Project Evaluation

Barb Anderegg and Russ Pimmel
Division of Undergraduate Educxcation
National Science Foundation

Annual ASEE Conference

June 24, 2007

Caution

The information in these slides represents the opinions of the individual program offices and not an official NSF position.

Warning on Generalizations

- NSF has several programs supporting undergraduate education
  - Different requirements
  - Different slants
- Proposal improvement ideas apply to all
  - But in varying degrees
- Choose ideas based on
  - Program solicitation
  - Judgment

Overview of Workshops

Goal: **Prepare you to write more competitive proposals**

Three separate but related workshops

- **Proposal strategies**
- **Broader impacts**
- **Project evaluation**

Framework for the Workshop

Framework for the Workshop

- Learning situations involve prior knowledge
  - Some knowledge correct
  - Some knowledge incorrect (i. e., misconceptions)
- Learning is
  - Connecting new knowledge to prior knowledge
  - Correcting misconception
- Learning requires
  - Recalling prior knowledge – actively
  - Altering prior knowledge

Active-Cooperative Learning

- Learning activities must encourage learners to:
  - **Recall** prior knowledge -- actively, explicitly
  - **Connect** new concepts to existing ones
  - **Challenge** and alter misconception
- The think-share-report-learn (*TSRL*) process addresses these steps

Workshop Format

- "Working" Workshop
  - Short presentations (mini-lectures)
  - Group exercise
- Exercise Format
  - *Think → Share → Report → Learn*
    - *(TSRL)*
- Limited Time – May feel rushed
  - Intend to identify issues & suggest ideas
    - Get you started
    - No closure -- No "answers" – No "formulas"

Group Behavior

- Be positive, supportive, and cooperative
  - Limit critical or negative comments
- Be brief and concise
  - No lengthy comments
- Stay focused
  - Stay on the subject
- Take turns as recorder
  - Report for group not your own ideas

Workshop Goals

The workshop will enable you to collaborate with evaluation experts in preparing effective project evaluation plans

It will not make you an evaluation expert

Workshop Outcomes

After the workshop, participants should be able to:

- Discuss the importance of goals, outcomes, and questions in evaluation process
  - Cognitive, affective, and achievement outcomes
- Describe several types of evaluation tools
  - Advantages, limitations, and appropriateness
- Discuss data interpretation issues
  - Variability, alternate explanations
- Develop an evaluation plan with an evaluator
  - Outline a first draft of an evaluation plan

Evaluation and Assessment

- Evaluation (assessment) has many meanings
  - Individual performance (grading)
  - Program effectiveness (ABET assessment)
  - Project progress or success (project evaluation)
- Workshop addresses project evaluation
  - May involve evaluating individual and group performance – but in the context of the project
- Project evaluation
  - Formative – monitoring progress
  - Summative – characterizing final accomplishments

Evaluation and Project Goals/Outcomes/Questions

Evaluation and Project Goals/Outcomes

- Evaluation starts with carefully defined project goals/outcomes
- Goals/outcomes related to:
  - Project management
    - Initiating or completing an activity
    - Finishing a "product"
  - Student behavior
    - Modifying a learning outcome
    - Modifying an attitude or a perception

Developing Goals & Outcomes

- Start with one or more overarching statements of project intention
  - Each statement is a *goal*
- Convert each goal into one or more expected measurable results
  - Each result is an *outcome*

Goals – Objectives – Outcomes -- Questions

- Converting goals to outcomes may involve intermediate steps
  - Intermediate steps frequently called *objectives*
    - More specific, more measurable than goals
    - Less specific, less measurable than outcomes
- Outcomes (goals) lead to questions
  - These form the basis of the evaluation
  - Evaluation process collects and interprets data to answer evaluation questions

Definition of Goals, Objectives, and Outcomes

Goal **– Broad, overarching statement of intention or ambition**

- **A goal typically leads to several objectives**

Objective **– Specific statement of intention**

- **More focused and specific than goal**
- **A objective may lead to one or more outcomes**

Outcome **– Statement of expected result**

- **Measurable with criteria for success**

NOTE: No consistent definition of these terms

Abstract

The goal of the project is …… The project is developing computer-based instructional modules for statics and mechanics of materials. The project uses 3D rendering and animation software, in which the user manipulates virtual 3D objects in much the same manner as they would physical objects. Tools being developed enable instructors to realistically include external forces and internal reactions on 3D objects as topics are being explained during lectures. Exercises are being developed for students to be able to communicate with peers and instructors through real-time voice and text interactions. The material is being beta tested at multiple institutions including community colleges. The project is being evaluated by … The project is being disseminated through …

Project Goals

1. Increase the students' understanding of the concepts in statics

2. Improve the students' attitude about engineering as a career

Project Outcomes

Conceptual understanding

- *Students will be better able to solve simple conceptual problems that do not require the use of formulas or calculations*
- *Students will be better able to solve out-of-context problems.*

Attitude

- *Students will be more likely to describe engineering as an exciting career*
- *The percentage of students who transfer out of engineering after the statics course will decrease.*

Exercise #1: Transforming Outcomes into Questions

Write a question for these expected measurable outcomes:

1. Students will be better able to solve simple conceptual problems that do not require the use of formulas or calculations

2. In informal discussions, students will be more likely to describe engineering as an exciting career

PD's Response -- Questions

Conceptual understanding

- Did the students' ability to solve simple conceptual problems increase ?
- Did the use of the 3D rendering and animation software increase the students' ability to solve simple conceptual problems?

PD's Response -- Questions

Attitude

- Did the students' discussions indicate more excitement, about engineering as a career?
- Did the use of the 3D rendering and animation software increase the students' excitement about engineering as a career in their informal discussions?

Tools for Evaluating Learning Outcomes

Examples of Tools for Evaluating Learning Outcomes

- Surveys
  - Forced choice or open-ended responses
- Interviews
  - Structured (fixed questions) or in-depth (free flowing)
- Focus groups
  - Like interviews but with group interaction
- Observations
  - Actually monitor and evaluate behavior

Olds et al, *JEE* 94:13, 2005

NSF's Evaluation Handbook

Evaluation Tools

- Tool characteristics
  - Advantages and disadvantages
  - Suitability for some evaluation questions but not for others

Example – Comparing Surveys and Observations

Surveys

- Efficient
- Accuracy depends on subject's honesty
- Difficult to develop reliable and valid survey
- Low response rate threatens reliability, validity, & interpretation

Observations

- Time & labor intensive
- Inter-rater reliability must be established
- Captures behavior that subjects unlikely to report
- Useful for observable behavior

Olds et al, *JEE* 94:13, 2005

Example – Appropriateness of Interviews

- Use interviews to answer these questions:
  - What does program look and feel like?
  - What do stakeholders know about the project?
  - What are stakeholders' and participants' expectations?
  - What features are most salient?
  - What changes do participants perceive in themselves?

The 2002 User Friendly Handbook for Project Evaluation, NSF publication REC 99-12175

Concept Inventories (CIs)

Introduction to CIs

- Measures conceptual understanding
- Series of multiple choice questions
  - Questions involve single concept
    - Formulas, calculations, or problem solving not required
  - Possible answers include "*detractors*"
    - Common errors
    - Reflect common "*misconceptions*"

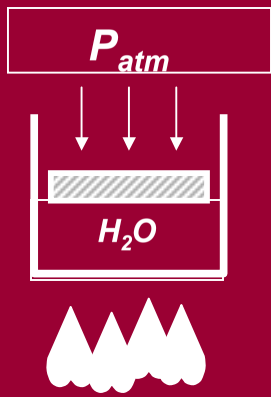
Introduction to CIs

- First CI focused on mechanics in physics
  - Force Concept Inventory (FCI)
- FCI has changed how physics is taught

The Physics Teacher 30:141, 1992

Optics and Photonics News 3:38, 1992

Sample CI Questions



H_2O is heated in a sealed, frictionless, piston- cylinder arrangement, where the piston mass and the atmospheric pressure above the piston remain constant. Select the best answers.

1. The density of the H_2O will:
   (a) Increase (b) Remain constant (c) Decrease
2. The pressure of the H_2O will:
   (a) Increase (b) Remain constant (c) Decrease
3. The energy of the H_2O will:
   (a) Increase (b) Remain constant (c) Decrease

Other Concept Inventories

- **Existing concept inventories**
  - Chemistry
  - Statistics
  - Strength of materials
  - Thermodynamics
  - Heat transfer
  - -- Fluid mechanics
  - -- Circuits
  - -- Signals and systems
  - -- Electromagnetic waves
  - -- Etc.

Richardson, in *Invention and Impact*, AAAS, 2004

Developing Concept Inventories

- Developing CI is involved
  - Identify difficult concepts
  - Identify misconceptions and detractors
  - Develop and refine questions & answers
  - Establish validity and reliability of tool
  - Deal with ambiguities and multiple interpretations inherent in language

Richardson, in *Invention and Impact*, AAAS, 2004

Exercise #4: Evaluating a CI Tool

- Suppose you were considering an existing CI for use in your project's evaluation
- What questions would you consider in deciding if the tool is appropriate?

PD's Response -- Evaluating a CI Tool

- Nature of the tool
  - Is the tool relevant to what was taught?
  - Is the tool competency based?
  - Is the tool conceptual or procedural?
- Prior validation of the tool
  - Has the tool been tested?
  - Is there information on reliability and validity?
  - Has it been compared to other tools?
  - Is it sensitive? Does it discriminate novice and expert?
- Experience of others with the tool
  - Has the tool been used by others besides the developer? At other sites? With other populations?
  - Is there normative data?

Tools for Evaluating Affective Factors

Affective Goals

GOAL: To improve

- Perceptions about
  - Profession, department, working in teams
- Attitudes toward learning
- Motivation for learning
- Self-efficacy, self-confidence
- Intellectual development
- Ethical behavior

Exercise #5: Tools for Affective Outcome

Suppose your project's outcomes included:

1. Improving perceptions about the profession
2. Improving intellectual development

Answer the two questions for each outcome:

- Do you believe that established, tested tools (i.e., vetted tools) exist?
- Do you believe that quantitative tools exist?

PD Response -- Tools for Affective Outcomes

- Both qualitative and quantitative tools exist for both measurements

Assessment of Attitude - Example

- Pittsburgh Freshman Engineering Survey
  - Questions about perception
    - Confidence in their skills in chemistry, communications, engineering, etc.
    - Impressions about engineering as a precise science, as a lucrative profession, etc.
  - Forced choices versus open-ended
    - Multiple-choice

Besterfield-Sacre et al , JEE 86:37, 1997

Assessment of Attitude – Example (Cont.)

- Validated using alternate approaches:
  - Item analysis
  - Verbal protocol elicitation
  - Factor analysis
- Compared students who stayed in engineering to those who left

Besterfield-Sacre et al , JEE 86:37, 1997

Tools for Characterizing Intellectual Development

- Levels of Intellectual Development
  - Students see knowledge, beliefs, and authority in different ways
    - " Knowledge is absolute" versus "Knowledge is contextual"
- Tools
  - Measure of Intellectual Development (MID)
  - Measure of Epistemological Reflection (MER)
  - Learning Environment Preferences (LEP)

Felder et al, JEE 94:57, 2005

Evaluating Skills, Attitudes, and Characteristics

- Tools exist for evaluating
  - Communication capabilities
  - Ability to engage in design activities
  - Perception of engineering
  - Beliefs about abilities
  - Intellectual development
  - Learning Styles
- Both qualitative and quantitative tools exist

Turns et al, *JEE* 94:27, 2005

Interpreting Evaluation Data

Exercise #6: Interpreting Evaluation Data

Consider the percentages for Concepts #1, #2, and #3 and select the best answer for the following statements for each question:

1. ***The concept tested by the question was:***

   (a) easy (b) difficult (c) can't tell

2. ***Understanding of the concept tested by the question:***

   (a) decreased (b) increased (c) can't tell

Interpreting Evaluation Data

Quest	No. of Students		Percent with Correct Answer	
	Pre	Post	Pre	Post-
1	25	30	29%	23%
2	24	32	34%	65%
3	25	31	74%	85%
-	-	-	-	-

PD's Response -- Interpreting Data

- CI does not measure difficulty
- Probably no change in understanding of Concept #1 and #3
- Probably an increase in understanding of Concept #2
  - Large variability makes detecting changes difficult
  - *25 % is expected value from random guessing*
  - *There are statistical tests for identifying significant changes*

Exercise #7: Alternate Explanation For Change

- Data suggests that the understanding of Concept #2
- One interpretation is that the intervention caused the change
- List some alternative explanations
  - Confounding factors
  - Other factors that could explain the change

PD's Response -- Alternate Explanation For Change

- Students learned concept out of class (e. g., in another course or in study groups with students not in the course)
- Students answered with what the instructor wanted rather than what they believed or "knew"
- An external event (big test in previous period or a "bad-hair day") distorted pretest data
- Instrument was unreliable
- Other changes in course and not the intervention caused improvement
- Students not representative groups

Exercise #8: Alternate Explanation for Lack of Change

- Data suggests that the understanding of Concept #1 did not increase
- One interpretation is that the intervention did cause a change but it was masked by other factors
- List some confounding factors that could have masked a real change

PD's Response -- Alternate Explanations for Lack of Effect

- An external event (big test in previous period or a “bad-hair day”) distorted post-test data
- The instrument was unreliable
- Implementation of the intervention was poor
- Population too small
- One or both student groups not representative
- Formats were different on pre and post tests

Culturally Responsive Evaluations

- Cultural differences can affect evaluations
- Evaluations should be done with awareness of cultural context of project
- Evaluations should be responsive to
  - Racial/ethnic diversity
  - Gender
  - Disabilities
  - Language

Evaluation Plan

Exercise #9: Evaluation Plan

- Suppose that a project's goals are to improve:
  1. The students' understanding of the concepts in statics
  2. The students' attitude about engineering as a career

- List the topics that you would address in the evaluation plan

Evaluation Plan -- PD's Responses

- Name & qualifications of the evaluation expert
- Goals and outcomes and evaluation questions
- Tools & protocols for evaluating each outcome
- Analysis & interpretation procedures
- Confounding factors & approaches for minimizing their impact
- Formative evaluation techniques for monitoring and improving the project as it evolves
- Summative evaluation techniques for characterizing the accomplishments of the completed project.

Working With an Evaluator

What Your Evaluation Can Accomplish

Provide reasonably reliable, reasonably valid information about the merits and results of a particular program or project operating in particular circumstance

- ***Generalizations are tenuous***
- ***Evaluation***
  - ***Tells what you accomplished***
    - ***Without it you don't know***
  - ***Gives you a story (data) to share***

Perspective on Project Evaluation

- Evaluation is complicated & involved
  - Not an end-of-project "add-on"
- Evaluation requires expertise
- Get an evaluator involved EARLY
  - In proposal writing stage
  - In conceptualizing the project

Finding an Evaluator

- Other departments
  - education, educational psychology, psychology, administration, sociology, anthropology, science or mathematics education, engineering education
- Campus teaching and learning center
- Colleagues and researchers
- Professional organizations
- Independent consultants
- NSF workshops or projects

Question: Internal or external evaluator?

Exercise #10: Evaluator Questions

- List two or three questions that an evaluator would have for you as you begin working together on an evaluation plan.

PD Response – Evaluator Questions

Project issues

- What are the goals and the expected measurable outcomes?
- What are the purposes of the evaluation?
- What do you want to know about the project?
- What is known about similar projects?
- Who is the audience for the evaluation?
- What can we add to the knowledge base?

PD Response – Evaluator Questions (Cont.)

Operational issues

- What are the resources?
- What is the schedule?
- Who is responsible for what?
- Who has final say on evaluation details?
- Who owns the data?
- How will we work together?
- What are the benefits for each party?
- How do we end the relationship?

Preparing to Work With An Evaluator

- *Become knowledgeable*
  - Draw on your experience
  - Talk to colleagues
- *Clarify purpose of project & evaluation*
  - Project's goals and outcomes
  - Questions for evaluation
  - Usefulness of evaluation
- *Anticipate results*
  - Confounding factors

Working With Evaluator

Talk with evaluator about your idea (from the start)

- Share the vision

Become knowledgeable

- Discuss past and current efforts

Define project goals, objectives and outcomes

- Develop project logic

Define purpose of evaluation

- Develop questions
- Focus on implementation and outcomes
- Stress usefulness

Working With Evaluator (Cont)

Anticipate results

- List expected outcomes
- Plan for negative findings
- Consider possible unanticipated positive outcomes
- Consider possible unintended negative consequences

Interacting with evaluator

- Identify benefits to evaluator (e.g. career goals)
- Develop a team-orientation
- Assess the relationship

Example of Evaluator's Tool – Project Logic Table

The Project

- **Goals**
- **Objectives**
- **Activities**
- **Outputs & outcomes**
- **Measures & methods**

Goals	Objectives	Activities	Outputs/ Outcomes	Measures

What do I want to know about my project?

(a)

(b)

Human Subjects and the IRB

- Projects that collect data from or about students or faculty members involve human subjects
- Institution must submit one of these
  - Results from IRB review on proposal's coversheet
  - Formal statement from IRB representative declaring the research exempt
    - Not the PI
  - IRB approval form
- See "Human Subjects" section in GPG

NSF Grant Proposal Guide (GPG)

Other Sources

- *NSF's User Friendly Handbook for Project Evaluation*
  - http://www.nsf.gov/pubs/2002/nsf02057/start.htm
- Online Evaluation Resource Library (OERL)
  - http://oerl.sri.com/
- Field-Tested Learning Assessment Guide (FLAG)
  - http://www.wcer.wisc.edu/archive/cl1/flag/default.asp
- Science education literature
  - *J. of Engineering Education*, Jan. 2005