Initial Interest, Goals, and Changes in CLASS Scores in Introductory Physics for Life Sciences

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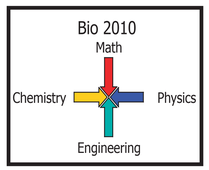
IPLS and Interest



Recent reforms to introductory physics for life sciences, inspired by reports from the **life science**[1] and **medical**[2] communities, emphasize:
- a deep understanding of physics principles,
- a high level of skill with modeling and problem solving, and
- the ability to apply these principles and methods across disciplines to biological and medical contexts

Research in the role of interest in learning indicates that helping students make meaningful connections to the material supports interest development; in turn, **interest enhances attention, persistence, and learning strategies.**[3]

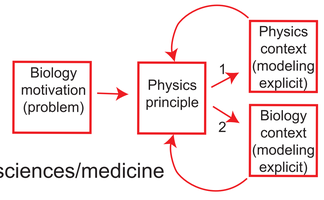
The **cognitive apprenticeship** model[4] indicates the critical importance of **context** for student learning. Students learn new ideas best in a global context that they understand and value.

Finally, instructional interventions using **life science contexts**[5] and **expansive framing**[6] suggest that explicitly connecting science to topics that interest students and to applications beyond the classroom support learning.

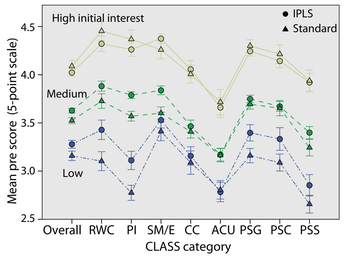
1. *BIO 2010: Transforming Undergraduate Education for Future Research Biologists,* National Research Council (Nat'l Academies Press, 2003).
2. *Scientific Foundations for Future Physicians*, HHMI-AAMC Committee (American Association of Medical Colleges, 2009).
3. M. Mitchell, J. Ed. Psych., 85, 424–436 (1993); S. Hidi and K. A. Renninger, Ed. Psych., 41 (2), 111-127 (2006).
4. For example, Collins, Seely Brown, and Holum, American Educator (Winter 1991).
5. P. Häussler and L. Hoffmann, J. Res. Sci. Teach. 39 (9), 870-888 (2002).
6. R. Engle, P. Nguyen, and A. Mendelson, *Instructional Science* 39, 603–628 (2011).

Study design

Students took standard 1st semester and reformed IPLS 2nd semester (different instructors)
- Both courses taught with Peer Instruction lecture (IPLS instructor is more experienced with PI), weekly lab, optional peer-led problem sessions
- First semester: no special framing or content
- IPLS course:
  - organized around biological contexts
  - explicit connections to other science courses
  - adapted PER materials to new content and contexts
  - framing: providing skills to support future work in other sciences/medicine



Data collected:
- *CLASS pre and post for both semesters, BEMA pre and post for IPLS*
- *Student goals for taking course (reported at start of IPLS)*
- *Course evaluation questions about interest and usefulness*
- *Student demographic information (collected separately to avoid stereotype threat)*

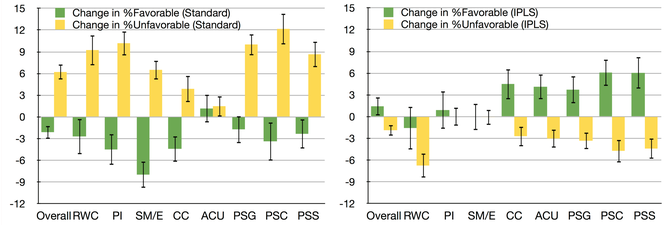


Developed initial physics interest metric (average of 12 pre-CLASS items scored on 5-point scale), based on developmental model of interest
- Divided class into low (bottom quartile), medium (middle half), and high (top quartile) initial interest
- CLASS pre-scores (5-point scale) track initial interest, including categories with little overlap with interest metric
- Student goals follow initial interest: high initial interest = learning material, low = meeting requirement

Data collected in 2011-12 and repeated in 2012-13
Had significantly greater IPLS enrollment in 2011-12 (N = 75) than in 2013 (N = 38) because of uncertainties in schedule
Same trends and conclusions from 2012-13 data though some details differ; here we report 2011-12 results.

CLASS results: low initial interest group improves most

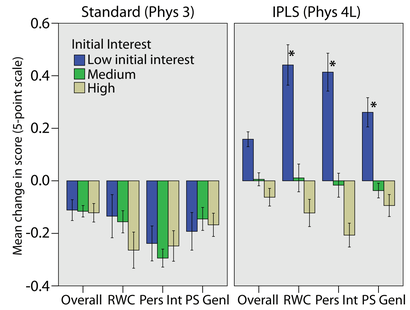
CLASS scores decline in standard course, hold steady or improve in IPLS course



In standard course, absolute scores are similar to those reported by Adams *et al (PRST-PER* **2***,* 010101 (2006))

Demographics do not appear to matter:
- Two-way repeated measure ANOVA shows no effect ($p < 0.05$) of major, math or E&M background (BEMA pre)
- Females respond less expertly in problem solving, but gender does not affect *changes* in responses either semester

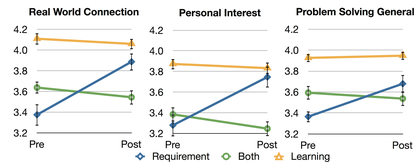
In 2012, IPLS students with low initial interest improve significantly; in standard course all decline



Scoring on 5-point scale facilitates interpretation and significance testing

2013 low interest group differs somewhat, but is much smaller (N = 6): see companion poster

Students with goal of meeting requirement likewise gain the most



Category	All students: Traditional (*n*=76) % Fav	% Unfav	Mean Change	IPLS (*n*=57) % Fav	% Unfav	Mean Change	Matched data (*n*=37): Traditional % Fav	% Unfav	Mean Change	IPLS % Fav	% Unfav	Mean Change	IPLS (Post to Post) % Fav	% Unfav	Mean Change
Overall	-3.0*	4.9***	-0.12***	1.4	-1.3	0.03	-2.1	6.2**	-0.13**	1.4	-1.9	0.02	-1.6	-4.3*	0.09*
Real World Connec	-4.1	6.9**	-0.19**	0.2	-6.4*	0.06	-2.7	9.2*	-0.17	-1.6	-6.8*	0.01	-2.9	-10.1*	0.11
Personal Interest	-7.5**	9.2***	-0.28***	1.0	-2.6	0.02	-4.5	10.2**	-0.24**	0.9	-0.0	-0.05	-2.1	-6.2	0.06
SenseMaking/Effort	-8.6**	8.3***	-0.27***	-1.1	1.5	-0.04	-8.0*	6.5*	-0.14***	0.0	-0.1	-0.03	-0.2	-0.3	-0.01
Concep Connect	-1.3	1.7	-0.05	5.2	-1.6	0.08	-4.4	3.9	0.01	4.5	-2.7	0.07	5.8	-4.8	0.17*
Appl Concep Underst	2.6	0.3	0.02	7.3**	-1.5	0.11*	1.2	1.5	-0.17	4.1	-3.0	0.08	3.3	-3.0	0.12*
Prob Solv Genl	-5.1	7.4**	-0.16*	1.3	-1.2	0.03	-1.7	10.0**	-0.18*	3.7	-3.3	0.04	8.1*	-6.6**	0.16*
Prob Solv Confid	-5.9	6.8*	-0.16*	3.6	-2.0	0.05	-3.4	12.2**	-0.18	6.1	-4.7	0.06	12.8*	-6.1	0.21*
Prob Solv Sophist	-5.3	8.0*	-0.18*	8.4**	-2.2	0.11	-2.3	8.6*	-0.15	6.0	-4.4	0.07	8.8*	-7.7*	0.20**

Interpretation and further work

Interest dependence of findings and course evaluation suggest improvement may be attributable to biological contexts

Course evaluation: students consider physics more useful for the life sciences after IPLS ($p < 0.001$)

"At the beginning of this course, I expected physics to be:
- very useful in understanding the life sciences — 21%
- somewhat useful in understanding the life sciences — 57%
- of little use in understanding the life sciences — 24%

"Now at the end of this course, I consider physics to be:
- very useful in understanding the life sciences — 55%
- somewhat useful in understanding the life sciences — 43%
- of little use in understanding the life sciences — 1%
- of no use in understanding the life sciences" — 1%

"I often found myself thinking, 'Oh, that's how it really works,' because I'd never thought about the physics behind some of the biological concepts I'm very familiar with."
—course evaluation comment, junior biology major

2013 only: students rated the course more interesting (4.5 ± 0.1, 4 = somewhat more interesting, 5 = much more) and more useful (4.3 ± 0.1) than it would be without the biological contexts

"I wanted to tell you how well Physics 4L prepared me for my summer research.... The [work] we did [in class] modeling the cell membrane as a capacitor and the discussions we had about neurons as parallel circuits really prepped me for the more complicated things we have been discussing here. Recently we've been calculating currents through membrane potassium and sodium channels and accounting for leakage. Just thought you'd like to hear that your class was a success."
—unsolicited student email

Further work

Examine first semester IPLS
Examine low interest group for reproducibility
Monitor interest development more closely for individual students
Develop strategies to combat the (slight) declines observed from high-interest students (more mathematical or technical life science applications are likely to help)

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