I2U2 Evaluation Toolkit

Version 1.0

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INTRODUCTION

Purpose of the Evaluation Toolkit

This document brings together in one place the goals, methods, instruments, responsibilities, steps and timeline for the 3 years of I2U2 project evaluation. Information in this document should be considered the latest and best available. Note – this version is still a draft. As the Toolkit gets revised based on changing circumstances and developer and user feedback, evaluators will disseminate and post changes for project staff.

The I2U2 evaluation tools will become an integral part of the final I2U2 Developer's Toolkit and serve as a model for future e-lab development.

Purpose of I2U2 evaluation

In scientific investigations, scientists monitor and evaluate all phases of their work. They use an integrated set of tools and processes that ensure the quality of their data and of their findings and conclusions. These tools and processes vary by discipline. Most involve calibration of instruments, use of documentation such as laboratory notebooks, application of quality controls, presentation of work in process, informal and formal peer review and publishing. Each member of the scientific collaborative understands and is responsible for ensuring that their work and the work of colleagues is of the highest quality and rigor.

The process of developing high-quality educational products relies on the same underlying principles of scientific research. Developers agree on theories of learning, and use a shared set of tools and processes to design what they believe will be effective learning environments. The evaluation tools and processes provide calibration, documentation, quality controls, and data from end users of learning environments.

Formative evaluation data are used to identify strengths and weaknesses of the design, from technical bugs to classroom implementation. These data come from a system of instruments and protocols used by members of the development team. Formative evaluation usually includes outcome data, which describe the impact of the learning environment on the end users (teachers and students, museum visitors, members of the public, etc.). Instruments include a set of research-based external assessments designed and implemented by the evaluation team (MJ Young & Associates).

Summative evaluation data are collected to inform potential users about the effectiveness of the final products/programs. These data are particularly important for I2U2 since the project had been funded to explore the educational application of the Grid. Therefore, we will also be looking at who is the appropriate audience for the e-labs, i.e., who do they work best for and in which contexts. Summative evaluation data are basically outcome data collected on implementation of the final product, although additional instruments may be used as needed.

Evaluation Goals

The I2U2 project is a collaborative education and outreach initiative funded by the US National Science. The goal of the I2U2 collaboration is to develop model learning environments and a suite of tools that others can use to develop new grid-based learning projects. The goals of the evaluation are to--

- Assess the impact and effectiveness of e-Labs on students.
- Assess impact of professional development of teachers.
- Determine why e-Labs can and could be used broadly—what works, with whom and under what circumstances.

Evaluation Study Questions

1. To what extent are e-labs user friendly, appropriate for intended users?
2. To what extent do e-labs contribute to the teaching of science curriculum/standards?
3. To what extent are teachers able to create environments (opportunities) for students to successfully complete an e-lab learning experience (conduct an investigation & analyze data)
4. To what extent do workshops and any follow-up support provide sufficient support for teachers to implement e-labs in a variety of contexts?
5. To what extent do online support mechanisms create a community of learners that support teachers' and students' ability to effectively use the e-labs?
6. To what extent do students achieve the learning goals for each e-lab?
7. How do e-labs and professional development work in a range of contexts and settings? With diverse teachers and students?

Role of I2U2 developers and staff in the evaluation

Developers and/or staff educators in the I2U2 team help collect, report, and analyze evaluation findings, using the instruments and protocols provided in this Toolkit. Programmers and IT staff provide statistics on access and use of the e-lab sites, data analysis activities, number of people served, bug reporting, and technical support needs of users (teachers and students).

It is essential for project reporting and future funding that all I2U2 developers collect and submit data in a timely way to the external evaluators.

Role of external evaluators

MJ Young & Associates provide evaluation services to the I2U2 project. Evaluators develop and refine the evaluation tools that will become part of the I2U2 developers' toolkit.

We work closely with developers to design systems for data collection, analysis and feedback to improve the quality and usability of a product for end-users (formative evaluation). We also provide expertise in designing tools to determine teacher and student outcomes in relation to project goals and objectives. We implement policy and practice guidelines established by our profession and by the NSF to report on the overall merit and worth of a project.

Evaluation Data Collection & Analysis Plan

The following table updates information previously distributed on the I2U2 project evaluation. After the meeting on January 7-8, 2009, MJ Young & Associates will follow up with an Evaluation Checklist that developers can use to track evaluation tasks for each e-lab.

Evaluation Instrument Design Phase (2009-2010)

Milestone: All evaluation instruments proved valid and reliable

Instrument, protocol or data source	Purpose	Respondent	Data collection & analysis plan
Learning Objectives	These describe what students will know and be able to do as a result of participating in an I2U2 e-lab. Learning objectives anchor the development of all instruments and measures of project outcomes. Achievement of LOs determines judgment of e-lab success/ effectiveness.	Project team & external evaluators	Objectives revised as needed based on data from production tests of e-labs.
Pre-post student assessment: validation protocol (item analysis)	Evaluators follow an item analysis protocol to determine the validity and reliability of test items. Data from student results in Year 1 (2009) are used to revise items for the final version of the assessment that is embedded in each e-lab. Documents the process of item development and analysis for future e-lab developers. Provides warrant for empirical findings reported to NSF.	NA	NA

Professional Development Design (Cosmic & LIGO 2009; CMS & Adler 2010)

Milestone: PD provides most (+85%) of teachers with preparation needed to implement e-lab with students

Instrument, protocol or data source	Purpose	Respondent	Data collection & analysis plan
Workshop information form	Provide background and context data for determining impact of workshop on teachers. Triangulates with data collected in participant satisfaction forms and teacher interviews. Data summarized across all e-labs. Provides information to funder on participants reached.	Teachers in all e-lab professional development sessions	Workshop (PD) leaders collect data during workshop. MJY&A summarize data across e-labs.
Participant satisfaction form	Provides background information and participant satisfaction for each teacher participant. Data can be used by developers to revise design of professional development. Analysis by MJY&A provided to NSF to report progress and outcomes.	Teachers in all e-lab professional development sessions	Workshop leaders collect data. MJY& A conducts descriptive stats, content analysis.
Site visits	MJY&A observe a sample of teacher workshops and conduct informal participant interviews. Data provided to the project as an informal report to make decisions about workshop improvement and compiled for each project to report to funders.	Teachers attending workshops	MJT&A conducts content analysis.

Teacher telephone surveys	In-depth teacher perspective, description of implementation, and reflection on successes/challenges. Provides development feedback to improve design of e-labs and workshops.	Sample (TBD) of teachers	MJ Young & Associates conducts interviews and content analysis.

e-Lab/i-Lab Early Development Phase (Cosmic & LIGO 2009, CMS & Adler 2010)
Milestone: e-lab is motivating, inviting, clear and easy-to-use. Users do not need to be directed through an investigation. All technical components operable.

Instrument, protocol or data source	Purpose	Respondent (who provides the data)	Data collection & analysis plan
Think Aloud Protocol: Student	Developers use with sample of students to test usability of the e-lab instructional design and interface. Student questions and difficulties are recorded and used to adjust pedagogy and/or interface. Or, developers document suggestions and reasons why changes were not made. External evaluators report progress to NSF. TA protocols should be used during at least two stages in the development of e-labs: near the beginning to get a sense of usability, and toward the end to see if users can use successfully without coaching.	2-3 students who have strong content background and technical skills. Use more if needed. Two or more students including those who are "typical" users.	Developers recruit reviewers and collect data via rubric (form). Developers analyze locally to adjust design of e-lab. Data across e-labs analyzed by MJY&A; report relevant data to all developers.
Think aloud protocol: Teacher	Developers use with sample of teachers to test usability of the e-lab instructional design and interface. Teachers' questions and difficulties are recorded and used to adjust pedagogy and/or interface. Or, developers document suggestions and reasons why changes were not made. External evaluators report progress to NSF. TA protocols should be used during at least two stages in the development of e-labs: near the beginning to get a sense of usability, and toward the end to see if users can use successfully without coaching.	2-3 teachers who have strong content background and technical skills. Use more if needed. Two or more teachers including those who may have been part of an e-lab workshop.	Developers recruit reviewers and collect data via rubric (form). Developers review feedback and make adjustments to e-lab. MJY&A summarize across e-labs; report relevant data to all developers.

Expert review (aka peer review)	To provide external perspective of other developers or "experts"--those who understand the science and educational purposes of an e-lab. Experts provide an initial review of e-lab interface and pedagogical design. Developers use feedback of experts locally to adjust design of interface and pedagogy. Data are also submitted to MJY&A for summative analysis and progress report to NSF.	3-5 other e-lab developers, e.g. "Insiders" to I2U2. Reviewers may include QuarkNet fellows or other 'expert' teachers.	Developers recruit reviewers and collect data via rubric (form). Developers review feedback and make adjustments. External evaluators summarize across e-labs.

Classroom/Museum Beta Testing Small Scale (Cosmic & LIGO 2009; CMS & Adler 2010)
Milestone: Teachers successfully implement e-lab with students. Evaluation findings incorporated into revisions of pre-post test, e-lab design, pedagogy, and professional development. Major bugs fixed.

Classroom/Museum Beta Testing Production Scale (Cosmic & LIGO 2010; CMS & Adler 2011)
Milestone: Teachers successfully implement e-lab with students. Learning outcomes achieved by at least 60% of students on pre-post assessments and rubrics. Technical applications robust across multiple platforms.

Ongoing evaluation (to end of project funding)
Milestone: Learning outcomes achieved by majority of students in different contexts. Technical or implementation challenges documented and addressed.

Instrument, protocol or data source	Purpose	Respondent	Data collection & analysis plan
Pre-post student assessment: Student demographics and contextual background survey	Data required to match student responses pre & post, and to determine contextual variables that may impact results (e.g., grade level, number of science credits, teacher, number of hours using e-lab, etc.). Provides data to project and funders on number and types of students served by project.	Students/ teachers	Students respond to on-line survey automated through web-based databases maintained by e-lab teams. MJY&A statistical analysis across e-labs.
Pre-post student assessment: revised process questions (penny items)	Provides empirical data to funder and future e-lab developers on impact of e-lab on student understanding of the nature and processes of scientific research. Pre-program data can also be used by teachers or developers to adjust the focus of content and instruction for a particular group of students.	Students in all e-labs	Students respond to on-line assessment automated through web-based databases maintained by e-lab teams. MJY&A analyze statistically.

Pre-Post Student assessment: e-lab specific learning objectives and content items	To determine impact of e-lab on students' understanding of physics concepts related to seismic waves and the LIGO detector/experiment. Pre-assessment data can also be used by teachers or developers to adjust the focus of content and instruction for a particular group of students. Provides outcome data to funder.	Students in LIGO, Cosmic, CMS, or Adler	Teachers administer to all students who use the e-lab. Students respond to on-line survey automated through web-based databases maintained by e-lab teams. MJY&A statistical analysis within/across e-lab.
Teachers' Personal logs (Beta test small scale only)	Provides individual teaches' perspective and description of implementation of e-lab in particular settings. Identify successes and challenges teachers encountered in implementation of e-lab. Data can be used by developers to adjust design of the e-lab or professional development. Analysis by MJY&A identifies patterns of implementation across e-labs. This informs future e-lab design and implementation. Triangulates with student outcomes.	Sample (TBD) of teachers	Developers recruit sample of teachers and follow-up to obtain data. Data submitted to MJY & A. MJY & A conducts descriptive statistics, content analysis
Teacher online comments and discussions	Provides real-time data on teachers' questions, ideas, concerns and solutions related to implementation of e-labs. Provides an on-line community where developers and teachers can interact asynchronously. Describe ways in which teachers implemented e-labs. Identify successes and challenges teachers encountered. Triangulated with other teacher implementation data and student outcomes.	Teachers who use the online comments and discussion features of e-labs	Automatically archived by e-lab. Developers provide feedback or support to teachers during implementation. MJY&A will do content analysis within and across e-labs.
Rubrics: Research and technology skills, GRID technology & collaboration, Writing and Language Arts	Rubrics serve as a tool for teachers and students to assess progress towards and achievement of understanding in an e-lab. Developers use findings across students to adjust content and pedagogy in an e-lab. MJY&A examine findings across e-labs to report progress to NSF. Rubric data triangulate (corroborate or refute) data from student pre- and post-assessments.	Sample (TBD) of teachers who implement e-lab or QuarkNet fellows (TBD)	TBD. Developers recruit teachers and follow through to obtain data. Suggestion made to create online rubrics connected to e-lab database & archive.
Student online communications, logs, and posters	Provides real-time and archived data on students' questions, ideas, concerns, solutions related to their use of the e-labs. Provides models of and data from actual investigations for future e-lab teachers and students. Rubrics (see above) guide the assessment of quality. External evaluators report outcomes to NSF. Data triangulate with student pre-post assessments and classroom implementation.	Students who use the electronic notebooks and create posters	Student work archived by e-lab. Rubrics used to assess students. Developers adjust design. MJY&A summative across e-labs.
Help desk reports	Provides details of technical difficulties encountered by teachers/students. Developers use data to improve code/interface. MJY&A report statistics on progress to NSF.	Teachers who request support	TBD

Common Student Learning Objectives for e-Labs

Through an iterative process over several months, we developed the following *common* student learning objectives for process skills, literacy and technology for each e/i-lab. e-lab developers work with staff and evaluators to develop *separate* content objectives. Below, each common learning objective is listed with its associated evaluative study question (the enduring understanding) and alignment to National Science Education Standards. and the content objective template. All are *student learning* objectives (students will know and be able to . . .). As per backward design [WMc1998], we continued from this starting point to develop a student pre- post-test for the common process learning objectives. Each e-lab writes their own questions to address content objectives from the template below. We assess technology and literacy common learning objectives using rubrics, and content objectives will be further assessed using poster rubrics. The common objective test for two of the four process learning outcomes, the content pre-test for the Cosmic Ray e-Lab, the think-aloud protocol and the rubrics are included in the accompanying document. Pre- and post-tests will be posted online for each e-Lab.

<u>Processes of scientific research and communication of results</u>

Explain the data collection process, including what corrections need to be made in order to obtain reliable data.

How are scientific instruments used to collect data? What do scientists do to correct for unreliability? (NSES Content Standard A: Abilities to do and understanding about scientific inquiry.)

Collect, organize and analyze data to obtain meaningful findings.

What patterns are evident in the data? What organization, e.g., charts, graphs, help you organize data in a meaningful way (allow you to identify patterns in the data)? How do scientists know which data are “data of interest”? (NSES Content Standard A: Abilities to do and understanding about scientific inquiry.)

Use data to provide evidence to support your claims.

To what extent does the data support claims? Are there alternate explanations? How well are the claims presented? (NSES Content Standard A: Abilities to do and understanding about scientific inquiry and Standard G: Nature of scientific knowledge.)

<u>Technology/Grid</u>

How are data accessed on the Grid? Which computing techniques provide a means for organizing and analyzing the data?

(NSES Content Standard A: Abilities to do and understanding about scientific inquiry and Standard E: Understanding about science and technology; National Education Technology Standards 1-6)

<u>Literacy/Scientific Communication</u>

Demonstrate an ability to express meaning in writing (such as in science notebooks, reports) and come to agreement about meaning with others (such as peer review, discussion).

Are students able to offer constructive criticism/feedback? Can students come to agree about meaning with others in their group, ask probing questions and have meaningful discussions? Why are developing drafts important? (Report writing rubric will provide evidence of ability to express meaning in writing.)

(NSES Content Standard A: Abilities to do and understanding about scientific inquiry and Standard G: Nature of scientific knowledge; National Council of Teachers of English Standards 4: Communicate effectively; 5: Employ range of written strategies; 11: Participate in literacy communities.)

Objectives related to the content/scientific inquiry in a specific e-lab

Describe the natural phenomenon under investigation and explain how the data collected will provide information about that phenomenon.

What do data collected previously tell us about the phenomenon? How do the data collected in the current investigation corroborate and/or expand what is known? What questions can we ask to expand upon or better understand the phenomenon?

(NSES Content Standard B: Physical Science)

Design an investigation based on a testable hypothesis from data collected using scientific instrumentation and explain how your research promotes further understanding about the phenomenon being investigated.

What can the data tell you about the answer to your question? In what ways do the answers further your understanding of the phenomena? How might the answers contribute to the field and/or provide greater understanding?

(NSES Content Standard B: Physical Science and Standard G: Nature of scientific knowledge)

The content and investigation LO "templates" are so called because they need to be specified differently for each experiment. Here is an example of the second content LO (and associated questions for a rubric), filled in with detail with respect to CMS:

> Design an investigation based on a testable hypothesis from the CMS test beam data, and explain how the answer(s) to the question promotes further understanding about how the CMS detector will function in the LHC.

What can the data tell you about the answer to your question? In what ways do the answers further your understanding of particle detection and the CMS detector in particular? How do findings such as yours contribute to the work CMS scientists do?

Instruments and protocols

The following sections of this document provide detailed information and instructions for each instrument and protocol in the I2U2 evaluation. These versions should be used through June 2009.[1] Along with e-labs, the I2U2 grant calls for developing valid and reliable instrumentation. Validation and reliability requires a design technology cycle of development, testing, and revision. Evaluators expect this process will take at least two years.

Selecting Teacher and Student Samples for Evaluation

Developers are responsible for recruiting teachers and students to participate in testing and evaluation of an e-lab. Select teachers and students who are representative of the larger groups who will eventually use the finished products.

Early development and beta test phases

During early development and beta-testing, more "expert" teachers and students can provide in-depth and thoughtful feedback on the design or technical features of an e-lab. If "expert" participants have difficulty with the design or interface of an e-lab, most other users will too.

Small-scale and production-scale classroom test phases

During small-scale testing, recruit a wider variety of teachers and students. Be sure that the teachers are able and willing to commit to providing evaluation data and to following through with the entire e-lab implementation.

Workshop information form

To be completed by the workshop provider and submitted to MJY&A along with the participant satisfaction surveys. Contextual information is needed in order to interpret the satisfaction data. These data should be collected every time you have a workshop. In order to be able to make follow-up telephone calls to a sample of teachers, evaluators will need contact information.

Participant Satisfaction Form

To be completed by ALL participants at the end of the workshop.

Think Aloud: Students

During early stages, as stated above, it is best to recruit high-achieving students who are computer literate to provide feedback. If the milestone cannot be reached with these students, it is not likely to be reached with any student.

During later phases, students should be “typical” users including students of teachers who may have participated in e-lab training.

Think Aloud: Teachers

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[1] ***Questions related to these current versions should be addressed to MJ Young & Associates. Due to the need to move forward with evaluation, no more changes will be made until the results of data collection from Spring 2009 are analyzed.***

The same principles apply here as with students. For early stages of development, teachers who are the most computer and content-literate are best. Later, a "typical" user is best to recruit including those who may have had some e-lab training. For example, a couple of teachers attending the LIGO workshop in the summer of 2008 were asked to participate in the TA protocol.

Expert (peer) Review

Other e-lab developers or others who are familiar with e-lab requirements, have some content proficiency and/or are pedagogy or instructional design experts. These "others" may include MJY&A, QuarkNet fellows, and/or QuarkNet staff.

The following instruments are still under development and will be finalized by February 1, 2009.

- Rubrics for assessing student work
- Teacher Log Protocol
- Content pre/post test items for LIGO

The following pages include a current version of all finalized instruments

Expert Review Protocol

Version 1.0 (January 2009)

e-lab:______________________________________

Name of Reviewer: _________________________________

Date: ______________________

Directions: The following checklist addresses criteria that match the I2U2 student learning objectives, agreed-upon formatting and content, and aspects of effective Web sites. Put a check by the item if it is appropriately addressed, double check if it appears to be particularly effective and if no check, provide comments on what is missing. Since the evaluators will use much of this to have teachers assess the e-labs, please also offer suggestions for what you might want them to look at that is not in this protocol.

<u>Engaged Learning Pedagogy</u>

A. The Web invite and motivate to:

1. start on the research/investigation by offering a task or situation that their curiosity		
2. come up with questions, concerns, issues, hypotheses, or problem-solving suggestions that guide their investigation and overall participation in the research/investigation		

B. The Web pages for students/participants provide *opportunities* for students to:

1. make their own choices for how to proceed and engage at their own pace		
2. determine the aspect of topic, problem, or issue to be investigated		
3. develop content understanding needed to complete the investigation/research		
4. develop skills needed to complete the investigation/research		

5. with regard to data

a. evaluate the data/determine reliability (defined as: stability of measurement over time)

b. collect and compile data, gather information

c. organize data in a way that is meaningful

d. analyze data

6. produce original work (data, information, analysis, conclusions—defined as providing evidence to support claims)

7. work in collaborative groups

8. record and reflect on their work individually

C. The Web pages for students provide opportunities for teachers to:

1. have students discuss ideas; brainstorm; problem solve

2. provide ongoing feedback/advice for completing investigation/project (teacher as coach)

<u>Use of Internet Tools</u>

A. Links are provided to:

1. useful places/sites that provide information to complete investigation

2. places/sites that provide skill development to complete investigation

3. datasets that are updated and blessed

B. Communication provides opportunity for students to:

1. collaborate with other classrooms (e.g., shared data collection)

2. publish data, links, and/or useful information for others online (e.g., present analysis and conclusions online)

Curriculum/Content

A. Multidisciplinary:

1. Addresses one or more of the national teaching, assessment, and content standards in one or more disciplines (science, mathematics, language arts)
2. Has opportunities to express meaning in writing (such as in science notebooks, reports)
3. Has opportunities for students to come to an agreement about meaning with others

B. Research-based:

1. Students are engaged in authentic scientific research through investigations.
2. Provides an authentic experience for the students that mirrors the way scientists conduct research.

C. Grade Appropriate:

1. Skills, especially those that require technology, are grade level appropriate.
2. Content is accessible by students.

Assessment

A. Prior Knowledge:

Strategies are used to assess students' prior understandings and skills related to the project.

B. Ongoing/Embedded:

1. Learner outcomes and activities for the project are congruent (consistent with each other).
2. Learner outcomes and assessment rubric for the project are congruent.
3. Mechanisms are in place for frequent assessment of student progress; students are provided feedback.
4. Students have opportunities to reflect on their progress at regular intervals.

Page Design

A. Visually Inviting:

1. Colors and patterns enhance readability rather than detract from or make it difficult to read.
2. Pages are not cluttered with text, have balanced layout and sufficient white space.
3. Pages have a consistent look and feel.
4. Graphics display correctly
5. Graphics are engaging.
6. Graphics do not take too long to load.
7. Animated gifs stop after a few cycles.

B. Writing:

1. Headings and subheadings are clear; enhance readability.
2. Changes in text size and color are used sparingly to enhance understanding.
3. Text is well organized; easy to follow.
4. Text is grammatically correct with no spelling errors.
5. Text is well written, clear.
6. Student pages are directed at students

C. Milestones

1. Milestones provide guidance to the exploration of concepts and tasks.
2. Milestones provide links to external resources that assist investigations.
3. Milestones are linked to the logbook and provide an opportunity to capture student comprehension and inquiry.
4. Milestones occur at appropriate intervals where significant work can be expected to have been accomplished by the student.

D. Look and Feel

1. e-Lab pages have a uniform look and feel.
2. e-Lab pages allow users to see quickly what action they must perform.
3. e-Lab pages provide links to glossary items as needed.
4. e-Lab pages provide ready access to logbook and milestones.

Student Pre/Post Assessment

Version 1.0 (January 2009)

NOTE: Due to ongoing discussions about the role of Grid technology in each e-lab, this version will not include any assessment items related to the Grid learning objective.

LEARNING OBJECTIVE 1

Explain the data collection process, including what corrections need to be made in order to obtain reliable data. How are scientific instruments used to collect data? What do scientists do to correct for unreliability?

LEARNING OBJECTIVE 2

Organize and analyze data to obtain meaningful findings. What patterns are evident in the data? What organization (e.g., charts, graphs) help you organize data in a meaningful way (allow you to identify patterns in the data)? How do scientists know which data are "of interest"?

LEARNING OBJECTIVE 3

Use data to provide evidence to support your claims. To what extent does the data support claims? Are there alternate explanations? How well are the claims presented?

Students in Ms. Marchant's third hour class did an experiment with 151 United States pennies. They were asked to write down the "observables" on the pennies and organize the results. Each group decided to inspect each penny and record their own set of observables Three groups asked their teacher for an electronic balance in order to measure the mass of each penny.

Groups brainstormed which observable to record and argued about whether or not some could be measured accurately. Their final list included:

the penny's shininess

the year that the penny was made

the mass of the penny

the worn-ness of the penny

the mint the stamped the penny

1. Which of these can be accurately and reliably determined? You may choose more than one. *(LO1)*
   A) shininess
   B) year
   C) mass
   D) worn-ness
   E) the mint location

2. Which of these characteristics requires measurement by a scientific instrument? *(LO1)*

   A) shiny-ness

B) year
C) mass
D) worn-ness
E) the mint location

3. How can the groups be sure that their measurements are accurate? *(LO1)*

A) use only one instrument for all measurements
B) compare measurements of each penny on all instruments
C) measure a known object on all instruments in use
D) write down all measurements on the blackboard for discussion

4. Students noticed that the scale they used read 4 grams with nothing on it. What should they do? *(LO1)*

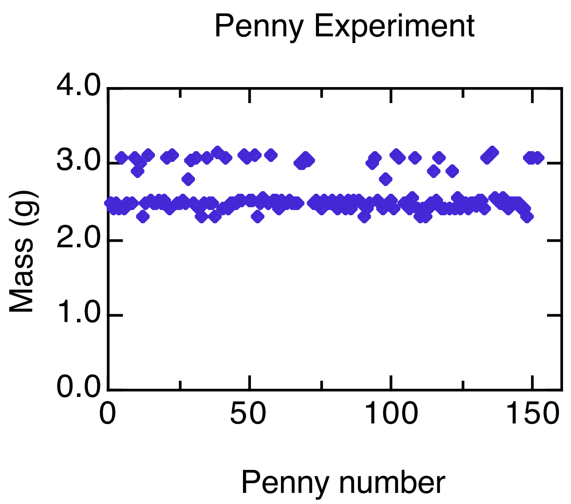
A) subtract four grams from all measurements on this scale
B) don't use this scale
C) measure a known object on this scale to see if the scale's error is always 4 grams
D) ignore the error

A student group measured the mass of each penny and created the following table of those measurements.

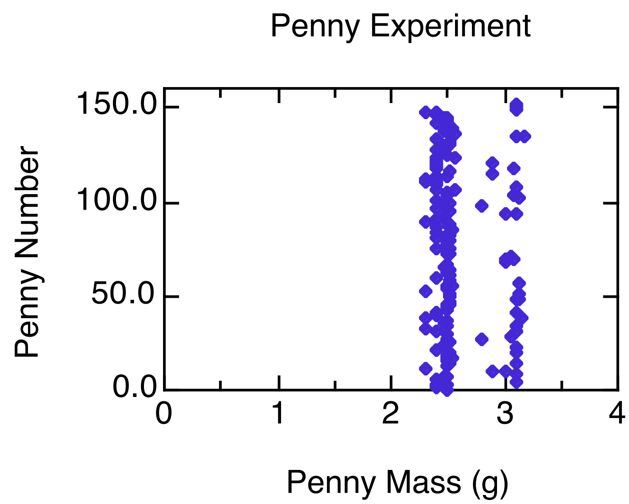
Penny Number	Mass (grams)	Penny Number	Mass (grams)	Penny Number	Mass (grams)	Penny Number	Mass (grams)
1	2.49	41	3.10	81	2.40	121	2.90
2	2.40	42	2.40	82	2.52	122	2.40
3	2.49	43	2.50	83	2.49	123	2.57
4	2.40	44	2.49	84	2.40	124	2.40
5	3.10	45	2.50	85	2.53	125	2.50
6	2.40	46	2.51	86	2.40	126	2.48
7	2.48	47	2.51	87	2.51	127	2.4
8	2.50	48	3.12	88	2.51	128	2.47
9	3.10	49	3.10	89	2.50	129	2.5
10	2.90	50	2.52	90	2.30	130	2.45
11	3.00	51	2.52	91	2.40	131	2.52
12	2.30	52	3.12	92	2.48	132	2.51
13	2.49	53	2.30	93	3.02	133	2.4
14	3.11	54	2.50	94	3.10	134	3.1
15	2.52	55	2.55	95	2.51	135	3.17
16	2.49	56	2.50	96	2.49	136	2.56
17	2.49	57	3.12	97	2.40	137	2.51
18	2.53	58	2.51	98	2.80	138	2.47
19	2.50	59	2.52	99	2.47	139	2.55
20	2.51	60	2.40	100	2.51	140	2.52
21	3.10	61	2.51	101	2.40	141	2.4
22	2.40	62	2.49	102	3.13	142	2.47
23	3.11	63	2.49	103	3.07	143	2.49
24	2.49	64	2.52	104	2.49	144	2.48
25	2.47	65	2.48	105	2.49	145	2.49
26	2.52	66	2.49	106	2.40	146	2.4
27	2.49	67	2.50	107	2.57	147	2.4
28	2.80	68	3.00	108	3.10	148	2.3
29	3.05	69	3.00	109	2.40	149	3.1
30	2.49	70	3.07	110	2.30	150	3.1
31	3.10	71	3.05	111	2.40	151	3.1
32	2.40	72	2.50	112	2.30		
33	2.30	73	2.51	113	2.40		
34	2.49	74	2.50	114	2.50		
35	3.10	75	2.40	115	2.90		
36	2.48	76	2.52	116	2.52		
37	2.50	77	2.50	117	3.08		
38	2.30	78	2.49	118	2.40		
39	3.16	79	2.52	119	2.40		
40	2.40	80	2.49	120	2.40		

The groups also created the following plots from these data:

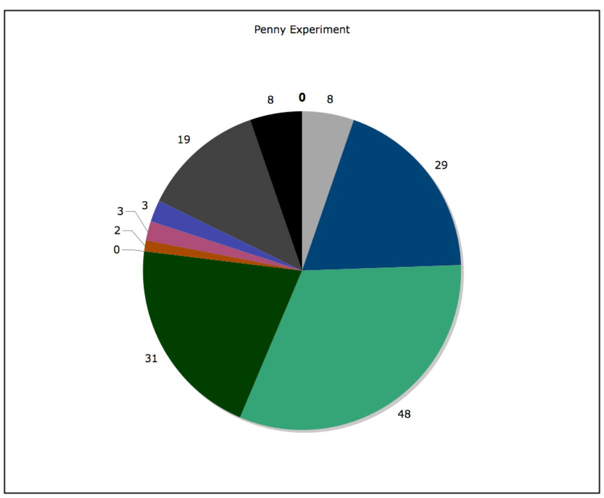
Plot A



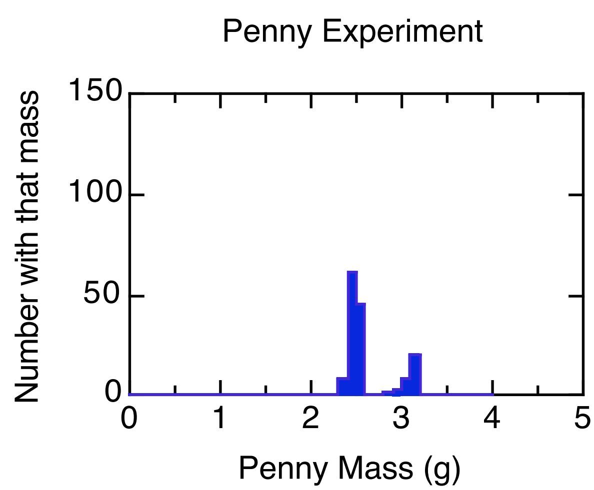
Plot B



Plot C



Plot D



5. Which of these representations of the penny mass data best reveal the distribution of penny masses? *(LO2)*

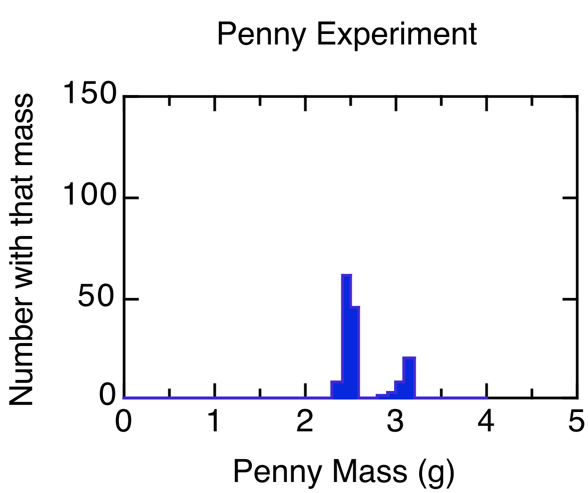
   A) the table
   B) Plot A
   C) Plot B
   D) Plot C
   E) Plot D

6. A student stated that there were two different penny masses in the 151 sampled pennies. Which plot provides support for this statement? *(LO3)*

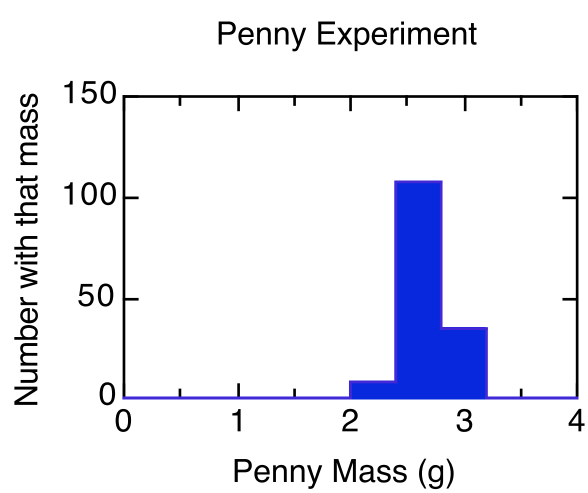
   A) the table
   B) Plot A
   C) Plot B
   D) Plot C
   E) Plot D

A student decided to re-draw Plot D with different bin sizes. Here is the original plot and her new one:

Old



New



7. The histogram above represents the same data with a larger bin size. What conclusion is best drawn from this histogram? *(LO2)*

   A) The two distribution patterns that seemed evident in the old plot were not real.
   B) The new plot misrepresents the data, since it obscures the patterns.
   C) The new plot represents another useful way of looking at the data.
   D) No conclusion can be drawn from this new plot alone.

8. A student looking at the data in the old plot formed a hypothesis: these pennies came from two different mints. How could she organize the available data to test that hypothesis? *(LO2)*

   A) Change the bin size in the histogram to spread out the distribution patterns that seem to be evident in the .1 bin size histogram.
   B) Re-sort the data by mint identification letter
   C) The existence of two distinct groupings in this histogram already provides evidence for that hypothesis.
   D) There is no way to use the available data to support that hypothesis.

9. Which is the most accurate and descriptive statement about the mass of these pennies? *(LO3)*

   A) All of the pennies have a mass less than four grams
   B) All of the pennies have a mass of more than four grams
   C) All of the pennies have a mass between two and three grams
   D) All of the pennies have a mass between 2.5 and 3.5 grams

10. During the data collection process, students noticed that some pennies were more tarnished than others. Which statement would you be most comfortable saying about this observation? *(LO3)*

   A) These more tarnished pennies have a larger mass.
   B) These more tarnished pennies have a smaller mass.
   C) These more tarnished pennies are newer.
   D) These more tarnished pennies are older.
   E) None of the above.

11. A student suggested that the pennies with smaller mass are older. She went on to say that "wear and tear" on the pennies rubs off atoms of copper, making the mass smaller. How would you reply to her? *(LO3)*

   A) This makes sense, I agree.
   B) There is no information about the year in these plots, let's draw some new ones.
   C) This is incorrect, I know that the older pennies have a large mass.
   D) Copper is a hard material, there is no wear and tear on a penny.

12. A student claimed that there are more pennies with smaller mass. How would you respond? *(LO3)*

A) I agree.
B) I disagree.
C) There are as many heavy pennies as light ones.
D) I don't know, there is no way to tell.

13. A student suggested that pennies with a larger mass have more copper in them. How would you respond based on the data here? *(LO3)*

A) I agree
B) I disagree
C) There is no way to tell from these data

‘Think Aloud’ Protocol: Student

Version 1.0 (January 2009)

1) Ask questions about courses they are or have taken, etc. as shown in the attached example questionnaire for the Cosmic e-lab.

2) Provide activities or information that assesses appropriate prior knowledge (according to prior knowledge needed/required).

3) Take them through the purpose of the e-lab and purpose of the protocol. Start the e-lab from the beginning and at each juncture ask them what sense they are making of what they are seeing/reading. It is assumed that the teacher will start students on the e-lab after assessing prior knowledge. So, like a teacher, provide necessary information and directions as in “guided inquiry.”

4) Ask them to pick a study they would like to pursue. After they pick one, encourage them to ask a question that is meaningful to them. Be sure to ask why they chose the study and why they want to know the answer to that question. AT THIS POINT, ASK THEM TO ‘THINK ALOUD’ WHAT THEY ARE DOING AND WHY THEY ARE DOING IT. You might want to tape record or videotape this part of the process. Try to intervene as little as possible.

5) Have them chose their own data and proceed with answering their own question. Note stumbling points, false starts, and dead ends. This is where the software will have to be revised.

6) Conduct a debrief interview to ask them questions that came up during the protocol and/or about overall impressions.

Cosmic Ray e-lab warm-up questions

1. What physics classes have you had (title, school, teacher)?
2. What concepts in particle or nuclear physics have you been exposed to in school?
3. What are cosmic rays?
4. What is a cosmic ray shower?
5. What information can be measured about cosmic rays; what data can be collected?
6. What do you know about protons, neutrinos, pions, gamma rays….?
7. Imagine you are a physicist investigating cosmic rays. Think about what steps you’d have to go through to investigate a research question. Write down how you’d get started; what are the steps you’d go through to learn something new about cosmic rays through a scientific research investigation.

‘Think Aloud’ Protocol: Teacher

Version 1.0 (January, 2009)

1) Ask questions about their background and courses in which they are going to use or could use the e-lab (if they don’t know, ask them after going through the program—see debrief). Background: pertinent college courses, experience with computers/computer programs, years teaching, how often they use computers in the course(s) they teach and if they include group investigations/projects in the course(s) they teach.

2) Take them through the purpose of the e-lab and purpose of the protocol in order to present the ‘big picture’ including that the pedagogical approach is expected to be “guided inquiry.”

3) Start the e-lab from the beginning. AT THIS POINT, ASK THEM TO ‘THINK ALOUD’ WHAT THEY ARE DOING AND THEIR IMPRESSIONS OF THE PROGRAM. At several intervals ask them how they might present this to their students; also their impression of usability of the program and how engaging it would be for students. Chose logical places such as after the introduction, and not too often. Try to intervene as little as possible. Note what they like and don’t like and perspectives on using it with their students. Also note stumbling points, false starts, and dead ends. This is where the software will have to be revised. You might want to tape record or videotape them as they go through the process.

4) If you have time, ask them to pick a study they would like to try out as in the student protocol, steps 4 and 5.

5) Conduct a debrief interview to ask them questions that came up during the protocol and/or about overall impressions.

I2U2 POST-WORKSHOP FORM
Version 1.0 (January 2009)

Please return the requested items and completed form immediately after your workshop.

Part I. I2U2 Professional Development Provider information

Name ________________________________ Date _______________

Number of participants at the session:

What is the duration of the professional development provided?

What is the purpose of the session (information/skill focused on at the session)?

How were participants recruited?

Who is the intended audience of the session?

What do you want participants to know and/or be able to do as a result of this professional development (i.e., objectives of the session, topics addressed).

Part II. Travel and Stipend Information: Items in red with asterisk are required.

We need receipts for ANYTHING charged to Fermilab
Hotel • Car • Airfare

Home Address

____

*** SOCIAL SECURITY NUMBER (For stipends only)**

____

*Traveler's Name:	*Travel Dates:	*Traveler's Signature:

Enclosed (Please √)	
	Boarding Passes (original)
	Limousine Receipt(s) (original)
	Rental Car Receipt(s) (original and itemized)
	Rental Car Gas Receipt(s) (original)
	Hotel Receipt(s) (original and itemized)
	Taxis/Bus/Train Receipt(s) (original or amount and reason there is no receipt)
	Parking/Toll Receipt(s) (original or amount and reason there is no receipt)
	Registration Fee Receipt(s) (original)
	Miscellaneous Receipt(s) EXPLAIN:

*Which did you use: a limousine, rental car, shuttle or taxi?

**If you shared a limousine with other I2U2 people, who were they and on what dates?

*Who received the receipt?

If you drove your personal vehicle:
Starting Point & Date:
Ending Point & Date:
Starting Point & Date:
Ending Point & Date:
Additional information should be included on the back of this page.

We cannot process your reimbursement unless we have all the original receipts and participant surveys

Put all the surveys and receipts along with this sheet in a large envelope and mail to:

Fermilab

P.O. Box 500, MS 226

Batavia, IL 60510-0500

Attn: Gayle Millman

Thank you!

I2U2 Participant Sheet

Version 1.0 (January 2009)

(Used for Cosmic Ray e-Lab workshops)

Dear Participant:

The I2U2 Program Staff and Fellows would greatly appreciate your responses to the following questionnaire. Your feedback will allow us to assess the content and quality of professional development opportunities so we will know how to best serve teachers and other educators in the future. Note that we are not asking for your name so that we can keep your feedback completely anonymous.

Date ________________ Facilitator______________________________________

1. What subject(s) do you teach and at what grade level(s)?

2. Would you consider your students high achievers, average achievers, low achievers or a mix?

3. Give your opinion about the professional development (PD) provided with regard to each of the following: (*Circle **one** on each line.*)

		Strongly Agree	Agree	Disagree	Strongly Disagree	Not Applicable
a.	The session was well-organized	1	2	3	4	N/A
b.	Objectives of the session were met	1	2	3	4	N/A
c.	The instructor was effective in facilitating the session	1	2	3	4	N/A
d.	The provider made good use of the time available for the session.	1	2	3	4	N/A
e.	The PD provided ideas for ways to use what I learned in the classroom	1	2	3	4	N/A
f.	The PD provided opportunities to ask questions and/or discuss ideas	1	2	3	4	N/A
g.	The PD helped me feel more comfortable with the topic(s)	1	2	3	4	N/A
h.	I increased my understanding of the material presented	1	2	3	4	N/A
i.	Questions were answered/addressed at my level of understanding	1	2	3	4	N/A
i.	I learned skills that I can teach to my students	1	2	3	4	N/A
j.	I want to learn more about the topic(s) presented	1	2	3	4	N/A

Comments (please include a comment if you rated any item ‘3’ or ‘4’):

Use the back of this sheet to answer the following:

4. What were the 2-4 most important things you learned from this session?

5. List any specific strengths and weaknesses you would like the facilitator to know about.