



Evaluation of student performance in authentic research experiences

William R. Robinson, Cianán Russell
& Gabriela C. Weaver
Department of Chemistry
Purdue University



CASPiE:

Introduce an authentic research experience into freshman and sophomore course laboratories

This requires ***authentic assessment*** and, because we are offering the research experience as a course, ***evaluation***.

(Here we talk about assessing the student product, not the program.)



Appropriate assessment & evaluation

Assessment: How are we doing?

Formative assessment: What are we doing and how can we improve it?

Summative assessment: What have we done?

"When the cook tastes the soup, that's formative assessment; when the customer tastes the soup, that's summative assessment"

Black (cited by Brookhart, 1999)

Evaluation: What is it worth?



Appropriate assessment & evaluation

The *National Science Education Standards* (1996) identify two factors characteristic of appropriate assessments:

The assessments are authentic, i.e. they approximate the learning situation.

The assessments use a variety of measurements to document outcomes.

After the assessment an instructor then evaluates, i.e., assigns a value to the outcomes.



Appropriate assessment & evaluation

Authentic research experiences cannot be assessed with fill-in-the-blank and short-answer answer sheets. If a research experience is authentic we do not know the ultimate outcome or the experimental route to that outcome. Thus, we cannot design such answer sheets and we cannot grade a numerical answer as right or wrong.

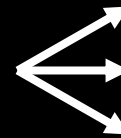
We do, however, understand appropriate experimental design and protocols and we can assess these.

Research timeline

Periodic discussions & Group meetings
(Review progress) (Present progress)

**Formative assessment of
process, results, & analysis**

**Occasionally,
summative assessment &
evaluation**



Publication

Presentation

Final oral

**Summative assessment:
author**

**Evaluation:
reviewers
readers
faculty**



Graduate student products

Discussion with group or research director

Laboratory notebook

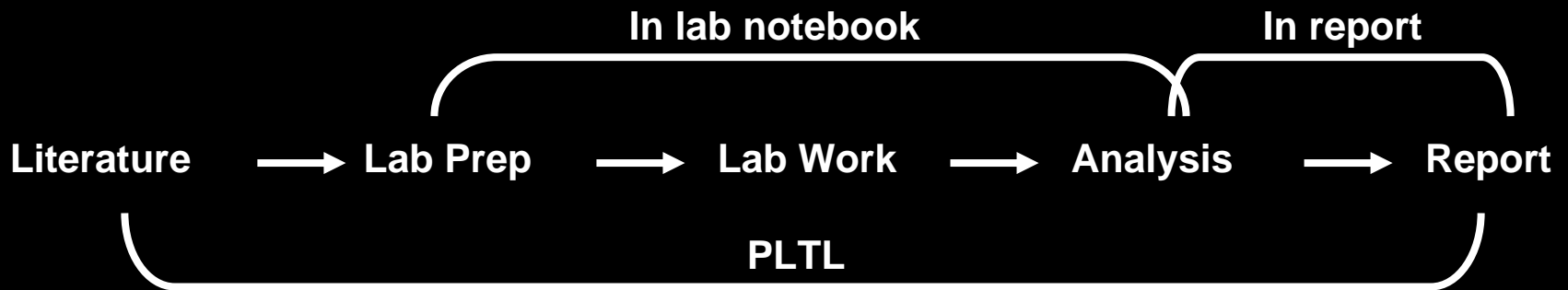
Research report

Manuscript

Oral presentation

Poster presentation

CASPiE timeline



Formative assessment:

Group work, PLTL, instructor feedback

Summative assessment:

**Instructor evaluation of
lab notebook, report, presentations**

Evaluation:

**Use lab notebook, report, and/or
presentation rubrics**



What is a rubric?

Rubric:

A set of

criteria for objectives

degrees of quality

instructor's value of each degree of quality



What is a rubric?

Rubric for one objective in a report:

Objective: Correct spelling and grammar

<u>Degrees of quality</u>	<u>Value</u>
All grammar & spelling correct	4 pts
Only 1 or 2 errors	3 pts
3 errors	2 pts
4 errors	1 pt
More than 4 errors	0 pts



Writing rubrics

- 1. Identify the objectives.**
- 2. List the items to be evaluated.**
- 3. Describe and evaluate degrees of quality (often in a grid), starting with the best and worst quality and then filling in the middle.**
- 4. Share with students before they complete the assignment so they understand the criteria for evaluation.**
- 5. Use to evaluate student work to determine if they have met the objectives.**



Grading the lab notebook

Three principal sections

- **Preparation for Lab**
 - introduction
 - outline of experiment
 - prelab calculations
- **Data and Results**
 - flow of experiment
 - quantitative & observational data
 - lab product
- **Post-lab Summary / Discussion**
 - data analysis
 - summary

Rubric for grading a lab notebook

Objectives and items to be evaluated

Score	A: Preparation for lab 10 points max			B: Results of Lab Work 8 points max			C: Post Lab Reflection 8 points max		
	Introduction	Outline of Experiment	Calculations	Logical Flow of Experiment*	Quantitative data	Observational data	Lab Product	Data Analysis	Summary
4		complete list of activities with detailed descriptions	complete and correct if necessary					fully analyzes data and analysis correct. Answers leading questions	summarizes findings and draws conclusions and/or notes changes in procedures, if appropriate*
3		complete list of activities but missing some detail or full detail but missing some activities	75% complete and correct					75% of a complete and correct analysis and answers to questions	75% of complete summary and conclusions
2	original and clear language, fully integrated, organized	list of activities with no detail	50% complete and correct	this week's activities follow logically from last week's reflection	organized and complete with clearly labeled data	organized and complete with clearly labeled data	laboratory product is adequate	50% of a complete and correct analysis and answers to questions	50% of complete summary and conclusions
1	adequately integrated purpose, techniques, equations, and/or context	partial list of activities	25% complete and correct	this week's activities follow the laboratory manual without considering the results of last week's reflection	organized but data labels unclear or source of data clear but disorganized. 25% of data missing	organized but data labels unclear or source of data clear but disorganized. 25% of data missing	laboratory product is marginal	25% of a complete and correct analysis and answers to questions	25% of complete summary and conclusions
0	misunderstands purpose or copies material from literature	incorrect list or absent	inadequate or absent	This week's activities are inconsistent with reflection or the lab manual	neither clear data labels nor organized. 50% or more of data missing	neither clear data labels nor organized. 50% or more of data missing	this week's laboratory product is unsatisfactory	No data analysis or answers to questions	does not summarize or omits conclusions or draws wrong conclusions

*Check the Reflection from the previous week or the Introduction to the current week for this information.

Degrees of quality

Value



Rubric for grading a lab notebook

A: Preparation for lab 10 points max			
Score	Introduction	Outline of Experiment	Calculations
4		complete list of activities with detailed descriptions	complete and correct if necessary
3		complete list of activities but missing some detail or full detail but missing some activities	75% complete and correct
2	original and clear language, fully integrated, organized	list of activities with no detail	50% complete and correct
1	adequately integrated purpose, techniques, equations, and/or context	partial list of activities	25% complete and correct
0	misunderstands purpose or copies material from literature	incorrect list or absent	inadequate or absent

Rubric for grading a lab notebook

B: Results of Lab Work 8 points max			
Logical Flow of Experiment*	Quantitative data	Observational data	Lab Product
this week's activities follow logically from last week's reflection	organized and complete with clearly labeled data	organized and complete with clearly labeled data	laboratory product is adequate
this week's activities follow the laboratory manual without considering the results of last week's reflection	organized but data labels unclear or source of data clear but disorganized. 25% of sata missing	organized but data labels unclear or source of data clear but disorganized. 25% of sata missing	laboratory product is marginal
This week's activities are inconsistent with reflection or the lab manual	neither clear data labels nor organized. 50% or more of data missing	neither clear data labels nor organized. 50% or more of data missing	this week's laboratory product is unsatisfactory



Rubric for grading a lab notebook

C: Post Lab Reflection 8 points max	
Data Analysis	Summary
fully analyzes data and analysis correct. Answers leading questions	summarizes findings and draws conclusions and/or notes changes in procedures, if appropriate*
75% of a complete and correct analysis and answers to questions	75% of complete summary and conclusions
50% of a complete and correct analysis and answers to questions	50% of complete summary and conclusions
25% of a complete and correct analysis and answers to questions	25% of complete summary and conclusions
No data analysis or answers to questions	does not summarize or omits conclusions or draws wrong conclusions



Rubrics evolve as expectations change

For the module *Phytochemical Antioxidants with Potential Health Benefits in Foods* the first three weeks are used for training.

Week 1: prepare reagents to be used in the next lab to estimate total antioxidant activity, to prepare and store reagents for ascorbic acid analysis, and to conduct a spectrophotometric measurement of the radical cation ABTS*, the key for conducting the TEAC assay.

Week 2: become familiar with the chemistry and procedures for measuring total antioxidant activity using the Trolox Equivalent Antioxidant Capacity (TEAC) method.

WEEK 3: become familiar with the chemistry and procedures for measuring ascorbate concentration and to become familiar with the use of high pressure liquid chromatography with complex mixtures.



Rubrics evolve as expectations change

We have found that students may not take these training activities seriously because there is no weight on results in the rubric.

The rubric will be modified to include a precision component during the first three weeks.



The research report

The final report will be written in the style of a publication in a primary research journal. In general research journal articles consist of the following sections:

Title

Abstract

Introduction

Experimental Details or Theoretical Analysis

Results


Discussion

Conclusions and Summary

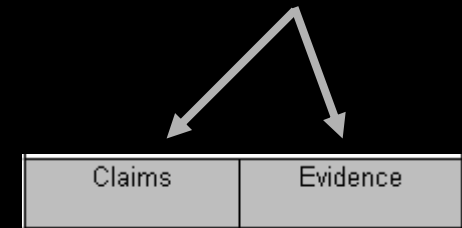
References

The content of each of these sections is described in the document from the American Chemical Society (ACS) web site.

Grading rubric for a research report



Score	Title Page	Abstract	Introduction	Experimental	Results	Discussion	Conclusions



Grading rubric for a research report

Score	Title Page	Abstract	Introduction	Experimental	Results	Discussion	Conclusions	
							Claims	Evidence
4		discusses all 4 items described below	discusses all 4 items described below	description of procedures, techniques, instrumentation, special precautions, etc. as appropriate	summary of relevant data, observations, findings	complete and correct set of observations and/or results of measurements	main conclusions of the project that are consistent with the data analysis	full justification of the conclusions
3		identifies 3 items	discusses 3 items	omits one of the above	summary of 2 of the 3: relevant data, observations, findings	75% of observations and/or results of measurements		
2		identifies 2 items	discusses 2 items	omits two of the above	summary of 1 of the 3: relevant data, observations, findings	50% of observations and/or results of measurements	Some conclusions missing or some do not follow from the data analysis	partial justification of the conclusions
1	complete	identifies 1 item	discusses 1 item	omits three of the above	data tabulation, if appropriate	25% of observations and/or results of measurements		
0	incomplete	no abstract or inappropriate information	copies introductory material from book	inadequate or absent	inadequate or absent	inadequate or absent	no conclusions or all conclusions do not follow from the data analysis	no justifications

Title page: title, author name(s), author's affiliation, date, origin of the report

Abstract: topic, scope, principal findings, conclusions.

Introduction: nature of problem and interest, background information and prior work, objectives, clear relationship of current project and earlier work

Experimental: description of procedures, techniques, instrumentation, special precautions, etc.

Results: summary of relevant data, observations, and findings using tabulation of data, equations, charts, figures, reaction schemes, if appropriate.

Discussion: analysis and interpretation--What do results mean? Relationship to project objectives. Resolve the problem?

Conclusions: main conclusions of the project

Grading rubric for a research report

The following section can be used to include a weighting for clarity of writing if the evaluator does not take that into account in grading prior sections

Clarity of Presentation:	unable to find specific details	details are somewhat sketchy	some details are non-supporting to the subject	supporting details specific to subject	
Multiply section score by:	0.25	0.5	0.75	1.00	
Spelling and Grammar:	More than 4 grammar and/or spelling errors	4 errors	3 errors	Only one or two errors	All grammar and spelling are correct
Score	0	1	2	3	4
Organization of Report:	Not organized, events make no sense	only contains sections consistent with instructions	within sections, some organization, events jump around, start and end are unclear	within sections, organized, events are somewhat jumpy	within sections, good organization, events are logically ordered, sharp sense of beginning and end
Score:	0	1	2	3	4

Format Points:

References use correct format: 1 point

Report is typed: 1 point

Tables and Figures numbered appropriately: 1 point

Score sheet for a research report

Item	Score	Scaling factor for Clarity	Points
Title Page		X	
Abstract			
Introduction			
Experimental			
Results			
Discussion			
Claims			
Evidence			
Spelling/grammar		X	
Organization		X	
Format		X	

Total:



Rubric for presentations

Oral Presentation Rubric

Possible Points

Provided depth in coverage of topic.

10

Presentation was well planned and coherent.

10

Presenters were models of thoughtfulness. Personal experience integrated where relevant and appropriate. **Explanations and reasons given for conclusions.**

10

Communication aids were clear and useful. Handout was useful for others interested in topic.

10

Bibliographic information for others was complete.

10

Rubric for presentations

Content

Score	Introduction	Methods	Results	Conclusions
4	States the reason(s) for the research in a clear, concise, complete, & logical way.	Clearly and concisely conveys the basis of the experiment in a clear, concise, complete, & logical way.	Clearly and concisely conveys the results of the experiment in a clear, concise, complete, & logical way.	Clearly and concisely conveys the conclusions of the experiment in a clear, concise, complete, & logical way.
3	Missing one of clear, concise, complete, & logical way.	Missing one of clear, concise, complete, & logical way.	Missing one of clear, concise, complete, & logical way.	Missing one of clear, concise, complete, & logical way.
2	Missing two of clear, concise, complete, & logical way.	Missing two of clear, concise, complete, & logical way.	Missing two of clear, concise, complete, & logical way.	Missing two of clear, concise, complete, & logical way.
1	Missing three of clear, concise, complete, & logical way.	Missing three of clear, concise, complete, & logical way.	Missing three of clear, concise, complete, & logical way.	Missing three of clear, concise, complete, & logical way.
0	Rambling and unclear introduction OR no introduction	Rambling and unclear methodology OR no methodology presented	Rambling, unclear, incorrect, OR no results	Rambling, unclear, incorrect, or OR conclusions

Format

Score	Graphics - Clarity	Layout	Labels	Title - Authors
2	All graphics are related to the topic and make it easier to understand. Graphics are all in focus and the content easily viewed.	The poster is attractive in terms of design, layout and neatness. Readability is good.	All items of importance on the poster are clearly labeled with labels that can be read from 3 ft. away	Title can be read from 6 ft. away and describes content well. Author information included
1	Most graphics are in focus and the content is easily viewed and identified from 3 ft. away.	The poster is acceptably attractive though it may be a bit messy.	Most items of importance are clearly labeled. Labels can be read from 3 ft. away.	Author information included. Title is small but describes the content well OR title is readable from 6 feet but is a poor descriptor
0	Many graphics are not clear OR are too small.	The poster is distractingly messy OR very poorly designed. It is not attractive.	Labels are too small to view OR no important items were labeled	No author information.



Summary

- 1. Identify the objectives.**
- 2. List the criteria to be evaluated.**
- 3. Describe and evaluate degrees of quality.**
- 4. Share with students before the assignment.**
- 5. Evaluate student work to determine if they have met the objectives.**

