STREAMLINING PROGRAM LEARNING OBJECTIVE ASSESSMENT WITH TARGETED ACTIVITIES AND DESCRIPTIVE RUBRICS

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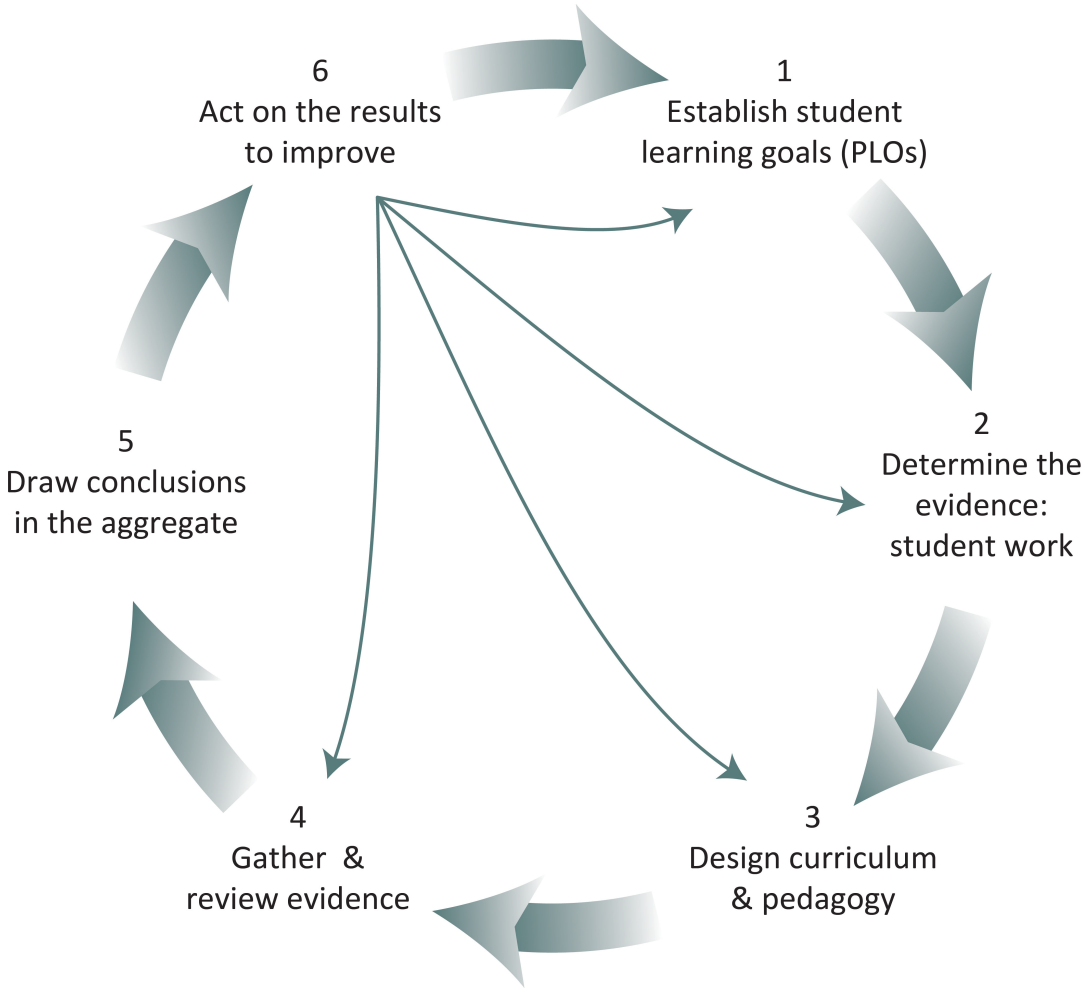
Abstract

- The undergraduate physics program has five program learning objectives (PLOs): (1) physical principles, (2) mathematical expertise, (3) experimental technique, (4) communication and teamwork, and (5) research proficiency. With one PLO assessed each year, we have just completed our first cycle. Our approach strives to maximize the ease and applicability of our assessment practices while maintaining faculty's flexibility in course design and delivery. Objectives are mapped onto the core curriculum and identified coursework is collected as direct evidence. We have found that descriptive rubrics lend themselves to more efficient assessment, higher inter-rater reliability, and can be applied to course *and* program-level assessment. The presentation will outline our progress, success with a descriptive presentation rubric, and our ongoing work with rubrics applied to more abstract PLOs that utilize students' written work.

Outline

- Assessment Cycle
- Physics PLOs
- Curriculum Matrix & Signature Assignments
- Rubrics
  - Developing: Types & Sources
  - Refining: Inter-rater reliability
  - Applying: Course *and* Program Assessment
- Successes
- Challenges

Assessment Cycle



Hybrid of Suskie, CIRTL Network, Wiggins & McTighe

Laura Martin, Introduction to Assessment Presentation, CGS Workshop, January 2013

Physics PLOs

1. **Physical Principles**. Students will be able to apply basic physical principles—including classical mechanics, electricity and magnetism, quantum mechanics, and statistical mechanics—to explain, analyze, and predict a variety of natural phenomena.

2. **Mathematical Expertise**. Students will be able to translate physical concepts into mathematical language. Furthermore students will be able to apply advanced mathematical techniques (e.g., calculus, linear algebra, probability, and statistics) in their explanations, analyses, and predictions of physical phenomena.

3. **Experimental Techniques**. Students will be able to take physical measurements in an experimental laboratory setting and analyze these results to draw conclusions about the physical system under investigation, including whether their data supports or refutes a given physical model.

4. **Communication and Teamwork Skills**. Students will be able to clearly explain their mathematical and physical reasoning, both orally and in writing, and will be able to communicate and work effectively in groups on a common project.

5. **Research Proficiency**. Students will be able to formulate personal research questions that expand their knowledge of physics. Students will be able to apply sound scientific research methods to address these questions, either by researching the current literature or developing independent results.

Curriculum Matrix: Courses & PLOs

Physics Core Courses							
Year	Course Title	Program Learning Objectives					Signature Assignment or Indirect Evidence Support
		1	2	3	4	5	
		Physical Principles	Mathematical Expertise	Experimental Techniques	Communication & Teamwork	Research Proficiency	
1	Introductory I						
1	Introductory II						
2	Introductory III						
2	Classical Mechanics						
2 – 3	Thermodynamics						
3 – 4	Electrodynamics						
3 – 4	Modern Physics Lab						
3 – 4	Quantum Mechanics						
4	Senior Research						
4	Senior Thesis						

I = Introduce, R = Reinforce, M = Master

Curriculum Matrix: Development

Physics Core Courses							
Year	Course Title	Program Learning Objectives					Signature Assignment or Indirect Evidence Support
		1	2	3	4	5	
		Physical Principles	Mathematical Expertise	Experimental Techniques	Communication & Teamwork	Research Proficiency	
1	Introductory I	I	I	I	W, T: I	I	
1	Introductory II	I	I	I	W, T: I	I	
2	Introductory III	I	I	R	W, T: R	R	
2	Classical Mechanics	R	R		W: R O: I	R	
2 – 3	Thermodynamics	R	R				
3 – 4	Electrodynamics	R	R				
3 – 4	Modern Physics Lab	R		R/M	W, O, T: R	R	
3 – 4	Quantum Mechanics	R	R/M		O, T: R,	R	
4	Senior Research	M	M	(M)	(T: M)	(M)	
4	Senior Thesis	M	M	M	W, O: M	M	

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Curriculum Matrix: Assessments

Physics Core Courses							
Year	Course Title	Program Learning Objectives					Signature Assignment or Indirect Evidence Support
		1	2	3	4	5	
		Physical Principles	Mathematical Expertise	Experimental Techniques	Communication & Teamwork	Research Proficiency	
1	Introductory I	I	I	I	W, T: I	I	
1	Introductory II	I	I	I	W, T: I	I	
2	Introductory III	I	I	R	W, T: R	R	
2	Classical Mechanics	R	R, A		W: R, A O: I	R, A	
2 – 3	Thermodynamics	R, A	R				
3 – 4	Electrodynamics	R	R, A				
3 – 4	Modern Physics Lab	R		R/M, A	W, O, T: R	R	
3 – 4	Quantum Mechanics	R, A	R/M		O, T: R, A	R	
4	Senior Research	M	M	(M, A)	(T: M)	(M, A)	
4	Senior Thesis	M, A	M, A	M, A	W, O: M, A	M, A	

I = Introduce, R = Reinforce, M = Master, A = Assessment

Curriculum Matrix: Signature Assignments

Physics Core Courses							
Year	Course Title	Program Learning Objectives					Signature Assignment
		1	2	3	4	5	
		Physical Principles	Mathematical Expertise	Experimental Techniques	Communication & Teamwork	Research Proficiency	
1	Introductory I	I	I	I	W, T: I	I	
1	Introductory II	I	I	I	W, T: I	I	
2	Introductory III	I	I	R	W, T: R	R	
2	Classical Mechanics	R	R, A		W: R, A O: I	R, A	PLO 2: Final exam: quantitative PLO 4, 5: Literature review
2 – 3	Thermodynamics	R, A	R				PLO 1: Final exam: conceptual
3 – 4	Electrodynamics	R	R, A				PLO2: Final exam: quantitative
3 – 4	Modern Physics Lab	R		R/M, A	W, O, T: R	R	PLO 3: Technical report
3 – 4	Quantum Mechanics	R, A	R/M		O, T: R, A	R	PLO 1: Final exam: conceptual PLO 4: Group video
4	Senior Research	M	M	(M, A)	(T: M)	(M, A)	PLO 3, 5: Advisor feedback
4	Senior Thesis	M, A	M, A	M, A	W, O: M, A	M, A	Senior Thesis & Presentation

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Curriculum Matrix: Indirect Evidence

Physics Core Courses							
Year	Course Title	Program Learning Objectives					Signature Assignment or Indirect Evidence Support
		1	2	3	4	5	
		Physical Principles	Mathematical Expertise	Experimental Techniques	Communication & Teamwork	Research Proficiency	
1	Introductory I	I	I	I	W, T: I	I	
1	Introductory II	I	I	I	W, T: I	I	
2	Introductory III	I	I	R	W, T: R	R	
2	Classical Mechanics	R	R, A		W: R, A O: I	R, A	PLO 2: Final exam: quantitative PLO 4, 5: Literature review
2 – 3	Thermodynamics	R, A	R				PLO 1: Final exam: conceptual
3 – 4	Electrodynamics	R	R, A				PLO2: Final exam: quantitative
3 – 4	Modern Physics Lab	R		R/M, A	W, O, T: R	R	PLO 3: Technical report
3 – 4	Quantum Mechanics	R, A	R/M		O, T: R, A	R	PLO 1: Final exam: conceptual PLO 4: Group video
4	Senior Research	M	M	(M, A)	(T: M)	(M, A)	PLO 3, 5: Advisor feedback
4	Senior Thesis	M, A	M, A	M, A	W, O: M, A	M, A	Senior Thesis & Presentation
All	Indirect Evidence	A	A	A	A	A	Campus: CRTE-led Focus Group
All	Indirect Evidence	A	A	A	A	A	Campus: IPA Senior Exit Survey

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Experimental Skills Development

Original

Year	Course Title	PLO 3 Expt. Techniques
1	Introductory I	I
1	Introductory II	I
2	Introductory III	I
2	Classical Mechanics	
2 – 3	Thermodynamics	
3 – 4	Electrodynamics	
3 – 4	Modern Physics Lab	R/M
3 – 4	Quantum Mechanics	
4	Senior Research	(M)
4	Senior Thesis	

Revised

Year	Course Title	PLO 3 Expt. Techniques
1	Introductory I	I
1	Introductory II	I
2	Introductory III	R
2	Classical Mechanics	
2 – 3	Thermodynamics	
3 – 4	Electrodynamics	
3 – 4	Modern Physics Lab	R/M
3 – 4	Quantum Mechanics	
4	Senior Research	(M)
4	Senior Thesis	M

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Teamwork Development

Original		
Year	Course Title	PLO
		4
		Teamwork
1	Introductory I	I
1	Introductory II	I
2	Introductory III	I
2	Classical Mechanics	
2 – 3	Thermodynamics	
3 – 4	Electrodynamics	
3 – 4	Modern Physics Lab	I
3 – 4	Quantum Mechanics	
4	Senior Research	(M)
4	Senior Thesis	

Revised		
Year	Course Title	PLO
		4
		Teamwork
1	Introductory I	I
1	Introductory II	I
2	Introductory III	I
2	Classical Mechanics	
2 – 3	Thermodynamics	
3 – 4	Electrodynamics	
3 – 4	Modern Physics Lab	I
3 – 4	Quantum Mechanics	R
4	Senior Research	(M)
4	Senior Thesis	

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Descriptive Rubrics

Updated: 04/30/2013

Physics Presentation Rubric

Presenter Name:	
Year & Term:	Title of Talk

Criteria	Capstone 4	Milestone 3	Benchmark 2	Poor 1
Organization and Planning	A well-defined structure is included with conventional elements (statement of problem, background, methods, results and conclusion). Student moves easily between slides, and maintains a consistently smooth pace throughout presentation.	Generally well-structured talk with most elements present. Student moves generally well between slides, maintains a smooth pace through most of the presentation.	Some structural elements present, speaker sometimes appears unfamiliar with slide content and sequence. The uneven pace periodically detracts from the presentation.	Lack of a clear structure in the talk. Slides seem disorganized and/or speaker is unfamiliar with their content. The uneven pace detracts from the presentation and message (i.e. overly long intro and rushes through conclusions).
Presentation Style	Speaker is clear and confident. Gives a professional impression.	Clear speech, and quickly overcomes occasional lapses in confidence or hesitation.	Somewhat nervous or hesitant style, but gets the message across. Some flaws i.e. avoids eye contact, looking a floor/screen or mumbling.	Very nervous, hesitant or disjointed style, which interferes with ability to communicate information to audience.
Use of Language	Uses descriptive, scientific language that is not overtly "jargony." Concepts are clear and professionally explained.	Uses mostly descriptive, scientific language, and explanations are mostly professionally and clearly explained.	Basic language choices, approaching professional explanations, but message is still clear. Minimal fillers ("um").	Lacks expected scientific vocabulary. May use many fillers ("um"), simplistic/ juvenile language, leading to unclear statements.
Visual Aids	Aids are clear, well organized and enhance the presentation significantly.	Aids enhance the presentation but with some flaws (i.e. font sizes, confusing layouts)	Aids are adequate but not well linked to the project and contain several flaws. Can be distracting.	Aids are disorganized, poorly chosen, detract from the presentation and message.
Central Message	Purpose of research is clearly stated and methods justified clearly and concisely	Purpose of research is stated and linked to methods but sometimes poorly	General theme of research is indicated. No justification of methods.	Purpose of research poorly explained or not articulated.

Additional Comments:

Sources for Rubrics

ORAL COMMUNICATION VALUE RUBRIC

for more information, please contact value@aacu.org

Association of American Colleges and Universities

Definition

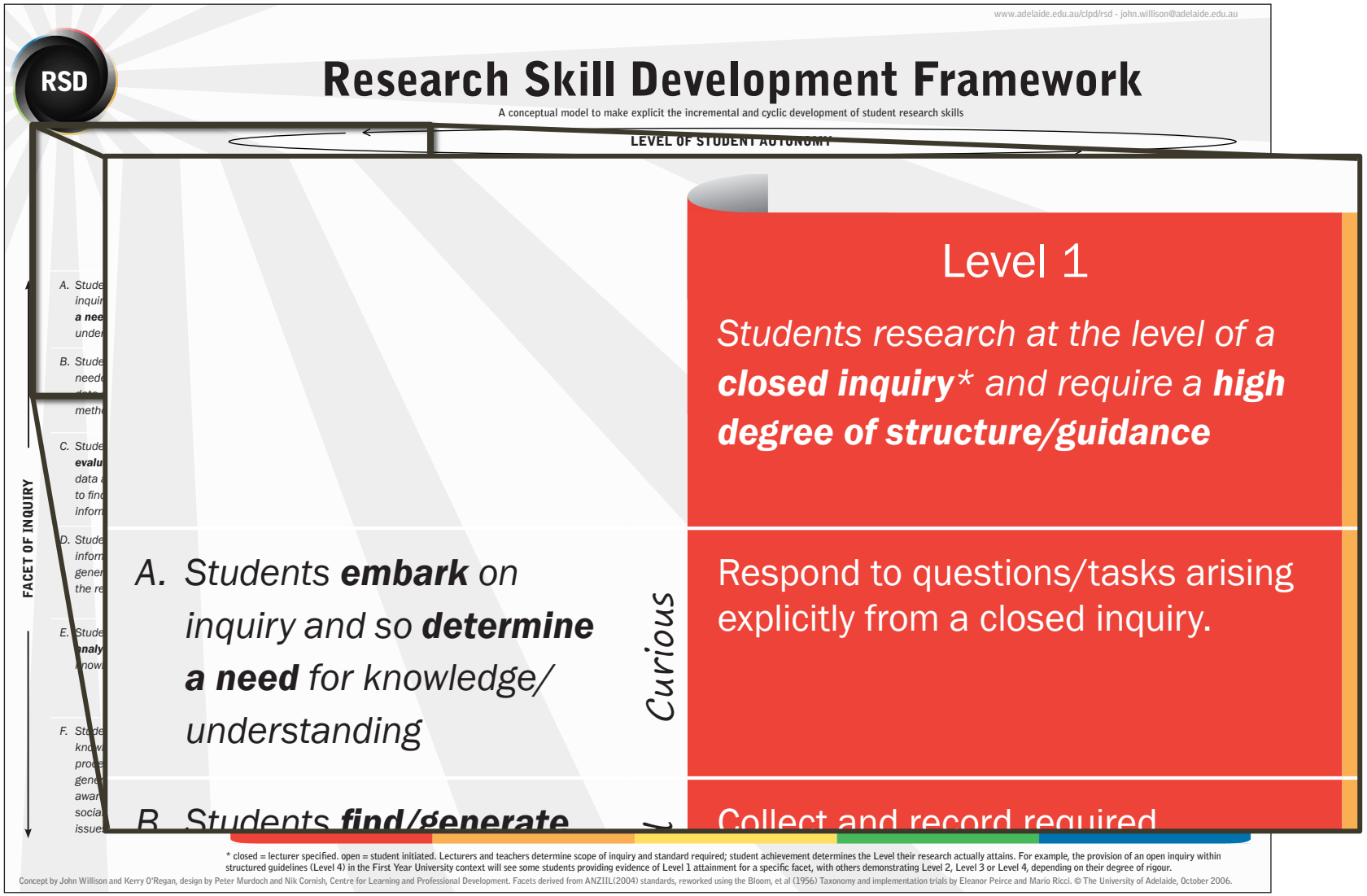
Oral communication is a prepared, purposeful presentation designed to increase knowledge, to foster understanding, or to promote change in the listeners' attitudes, values, beliefs, or behaviors.

Evaluators are encouraged to assign a zero to any work sample or collection of work that does not meet benchmark (cell one) level performance.

	Capstone 4	**Milestones** 3	2	**Benchmark** 1
Organization	Organizational pattern (specific introduction and conclusion, sequenced material within the body, and transitions) is clearly and consistently observable and is skillful and makes the content of the presentation cohesive.	Organizational pattern (specific introduction and conclusion, sequenced material within the body, and transitions) is clearly and consistently observable within the presentation.	Organizational pattern (specific introduction and conclusion, sequenced material within the body, and transitions) is intermittently observable within the presentation.	Organizational pattern (specific introduction and conclusion, sequenced material within the body, and transitions) is not observable within the presentation.
Language	Language choices are imaginative, memorable, and compelling, and enhance the effectiveness of the presentation. Language in presentation is appropriate to audience.	Language choices are thoughtful and generally support the effectiveness of the presentation. Language in presentation is appropriate to audience.	Language choices are mundane and commonplace and partially support the effectiveness of the presentation. Language in presentation is appropriate to audience.	Language choices are unclear and minimally support the effectiveness of the presentation. Language in presentation is not appropriate to audience.
Delivery	Delivery techniques (posture, gesture, eye contact, and vocal expressiveness) make the presentation compelling, and speaker appears polished and confident.	Delivery techniques (posture, gesture, eye contact, and vocal expressiveness) make the presentation interesting, and speaker appears comfortable.	Delivery techniques (posture, gesture, eye contact, and vocal expressiveness) make the presentation understandable, and speaker appears tentative.	Delivery techniques (posture, gesture, eye contact, and vocal expressiveness) detract from the understandability of the presentation, and speaker appears uncomfortable.
Supporting Material	A variety of types of supporting materials (explanations, examples, illustrations, statistics, analogies, quotations from relevant authorities) make appropriate reference to information or analysis that significantly supports the presentation or establishes the presenter's credibility/authority on the topic.	Supporting materials (explanations, examples, illustrations, statistics, analogies, quotations from relevant authorities) make appropriate reference to information or analysis that generally supports the presentation or establishes the presenter's credibility/authority on the topic.	Supporting materials (explanations, examples, illustrations, statistics, analogies, quotations from relevant authorities) make appropriate reference to information or analysis that partially supports the presentation or establishes the presenter's credibility/authority on the topic.	Insufficient supporting materials (explanations, examples, illustrations, statistics, analogies, quotations from relevant authorities) make reference to information or analysis that minimally supports the presentation or establishes the presenter's credibility/authority on the topic.
Central Message	Central message is compelling (precisely stated, appropriately repeated, memorable, and strongly supported.)	Central message is clear and consistent with the supporting material.	Central message is basically understandable but is not often repeated and is not memorable.	Central message can be deduced, but is not explicitly stated in the presentation.

VALUE Rubrics. *Assessing Outcomes & Improving Achievement: Tips & Tools for Using Rubrics*, T. L. Rhodes ed., Association of American Colleges & Universities, 2010.

Rubrics: Research Skills



J. Willison, K. Regan, *The Research Skills Development Framework*, www.adelaide.edu.au/rsd/framework, 2006.

Rubrics: Research Skills

Mentor Questionnaire for PLO#5: Research Proficiency 3

Attributes *The student with research skill…*	**Level I** *Students research at the level of a **closed inquiry*** and require a **high degree of structure/guidance***	**Level II** *Students research at the level of a **closed inquiry*** and require **some structure/guidance***	**Level III** *Students research **independently** at the level of a **closed inquiry****	**Level IV** *Students research at the level of an **open inquiry*** within **structured guidelines***	**Level V** *Students research at the level of an **open inquiry*** within **self-determined guidelines** in accordance with the discipline*
"…research questions that expand their knowledge of physics."	Synthesize and analyze information/data to reproduce existing knowledge in prescribed formats.	Synthesize and analyze information/ data to reorganize existing knowledge in standard formats.	Synthesize and analyze information/ data to construct emergent knowledge.	Synthesize and analyze information/ data to fill recognized knowledge gaps.	Synthesize, analyze, and apply information/ data to fill self-identified gaps or extend knowledge.

1. **Characteristics of Mentee:**
   a. How does the mentee exhibit the characteristics for the level you highlighted above?

   b. What would the mentee need to do to reach the next level? And how is that higher level expected, needed, or otherwise appropriate for the mentee's education and/or career goals?

2. **Opportunities within their project/working in your research group:**
   a. How have you gauged the mentee's expansion of their knowledge?

3. **Other examples:**
   a. Describe any other instances (if any) where the mentee has formulated personal research questions.

Based on J. Willison, K. Regan, *The Research Skills Development Framework*, www.adelaide.edu.au/rsd/framework, 2006.

Inter-rater reliability

- PLO: Physical Principles
- Distribution Matrix
- Correlation coefficient: 0.78

		Mitchell		
		E	A	U
Menke	E	6	1	0
	A	2	15	3
	U	0	1	6

Unacceptable	Acceptable	Excellent
• Knowledge of basic physical principles is missing. • Knowledge of basic physical principles evident, but ○ Application is missing. ○ Significant errors exist in their application. ○ *Example: student can write down Maxwell's equations, but cannot calculate the magnetic field around a wire.* • Knowledge and/or application of two or more physical principles are confused.	• Knowledge of basic physical principles is evident. • Those principles are applied correctly, ○ although some errors exist. • Misconception in knowledge or application of more subtle feature of principle may exist.	• Knowledge of basic physical principles is evident. • Those principles are applied correctly. ○ although minimal errors may be present. • Evidence that more subtle aspects of physical principles known and correctly applied.

Course *and* Program

SECTION	GOAL	EVALUATION		
		Excellent 3 points	**Good 2 points**	**Poor 1 point**
Title Scale = 1	To give content information to reader	• Engaging	• Appropriate	• Not enough content information or too much
Authors Scale = 1	To formally recognize all contributors to the lab work	• Listed and properly attributed	• n/a	• Not all listed and properly attributed.
Abstract Scale = 3	To concisely summarize the experimental question, general methods, major findings, and implications of the experiments in relation to what is known or expected	• Key information is presented completely and in a clear, concise way • All information is correct • Organization is logical • Captures any reader's interest	• Sufficient information is presented in proper format • Would benefit from some reorganization • Understandable with some prior knowledge of experiment	• Some key information is omitted or tangential information is included • Some information is misrepresented • Some implications are omitted • Incorrect format is used
Background Scale = 3	To identify central experimental questions, and appropriate background information. To present a plausible hypothesis and a means of testing it	• Relevant background information is presented in balanced, engaging way • Your experimental goals and predictions are clear and seem a logical extension of existing knowledge • Writing is easy to read • All background information is correctly referenced	• Relevant background information is presented but could benefit from reorganization • Your experiment is well described and a plausible hypothesis is given • With some effort, reader can connect your experiments to background information • Writing is understandable • Background information is correctly referenced	• Background information is too general, too specific, missing and/or misrepresented • Experimental question is incorrectly or not identified • No plausible hypothesis is given • Writing style is not clear, correct or concise • References are not given or properly formatted
Materials and methods Scale = 4	To describe procedures correctly, clearly, and succinctly. Included a correctly formatted citation of the lab manual	• Sufficient for another researcher to repeat your experiment • Lab manual cited	• Procedures could be pieced together with some effort • Lab manual cited	• Procedures incorrectly or unclearly described or omitted • Lab manual not cited
		• Text tells story of	• Text presents data but	• Text omits key findings,

Conclusions & Actions of Assessments

- **Program Learning Objectives**: Important discussion on what constitutes research proficiency (PLO 5), led to focus on information literacy in early years and encouraging students to engage in undergraduate research early.

- **Curriculum Matrix & Evidence**:
  - Allowed us to identify gaps in learning objective development opportunities with Experimental Techniques (PLO 3) and Teamwork (PLO 4).
  - Evidence is consistently collected and spread out over all semester-long core courses.

- **Pedagogical Validation**: Existing writing assignments and presentations effectively support Communication skills (PLO 4).

- **Pedagogical Adoptions**:
  - Conceptual questions explicitly integrated into final exams to separate principles (PLO 1) from mathematics (PLO 2).
  - Video project adopted in Quantum Mechanics to provide in-class teamwork opportunities (PLO 4).
  - Stronger emphasis on data analysis in Intro. III provide reinforcement for experimental techniques (PLO 3).

- **Applying Rubrics to Course and Program**:
  - Robust program rubrics are applicable to course-level work and allowing for quicker program assessment when taken in aggregate.
  - Inter-rater reliability checks are needed to ensure program applicability.

Challenges

- Organization
- Student writing
- Robust rubrics
- Participation
  - Faculty
  - Students

References

1. Laura Martin, Introduction to Assessment Presentation, CGS Workshop, http://crtecertificatespring2013.files.wordpress.com/2012/12/introduction-to-assessment-1-14-2013-final.pdf, January 2013

2. L. A. Suskie, *Assessing Student Learning: A Common Sense Guide* (Jossey-Bass, San Francisco, CA 2009).

3. Center for the Integration of Research, Teaching, and Learning (CIRTL Network), *Teaching-as-Research (TAR): Developmental Framework,* www.cirtl.net/CoreIdeas/teaching_as_research, 2013.

4. G. Wiggins, J. McTighe, *Backward Design in Understanding by Design* (Assn. for Supervision & Curriculum Development, Alexandria, 2005).

5. VALUE Rubrics. *Assessing Outcomes & Improving Achievement: Tips & Tools for Using Rubrics*, T. L. Rhodes ed., Association of American Colleges & Universities, 2010.

6. J. Willison, K. Regan, *The Research Skills Development Framework*, www.adelaide.edu.au/rsd/framework, 2006.