PILOT INVESTIGATION OF ZOO INQUIRY PROJECTS FOR INTRODUCTORY CHEMISTRY LABORATORIES

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Introduction

- Chemistry laboratories often follow a cook-book style approach (Abrahams & Millar, 2008).
- Such approaches limit student creativity and constrain students' engagement with and understanding of chemistry (Donnelly et al, 2014).
- This research investigates the effects of zoo inquiry projects (ZIPs) on student learning and instructor-student interactions compared to existing laboratory structures.

Research Questions

Compared to the existing laboratory structure, does the ZIP laboratory structure improve students'…

1. **conceptual understanding?**
2. **experimental design understanding?**
3. **power relations with instructors?**

ZIP Laboratory Structure

Students collected water samples from the local zoo and worked with them throughout the semester. 3 labs/topic (4 topics).

Topics

- Salinity
- Thermodynamics
- Spectroscopy
- Buffer Capacity

Laboratory Activity

Week 1	Week 2	Week 3
Planning Lab.	Experiment Lab.	Presentation Lab.
•Research topic •Generate research question •Create experimental design procedure	•Perform experiment •Collect experimental data •Analyze data	•Present findings in poster presentation •Peer-review posters •Receive feedback to improve experiment

Knowledge Integration (KI) Framework

(Linn & Eylon, 2011)

Constructivist instructional framework with four components:

1. Elicit ideas → 2. Add ideas → 3. Distinguish ideas → 4. Reflect on ideas → 1. Elicit ideas

KI Framework

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Methods

Research Design and Participants

- Mixed method study – Quantitative (Conceptual & experimental design items) and qualitative (Power relations)
- 55 undergraduate non--science majors from diverse backgrounds (Predominantly female and Hispanic)
- The pre/post items were scored 0-5 with KI Framework rubrics, ranging from non-normative ideas to normative ideas containing disciplinary links.

Conceptual Items

1. Specific Heat Capacity
2. Polarity
3. Molarity
4. Redox Reaction/ Conservation of Mass
5. Solubility
6. Formula Mass

Experimental Design Items

Based on Experimental Design Ability Test (EDAT; Sirum & Humburg, 2011)

1. Experiment features (General EDAT)
2. Investigation of iron in cereal (General EDAT)
3. Instrument advertisement for sodium chloride density (Specific EDAT; Post-test only)
4. Hypothesis critique (Specific EDAT; Post-test only)

Power Relations Data (Donnelly et al., 2014)

- Two post-test questions, four video observations (Two from each laboratory structure), four student interviews, and two instructor interviews

Conceptual Findings

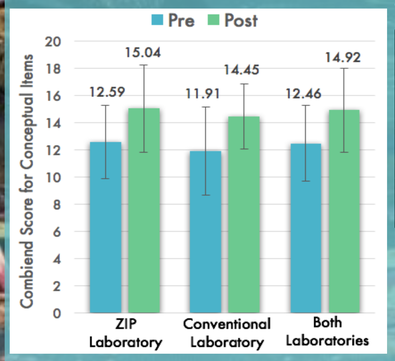

Table 1. Pre/Post Conceptual Gains by Treatment

	n	Pre (SD)	Post (SD)	Gain (SD)	t	p*	d
ZIP	46	12.59 (2.70)	15.04 (3.23)	2.46 (2.80)	5.95	.001	0.83
Conv.	11	11.91 (3.26)	14.45 (2.42)	2.55 (1.37)	6.17	.001	0.92
Total	57	12.46 (2.80)	14.92 (3.08)	2.47 (2.57)	7.24	.001	0.84

*Significance determined at p<.05

No significant difference between conditions with a repeated measures model ($F(2,55) = 0.01$, $p = 0.919$).

Experimental Design Findings

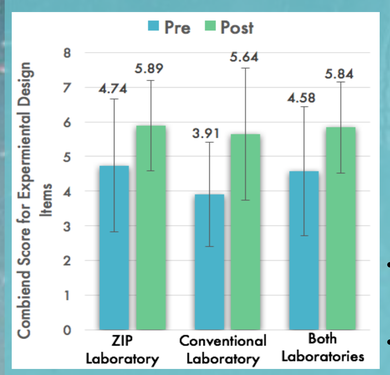

Table 2. Pre/Post Experimental Design Gains

	n	Pre (SD)	Post (SD)	Gain (SD)	t	P*	d
ZIP	46	4.74 (1.91)	5.89 (1.30)	1.15 (1.77)	4.40	.001	0.71
Conv	11	3.91 (1.51)	5.64 (1.91)	1.73 (1.62)	3.54	.001	1.05
Total	57	4.58 (1.86)	5.84 (1.31)	1.26 (1.75)	5.45	.001	0.79

*Significance determined at p<.05

- On average, the ZIP condition scored higher on the 2 post-test specific experimental design items (7.59/10) than the conventional condition (6.09/10).
- Significant difference between conditions for specific post-test only items with a univariate model ($F(55) = 5.87$, $p=0.019$), if equivalent pre-test score assumed.

Power Relations Findings

When asked what was enjoyable about the laboratory section…

- More students in the ZIP laboratory (42.2%; n = 19/45) stated that they enjoyed the ownership they had over their own experimental designs when compared to students within the conventional laboratory (0%; n = 0/10).
  - *"The creativity to the projects and individuality. We could make the experiments our own,"* - ZIP Student #18
  - *"That we got to make our own experiments rather than learning and doing them from a set book; it allowed more room for creativity."* - ZIP Student #18
  - *"But the difference, if I compare that to when I taught the traditional format, is that nobody in the traditional format took ownership. It was a 'get my task done' type of thing. So, I think there's a big difference there as far as perceived ownership, they [ZIP Students] talk about it as 'my experiment.'" -Laboratory Instructor interview*
- More conventional students (60%; n= 6/10) mentioned they enjoyed the support they received from the instructor compared to students in the ZIP laboratory (4.4%; n = 2/45)
  - "*Having a teacher who was kind and helped us*" - Conventional Student #52
  - *"In the lab section [instructor name removed] kind of took care of everything for us. She made sure everything was set up so it was nice."* – Conventional Student interview

Conclusion and Future Work

- Conceptual and experimental design gains for the ZIP laboratory and conventional laboratory are similar, but the two specific post-test experimental design items appear to favor the ZIP condition. Also, ZIP students report greater experimental ownership, with less instructor dependence.
- Having refined the assessment items through this pilot study, the ZIP structure is being implemented and investigated in 11 of 22 Introductory Chemistry Laboratories for non-science majors for an increased sample size of ~ 500 students.

Literature Cited

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