



# 21<sup>st</sup> Century Skills in STEM Workforce Training Assessments

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# STEM Workforce Growth Areas



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- Green jobs
- Natural science
- Physical science
- IT
- Engineering



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# Focus: STEM Workforce *Technicians*



[enterpriseconnect.gov.au](http://enterpriseconnect.gov.au), [gettyimages.com](http://gettyimages.com)



# HOW TECHNICIANS ARE TAUGHT

- In common practice, career and technical educators engage students in hands-on practice
- Usual result: Teaching students basic technical procedures
- Problem: Not developing higher-order cognitive skills and social skills required to compete and thrive in the new knowledge-based economy (Lynch, 2000)

# SKILLS STEM TECH EMPLOYERS SEEK



## •SOCIAL-TECHNICAL

- Translating client needs into technical specifications
- Researching technical information to meet client needs
- Justifying or defending technical approach to client

## •SOCIAL

- Reaching consensus on work team
- Polling work team to determine ideas

## •TECHNICAL

- Using tools, languages, and principles of domain
- Generating a product that meets specific technical criteria
- Interpreting problem using principles of domain

Source: Yarnall & Ostrander, in press

# NEW VISION FOR TEACHING STEM TECH ED:

- **Technical Skills and Knowledge**
  - Higher-order, application Focus
  - Press for demonstration of competence on specific technologies
  - Over-learning (practice, practice, practice)
- **Social Skills and Knowledge**
  - Cooperative learning/ teaming
- **Social-Technical Skills and Knowledge**
  - Practice with reflection and feedback opportunities on performance
  - Use of modeling and faded scaffolding
  - Use of a variety of examples (include error-prone examples)
  - Use of inquiry-based instructional practices

# ONE MODEL TO ACHIEVE VISION

- Scenario-Based Learning (SBL) Project
  - Instructional materials development
  - SBL is a type of problem-based learning (Schank, 1997)
    - 8 multi-part workplace scenarios
    - 72 final assessments, 44 in-class assessments
  - Funding: NSF's Advanced Technological Education (ATE) program

# KEY ELEMENTS OF SBL TEACHING APPROACH

- Workplace problems with some complexity
  - Presentation: Online letters from a manager to the student teams
- Students work in teams (Cooperative learning approach)
  - Students figure out how to approach a complex problem, delegate tasks, and learn “on the fly” (Inquiry-based instructional approach)
  - Students reflect on results (Practice with reflection approach)
  - Student teams conduct presentations about solutions (Variety of examples approach)
- Instructor plays role of workplace manager
  - Conducts team check-ins (Feedback opportunities approach)
  - Provides regular feedback as project unfolds (Feedback opportunities approach)





## Welcome & Orientation

Welcome

Orientation

## Tasks & Assignments

1.0: Bicycle Club Website

1.1: Requirements document

1.2: One feature fully implemented

1.3: Two features fully implemented

1.4: All features fully implemented

### 1.3: Two Features Fully Implemented

Overview

Requirements

Resources

Debrief

<b>From</b>	<b>Project Manager</b>
<b>Subject</b>	<b>Deliverable 3</b>

I'm glad to see that most of you have implemented one feature. Our client is impressed with the quick results, and it is very helpful for marketing to have something concrete to show them.

In fact, our clients are so impressed that they have offered a bonus of \$1000 per team. You will each be able to divide up this \$1000 between team members in whatever way you feel is fair. When you submit the fourth and final deliverable as a group, you will each (individually, and privately) also submit a note telling me how you think the bonus should be divided up between your group's members.

For the meeting next week, you need to fully implement another feature. Again, the screen layout doesn't have to be real pretty because we'll put the graphic designers on it later. Please just make it easy to read.

Again, please post questions and post your deliverable to the website.



# ..Palo Alto Bicycle Club

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## Current Weather

04/10/2009

Palo Alto



51 °F

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## Top 10 Reasons To Join Palo Alto Bicycle Club

- 10) would bike your way to health and happiness.
- 9) would remember to pray before a meal and stretch before a bike ride.
- 8) would remember to CYA in office and bike ride.
- 7) would remember when biking and talking. You are YELLING.
- 6) would remember any saddle no good for men, but might be fun for women.

Find out the rest by joining P.A.B.C. !!!

## Club Membership

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## Latest News

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# ROLE AND IMPORTANCE OF ASSESSMENT IN SBL

- Early trials with SBL revealed:
  - Students liked learning from team members, but
    - Wanted clearly defined learning goals, better evidence that they were learning, and instructor feedback.
  - Instructors liked giving students the projects, but
    - Wanted to know how to manage teams and track individual student progress.
  - Consistent with past work in problem-based learning
    - Underscored benefits of building a consistent and objective assessment framework early in the adoption of PBL (Alverno College, 1977; Woods, 2000)
    - Assessment helps students and instructors commit to course learning goals and see evidence of learning over time.

# KEY ELEMENTS OF SBL ASSESSMENT APPROACH

- Assessment, both informal and formal, focused on:
  - Technical skills and knowledge
  - Social skills and knowledge
  - Social-technical skills and knowledge

# SBL ASSESSMENT DESIGN PROBLEM

- Traditional classroom assessments:
  - Measure recall of isolated facts and technical procedures
  - Often fail to track the development or application of more complex cognitive skills and professional behaviors (Silva, 2008)
- Assessment researchers recommend using a wider array of assessments for PBL-type instructional activities:
  - **Formative assessment** (Black & Wiliam, 1998)
    - Check progress and provide timely feedback
  - **Performance assessment** (Quellmalz, Schank, Hinojosa, & Padilla, 1999)
    - Evaluate meta-cognitive strategies and technical procedures during complex tasks
  - **Authentic assessments** (Allen, 1996; Newmann & Wehlage, 1993)
    - Check application of technical procedures or professional and social skills



# EVIDENCE-CENTERED DESIGN PROCESS

- Needed to help faculty designing SBL tasks define the range of knowledge and skills potentially learned through their tasks
- Reflection frameworks have been used to elicit complex range of skills (Herman, Aschbacher, & Winters, 1992)
- Engaged faculty in a reflection interview process based on principles of evidence-centered design (ECD) (Messick, 1994; Mislevy&Risconscente, 2006) and Principled Assessment Design for Inquiry (PADI) (Mislevy&Haertel, 2006)
- Called it *evidence-centered assessment reflection* (EC-AR)

# BRIEF OVERVIEW OF Evidence-Centered Assessment Reflection (EC-AR) ELEMENTS

- Domain analysis:
  - Characterize knowledge, skills required in technical field
- Domain modeling:
  - Describe features of assessments to provide evidence of student learning
- Conceptual assessment framework (CAF):
  - Documents specific prompts, stimuli, performances, scoring rubrics for assessments per learning outcome
- Assessment implementation:
  - Assessment delivery and validation

# PURPOSE AND FINDINGS OF EC-AR REFLECTION

- Help instructors clarify the full range of skills in competent workplace performance.
- Identified common skill families of SBL across technical fields:
  - **Technical skills:**
    - Research and analysis
    - Framing a problem
    - Generating a product or solution
    - Using tools
    - Making inferences
  - **Social skills**
    - Collaborating to solve a problem
  - **Social-technical skills**
    - Presentation and communication



# TECHNICAL SKILLS: Knowledge/Skills/Abilities, Evidence, Characteristic Task Features

## ■ Sample technical skill KSAs:

- Ability to document system requirements using a simplified use case format
- Ability to address user needs in specifying system requirements

## ■ Sample technical skill evidence:

- Presented with a list of user's needs/uses, the student will correctly specify Web functionalities that address each need.

## ■ Sample technical skill characteristic task features:

- Generating a product:
  - The assessment task must engage students in the use of tools, procedures, and knowledge representations employed in Ajax programming
  - The assessment tasks requires students to summarize the intended solution

# SOCIAL SKILLS:

## Knowledge/Skills/Abilities, Evidence, Characteristic Task Features

### ■ Sample social skill KSAs:

- Ability to listen to team members with different viewpoints and to propose a consensus.

### ■ Sample social skill evidence:

- Presented with a group of individuals charged with solving a problem, the student will demonstrate correctly indicators of active listening and collaboration skills, including: listening attentively, waiting an adequate amount of time for problem solutions, summarizing ideas; and questioning to reach a decision.

### ■ Sample social skill characteristic task features:

- Teamwork:
  - The assessment task will be scenario-based, involve a group of individuals charged with solving a work-related problem.
  - The assessment will involve a conflict among team members and require the social processes of listening, negotiation, and decision-making

# SOCIAL-TECHNICAL SKILLS: Knowledge/Skills/Abilities, Evidence, Characteristic Task Features

## ■ Sample social-technical skill KSAs:

- Ability to ask questions to specify user requirements.
- Ability to engage in software design brainstorming by generating examples of possible user interactions with the Web site.

## ■ Sample social-technical skill evidence:

- Presented with a client interested in developing a web-site, the student will correctly define the user's primary needs.
- Presented with a client interested in developing a web-site, the student will correctly define the range of possible uses for the Web site.

## ■ Sample social-technical skill characteristic task features:

- Framing a problem:
  - The assessment task will be scenario-based and involve the design of a web-site with at least two constraints.
  - The assessment task will require the use of “querying” to determine client needs.
  - The assessment task will require a summation of client needs.

# SAMPLE AJAX ASSESSMENT ITEM

## ■ Generating a product prompt:

- “Considering the use case requirements you wrote for Question #3, list the Web tools, languages, or widgets you plan to use to implement the use case and describe how you might combine them and why you are choosing them.”

## ■ Teamwork assessment prompt:

- “Rate each member of your team according to the following:
  - Listening
  - Appreciating different points of view
  - Reaching a consensus

## ■ Framing a problem prompt:

- “Generate 3 questions for the Everest Hiking and Rock Climbing Club client so you can understand how the Web site will be used and what the end user needs are.”

# INSIGHTS FOR K12 SCIENCE EDUCATORS

- When designing your tests, go beyond “the usual suspects”
  - Do not settle for measuring recall of “Jeopardy-style” knowledge
  - Instead try focusing on how students will apply the knowledge you’re teaching to real world problems
  - Then try imagining how you would distinguish a high quality application of that knowledge from a low quality application

# INSIGHTS FOR K12 SCIENCE EDUCATORS

- Think about how students will use the knowledge you're teaching outside of school or in college
  - How would you like them to apply it to everyday life?
  - What knowledge is most fundamental for future learning?

# INSIGHTS FOR K12 SCIENCE EDUCATORS

- Think about what it looks like when someone can use the knowledge you're teaching:
  - What qualities of thinking or awareness stand out?
  - What work products or knowledge representations can students produce to reveal those levels of understanding or awareness?



Thank you

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