Wendell Potter, Robert Lynch UC Davis

Additional Evidence of Far Transfer of Scientific Reasoning Skills Acquired in a CLASP Reformed Physics Course

What Gets Transferred?

We venture that what gets transferred is primarily not better content preparation, but rather **attitudes and abilities related to thinking, reasoning, and figuring things out.** Students spend much of their class time in our CLASP course in their small groups working out explanations, making sense of phenomena in terms of models they are learning, getting frustrated at times, but feeling really good when they "get it."

The **continued focus on sense making and reasoning**, rather than "getting the answer" or "trying to remember what the answer was" or "getting through the assignment or the lab" **provides a very different experience than they get in their other science and math courses.**

Perhaps what the students get and what is transferred is best captured in an exclamation one student shouted as she ran into my office following a quiz in the second quarter of the course. I had been her discussion/lab instructor the previous quarter as she really struggled to get through the course.

"Dr Potter! Dr Potter! I finally get it! You don't expect us to *know* how to answer the questions when we first read them on the quiz. That's because you've given us what we need to figure out what to do. And I just did it!"

Experiment Background

- Originally conceptualized to investigate the effect on student performance of incoming freshmen who **simultaneously took math, chemistry, and physics courses/sections that all emphasized active engagement.** NSF DUE-0633317
- Cohorts of 48 students **did take courses together in the same sections**, and there are interesting **cohort effects**. (See Lynch Poster: **A Qualitative Look at The Long Term Effects of Early Enrollment in Physics**)
- Problems arose in turning sections of chemistry into active engagement; essentially no changes in course.
- **Fortuitously**, problems in scheduling resulted in pushing back the Physics course (CLASP) to the spring quarter for Cohort 1 and the delay of the chemistry course to the winter quarter for Cohort 2. These two changes from the original proposal provided an almost ideal setup (unrecognized at the time) to investigate transfer from physics to chemistry.

Question: What is effect on Chemistry Grade of taking 1st quarter of reformed Physics prior to starting Chemistry?

Experiment: Compare course performance of two very similar cohorts:

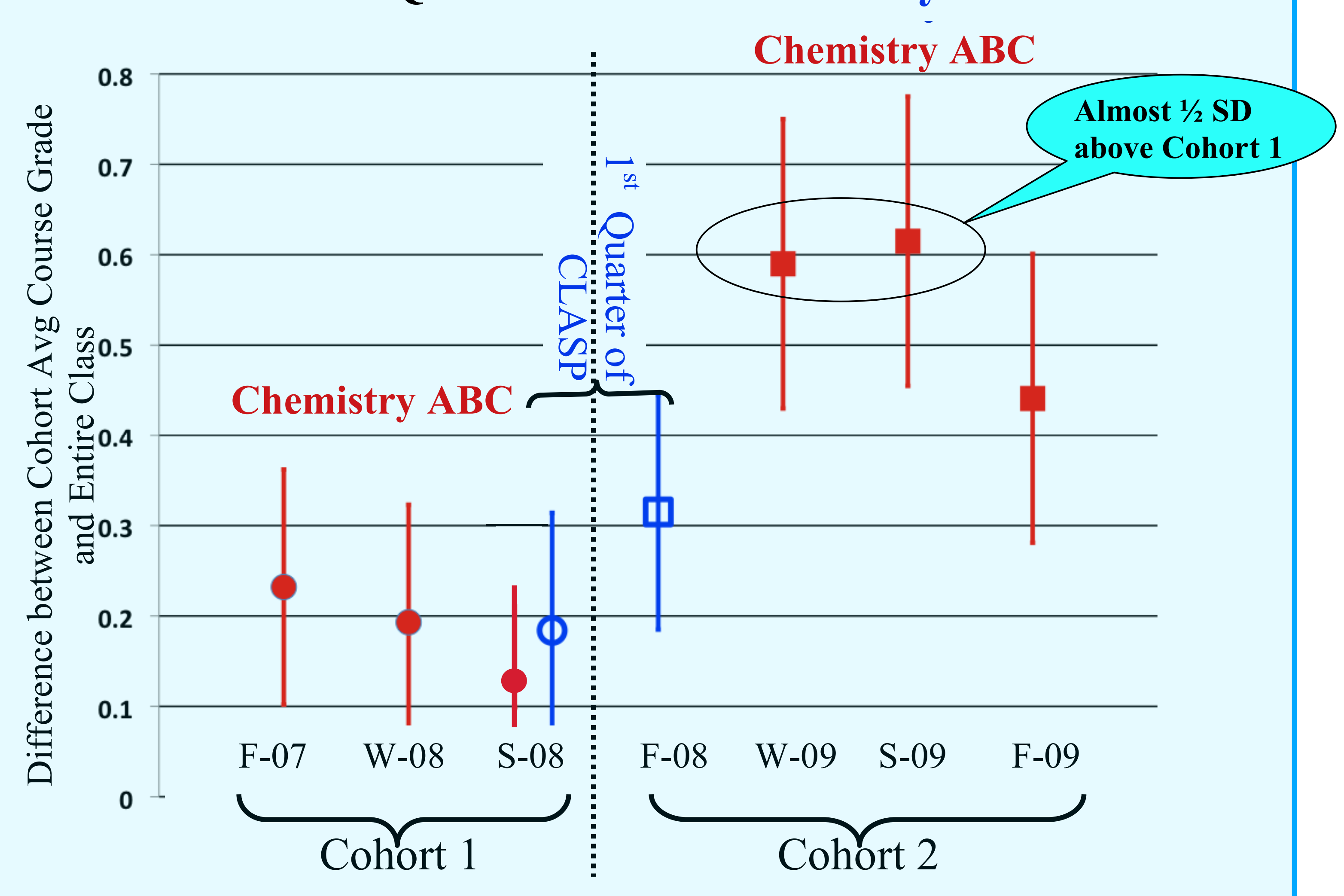
Cohort 1 took **CLASP Part 1 in Spring quarter** of freshman year simultaneously with 3rd quarter of chemistry.

Cohort 2 took **CLASP Part 1 fall quarter** as entering freshmen and began chemistry in 2nd quarter.

Result: Cohort 2's average chemistry grade (1st two quarters) was boosted by 0.4 letter grade over Cohort 1's chemistry grade.

Conclusion: Something that students gained in 1st quarter CLASP **transfers** and shows up as increased chemistry grades.

Effect on Chemistry Grade Before and After First Quarter of Reformed Physics



Statistics Detail

	Quarter	N Tot class (SD) grade dstrbtn	N Cohort (SD) grade dstrbtn	p Two-tailed	Standard Error Difference SED	Difference in Avg Grade
Cohort 1	F-7 Chem	388 (.80)	46 (.76)	.062	.124	.232
	W-08 Chem	350 (.90)	45 (.67)	.16	.138	.193
	S-08 Chem	390 (.89)	42 (.73)	.39	.143	.123
	S-08 Phy	324 (.57)	19 (.48)	.17	.133	.184
Cohort 2	F-08 Phy	259 (.78)	39 (.67)	.018	.13	.31
	W-09 Chem	297 (.90)	36 (.76)	.0002	.16	.59
	S-09 Chem	295 (.91)	35 (.72)	.0001	.16	.62
	F-09 Chem	311 (.90)	23 (.71)	.027	.19	.43

Considered meaningful if Diff is ≥ twice SED

Statistically Significant

Unique Features of CLASP
UC Davis Physics 7ABC

NSF DUE-9354528

Instructional Setting	280 minutes per week working in small groups in discussion/lab; 80 minutes per week in lecture
Content	Organized around 29 general models, instead of topics
Content Sequencing	Course begins with models based on conservation of energy, particles, and thermodynamics
Primary goal	Making sense of a wide variety of phenomena in terms of generally applicable models; learning and *practicing Model-Based-Reasoning*
Student Assessment	Weekly quizzes in lecture typically using a model(s) to construct an explanation of a previously unseen phenomenon (both qualitative and quantitative)
Student Materials	Developed in house and sold by Hayden McNeil
Student Population	All biological science majors are required to take a "calculus-based" introductory one-year physics course. Over 1700 students enroll each year.

Models Used in CLASP

Part 1 1st Quarter

1. Three-Phase Model of Matter
2. Energy-Interaction Model
3. Intro Spring-Mass Oscillator Model
4. Intro Particle Model of Matter
5. Particle Model of Bond Energy
6. Particle Model of Thermal Energy
7. Intro Model of Thermodynamics
8. Ideal Gas Model
9. Intro Statistical Model of Thermodynamics

Part 2 2nd Quarter

10. Steady-State Energy-Density Model (fluids, electric circuits)
11. Linear Transport Model (fluid & charge transport, heat flow, diffusion)
12. Exponential Change Model
13. Galilean Space-Time Model
14. Force Model
15. Momentum Conservation Model
16. Angular Momentum Conservation Model
17. Newtonian Model
18. Simple Harmonic Motion Model

Part 3 3rd Quarter

19. Plane Wave Model
20. Wave Superposition and Interference Model
21. Ray and Wavefront Model
22. Electric Charge and Electric Force Model
23. Electric Field and Potential Model
24. Magnetic Fields and Force Model
25. Electromagnetic Wave Model
26. Quantum Wave-Particle Duality Model
27. Quantum States Model