

# Scaling Implementation of Inquiry into Large Enrollment General Chemistry Laboratories

UMD

UNIVERSITY OF MINNESOTA DULUTH  
Driven to Discover

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## Introduction

- General Chemistry instructional laboratories have traditionally been taught in a cookbook style format.
- There has been a shift in instructional strategies towards guided-inquiry to develop students' experimental design skills
- Inquiry-based labs have been previously implemented in a small enrollment General Chemistry Lab for Majors at UMD by Fringer *et al.*

### Research Question:

Can inquiry-based labs be scaled to a large enrollment non-major general chemistry laboratory while maintaining student development of experimental design skills?

**Table 1:** Levels of Inquiry as described by Fay *et al.* Level 0 (grey) correlates to cookbook or traditional labs. Level 2 (green) correlates to the level of Inquiry implemented in this study.

Level	Problem/Question	Procedure	Solution
0	Provided to Student	Provided to Student	Provided to Student
1	Provided to Student	Provided to Student	Constructed by student
2	Provided to Student	Constructed by student	Constructed by student
3	Constructed by student	Constructed by student	Constructed by student

### Learning Objectives

- Use the basic laboratory equipment, including glassware and instrumentation.
- Design experiments applying laboratory techniques to answer novel chemical questions.
- Collect, record, and report data from their experiments.
- Analyze and interpret quantitative data.
- Communicate their scientific results to others, in laboratory notebooks, lab reports and oral presentations.
- Maintain a clean and safe working environment in the laboratory.

## Fidelity of Implementation (FOI)

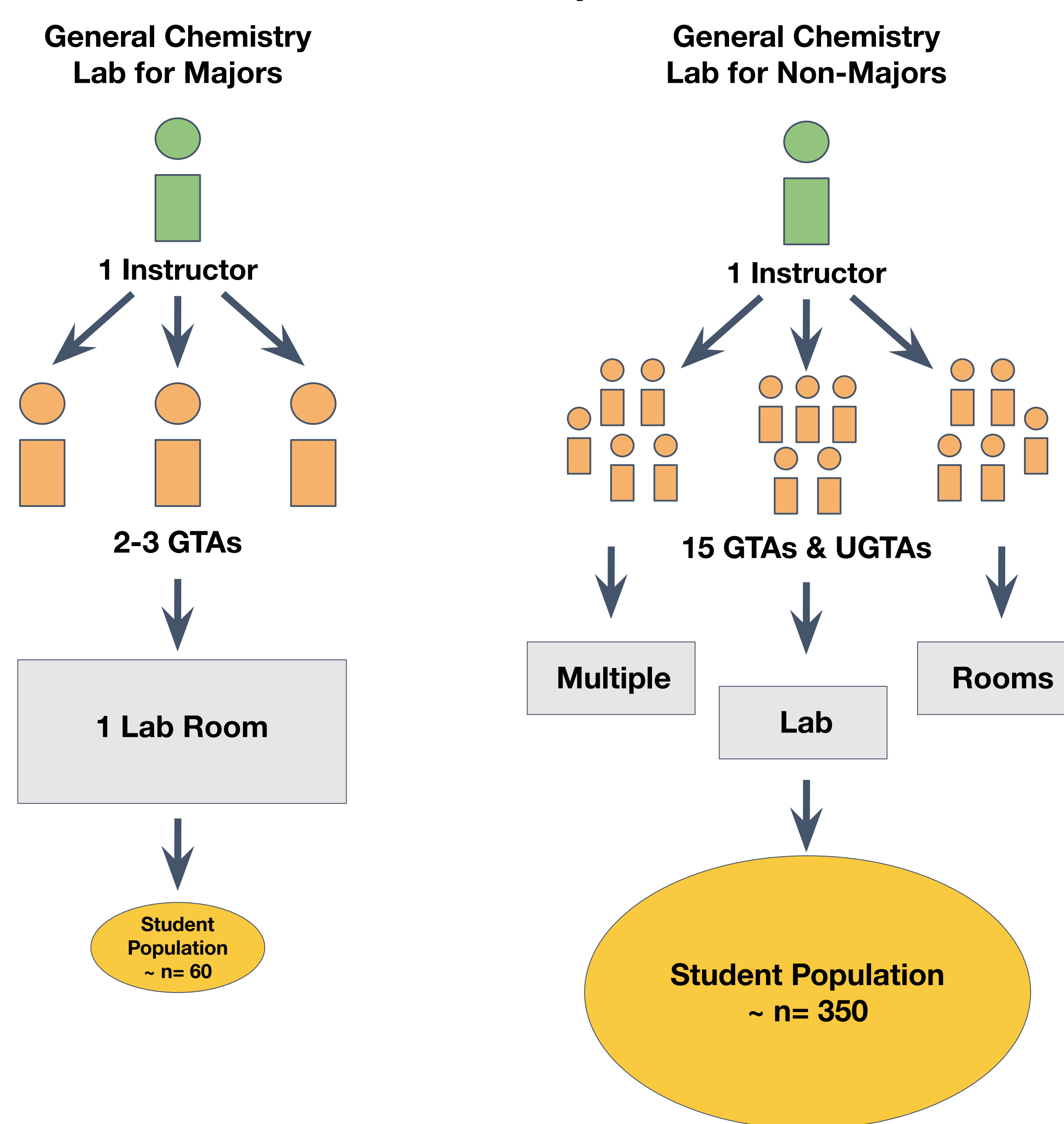
- The degree to which the curriculum is delivered as intended. Has structural and process components.

### Structural Components

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Traditional															
Inquiry															

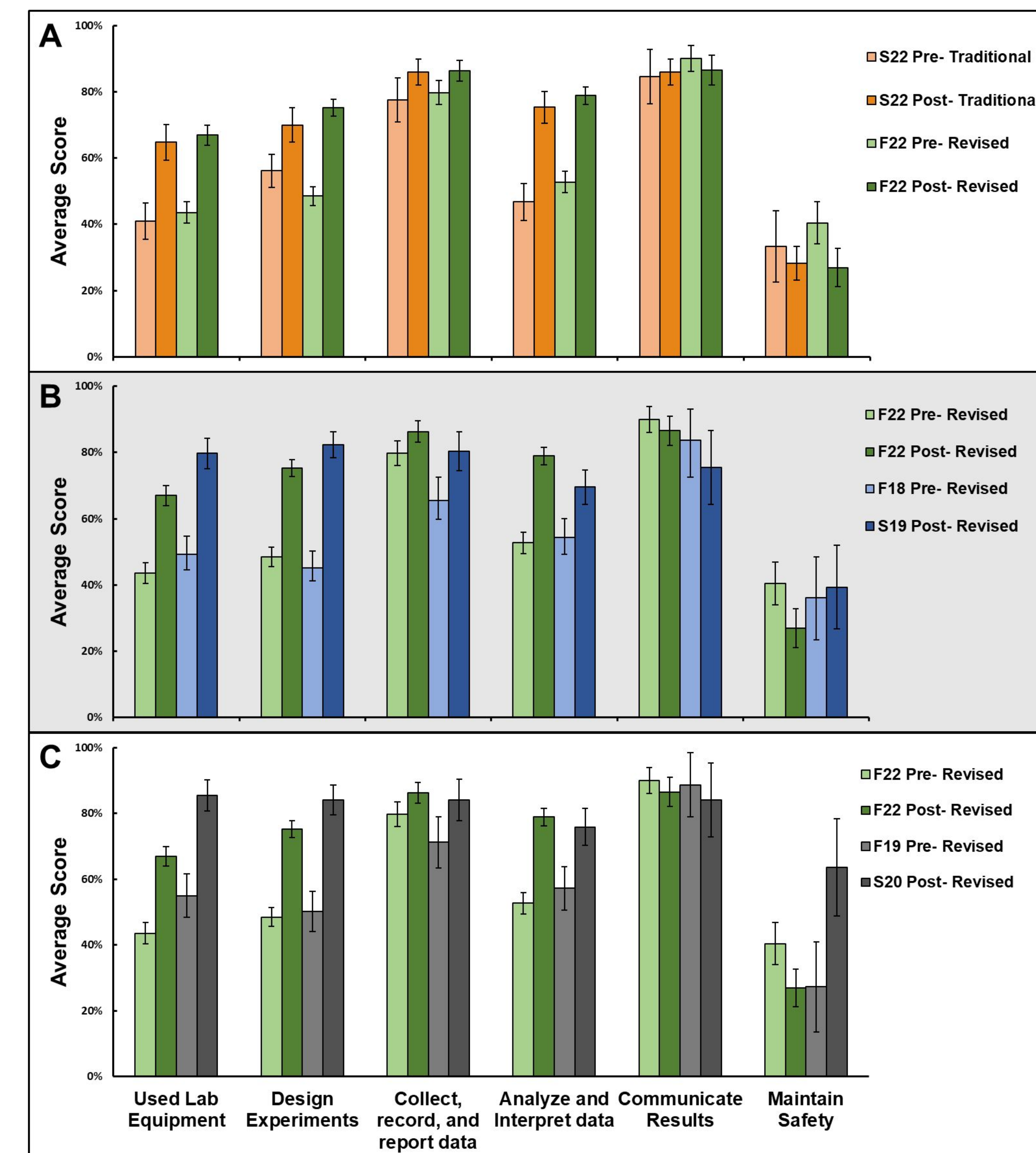
= Admin   
  = Cookbook Lab   
  = Inquiry Lab   
  = Break

### Process Components



- Changes to pre semester TA training
  - Workshops introduced:
    - Understanding Student Backgrounds
    - Pedagogy
    - Questioning Techniques
    - Grading
- Changes to in semester TA training
  - Weekly TA meetings on Friday's were lead by lead TA.
  - Modeled how to effectively instruct an inquiry lab.
- The TELCA instrument from Ludlow *et al.* indicated **decreased anxiety** and **increased confidence** towards teaching post training.

## Assessment



**Figure 1:** Average scores from the multiple-choice section divided by learning objectives. (A) Traditional (orange) vs Revised (green) non-majors curriculum, (B) Revised non-majors curriculum (green) vs Year 1 Revised Majors curriculum (blue) from Fringer *et al.*, (C) Revised non-majors curriculum vs Year 2 Majors curriculum from Fringer *et al.* Lighter bars represent pre test while darker bars represent post tests. The error bars represent the confidence intervals for each cohort.

## Conclusions

- Curriculum was effectively scaled maintaining a high fidelity of implementation.
- Results are qualitatively similar to revisions implemented on a smaller scale.

## References

- Fay, M. E., Grove, N. P., Hamby Towns, M., & Lowery Bretz, S. A rubric to characterize inquiry in the undergraduate chemistry laboratory. *Chem. Educ. Res. Pract.*, **2007**, 8, 212-219. Fringer, V. S.;
- Farley, E. R.; Mandery, K.; Badger, M.; Johnson, C.; Hanson, K.; Zamzow, M.; Armstrong, Z.; Lebourgeois, L.; Bibelnieks, T.; Wainman, J. W. Steps in the Right Direction: A Quasi-Experimental Comparison of an Inquiry-Based and a Traditional First-Year Laboratory. *J Chem Educ* **2022**, 99 (12), 3923-3931.
- Ludlow, L.; Rollison, J.; Cronin, J.; Wallingford, T. Development of the Teaching Economic Literacy: Confidence and Anxiety (TELCA) Instrument. *The International Journal of Educational and Psychological Assessment* **2012**, 9 (2), 82-103.