

Supplemental Material

CBE—Life Sciences Education

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Appendix 1: Timepoint 2 interview scripts

1. How do you feel your first experience with the PARE project went?
2. (if necessary) Remind me, what kind of class were you putting PARE into?
3. What modifications did you make to the standard PARE protocol?
4. How did you tie the project to your course's content?
 - a. Did PARE replace a specific lab or project?
5. Did you tie or spin the PARE project to your own specific area of expertise or research interest?
6. How do you feel the PARE project affected student learning? How about engagement with science or the course?

Follow up as needed:

 - a. (if needed) How do they react to the citizen-science aspects of the class?
 - b. Did students: make hypotheses, do data analysis, do any presentations?
7. What challenges did you encounter during your first implementation?
8. How did the PARE project compare to previous instructional methods you've used in this course (or this type of course)?
 - a. Clarifying statement: For both student learning/engagement and for you as an instructor
9. Have you discussed the PARE project with any colleagues? What has their reaction been?
10. How has your department/institution reacted to your use of the PARE project?
11. Will you use PARE again? **Why or why not?** (Probe here)
 - a. If yes:
 - i. Will you make any changes to how you implemented the first time?
 - ii. Do you think PARE will become a regular fixture of your course?
 - iii. Expansion? Would you prefer to use library of modules or would you prefer to take it in your own direction?
 - iv. If you were to implement more modules, what would be the barriers/challenges?
 - b. If no:
 - i. What will you use instead? Will you go back to what you were using before or try something different?

Appendix 2: Timepoint 3 interview script

Interview preamble: Thank you so much for taking the time to chat with me. As I mentioned in our earlier email, I am doing research on how instructors decide to use or discontinue use of course-based research experiences, with the long-term goal of finding ways to make CUREs more sustainable. I know that trying something new in the classroom is always met with certain challenges; it is those challenges, as well as the positive aspects of using PARE, that we'd like to capture in this interview. Also, while in previous interviews you talked directly to the PARE team, this time I [*author MF-not affiliated with PARE*] am conducting these interviews so that you might feel more comfortable, during the interview, being totally honest with your experiences, good or bad. For full disclosure, we may use the information you provide and quotes from this interview in future publications, but it will be anonymized, so that it cannot be attributed to you specifically.

Before we start, I would like to ask for your consent to record this interview. Do you agree?

1. So before we even start talking about PARE, I am going to ask you a more general psychology-ish question. People have lots of different ideas about what is actually going on in student's minds when they learn new concepts. I'm wondering what your personal theory is. Not so much in terms of techniques for teaching, but more... What do you think is happening, cognitively, in the students' heads?
 - a. How does your teaching practice address this philosophy?
2. So, I know you implemented PARE at least once before. How has it been going since then? *Next, [regardless of how well PARE worked for them], I'd like to ask you some questions about your feelings about PARE and how PARE worked for you as an instructor.*
3. What expectations for PARE did you have before implementing, and did classroom use of PARE match those expectations?
 - a. Did it match your expectations for students?
4. How WELL did PARE fit into your existing course curriculum and course structure?
 - a. [If needed]: Did it match your expectations for fit with the course curriculum/course structure?
5. Keeping what you've mentioned up to this point (including your philosophy and expectations) in mind, what do you feel is the most critical aspect of PARE for you? In other words, if you had to strip away this program to its bare bones, what would absolutely have to remain to meet your goals for your students?
6. How did your students feel about PARE relative to what you have previously taught or relative to their other classroom laboratory experiences? (possible follow up - compared to other CUREs or to other classes)
 - a. What did they dislike the most about participating in PARE?
 - b. What did the students enjoy the most about participating in PARE?
7. In general, what barriers or challenges have you, yourself, encountered in using PARE in your classroom? (this is purposely open to see what first comes to mind)
[LET THEM ANSWER GENERALLY FIRST BEFORE ASKING FOLLOW-UPS]
Suggested follow-ups, as needed:
 - a. Did you encounter any challenges with working with or managing students on the project?
 - b. If they didn't already talk about this in expectations section: How do you feel the skills required for PARE aligned with the readiness of your students?

- c. Could you speak to the cost to implement and/ or equipment and supply requirements for implementing PARE? Was it more or less expensive than you expected?
 - i. Has this impacted your use of PARE?
- d. Could you speak to the personal time requirement for you to implement PARE relative to other CUREs you have tried and/or relative to your previous teaching methods? Did it take more or less time than you expected?
 - i. [If necessary]: Has this impacted your use of PARE?
- 8. What does the course in which you originally implemented PARE look like now?
 - a. What are your plans for the next iteration of this course?
 - b. [ONLY If definitely using PARE next time]: Do you consider PARE to now be a standard part of course?
- 9. Has your experience with PARE changed the way you teach or your approach to teaching? (including how you teach other courses, maybe)
- 10. Have you used any other CUREs in this class or other classes? I don't necessarily need to know the specifics of the CURE, just if there was another CURE.
 - a. [If they haven't already said this]: Did you start using this/these [other CURE] before or after PARE?
 - b. Do you think your use of one influenced your decision to use the other?
 - c. [If they're using another CURE]: Why are you using that CURE? What's working for you with that CURE?

Now I'm going to switch gears a little and ask a few questions about your institution and colleagues.

- 11. How has your institution's, department's, or colleagues' attitude towards CUREs changed since you've been using PARE? [clarify (if needed): Do you think your use of PARE influenced the perceptions of CUREs for others in your department? For others at your institution (outside of department)? Please explain.]
Follow ups as needed:
 - a. Have colleagues observed it run?
 - b. Has your use of PARE impacted other instructors' teaching practice?
- 12. Is/was there any kind of institutional support that helps/helped you use PARE? Is there some kind of institutional support that would make using PARE easier for you? [for people not currently using, when appropriate].... Would have helped you continue using PARE? AND/OR Is there any kind of institutional support that would be helpful in the future to implement PARE again?]
- 13. Is/was there any kind of support from the PARE team or changes to the PARE project that helps/ed you use PARE?
 - a. What kind of support from the PARE team or changes to PARE project would/would have made using PARE easier for you?
- 14. Now I'm going to ask just some nitty-gritty general housekeeping questions:
 - a. Does the course in which you use or used PARE repeat each term or is it a once per year course?
 - b. What is the size of this course? Does it have multiple sections?
 - i. If it has multiple sections: Do all sections participate in PARE?
 - c. Did you expand the core PARE module at all with add-on modules or other modifications?
 - i. [if Yes] Please describe which modules or modifications you have used.
 - d. About how many total class periods or in-class hours are/were devoted to PARE-related work?

Ok those are all my questions. Is there anything else you'd like to add?

Appendix 3: Coding rubric for Timepoints 2 and 3 interview transcripts

DOI theme	Sub-theme	Specific code name	Description of code
Compatibility	Individual	Fit with past experiences	Motivated to use PARE because it's compatible with past research field, teaching experience, etc.
	Innovation	Ease of use- Instructor*	Talking about how the PARE project was easy to use/ teach from instructor's perspective.
	Innovation	Ease of use- student*	Talking about how the PARE project was easy for students to carry out.
	Innovation or context	Fit with available resources	Using PARE because it is compatible with the resources (funding, equipment) available.
	Innovation or context	Fit with course structure/content	Topic or format of PARE fits with the course well. Can include things like PARE uses skills instructor wants students to learn, covers a scientific concept that fits with the course, short duration fits time available for course, fits with learning goals of course, etc.
	Innovation	Support from CURE team or network*	When the CURE leaders or broader community are a positive.
	Context	Support from institution	Lab technicians, funding, enthusiasm of department chairs/admins, etc.
Relative advantage	Individual	Dissatisfaction with old methods	Motivated to use PARE because of perceived limitations of whatever instructor was using before.
	Individual	Interest of the instructor*	Personal motivation to use PARE- their own interest, enjoyment, excitement, learning experience. Enjoyed doing the project. Do not apply when interest is based on student outcomes.

Relative Advantage	Innovation	Broader impact	Specifically about how the data generated by PARE will be used outside the classroom, part of a larger research project, shared with larger community, have effect on world, etc. e.g. "research/experience/etc was part of a larger project/community/etc" Also, mention of the students as part of a larger research effort.
	Innovation	Student engagement	Students enjoying/liking project, student enthusiasm, feeling ownership of project, being more invested in course, more collaborative (but only if the students enjoyed the collaborative aspect).
	Innovation	Student experience as a scientist*	Instructor likes it because students doing real research, acting like scientists. Use when instructor is specifically saying things like "students do real science," "students acting like scientists." Don't code if talking only about specific methodology students do.
	Innovation	Student learning	Indication that students are learning class content, scientific concepts, lab skills, etc. well (or better) because of PARE.
	Innovation	Tie to local community*	Talking about students or instructor being specifically excited/interested/engaged by opportunity to test sample from local area.

Complexity	Individual	Frustration or disappointment of instructor*	Instructor is frustrated or disappointed with project. Can be coded with specific challenges, but only if instructor seems discouraged/frustrated/etc by them.
	Individual	Lack of instructor knowledge/experience with research methods*	A challenge/barrier related to research methods of PARE- e.g., lab techniques, microbiology knowledge, etc.
	Individual	Lack of instructor knowledge/experience with teaching method*	A challenge/barrier related to teaching the CURE- e.g. adapting to course, grading students, etc.
	Individual	Lack of instructor bandwidth	Challenge relating to instructor not having enough personal time, energy, mental space. A challenge stemming from a personal issue. Not to be confused with lack of time in the semester.
	Individual	Confidence in student data *	Instructor is struggling with authentic scientific data not always being perfect like in a textbook (e.g. uncertain results, messy/hard to interpret results, unreadable data, high variability, etc). Feeling that student data isn't good enough.
	Innovation	CURE-specific technical issues	Technical or troubleshooting issues with PARE. A common one is the number of plates they have to make and manage. Also adding anti-fungal, problems with cells growing, fungal growth, etc.
	Innovation or context	Lack of resources	Includes trouble with funding as well as lack of materials, equipment or proper facilities.

Complexity	Innovation	Not easy or difficult to use*	Not CURE-specific technical problems, but more like... "hard to use", labor pains of set up, non-specific statements about it being hard, lots of work, etc.
	Innovation	Perceived scrutiny of the data*	Anxiety over quality of data, fear data is not good enough for sharing to larger CURE community, having to be extra precise with techniques (beyond what would be normal in a cookbook lab).
	Context	Challenge with laboratory technician*	If instructor has a lab technician—not being on same page, technician resistance to workload, lab tech not having enough time, being overburdened, etc.
	Context	Institutional conflicts	Conflicts within institution (with administrators, other faculty, other courses/campuses) that interfered with doing PARE or made it more difficult. Include statements about not having total control over course as a challenge.
	Context	Lack of time in the semester	PARE wasn't a good or perfect with their class, lacking time in semester to do PARE, struggles with how to fit PARE into semester. Instructor having trouble getting everything done within allotted class time, not enough weeks in semester, schedule for other topics in class is too tight, not enough classes to dedicate to PARE, etc.
	Context	Managing teaching assistants	Difficulty working with teaching or learning assistants (not lab technicians).

Complexity	Context	Scaling for class sizes	Difficulties with managing large number of students/sections OR class being too small. Basically, problems relating to the number of students in the course—big or small
	Student	Frustration or disappointment of students*	Students were frustrated or disappointed with results. Specific to results of experiment: e.g. issues of messy data, not getting any antibiotic-resistant organisms, etc.
	Student	Student readiness/preparation/ability	Challenges relating to students' ability, competency, or preparation to carry out project (lab technique skills, math skills, background knowledge, etc). Students struggling with the techniques.
	Student	Student reluctance	Students not doing their work, not filling things out like they should, not caring about project, pushing back.
	Student	Decreased student learning*	Students didn't learn concepts as well using PARE as they might have with another experience.
* code is new for Timepoints 2/3			

Appendix 4: Status of each instructor in cohort

Instructor	Institution type	Prior CURE experience	CURE use by others	Has lab prep staff?	Course type	Tenure track	Job title	Timepoint 2 status	Timepoint 3 status
A	Assoc	No	Yes	No	Intro micro	No	Lab coordinator/ Adjunct	Core PARE only	Discontinued use- disruption, considering
B	PUI	No	Yes	No	Intro micro	No	Assist. Professor	Core PARE only	Expanded use- new CURE
C	Doc	No	Un- known	Un- known	Gen bio	No	Lecturer	Core PARE only	Sustained use
E	PUI	Yes	Yes	Yes	Upper micro/ bio	Yes	Assistant Professor	Core PARE only	Expanded use- PARE add-on modules
F	Assoc	No	No	Yes	Upper micro/ bio	No	Adjunct Assist. Professor	Core PARE only	Discontinued use- disruption, considering
G	PUI	Yes	Yes	Yes	Gen bio	No	Lecturer	Expanded use	Expanded use- PARE add-on modules, new CURE
H	Assoc	No	No	Yes	Intro micro	Yes	Professor	Core PARE only	Expanded use- PARE add-on modules
I	PUI	No	Yes	Yes	Upper micro/ bio	Yes	Assistant Professor	Core PARE only	Expanded use- PARE add-on modules
J	PUI	Yes	Yes	Yes	Gen bio	Yes	Assistant Professor	Expanded use	Expanded use- new CURE
K	Assoc	No	Yes	Yes	Gen bio	Yes	Assistant Professor	Did not implement	N/A
L	Doc	Yes	No	Yes	Gen bio	No	Lecturer	Core PARE only	Discontinued- discouraged, considering
M	PUI	Yes	No	Yes	Other	Yes	Associate Prof	Expanded use	Expanded use- PARE add-on modules, new CURE
N	Assoc	No	Yes	Yes	Other	Yes	Instructor (chair)	Core PARE only	Discontinued- disruption, considering
O	PUI	No	No	No	Intro micro	Yes	Assistant Professor	Core PARE only	Expanded use- PARE add-on modules, new CURE, new sections/classes
P	Doc	No	No	Yes	Gen bio	No	Lecturer	Did not implement	N/A
Q	Doc	Yes	Yes	Yes	Gen bio	No	Assistant Clinical Professor	Core PARE only	Expanded use- new CURE, new sections/classes
R	PUI	Yes	No	No	Intro micro	Yes	Associate Professor	Core PARE only	Expanded use- PARE add-on modules
S	PUI (HBCU)	No	Yes	Yes	Intro micro	Yes	Assistant Professor	Did not implement	N/A
T	PUI	No	No	Yes	Gen bio	Yes	Professor	Core PARE only	Expanded use- new sections/classes, new CURE (someone else's class)

Appendix 5: DOI Sub-theme codes expressed per each instructor

This section contains tables similar to Table 4a of the results, but for sub-themes not discussed in the main manuscript.

Appendix 5, Table 1a: Analysis of Complexity codes relating to the <i>Innovation</i> (PARE)				
Instructor	Institution type	Timepoint 3 implementation status	No. codes expressed in this sub-theme (Timepoint 2)	No. codes expressed in this sub-theme (Timepoint 3)
B	PUI	Expanders	3	2
E	PUI		0	2
G	PUI		1	2
I	PUI		0	2
J	PUI		1	0
M	PUI		1	2
O	PUI		1	2
Q	Doc		0	1
R	PUI		2	1
T	PUI		3	1
H	CC		2	(not interviewed)
Average number of different codes expressed per instructor			1.3	1.5
A	CC	Non-expanders	3	1
C	Doc		2	3
F	CC		0	0
L	Doc		2	2
N	CC		4	0
Average number of different codes expressed per instructor			2.2	1.2

Appendix 5, Table 1b: Analysis of **Complexity** codes relating to the **Context** of implementation (institution)

Instructor	Institution type	Timepoint 3 implementation status	No. codes expressed in this sub-theme (Timepoint 2)	No. codes expressed in this sub-theme (Timepoint 3)
B	PUI	Expanders	1	2
E	PUI		2	2
G	PUI		4	1
I	PUI		0	0
J	PUI		1	1
M	PUI		0	2
O	PUI		0	1
Q	Doc		1	5
R	PUI		0	1
T	PUI		2	1
H	CC		1	(not interviewed)
Average number of different codes expressed per instructor			1.1	1.6
A	CC	Non-expanders	1	4
C	Doc		4	2
F	CC		1	1
L	Doc		2	1
N	CC		1	3
Average number of different codes expressed per instructor			1.8	2.2

Appendix 5, Table 1c: Analysis of **Complexity** codes relating to **Students**

Instructor	Institution type	Timepoint 3 implementation status	No. codes expressed in this sub-theme (Timepoint 2)	No. codes expressed in this sub-theme (Timepoint 3)
B	PUI	Expanders	2	2
E	PUI		2	3
G	PUI		1	2
I	PUI		0	0
J	PUI		3	2
M	PUI		0	2
O	PUI		0	2
Q	Doc		4	3
R	PUI		1	2
T	PUI		0	2
H	CC		1	(not interviewed)
Average number of different codes expressed per instructor			1.3	2.0
A	CC	Non-expanders	0	1
C	Doc		1	3
F	CC		1	1
L	Doc		2	1
N	CC		1	2
Average number of different codes expressed per instructor			1.0	1.6

Appendix 5, Table 2a: Analysis of Relative Advantage codes relating to the <i>Individual</i>				
Instructor	Institution type	Timepoint 3 implementation status	No. codes expressed in this sub-theme (Timepoint 2)	No. codes expressed in this sub-theme (Timepoint 3)
B	PUI	Expanders	0	1
E	PUI		0	1
G	PUI		1	1
I	PUI		2	1
J	PUI		1	1
M	PUI		1	2
O	PUI		2	1
Q	Doc		0	1
R	PUI		2	1
T	PUI		1	0
H	CC		2	(not interviewed)
Average number of different codes expressed per instructor			1.1	1.0
A	CC	Non-expanders	1	0
C	Doc		1	1
F	CC		2	1
L	Doc		0	0
N	CC		2	1
Average number of different codes expressed per instructor			1.2	0.6

Appendix 5, Table 2b: Analysis of Relative Advantage codes relating to the <i>Innovation</i> (PARE)				
Instructor	Institution type	Timepoint 3 implementation status	No. codes expressed in this sub-theme (Timepoint 2)	No. codes expressed in this sub-theme (Timepoint 3)
B	PUI	Expanders	3	3
E	PUI		5	2
G	PUI		5	6
I	PUI		3	3
J	PUI		4	2
M	PUI		5	4
O	PUI		3	3
Q	Doc		2	2
R	PUI		3	3
T	PUI		4	5
H	CC		4	(not interviewed)
Average number of different codes expressed per instructor			3.7	3.3
A	CC	Non-expanders	4	4
C	Doc		2	3
F	CC		5	6
L	Doc		2	1
N	CC		5	3
Average number of different codes expressed per instructor			3.6	3.4

Appendix 5, Table 3a: Analysis of Compatibility codes relating to the <i>Individual</i>				
Instructor	Institution type	Timepoint 3 implementation status	No. codes expressed in this sub-theme (Timepoint 2)	No. codes expressed in this sub-theme (Timepoint 3)
B	PUI	Expanders	1	0
E	PUI		0	1
G	PUI		0	1
I	PUI		0	0
J	PUI		1	0
M	PUI		1	0
O	PUI		1	0
Q	Doc		1	0
R	PUI		0	0
T	PUI		0	0
H	CC		1	(not interviewed)
Average number of different codes expressed per instructor			0.5	0.2
A	CC	Non-expanders	0	1
C	Doc		0	0
F	CC		0	0
L	Doc		0	0
N	CC		0	0
Average number of different codes expressed per instructor			0.0	0.2

Appendix 5, Table 3b: Analysis of Compatibility codes relating to the <i>Innovation</i> (PARE)				
Instructor	Institution type	Timepoint 3 implementation status	No. codes expressed in this sub-theme (Timepoint 2)	No. codes expressed in this sub-theme (Timepoint 3)
B	PUI	Expanders	1	3
E	PUI		3	2
G	PUI		3	2
I	PUI		2	2
J	PUI		0	2
M	PUI		1	3
O	PUI		3	3
Q	Doc		0	2
R	PUI		2	3
T	PUI		1	5
H	CC		3	(not interviewed)
Average number of different codes expressed per instructor			1.7	2.7
A	CC	Non-expanders	1	3
C	Doc		0	2
F	CC		3	1
L	Doc		3	2
N	CC		0	3
Average number of different codes expressed per instructor			1.4	2.2



