Supplemental Material

CBE—Life Sciences Education

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Appendix A: Formative pre-implementation survey full items

Thank you for accessing the PARE instructor pre-implementation survey. Your answers to the following questions will help us to identify areas of concern and to modify the program if appropriate. Participation is voluntary; you may choose to exit the survey at any time or to skip any questions. There are no known risks to participating in this survey. It is anticipated that it will take five minutes to fill out the survey.

1. Do you teach undergraduates or high school students?
   Selection option:
   a. High school students
   b. College students
2. Have you implemented research in the classroom for which the outcome was unknown to you and the students?
   Select option:
   a. Yes
   b. No
   c. Unsure
3. Have you implemented any of the following classroom research projects? Click all that apply.
   Selection option(s):
   a. Phage Hunters
   b. Small World Initiative
   c. Genomics Education Partnership
   d. Other well-known program not listed
   e. A program I developed

4. For approximately how many years have you been implementing authentic research in the classroom?
   Select option:
   a. less than 1 year
   b. 1-2 years
   c. 3-4 years
   d. 4-6 years
   e. More than 6 years

5. The components of this project that concern me the most are: -
   For each option select: Strong disagree, disagree, somewhat disagree, neither agree nor disagree, somewhat agree, agree, strongly agree
   a. making classroom time for this project.
   b. finding personal time required to implement something new.
   c. my administration may not be supportive.
   d. my ability to explain the project.
   e. my students' ability to understand the project.
   f. my ability to execute the project.
   g. the students' abilities to execute the project.
   h. dealing with unknown outcomes.
   i. my lack of research experience.
   j. guiding the students through the necessary calculations.
   k. database upload.

If there are other issues that concern you, please indicate below:

6. The components of this project that excite me the most are:
   For each option select: Strong disagree, disagree, somewhat disagree, neither agree nor disagree, somewhat agree, agree, strongly agree

   a. the potential to generate student excitement at levels greater than with my current curriculum.
   b. the potential to convey the true nature of the scientific process to my students.
   c. contributing to answering an authentic research question.
   d. learning about a topic that is new to me.
   e. the opportunity to serve as a role model for my peers.
   f. the opportunity to do something new and potentially exciting.
   g. the potential to increase (or revitalize) my motivation to teach.
   h. The opportunity for personal interaction with other science instructors.
   i. the opportunity for my students to interact with undergraduate/high school students.
   j. Professional opportunities for myself (e.g. publication, recognition from administration)

   If there are other aspects of the project that excite you, please indicate below.

7. Which of the following are of value to you at your institution?
   Rank the items from 1 (most important) to 6 (least important). Use a zero if the item is not relevant at your institution.
   a. Opportunities to publish
   b. Professional Development/Continuing Education Unit credits
   c. "release" from course instruction
   d. recognition/appreciation from administration
   e. opportunities to write grants
   f. invitations to travel/present your work

8. How many years of teaching experience do you have?
   Selection option:
   a. Less than 1
   b. 1 to 3
   c. 4-6
   d. 7-10
   e. 10-15
   f. More than 15

9. For the years you've taught, have you generally taught in the summer?
   Select option:
   a. Yes
   b. No
   c. unsure

Appendix B1: Demographics of interview study participants

Demographics of interview participants			
Instructor	**Institution type**	**Course type**	**Previous CURE experience?**
A	Community college	Microbiology, intro level	No
B	PUI	Microbiology, intro level	No
C	Doctoral granting	Microbiology, intro level	No
E	PUI	Microbiology, upper-level	Yes
F	Community college	Cell biology	No
G	PUI	General biology	Yes
H	Community college	Microbiology, intro level	No
I	PUI	Microbiology, intro level	No
J	PUI	General biology	Yes
K	Community college	General biology	No
L	Doctoral granting	Non-majors biology	Yes
M	PUI	Evolutionary biology	Yes
N	Community college	Plant science	No
O	PUI	Microbiology, intro level	No
P	Doctoral granting	Non-majors biology	No
Q	Doctoral granting	General biology	Yes
R	PUI	Microbiology, upper-level	Yes
S	PUI (HBC)	Microbiology, intro level	No
T	PUI	Non-majors biology	No
Note: PUI stands for primarily undergraduate institution. HBC stands for Historically Black College			

Appendix B2: Semi-structured Interview script

Warm up questions:

What is your institution? What is its classification?

What type of course are you planning to implement the PARE project in? Learning goals for class?

When are you planning to implement PARE (next week? next semester?)

Interview proper:

1. What originally caught your interest in the PARE program?

2. PARE is what's known as a course-based research experience, or "CURE." How do you feel about course-based research compared to traditional labs or other teaching methods?

3. What would you say the key elements of a CURE are? What makes a CURE a CURE?

4. Before implementing PARE, what was your course design like?

5. (If not already answered in Q4) Have you implemented course-based research before?

If YES:

5.a.1. What did you use? Developed own program? Used an existing program?

5.a.2. Are you still using this CURE? Why or why not?

If needed: 5.a.3. What are some challenges you have encountered?

5.a.4. Did you consider any other CUREs?

If NO:

5.b.1.Have you heard of other CUREs before?

5.b.1.2. Did you consider using any other CUREs?

5.b.2.What has prevented you from implementing a CURE before?

-*Follow up on challenges; make sure it's clear*

6. Why are you planning to implement PARE and not another CURE?

OR Why have you switched from a different CURE to PARE (or added PARE in addition to other CURE)?

7. Do you feel that others in your department- such as colleagues, the chair, administration, etc.- are supportive of implementing CURES? Why or why not?

7a. Do you feel that attitude is shared by key administrative leaders such as provosts or presidents? Do you anticipate that your institution will provide any assistance to overcome potential challenges?

7b. (*if appropriate*) Are you given any incentives for implementing course-based research? What's required for promotion at your institution? reward structure?

8. What **barriers** or challenges have you encountered, or anticipate encountering when implementing PARE? *(make sure to press on this issue)*

9. How did your professional training influence your decision to implement PARE? Do you identify primarily as a teacher or a researcher?

If there's time:

10. How will you decide whether to continue to use PARE in future semesters?

11. Are you interested in expanding PARE with additional modules in the future?

12. Demographic questions
Job title? Tenure track? full time?
Highest level of education?
How much opportunity for authentic research do students at your institution have access to?
Do you have TAs assisting with your course?
Do you have a laboratory prep staff assisting with your course?

13. Anything else that you'd like to add?

Appendix C. Coding rubrics

C1. List of upper-level coding categories for full coding rubric:

First pass:

- Trialability
- Complexity-general
- Learning goals for the course
- CURE definition— Key elements of CUREs
- "Can never get rid of cookbook labs entirely:"
- Aware of another CURE
- Previous course design
- Previous CURE experience
- Reasons for not previously implementing CUREs
- Influence of professional training

Second pass:

- Observability
- Relative Advantage
- Compatibility
- Institutional environment
- Barriers and challenges

Appendix C2- coding rubric used in this study

DOI persuasion factor coding rubric			
Top-level code	**Intermediate-level code**	**Sub-code**	**Description of code**
Relative Advantage (Positively correlated with adoption)	PARE or CUREs	Career Incentive	Using PARE/CUREs will further career goals (tenure, pay scale, etc.)
		Dissatisfaction with old methods	Felt need for change.
		Impact	The broader scientific contribution of the work.
		Student engagement	Liking the course, having fun, feeling more like a scientist, excitement, holding attention, better attendance, etc.
		Student learning	CUREs/PARE helps student understanding content, including "process of science," and career options.
Compatibility (Positively correlated with adoption)	PARE or CUREs	Cost/resources	Money for course, equipment on hand, etc. Use when instructor says PARE/a CURE works with their budget/ equipment/materials/etc.
		Past experiences	When their past experience with research or CUREs influences their decision to want to do a CURE/PARE now.
		Values and beliefs	When they're talking about their feelings and personal beliefs about learning, student ability, educational philosophy, etc.
		Course structure and content	CURE/PARE is being used because it goes well with the course(s) they teach.
Observability (Positively correlated with adoption)	PARE or CUREs	Community Support	Help provided from other people who use the CURE
		Friend or Colleague	Know someone else who uses the CURE
		Buzz in science community	Learned about CUREs/PARE at a conference, in research journals, etc.
Trialability (Positively correlated with adoption)		PARE trialability-positive	Statements about testing it out CURE/PARE; the degree to which an innovation may be experimented with on a limited basis. Includes statements about ease of access
		PARE trialability-negative	
		CURE trialability-positive	
		CURE trialability-negative	

Complexity (Negatively correlated with adoption)	Barriers and challenges encountered/anticipated (complexity)	PARE or CUREs	Instructor bandwidth/time	Instructors describe being stressed or stretched too thin, or not having time to prepare for teaching CURE/PARE.
			Technical issue with protocol	Difficulties with executing specifics of CURE/PARE
			Scaling, number of students	Managing a CURE/PARE in a large enrollment course
			Having to transform whole class	The CURE/PARE is difficult to execute because the entire existing course structure would need to be changed
			Teaching assistant training and management	Difficulties managing/incentivizing teaching assistants
			Lack of student preparation or competency	When students don't have necessary skills or background knowledge to do CURE/PARE
			Student resistance	When the students don't want to have to put in the extra effort required for a CURE . Also includes frustration over "messiness" of science.
			Equipment/materials	Lack the tangible resources needed to do the CURE
			Funding/cost	Budget limits CURE
			Time in semester or class	Having time limitations within a semester for doing CUREs
	Reasons for not previously implementing a CURE (complexity)	N/A	Institutional conflicts	Includes conflicts with co-teachers, conflicts with other courses at institution, opposition from admin or other teachers.
			Instructor Bandwidth/time	Instructor doesn't have enough time to figure out implementation of CURE/PARE OR Instructor is too stressed, stretched too thin.
			Just started teaching	First-time instructor (not included in "complexity" category)
			Lack of awareness	Hadn't previously known about CUREs
			Content needs/ student level needs	Hadn't found a CURE that matches the content and level of their course
			Cost	Haven't found a CURE that meets budget needs
			Equipment	Unable to use a CURE because they are lacking the right equipment
			Time (in semester/class)	Hadn't found a cure that would fit in with the time limits of their course.

Key elements of a CURE	N/A	Broadly relevant, important work	Meaning beyond the course, interesting to students, connected to larger research effort
		Discovery	Outcome unknown, ambiguous data, surprising outcomes, hypothesis testing
		Scientific practices	Navigating messy data, analyzing data, reading literature
		Iteration	Repeat experiment, build on previous work, revise experimental strategy based on results
		Collaboration	Discuss and interpret results with others, work in groups, etc.
		Ownership	Students feeling a sense of ownership/personal responsibility/pride in project.

Appendix D: How each individual interviewed instructor defined CUREs

Instructor	Prior CURE experience?	Key CURE element					
		Broadly relevant	Collaboration	Discovery	Iteration	Ownership	Scientific practices
A	No	√		√			√
B	No			√			√
C	No	√		√	√		
E	Yes			√		√	√
F	No	√	√			√	
G	Yes	√				√	
H	No					√	√
I	No			√		√	
J	Yes			√		√	√
K	No			√			
L	Yes	√		√			√
M	Yes	√			√		√
N	No			√			√
O	No			√	√		
P	No	√				√	
Q	Yes			√		√	√
R	Yes	√					
S	No		√			√	√
T	No	√	√				
Total	--	9	3	11	3	9	10