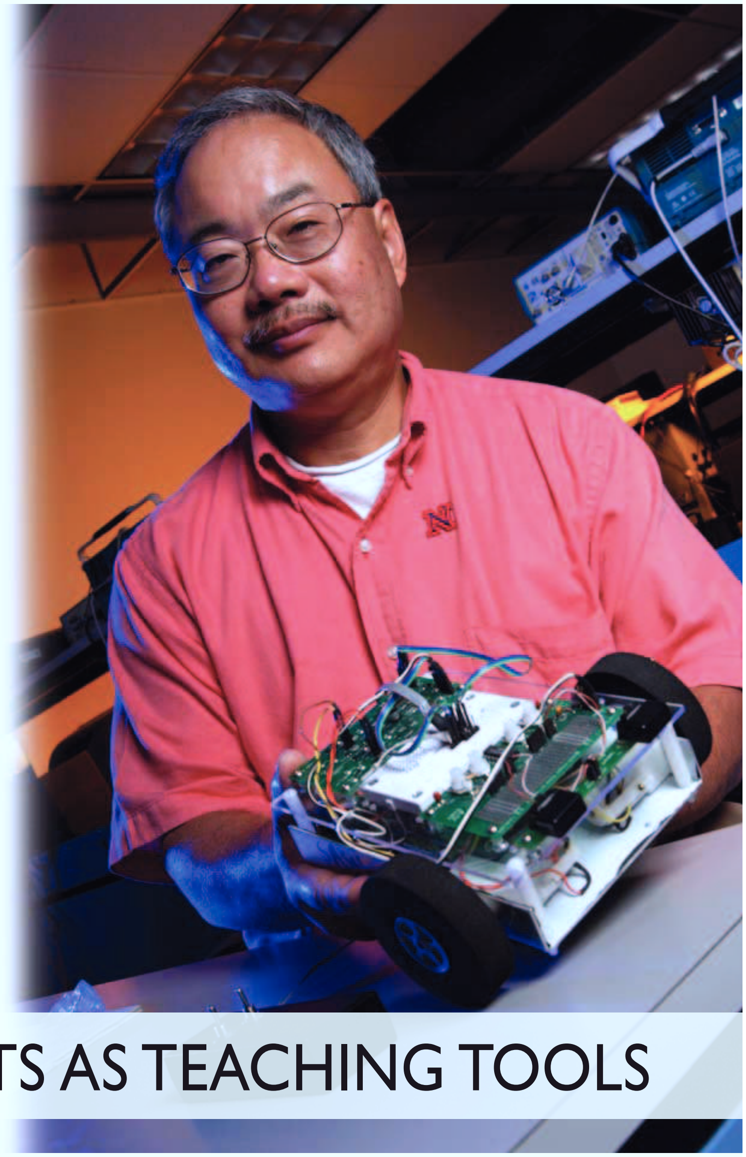
"These teachers represent the front line of math and science education," Chen said. "We have to empower our teachers and give them a sense of possibility about engineering sciences."

The college is working with faculty from the University of Nebraska at Omaha's College of Education to measure the program's effectiveness. Chen said he hopes someday, there will be enough schools using the curriculum to have a citywide TekBot® competition.

"We have to make certain that our youngest children have a sense that engineering is a good opportunity," he said. "We have to reignite the sense of wonder, the sense of creativity, of why this is a dynamic, not static, subject."

—Ashley Washburn





Call it "Invasion of the TekBots." At the Peter Kiewit Institute, these little robots – raw circuitry and wires on wheels – are rolling into classrooms, morphing into high-tech gadgets with wireless communication and video systems as innovative students tinker with them.

Bing Chen, chair of UNL's Computer and Electronics Engineering Department at the Omaha-based institute, couldn't be happier with these 21st-century teaching tools. He introduced TekBots to the university's engineering programs two years ago to encourage students to think creatively about applying classroom knowledge and to have fun with engineering. Now, he's letting TekBots loose in Omaha's middle schools with his new Silicon Prairie Initiative on Robotics in Information Technology, or SPIRIT, program.

Funded by a $1.2 million four-year grant from the National Science Foundation and in collaboration with Omaha Public Schools, SPIRIT is teaching middle school teachers to use TekBots to illustrate algebraic equations and to demonstrate such principles as friction, wireless and computer processing, and electronics. For example, students can learn the circumference of a circle equals $2\pi r$, then ink a TekBot wheel, measure it for themselves and use the equation to calculate revolutions and distance.

TURNING LOOSE TEKBOTS AS TEACHING TOOLS

Bing Chen with a TekBot.

Students, Chen said, "don't always see the payoff to what they're studying." He thinks that's one reason fewer American students choose math and science careers. He designed SPIRIT to introduce young people to math and science at an early age and perhaps encourage more of them, particularly underrepresented women and minorities, to choose engineering careers.

"The teachers are, obviously, the front line," Chen said. So in summer 2006, about 40 middle school teachers built their own TekBots and, with the help of UNL engineers, brainstormed lesson plans for their classrooms. SPIRIT aims to train 100 teachers in the next three years. The program will host a Web site and ongoing training so teachers can share stories and new ideas. UNL engineering students will mentor middle school students throughout the school year.

Chen hopes the classroom is just the beginning for TekBots. He envisions robotics clubs and citywide TekBot competitions in which student-designed robots must complete mazes and other challenges.

"I see this as a mechanism for the 21st-century Soapbox Derby."

Opposite: Derrick Nero, a teacher at Omaha's Lewis and Clark Middle School, works on a TekBot.

SSW14. Teachers rev up robotics knowledge

By Julie Blum **jblum@columbustelegram.com**

Friday, June 26, 2009 - 09:20:49 am CDT

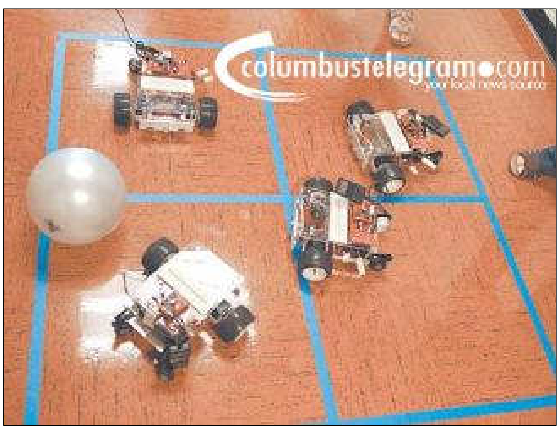
COLUMBUS - Small robotic cars will be making appearances in the classroom to help students learn about math, science and technology.

Several local and area teachers are taking part in a two-week Summer Robotics Institute at Central Community College-Columbus. The 21 teachers built the cars last week and are currently developing lesson activities they will be able to use with their students for the upcoming school year.

Jeff Korus, right, a math teacher at Humphrey St. Francis High School, speaks with University of Omaha Math Professor Neal Grandgenett about robotics during a two-week Summer Robotics Institute at Central Community College-Columbus. Telegram photo by Blaine McCartney

"This puts math and science concepts in a realistic context," said Neal Grandgenett.

He is a math professor at the Peter Kiewit Institute, one of the partners along with CCC-Columbus, Columbus Public Schools, the University of Nebraska-Lincoln and the University of Nebraska-Omaha for the workshop.



A game of four square is played by Nebraska high school teachers using the radio-controlled robot cars. Telegram photo by Blaine McCartney

A two-year Career Education Partnership Act grant is funding the workshop.

Teachers participating are at the middle school and high school levels teaching in the math, science and technology areas. Each teacher gets to take three robotic cars back to their schools when they complete the workshop.

Shantelle Suiter, a math teacher at Columbus Middle School, said she is looking forward to using the robot in her classroom. Her students, she said, are technologically savvy, so this will be right up their alley.

It will provide a unique way to help students get hands-on lessons in mathematics because every part of the robot, from the circumference of wheels it rolls on to the engineering it takes to develop it, involves numbers and formulas.

"Technology is math. Without the math, you wouldn't have technology," she said.

St. Isidore Elementary School teacher Megan DeWispelare said she was involved in the workshop because she was looking for ways to incorporate more technology into her teaching. She teaches computers, and also math and science to sixth graders.

She plans on using the robots with her computer students. Even the youngest kindergarten students will be able to use them because the cars are controlled with a device that many of them are used to, a PlayStation 2 controller.

Dan Davidchik, Mechatronics Project Coordinator at CCC-Columbus, said the workshop is another way of growing the awareness of technology as a teaching tool. The Mechatronics Education Center at CCC-Columbus emphasizes technical careers. Several workshops open to middle school, high school and college teachers, and industry workers focusing on technology have been offered through the center.

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http://www.columbustelegram.com/articles/2009/06/27/news/local/doc4a44d11654144160425670.txt

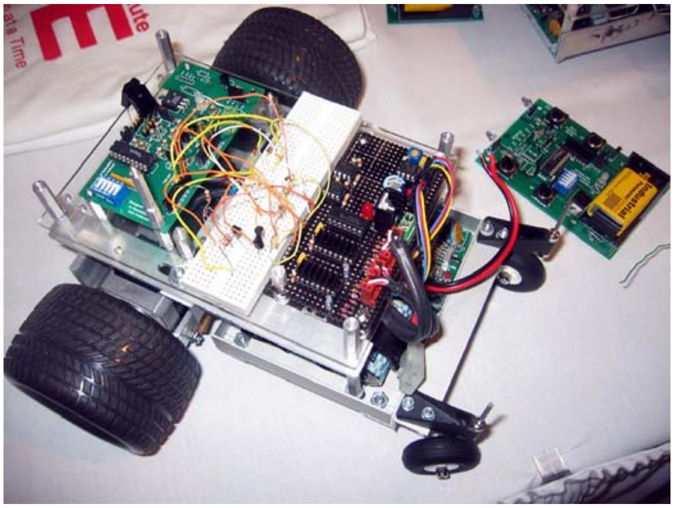
The BUZZ
Nebraska's Dream It Do It® Newsletter

Dwayne Probyn
Executive Director

Published by The Nebraska Advanced Manufacturing Coalition (NAMC)

October, 2009

Dream It. Do It. Receives Grant



The Midlands Community Foundation places an emphasis on prevention and education. The mission of the foundation is to benefit the diverse needs of the Sarpy and Cass county communities.

Dream It. Do It. has been awarded a grant for $22,400 from the Midland Community Foundation. This grant money will be used to purchase 72 CEENBot kits (see picture of completed CEENBot).

The following schools will receive 10 CEENBots each:

Papillion La-Vista High School	Papillion La-Vista South
Conestoga High School	Louisville High School
Elmwood Murdock High School	Plattsmouth High School
Weeping Water High School	2 CEENBots for DIDI

The CEENBot is an educational tool to use in STEM classes (Science, Technology, Engineering, Math) to introduce robotics to students. The CEENBot platform is developed by the Peter Kiewit Institute in Omaha. This platform is a flexible education tool allowing teachers to integrate the platform into their current instruction with ready-made education lessons that are mapped to national standards in STEM.

For more information on the CEENBot and to view the education tools, go to:
http://www.ceen.unomaha.edu/TekBots/SPIRIT2/

IMES

The Nebraska Department of Education sponsored an IMES (Industrial, Manufacturing and Engineering Systems)
in-service throughout the state of Nebraska and asked Dream It. Do It. to present its program again this year.

IMES sessions were held in Scottsbluff, North Platte, Hastings, Lincoln, Norfolk, and Omaha.

This is a wonderful opportunity to get the Dream It. Do It. coalition's message out to teachers and the community in Nebraska.

EPSCOR

DIDI hosts a table at the EPSCOR (Experimental Program to Stimulate Competitive Research) 5th Annual Innovation Conference.

In picture– Tyler Wortman, CDT Spokesperson; Dwayne Probyn, DIDI Executive Director; and Senator Scott Price

CCC Design Technology

More then 270 people visited one of the nation's best-equipped machine tool technology education programs on October 29th when Central Community College-Hastings sponsored an open house for its **Midwest Center for Plastics and Design.**

A big draw for representatives of some 50 business and industries who attended the open house was **15 new CNC machine tools** recently added to the campus machine tool technology program.

The new equipment was provided through a $2.1 million Community-Based Job Training grant from the US Dept. of Labor awarded to the college to develop a program in design technology and to establish the Midwest Center for Plastics and Design.

NAMC Scorecard

2009 Events We've Attended	Est. Attend.	Est. Contacts	Quality Contacts
High School Career Fairs	5,543	1,915	688
Classroom presentations	1,232	882	587
College Career Fairs	308	120	70
Civic/Community Presentations	963	870	770
Mfg. Tours	915	915	500
Miscellaneous	4,960	2,013	917
Year-to-date 2009	13,921	6,715	3,532
Totals from 2006-2008 Events	38,455	16,018	9,490
Campaign Totals	**52,358**	**22,715**	**13,004**

Reasons To Celebrate!

SEPTEMBER 2009

LINCOLN: Lincoln Machine participated in a job shadowing program with UNL Mechanical Engineering students.
NATIONAL: Dwayne Probyn attends DIDI Executive meeting in San Antonio.
COLUMBUS: Columbus Regional Career Dream Team spot-lighted at local football games during half-time.
HASTINGS: CCC Design Technology Open House (see article on front).
STATE: DIDI presents at Industrial, Manufacturing & Engineering Systems (IMES) in-service across the state of Nebraska.
STATE: Tony Raimondo Presents DIDI at Manufacturing Summit in Lincoln, NE.
LINCOLN: TMCO hosts open house with manufacturing tours to approximately 500 students.
LINCOLN: Tyler Theillen of Lincoln Machine presents to Lincoln Northeast career classes—approx. 100 students.

NAMC Board of Directors

Tony Raimondo, Chairman* Behlen Mfg. Co.
Tom Whalen, Vice Chair* Blue Cross/Blue Shield of Nebraska
Dennis Baack* Nebraska Community College System
J.B. Milliken University of Nebraska
Catherine Lang Commissioner, Nebraska Dept. of Labor
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David Brown Omaha Chamber of Commerce
Wendy Birdsall Lincoln Chamber of Commerce
K.C. Belitz Columbus Chamber of Commerce
Mike Baldino NAMC Secretary
Dwayne Probyn NAMC Executive Director
*Denotes Executive Committee Members

October
Mentor of the Month

Sarah Hampton

Sarah Hampton (Hanson) with Valmont Industries has been selected as October's Mentor of the Month for her continued dedication to the DIDI Career Dream Team program. Some of the activities Sarah has been involved in include the DIDI Omaha Education Extension Committee, helped to select the Career Dream Team Candidate for Valmont, and Hosted the Career Dream Team members during the Texas Tech game on October 17th. Thanks Sarah — keep up the good work!

NAMC AREA DIRECTORS

Executive Director	Dwayne Probyn dbp628@aol.com	402-344-6122
Omaha	John Vyhlidal johnv@tri-vtool.com	402-895-9000
Lincoln	Linda Lichtenberg linda.lichtenberg@lincolnmachine.com	402-434-9140
Northeast Nebraska	Jeff Scherer max@smeal.com	402-568-2937
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Western Nebraska	Dan Koch dankoch@perrinmfg.com	308-762-2975
Dawson County	John Bell jbdad@cozadtel.net	308-784-3902

Blog— http://www.didicdt.com
You Tube—http://www.youtube.com in the search box type DProbyn
Facebook—http://www.facebook.com search for DreamItDoIt Nebraska
Web Site: - http://www.dreamit-doit.com/Nebraska

SPIRIT Teacher Participant Questionnaire - Start of Project
A Survey of Teachers

Date ____________ **IRB #: 2005-05-341 EX (UNL)**
173-05-EX (UNO)

Purpose: This brief survey is designed to help us understand a few of your educational opinions and perceptions so that we can better plan the year's Educational Robotics Institute activities. Your responses will remain anonymous but we ask for an ID number that you create in order to compare your responses before and after the Institute, to help us evaluate whether our Institute has been beneficial to you, based upon your opinion.

Private and Voluntary Participation: All data collected in this survey will be kept in the strictest confidence. No individual names will be reported in any report and only group information will be described. Individuals have the full right to participate or not participate in the survey as desired.

Survey Coordinated by: This survey is being coordinated by the University of Nebraska at Omaha. For information related to this survey, please contact:

Elliott Ostler, Ed.D. (Facilitator)
107 Kayser Hall
University of Nebraska at Omaha *Phone: (402) 554-3486*
Omaha, Nebraska 68182-0163 *E-mail: elliottostler@mail.unomaha.edu*

Mike Timms, Ph.D. (External Project Evaluator)
Measurement and Evaluation Consultant
2700 West Newell Ave. *Phone: (925) 998-8820*
Walnut Creek, CA 94595 *E-mail: mtimms@wested.org*

Study Principal Investigator: For more information related to the study contact:

Neal Grandgenett, Ph.D. (Principal Investigator)
107 Kayser Hall
University of Nebraska at Omaha *Phone: (402) 554-2690*
Omaha, Nebraska 68182-0163 *E-mail: ngrandgenett@mail.unomaha.edu*

Temporary and Coded Identification

Please provide a temporary and coded ID number in order to help us track future responses for the coming year as you implement what you learn at the Institute.

Please designate an ID number that you will be able to remember: __________________
(Note: Please do not use any portion of a Social Security Number)

Background and Demographics

Please respond to the items below to help us summarize general background and demographics information for students responding to this survey. All information will be kept confidential. Thank you!

1. Gender

Male	Female
❍	❍

2. Ethnicity

African American	Asian	Latino	Native American	Caucasian	Other (please specify)
❍	❍	❍	❍	❍	❍

3. Academic Qualifications (Check and give details of all that apply)

Bachelor's Degree (BA, BS, etc.)	Master's Degree (MA, MS, etc.)	Advanced Degree (PhD, EdD, etc.)	Other Academic Qualification (please specify)
❑	❑	❑	❑
Subject:	Subject:	Subject:	Subject:

4. Do you have any particular qualifications or experiences related to engineering, electronics, or educational robotics that you want us to know about?

5. Teaching Experience

Total years of teaching: _______ years

Of those total years, how many years have you taught any of the following topics?

Science: ___ Math: ___ Engineering: ___ Electronics: ___ Robotics: ___

Recent Professional Development

6. Please list any professional development workshops you have taken in the last 3 years.

Topic of the professional development	Duration

7. Please describe any other relevant professional activities in the last 3 years. (e.g., mentoring new teachers, grants received, awards, committee service, etc.)

Topic of the professional activity	Duration

Perceptions - Project Based Learning

8. Please rate your level of agreement with the following statements.

	Do Not agree	Agree Somewhat	Agree	Strongly Agree
a. My students are not used to long-term projects	❍	❍	❍	❍
b. My teaching often includes group activities for students	❍	❍	❍	❍
c. I have very little experience with Project-Based Learning	❍	❍	❍	❍
d. I have strategies for assessing students' work in groups	❍	❍	❍	❍
e. Project-Based Learning takes more time than it is worth	❍	❍	❍	❍
f. I am comfortable designing project-based learning activities	❍	❍	❍	❍
g. Students learn better individually than in groups	❍	❍	❍	❍
h. I know how to pace student learning in long-term projects	❍	❍	❍	❍
i. Project-based learning is effective for teaching science, technology, engineering and mathematics topics	❍	❍	❍	❍
j. I am comfortable with observing students in small groups	❍	❍	❍	❍

Perceptions – Science Technology, Engineering and Mathematics (STEM) Disciplines

9. Please rate your level of agreement with the following statements.

	Do Not agree	Agree Somewhat	Agree	Strongly Agree
a. Learning about science, engineering, technology and math is important to a students' academic success	❍	❍	❍	❍
b. I intend to take more professional development with a STEM focus.	❍	❍	❍	❍
c. I would advise my students to take as many STEM courses as they can.	❍	❍	❍	❍
d. Learning STEM subjects is difficult for students.	❍	❍	❍	❍
e. I know as much as I need to know about teaching STEM subjects.	❍	❍	❍	❍
f. I believe that **all** students can succeed in STEM disciplines.	❍	❍	❍	❍
g. My students struggle with STEM subjects.	❍	❍	❍	❍
h. Girls are less likely to succeed in STEM subjects than boys.	❍	❍	❍	❍
i. Minority students are less likely to succeed in STEM subjects than White students.	❍	❍	❍	❍
j. Students with a solid grasp of STEM subjects are better prepared for future careers than those who do not have a solid grasp of such subjects.	❍	❍	❍	❍
k. I personally find STEM subjects interesting.	❍	❍	❍	❍
l. Educational robotics is a useful context for learning STEM concepts.	❍	❍	❍	❍
m. Educational robotics can be easily integrated into many STEM courses within a middle school context.	❍	❍	❍	❍

10. Any other comments?

Evolving SPIRIT Experiences

11. To help us better understand how your experience level changes and evolves during this year of activities, please identify your "general experience" with each of the following topics at this time. Please check the most appropriate response.

A: Not at all - no experience at all
B: Low - a little experience
C: Medium - some moderate experience
D: High - very experienced

a.	**Engineering**	Not at all	Low	Medium	High
b.	**Electronics**	Not at all	Low	Medium	High
c.	**Robotics**	Not at all	Low	Medium	High
d.	**Programming**	Not at all	Low	Medium	High
e.	**Computers**	Not at all	Low	Medium	High
f.	**Cooperative Learning**	Not at all	Low	Medium	High
g.	**Problem Based Learning**	Not at all	Low	Medium	High

Evolving SPIRIT Expectations

12. We would also like to know what you most desire and expect to get out of the project at this time. Please answer the following two questions:

a. What do you personally hope to get out of the project?

b. What do you most hope to accomplish related to your students?

Thank-You!

Thank-you for completing this survey, and we look forward to working with you in the SPIRIT project this year!

Pilot and Field Testing of the National 4-H Educational Robotics Curriculum

Curriculum Pilot Testing
Teacher Facilitator Feedback Survey

Form Purpose: The following feedback form is to be used by facilitators in piloting the 4-H educational robotics lessons and activities in the classroom, and for making suggestions for improvement. All responses will be kept completely confidential, and only used in the lesson revision process.

Lesson Information:
Reviewer/Facilitator Name: ______________________________________
Robotics Lesson/Activity Piloted: ______________________________
Location Where Piloting Took Place: ____________________________

Project Evaluation Contact:
Dr. Neal Grandgenett, UNO
Phone: 402-554-2690
ngrandgenett@mail.unomaha.edu

Piloting Feedback

Lesson Feedback: Please give your perceptions on the different educational robotics lesson components.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1) The lesson/activity helped youth to learn about **science** or science concepts.	○	○	○	○	○
2) The lesson/activity helped youth to learn about **technology** or technology concepts.	○	○	○	○	○
3) The lesson/activity helped youth to learn about **engineering** or engineering concepts.	○	○	○	○	○
4) The lesson/activity helped youth to learn about **mathematics** or mathematics concepts.	○	○	○	○	○
5) The lesson/activity was **interesting** to youth.	○	○	○	○	○
6) The lesson/activity was **engaging** to youth.	○	○	○	○	○

7) For you personally as a teacher or facilitator, what were the positive aspects of the lesson?

8) For you personally as a teacher or facilitator, how could the overall lesson or activity be improved?

Important Final Task: Please make any instructional comments, suggested edits, or revision thoughts on an attached copy of the lesson or activity itself. Thanks! Your feedback is deeply appreciated!

Pilot and Field Testing of the SPIRIT Project Curriculum

Curriculum Pilot Testing
Student Feedback Form

Form Purpose: Thank-you for trying out some of the robotics activities with us. We want to know what you learned, how you liked the robotics activities, and if you have any suggestions for their improvement. Your feedback will be kept confidential and will only used to make the activities better.

Lesson Information:
Reviewer/Facilitator Name: ______________________________
Robotics Lesson/Activity Piloted: ______________________________
Location Where Piloting Took Place: ______________________________

Project Evaluation Contact:
Dr. Neal Grandgenett, UNO
Phone: 402-554-2690
ngrandgenett@mail.unomaha.edu

Robotics Activity Student Feedback

Activity Feedback: Please give your perceptions on the different educational robotics lesson components.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1) The lesson/activity helped me to learn about **science** or science concepts.	○	○	○	○	○
2) The lesson/activity helped youth to me to learn about **technology** or technology concepts.	○	○	○	○	○
3) The lesson/activity helped me to learn about **engineering** or engineering concepts.	○	○	○	○	○
4) The lesson/activity helped me to learn about **mathematics** or mathematics concepts.	○	○	○	○	○
5) I found the lesson or activity to be interesting.	○	○	○	○	○
6) I would tell my friends that the activity was a good one.	○	○	○	○	○

7) For you personally, what was the best part of the lesson? Why?

8) For you personally, how could the overall lesson or activity be improved?

9) Anything else that you would like to tell us?

Thank-you! Your feedback to us is deeply appreciated!

Sample Questions - 4-H Robotics and GPS/GIS and SPIRIT Content Quiz - Pre

Name: ____ **State** __________

Leader Name: ______________________________________

Age: ________ **Gender (circle one): Male Female**

Multiple Choice: For each of the following questions, circle the letter of the answer that best answers the question.

1. In order to follow a delayed sequence of set movements, without direct user control, a robot must be _____
   A. controlled by a remote.
   B. computerized.
   C. programmed.
   D. trained.

2. A programming "loop" does which of the following?
   A. Starts the program code
   B. Stops the program code
   C. Performs multiple functions
   D. Repeats a section of program code

3. A computer program consists of ______ that tells the computer to do something.
   A. sensors
   B. code
   C. lights
   D. robots

4. Which of the following enables a robot to investigate and react to its environment?
   A. Tires
   B. Sensors
   C. LCD panels
   D. Mechanical arms

5. What is a computer program?
   A. Computer generated text
   B. The hardware that controls a computer
   C. Instructions written in a language a computer understands
   D. Language that is built into a robot

6. Which of the following is a wireless connection?
   A. Bluetooth
   B. RCX
   C. USB
   D. Serial port

7. When programming your robot, a switch block or if/else/then statement is used to _____
   A. ask a question.
   B. stop the program.
   C. speed up the program.
   D. repeat the code.

8. Which of the following is an example of multi-tasking?
    A. Having your robot move forward on a table
    B. Having your robot turn to the left for 2 seconds
    C. Having your robot measure a distance as it identifies an object to lift
    D. Having your robot use its light sensor

9. The process of refining an instrument, like your robot, so that it is as accurate as possible by collecting information about how far your robot will travel in a given amount of time and using the information to estimate how long it will take the robot to go a given distance is called _____
    A. a ratio.
    B. the Pythagorean Theorem.
    C. a threshold value.
    D. calibration.

Amie and Cody are engineers working to design a robot that will be able to plant trees in a fruit production orchard with apples, apricots, oranges and/or peaches. They need your help to apply the steps of the Engineering Design Process. Answer the questions below to provide your assistance.

Image of an apple orchard from Kelowna Land and Orchard Company Ltd. (KLO) in British Columbia, Canada. Image from http://media-cdn.tripadvisor.com/media/photo-s/00/11/f9/0a/orchard-at-kelowna-land.jpg used without permission.

10. Which of the following would not be part of the problem that Amie and Cody need to solve in order to begin designing their robot?
    A. The robot must be able to travel in standing water.
    B. The robot must be able to avoid obstacles such as large rocks and existing trees.
    C. The robot must be able to go to a specific location, using GPS.
    D. The robot must be able to dig a hole.

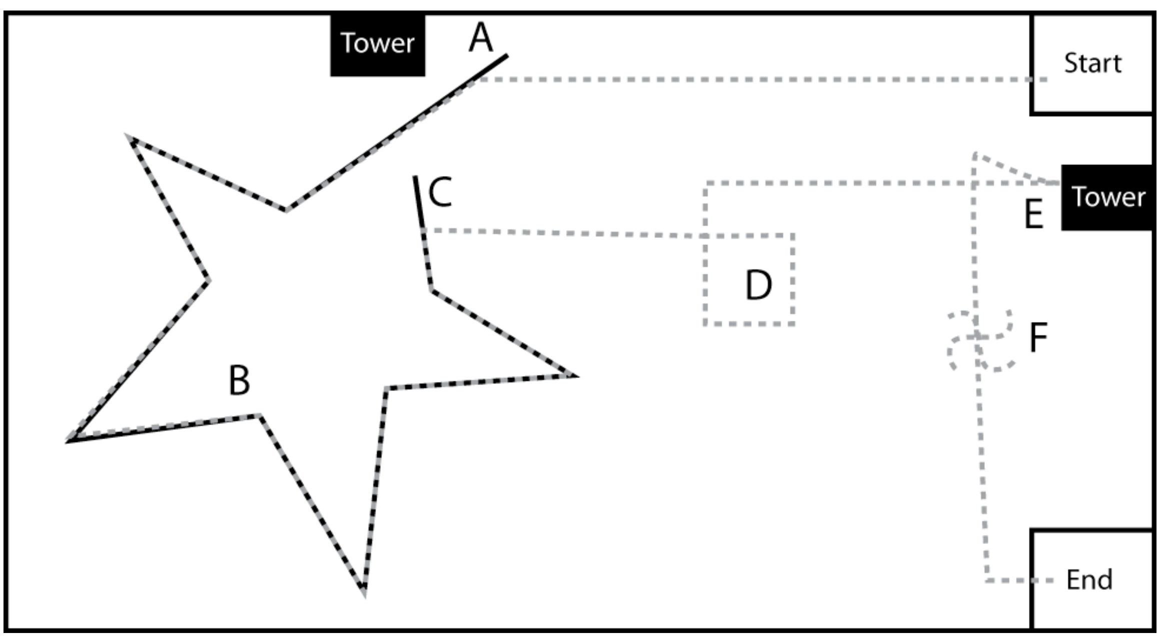
11. As a part of the design process, Amie and Cody visit an engineering library to look at existing patents. Which step in the Engineering Design Process are they doing?
    A. Identify the problem
    B. Research the problem
    C. Select a solution
    D. Construct a prototype

12. Amie and Cody are reviewing the possible solutions to select one to test by building a prototype. Which of the solutions below do you think is **most** important to the project?
    A. The robot should operate quietly to lessen the disturbance to wildlife in the area.
    B. The robot should be on tracks to cover diverse terrains.
    C. The robot should have a camera so the operators can see what it is doing from anywhere with an Internet connection.
    D. The robot should have a robotic arm that can do tasks such as dig the hole, place the tree and replace the soil.

13. Which of the following strategies would be important to evaluating Amie and Cody's solution?
    A. Testing the prototype by planting trees in different orchard settings or environments
    B. Asking other engineers on your team to review their design and prototype
    C. Check the design with specialized computer software to find potential flaws
    D. All of the above

Technology – Robotic Programming

Use the obstacle course shown to answer the robot programming questions below. The dashed line(s) shows the path of the robot. The solid line is a black electrical tape one inch wide



14. Which sensor is most likely used to navigate the robot between points A and C?
    A. Light
    B. Sound
    C. Touch
    D. Ultrasonic

15. Which of the marked points on the image above corresponds to the pseudocode shown here:
    Loop 4 times – Forward one tire rotation, Turn ninety degrees right
    A. Point B
    B. Point D
    C. Point E
    D. Point F

16. At point F, the robot spins counterclockwise for at least 1080 degrees. Which pseudocode line would cause the robot to turn 1080 degree?
    A. Forward, left motor 10 rotations
    B. Forward, right motor 10 rotations
    C. Forward turning to the left, left and right motors 10 rotations
    D. Forward turning to the right, left and right motors 10 rotations

17. Which of the marked points in the image above corresponds to the pseudocode shown here:
    Wait until touch, reverse two wheel (720 degrees) rotations
    A. B
    B. D
    C. E
    D. F

18. Which of the sensors listed would most likely not be used to complete this challenge?
    A. Light
    B. Sound
    C. Touch
    D. Rotation

19. Which pseudocode is the most reliable way to program the robot at point C (find the tower and then turn, using an ultrasonic sensor) in the image above?
    A. Forward 2.3 wheel rotations to the tower
    B. Forward 828 degrees to the tower
    C. Forward 1.6 seconds to the tower
    D. Forward until 15 inches from the tower

Robotics Workplace Skills Youth Questionnaire (Pre)

Name: ______________________________	**Date:** ____________	
Club or School:______________________	**Gender (circle one)**	**Male** **Female**

We want to know how well the robotics activities help you to develop certain skills. **Please respond to the items below in terms of how you can contribute to your team in undertaking the robotics activities or in preparing the team project and documentation for the Robotics Showcase.** It should take you about 5 to 10 minutes to fill out this survey. The results will help us to learn how you are benefiting from this educational program and if we need to make any changes.

Statement	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
1. I am able to brainstorm (come up with) a number of possible strategies to accomplish the robotics challenge.	5	4	3	2	1
2. I am able to determine how mistakes in programming the robot can lead to a problem with other parts of the design and build process.	5	4	3	2	1
3. I am able to evaluate solutions suggested by my teammates and predict which of them might work.	5	4	3	2	1
4. I am able to identify and ask questions that will lead to a better team solution.	5	4	3	2	1
5. I am able to explain my ideas and findings to my team.	5	4	3	2	1
6. I am comfortable presenting results produced by my team to the judges.	5	4	3	2	1
7. I am able to interact professionally with the contest officials.	5	4	3	2	1
8. I am able to come up with creative ideas to help solve problems.	5	4	3	2	1
9. I am able to evaluate alternative ideas and solutions in order to improve the robot's computer program.	5	4	3	2	1
10. I am patient with my teammates.	5	4	3	2	1
11. In the competition I realize that it is often necessary to work with different people.	5	4	3	2	1
12. I am open to ideas from other team members.	5	4	3	2	1
13. I am able to help my team to accomplish the task within the allocated time frame.	5	4	3	2	1
14. Compromising with other team members is sometimes necessary to accomplish our goals.	5	4	3	2	1
15. I am able to share responsibility with my teammates.	5	4	3	2	1

16. Whatever my role in the competition I am able to follow through on the tasks needed to help to complete our team activity.	5	4	3	2	1
17. I am able to work with the team to help to prioritize, plan and manage the work to achieve the desired results.	5	4	3	2	1
18. I am an active participant in our team.	5	4	3	2	1
19. I am able to evaluate alternative ideas and solutions in order to improve the team project.	5	4	3	2	1
20. I am able to demonstrate leadership on selected tasks to help support my team.	5	4	3	2	1
21. Other team members are able to count on me to get something done.	5	4	3	2	1

Nebraska 4-H Robotics and GPS/GIS and SPIRIT Project

4-H Robotics and GPS/GIS and SPIRIT Interest Questionnaire - Pre

Name: ____ **State** __________

Leader Name: ____

Age: ________ **Gender (circle one): Male Female**

Ethnicity (circle one):

African American **American Indian** **Asian or Pacific Islander** **Hispanic** **White (non Hispanic)** **Other**__________

We are interested in learning about your attitudes towards science, technology, engineering, and mathematics. We particularly want to get your reaction to learning about robotics, which involves the building and programming of small robots. We also are interested in your attitudes about GPS (Global Positioning Systems) and GIS (Geographical Imaging Systems). GPS helps us record and use satellite data to understand geographical location and mapping concepts. GIS is a computer tool you can use to develop, analyze, and display geographic maps.

Read the statements below and circle your opinion.

Statement	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
1. It is important for me to learn how to conduct a scientific investigation.	5	4	3	2	1
2. It is important for me to learn about robotics.	5	4	3	2	1
3. It is important for me to learn how to use appropriate tools and techniques to gather, analyze and interpret data.	5	4	3	2	1
4. It is important for me to learn about GIS.	5	4	3	2	1
5. It is important for me to learn how to use mathematical formulas to help solve practical problems.	5	4	3	2	1
6. It is important for me to learn how to make accurate measurements to help solve mathematical problems.	5	4	3	2	1
7. It is important for me to be able to record measurements and calculations into tables and charts.	5	4	3	2	1
8. It is important for me to learn how to collect and interpret data to verify a prediction or hypothesis.	5	4	3	2	1
9. It is important for me to understand basic engineering concepts (e.g. design tradeoffs, speed, torque) related to building and moving a robot.	5	4	3	2	1
10. It is important for me to learn how to program a robot to carry out commands.	5	4	3	2	1
11. It is important for me to learn about GPS.	5	4	3	2	1
12. I like learning new technologies such as robotics.	5	4	3	2	1

Statement	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
13. I like using the scientific method to solve problems.	5	4	3	2	1
14. I like using mathematical formulas and calculations to solve problems.	5	4	3	2	1
15. I like learning new technologies like GPS.	5	4	3	2	1
16. I use a step by step process to solve problems.	5	4	3	2	1
17. I make a plan before I start to solve a problem.	5	4	3	2	1
18. I am confident that I can program a robot to move forward two wheel rotations (i.e. 720 degrees) and then stop.	5	4	3	2	1
19. I try new methods to solve a problem when one does not work.	5	4	3	2	1
20. I carefully analyze a problem before I begin to develop a solution.	5	4	3	2	1
21. In order to solve a complex problem, I break it down into smaller steps.	5	4	3	2	1
22. I am certain that I can build a robot by following design instructions.	5	4	3	2	1
23. I am certain that I can fix the software program for a robot that does not behave as expected.	5	4	3	2	1
24. I am certain that I can log locations of a series of waypoints within a GPS unit.	5	4	3	2	1
25. I am confident that I can program a robot to follow a black line using a light sensor.	5	4	3	2	1
26. I am confident that I can read and understand maps.	5	4	3	2	1
27. I am confident that I can make a digital map.	5	4	3	2	1
28. I am confident that I can use GPS technologies to get to places that I have never been before.	5	4	3	2	1
29. I like listening to others when trying to decide how to approach a task or problem.	5	4	3	2	1
30. I like being part of a team that is trying to solve a problem.	5	4	3	2	1
31. When working in teams, I ask my teammates for help when I run into a problem or don't understand something.	5	4	3	2	1
32. I like to work with others to complete projects.	5	4	3	2	1
33. I like learning new technologies such as GIS.	5	4	3	2	1

How interested are you in each of the jobs below for possible future careers?

Job	Very Interested	Somewhat Interested	Neither Interested nor Uninterested	Somewhat Uninterested	Very Uninterested
1. Scientist	5	4	3	2	1
2. Engineer	5	4	3	2	1
3. Mathematician	5	4	3	2	1
4. Computer or Technology Specialist	5	4	3	2	1
5. Job involving GPS/GIS	5	4	3	2	1

GEAR-TECH-21

GEOSPATIAL AND ROBOTICS TECHNOLOGIES FOR THE 21ST CENTURY

4-H Robotics and GPS/GIS and SPIRIT Longitudinal Survey

Today's Date: ____________________

First Name: ______________________ **Last Name:** ____________________

School: _________________________ **Age:** __________________________

Grade in School: ___ **7** ___ **8** ___ **9** ___ **10** ___ **11** ___ **12** ___ **not currently in school**

Gender: ____**F** ____**M**

Race/Ethnicity: ***Check all that apply***

___ Asian/Pacific Islander
___ Native American
___ Hispanic/Latina/o
___ Black/African-American (non- Latina/o)
___ White (non-Latina/o)
___ Multi-Racial
___ Other: ______________

Years you attended the Robotics and GPS/GIS summer camp: ***Check all that apply***
___2007 ___ 2008 ___ 2009 ___ 2010 ___2011

Did you attend a year two camp? ___ No ___Yes → **If yes, what year?** ______

CONTACT INFORMATION FOR FOLLOW-UP SURVEY

4-H/SPIRIT is interested in the courses you take in school after attending a course, camp or club program. The following information will help us to find you in the coming years, for the follow-up surveys. Thank you for giving us the names of people who will be able to help locate you in case you have moved.

Your email address: __________________________

Your cell phone number: ______________________

Your current mailing address: ____

____

School that you plan to attend next year (2009-2010):

___ Same school
___ New school (Name of new school: _______________)
___ Don't know

Name, phone number and address of a relative (grandparent, aunt, uncle) or friend who will know how to contact you if you are to move:

____

____

1) Did the robotics activities influence your decision to take more science, technology, engineering, or mathematics classes? ___Yes ___ No

2) Please list all the classes that you are **currently** taking:

Course	Name of the course
Mathematics	
Science	
Technology	
Engineering	

3) Here is a list of science, math, technology and engineering courses offered in many high schools. Mark the courses you think you'll take some time during high school. *Check one answer for each course.*

Course	Very Likely	Likely	Unlikely	I don't know	Already taken
Pre-Algebra					
Algebra I					
Geometry					
Algebra II					
Pre-Calculus					
Calculus					
Chemistry					
Physics					
Biology					
Computer					
Computer Science					
Earth Science					
Anatomy					
Environmental Science					

Course	Very Likely	Likely	Unlikely	I don't know	Already taken
Other: ________________					
Other: ________________					
Other: ________________					
Other: ________________					

4) What level of education do you think you will complete? *Check one.*

___ High School
___ GED (General Education Diploma)
___ Community College (two-year college program)
___ College (four or five year college program)
___ Graduate School - Master's Degree
___ Graduate School - Doctoral Degree (Ph.D.)
___ Medical, Dental, or Veterinary School
___ Law School
___ Other (*Please describe* ________________________________)

5) What do you think will be your major in college?

____

6) List one job that you think you'd like to have as an adult.

____

7) How interested are you in each of the jobs below for possible future careers?

Job	Very Interested	Somewhat Interested	Neither Interested nor Uninterested	Somewhat Uninterested	Very Uninterested
1. Scientist	5	4	3	2	1
2. Engineer	5	4	3	2	1
3. Mathematician	5	4	3	2	1
4. Computer Specialist	5	4	3	2	1
5. Job involving GPS/GIS	5	4	3	2	1

Thank you for your participation!

KUDER® ...it's how you get there

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- Administrators

Kuder Career Search with Person Match (Interest Inventory)

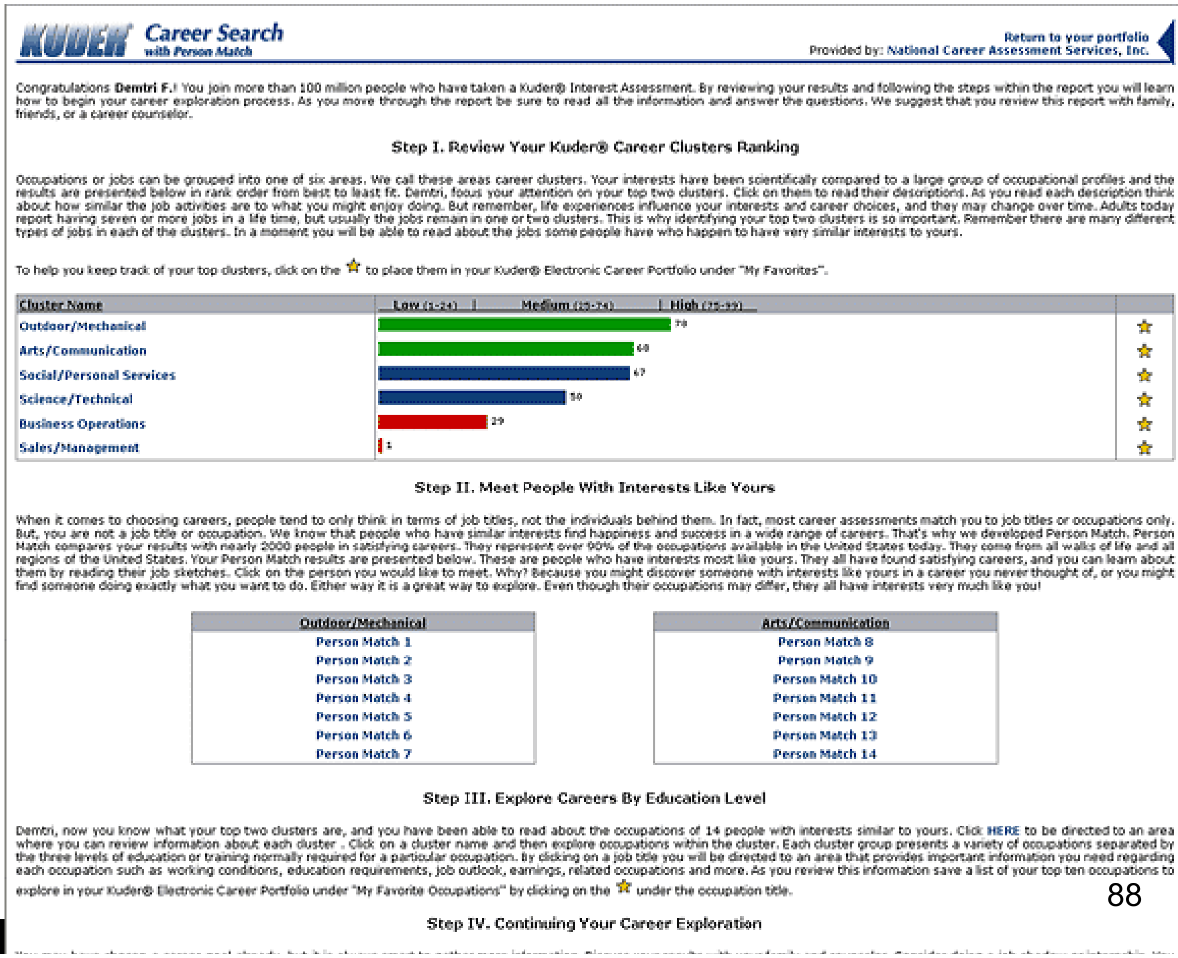
The *Kuder Career Search with Person Match* helps you discover your career interests, explore occupations beyond job titles, and effectively apply your personal interests to your career plans.

The Internet-based assessment is completed in approximately 20 minutes and provides immediate online scoring and reporting. You will receive an accurate report of your career interests which provides guidance for interpreting and using your results.

The report also includes the unique Person Match feature which compares your assessment results to a database of nearly 2,000 individuals working in today's occupations. Access career sketches for the 14 individuals—7 in each of your top two Kuder career clusters—whose interests most closely match your own. Learn about how these individuals came to work in this occupation and why they like what they do.

The online Kuder Career Search with Person Match report includes:

- *Kuder* Career Clusters ranked by how closely they match your interests. Clicking on a cluster name provides a description of the cluster and avenues for further exploration.
- 14 Person Match career sketches—7 each in your top two career clusters—for individuals in the career database whose interests most closely match your own. (In states that use the federal career clusters classification system, the report provides the top 3 Person Match sketches for each of your top 5 career clusters.)
- Links to explore occupational listings by education level within each of the clusters. Each occupation is crosswalked with and linked directly to additional information from the *Occupational Outlook Handbook*, O*Net™, and related military occupations to allow further exploration.
- Suggested steps for continuing career exploration and links to help you explore options for continuing your education.



KUDER Career Search with Person Match

Return to your portfolio
Provided by: National Career Assessment Services, Inc.

Congratulations **Demtri F.**! You join more than 100 million people who have taken a Kuder® Interest Assessment. By reviewing your results and following the steps within the report you will learn how to begin your career exploration process. As you move through the report be sure to read all the information and answer the questions. We suggest that you review this report with family, friends, or a career counselor.

Step I. Review Your Kuder® Career Clusters Ranking

Occupations or jobs can be grouped into one of six areas. We call these areas career clusters. Your interests have been scientifically compared to a large group of occupational profiles and the results are presented below in rank order from best to least fit. Demtri, focus your attention on your top two clusters. Click on them to read their descriptions. As you read each description think about how similar the job activities are to what you might enjoy doing. But remember, life experiences influence your interests and career choices, and they may change over time. Adults today report having seven or more jobs in a life time, but usually the jobs remain in one or two clusters. This is why identifying your top two clusters is so important. Remember there are many different types of jobs in each of the clusters. In a moment you will be able to read about the jobs some people have who happen to have very similar interests to yours.

To help you keep track of your top clusters, click on the ☆ to place them in your Kuder® Electronic Career Portfolio under "My Favorites".

Cluster Name	Low (1-24) | Medium (25-74) | High (75-99)	
Outdoor/Mechanical	78	☆
Arts/Communication	68	☆
Social/Personal Services	67	☆
Science/Technical	50	☆
Business Operations	29	☆
Sales/Management	1	☆

Step II. Meet People With Interests Like Yours

When it comes to choosing careers, people tend to only think in terms of job titles, not the individuals behind them. In fact, most career assessments match you to job titles or occupations only. But, you are not a job title or occupation. We know that people who have similar interests find happiness and success in a wide range of careers. That's why we developed Person Match. Person Match compares your results with nearly 2000 people in satisfying careers. They represent over 90% of the occupations available in the United States today. They come from all walks of life and all regions of the United States. Your Person Match results are presented below. These are people who have interests most like yours. They all have found satisfying careers, and you can learn about them by reading their job sketches. Click on the person you would like to meet. Why? Because you might discover someone with interests like yours in a career you never thought of, or you might find someone doing exactly what you want to do. Either way it is a great way to explore. Even though their occupations may differ, they all have interests very much like you!

Outdoor/Mechanical	Arts/Communication
Person Match 1	Person Match 8
Person Match 2	Person Match 9
Person Match 3	Person Match 10
Person Match 4	Person Match 11
Person Match 5	Person Match 12
Person Match 6	Person Match 13
Person Match 7	Person Match 14

Step III. Explore Careers By Education Level

Demtri, now you know what your top two clusters are, and you have been able to read about the occupations of 14 people with interests similar to yours. Click HERE to be directed to an area where you can review information about each cluster . Click on a cluster name and then explore occupations within the cluster. Each cluster group presents a variety of occupations separated by the three levels of education or training normally required for a particular occupation. By clicking on a job title you will be directed to an area that provides important information you need regarding each occupation such as working conditions, education requirements, job outlook, earnings, related occupations and more. As you review this information save a list of your top ten occupations to explore in your Kuder® Electronic Career Portfolio under "My Favorite Occupations" by clicking on the ☆ under the occupation title.

Step IV. Continuing Your Career Exploration

Step IV. Continuing Your Career Exploration

You may have chosen a career goal already, but it is always smart to gather more information. Discuss your results with your family and counselor. Consider doing a job shadow or internship. You can interview people who are working in areas that interest you, and visit the library or use the internet to do additional research. If you are thinking about going to college, determine whether you would benefit most by attending a technical school, community college or if you need a four year or more degree. Look at the **technical education** opportunities in your state or if you are considering college, explore **College Majors** to review college programs and corresponding careers within each area, or go to **College Search** to find colleges that offer programs you want. Remember to keep your Portfolio current, and record all of your exploration activities.

Demtri, today you discovered your prime interests and how to apply your personal results to your career search. But there is more that you need to know!

1. What are your best skills? (How can you use them?)
2. What work values are most important to you?

You should complete the Kuder Skills Assessment and Super's Work Values Inventory-revised, if you haven't already. By combining your interests, skills, and work values results, you establish a solid foundation to build your career goals and plans.

Demtri, thank you for completing the Kuder Career Search with Person Match. If you have any questions please contact us at 800-314-8972 (M-F 8:00AM to 5:00PM Central), e-mail us at **ncasi@ncasi.com**, or write us at National Career Assessment Services, Inc., 210 N 10th St, PO Box 277, Adel IA 50003.

The more you can learn about yourself and the world of work, the more likely you'll be able to identify careers that will bring you satisfaction and success!

Back to top

For more information about development, administration, and interpretation of the interest assessment, please see the Technical Manual

The *Kuder* Interests and Skills Composite Report

Once you have completed both the *Kuder Career Search with Person Match* interest inventory and the *Kuder Skills Assessment*, an additional report, the *Kuder* Interests and Skills Composite Report, is automatically generated. The results of both assessments are juxtaposed to provide you with an easy-to-understand comparison of your interests and skills based on the career clusters. You can readily see areas where there are consistencies or inconsistencies in the relationship of your interests and skills. The interactive report provides information and suggestions about the relationships and how to proceed with your education and career exploration and planning.

KUDER ***Interests and Skills Composite Report***

Return to your portfolio
Provided by: National Career Assessment Services, Inc.

Congratulations **Demtri F.**! You have completed both the Kuder® Career Search with Person Match and the Kuder® Skills Assessment. This report presents the results from the two, and makes suggestions for your career exploration and planning.

Step I. Review Your Interest/Skill Profile

Your interests and skills scores are shown below in a form that allows you to compare how your skills are related to your interests in each of the six career clusters. Click on the first cluster name to review the definition. Notice how your skills compare to your interests within this cluster. Read the statements carefully. Repeat this procedure for each of the clusters.

To help you keep track of your top clusters, click on the ☆ to place them in your Kuder® Electronic Career Portfolio under "My Favorites".

Cluster Name	Low (1-24) | Medium (25-74) | High (75-99)	
Outdoor/Mechanical (Interest / Skill)	Interest 78; Skill 95. This is a high-potential cluster for you. Find out more about the occupations in this cluster. They could promise success and satisfaction.	☆
Arts/Communication (Interest / Skill)	Interest 68; Skill 90. People sometimes downplay their interest in jobs that are easy for them. Have you looked carefully at the rewards of occupations in this cluster? Find out what people working in this area like about their jobs.	☆
Social/Personal Services (Interest / Skill)	Interest 67; Skill 0	☆
Science/Technical (Interest / Skill)	Interest 50; Skill 90. People sometimes downplay their interest in jobs that are easy for them. Have you looked carefully at the rewards of occupations in this cluster? Find out what people working in this area like about their jobs.	☆
Business Operations (Interest / Skill)	Interest 29; Skill 83. People sometimes downplay their interest in jobs that are easy for them. Have you looked carefully at the rewards of occupations in this cluster? Find out what people working in this area like about their jobs.	☆
Sales/Management (Interest / Skill)	Interest 1; Skill 76. You have medium or high skills in this cluster, but your interest appears low. Keep possibilities in this cluster "in reserve," and perhaps review how your work values affect your choices.	☆

Step II. How to Use Your Results

Having a high interest in a given cluster is an excellent way to begin to filter through all the career possibilities that exist. If you also have high skills in that same cluster, your career exploration becomes a little easier. If you have a moderate interest and a high to moderate skill ranking in a cluster, this is also an area to explore. Here is a plan to follow that will help you gather information.

Select seven possible careers from your top-ranked clusters. You may have already placed several in your portfolio or you can review occupational options by clicking **HERE** or select from your Person Matches. Now begin to gather information about them. You should learn at least the following about each occupation:

1. Job Description
2. Required Training
3. Employment Prospects
4. Where Jobs Are Located
5. Income Possibilities

Your school or local library will provide many other good sources of occupational information, both online and off the shelf. As you look at the different jobs within the clusters, think "Can I see myself in this picture? Is it an occupation that I would like to work in?"

Step III. Curriculum Planning

Next, ask yourself if you are willing to acquire the skills that the jobs require. Find out whether the required training is on-the-job, at a community college or technical school, or whether you need a four-year or more degree. See if you can discover what the key courses are, like calculus for engineers, or important skills, like grammar and punctuation for journalism. Remember, the greater the skill level you acquire, the more rewarding your occupation will be in income and potential satisfaction. The more you find out about a career you are considering, the more confident you will be as you prepare for it.

The best way to learn about the requirements and rewards of any occupation is to get some direct, personal experience with it. Talk to someone who is actually in the career. Find out what they do in an average day or week; what is good and what is hard about it; what they had to do to get started; what they plan to do next. Try for a part-time or temporary job as an assistant or an intern, or at least do a day of job shadowing. This way you can learn what a career is really about, without it costing you a lot in time and effort. If you find that a career isn't so appealing after personal experience with it, don't give up hope. There are lots of job opportunities in each cluster that may fulfill your hopes and wishes. Be sure to record your experience in your Kuder Electronic Career Portfolio.

Step IV. What Else To Consider

Today you have discovered how your interests and skills relate to the Kuder® Career Clusters. There are many occupations in each, and you will need a thorough review to settle on a smaller number for which you can make plans. If you have completed Super's Work Values Inventory-revised, use the results to consider your preferences for the characteristics of occupations and jobs. This is another tool you can use to fine-tune your career exploration. If you haven't completed the inventory, you should consider doing so. It is also a good idea to discuss your results with your family, friends, or a counselor.

University of Nebraska Medical Center

Office of Regulatory Affairs (ORA)
Institutional Review Board (IRB)

October 15, 2009

Neal Grandgenett
107 Kayser Hall
UNO - VIA COURIER

IRB#: 443-09-EX

TITLE OF PROTOCOL: Evaluating the Silicon Prairie Initiative for Robotics in Information Technology (SPIRIT 2.0): Phase 2 Lesson Refinement

Dear Dr. Grandgenett:

The Office of Regulatory Affairs (ORA) has reviewed your application for Exempt Educational, Behavioral, and Social Science Research on the above-titled research project. According to the information provided, this project is exempt under 45 CFR 46:101b, category 1. You are therefore authorized to begin the research.

It is understood this project will be conducted in full accordance with all applicable HRPP Policies. It is also understood that the ORA will be immediately notified of any proposed changes that may affect the exempt status of your research project.

Please be advised that this research has a maximum **approval period of 5 years** from the original date of approval and release. If this study continues beyond the five year approval period, the project must be resubmitted in order to maintain an active approval status.

Sincerely,

E D Prentice

Ernest D. Prentice, Ph.D.
Executive Chair, IRB