# Features that Support Transformative Experiences in Physics Education


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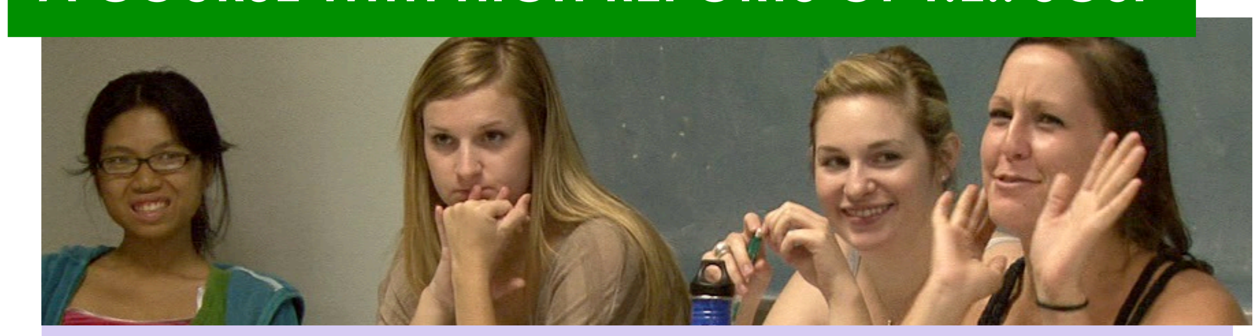
The overall goals of physics instruction are not gains on concept inventories or improved scores on surveys of epistemological beliefs. While these measures provide evidence of science learning, they are proxies for the broader goal of developing scientifically literate citizens and scientists who draw on their physics knowledge outside of classroom settings. These moments–experiences in which **students actively use science concepts to see and experience their everyday world in meaningful, new ways– have been termed "transformative experiences" (TE).** [1] As part of a broader effort to measure TE and understand features that support TE in physics, **we report on a comparison between two classrooms, one with high TE and one with low TE, and propose possible classroom features that generate high measures of TE in physics.**

## WHAT ARE TRANSFORMATIVE EXPERIENCES?

"The majority of our efforts for educating children have focused on transmitting knowledge rather than enriching, expanding, and transforming everyday experience…"

"[We propose] a transformative perspective... in which the goal is to engage students in transformative experiences with science concepts. **Transformative experiences have been defined as those experiences in which students actively use science concepts to see and experience their everyday world in meaningful, new ways."[1,2]**

## A COURSE WITH HIGH REPORTS OF T.E.: SGSI



***Student-Generated Scientific Inquiry*** *(SGSI)* is an undergraduate science course for future elementary teachers. Topics include light, color, and sound - chosen for their intersection with biology and ability to be investigated with simple materials.

Students work in **small groups** to answer questions that arise in response to an initial question or a puzzling phenomenon. As these investigations yield findings and new questions, **whole-class conversations** take place.

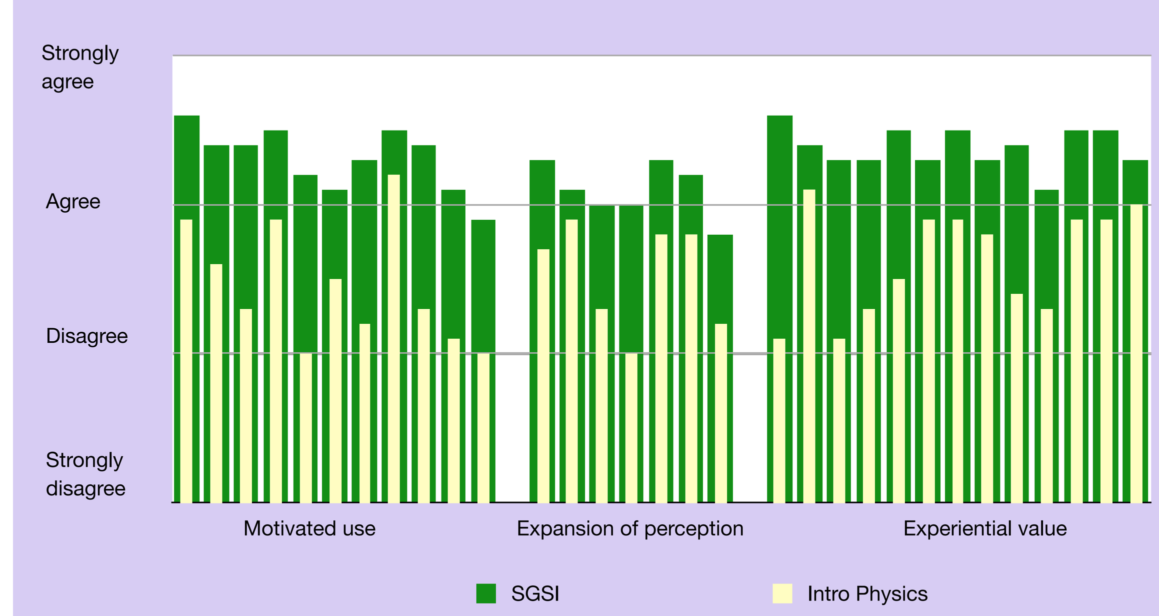
Care is taken throughout the course to emphasize **students' ownership of the curriculum, assessment, and findings.** They develop a rubric for their lab notebooks (based on images of famous scientific notebooks), develop and critique others' ideas and representations, establish norms for representations, and work towards consensus ideas.

## DATA: HIGH INCIDENCE OF T.E.

**SGSI v. Tradiational Insttruction: TE Survey Results**

We compare two courses taught at the same institution that address Snell's Law and lenses. In SGSI, we find high TE scores; in the traditionally taught class (for engineers and scientists) they are much lower. We examine how student reports of TE in the high-TE course give insights into class structures that promote TE. Course data is below:

| | Average, SGSI (n = 22) | Average, Intro Phys (n=38) | difference |
|---|---|---|---|
| **Motivated use** | | | |
| 1. During class, I talk about… | 3.6 | 2.9 | 0.8 |
| 2. I think about…, when I see… | 3.4 | 2.6 | 0.8 |
| 3 Outside of class, I talk about… | 3.4 | 2.3 | 1.1 |
| 4. During class, I think about… | 3.5 | 2.9 | 0.7 |
| 5. I talk about… just for the fun of it | 3.2 | 2.0 | 1.2 |
| 6. Outside of class, I think about… | 3.1 | 2.5 | 0.6 |
| 7. I find myself thinking about… in everyday life. | 3.3 | 2.2 | 1.1 |
| 8. During class, I use the knowledge I've learned about … | 3.5 | 3.2 | 0.3 |
| 9. Outside of school, I use the knowledge I've learned about… | 3.4 | 2.3 | 1.0 |
| 10. I use the stuff I've learned about…even when I don't have to. | 3.1 | 2.1 | 1.0 |
| 11. I look for chances to use my knowledge of…in my everyday life | 2.9 | 2.0 | 0.9 |
| **Expansion of perception** | | | |
| 12. During class, I see things in terms of the laws I've learned about… | 3.3 | 2.7 | 0.7 |
| 13. When I am working on a class assignment about… I tend to think of them in terms of… | 3.1 | 2.9 | 0.1 |
| 14. If I see a really interesting situation..., then I think about it in terms of… | 3.0 | 2.3 | 0.7 |
| 15. I can't help but see situations in terms of the laws of… | 3.0 | 2.0 | 1.0 |
| 16. During class, I notice examples of… | 3.3 | 2.8 | 0.5 |
| 17. I notice examples outside of class of… | 3.2 | 2.8 | 0.4 |
| 18. I look for examples outside of class of… | 2.8 | 2.2 | 0.6 |
| **Experiential value** | | | |
| 19. Learning about…is useful for my future studies or work. | 3.6 | 2.1 | 1.5 |
| 20. Knowledge of…helps me to better understand the world around me. | 3.4 | 3.1 | 0.3 |
| 21. Knowledge of… is useful in my current, everyday life. | 3.3 | 2.1 | 1.2 |
| 22. I find that knowledge of…makes my current, out-of-school experience more meaningful and interesting. | 3.3 | 2.3 | 1.0 |
| 23. Knowledge of…makes learning physics much more interesting. | 3.5 | 2.5 | 1.0 |
| 24. In class, I find it interesting to learn about… | 3.3 | 2.9 | 0.4 |
| 25. I think…is an interesting topic | 3.5 | 2.9 | 0.7 |
| 26. I find it interesting in class when we talk about… in terms of… | 3.3 | 2.8 | 0.6 |
| 27. I'm interested when I hear things about…outside of school | 3.4 | 2.4 | 0.9 |
| 28. I find it exciting to think outside of school about… | 3.1 | 2.3 | 0.9 |
| 29. The ideas we learned changed the way I see… | 3.5 | 2.9 | 0.6 |
| 30. I think about…differently now that I have learned about… | 3.5 | 2.9 | 0.5 |
| 31. I pay more attention to…now. | 3.3 | 3.0 | 0.4 |

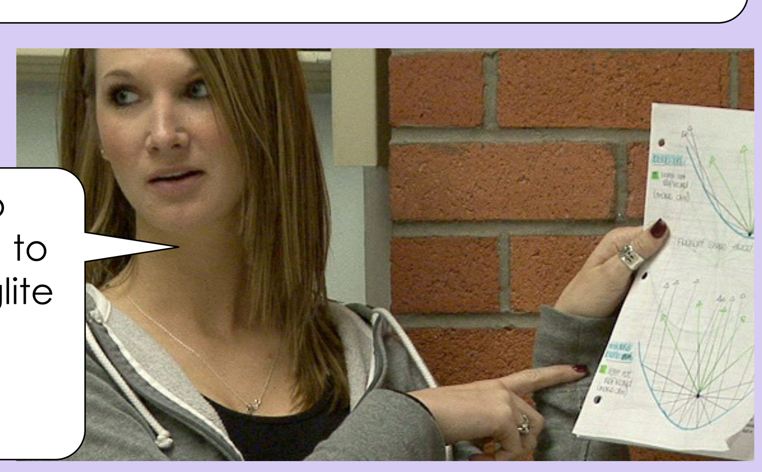



# What do transformative experiences in SGSI look like?

## SHARING IDEAS WITH FRIENDS & FAMILY

Students overwhelmingly report sharing ideas from class at home on breaks, and with friends between classes. Some note that their peers have asked them to *stop* mentioning class so often. Many express pride in their ability to share and explain ideas in this way.

"It was absolutely awesome when my husband started asking me stuff about the eye and I was able to really explain things to him. That never happens with sciencey-type stuff!"

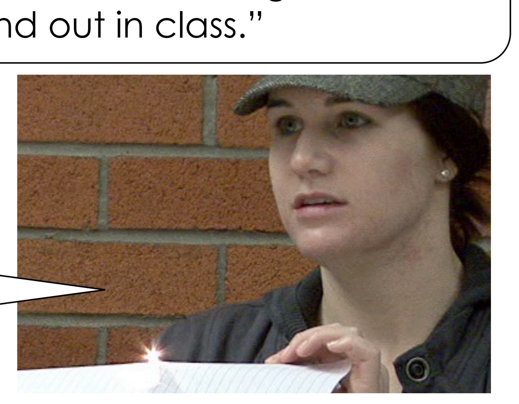


"During a camping trip this summer, I explained to my friends why my maglite projected a dark spot surrounded by different rings of intensity."

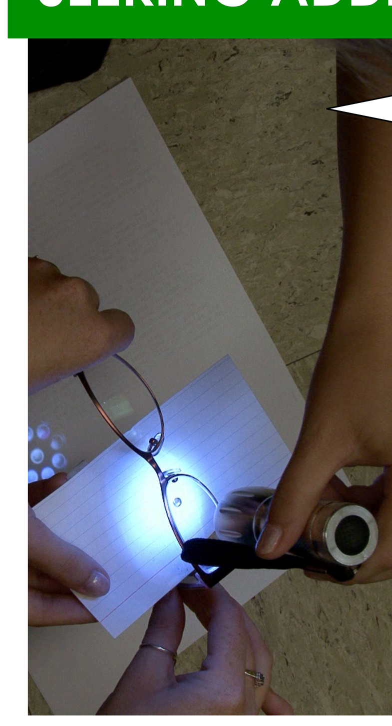
## EXPLAINING EVERYDAY PHENOMENA

"I was just thinking about how the light was hitting, reflecting off, and passing through my wind shield as I was driving to work. Then I started applying our rules to the glass, and making connections to things that we found out in class."

"…Now that I know for certain that we see something because the light rays carrying that image hit our retinas, the fact that I can see stars is crazy!"



## SEEKING ADDITIONAL DATA



"…our group is working on the idea of how glasses …change the shape of your cornea to balance out a person's misshapen cornea. We thought people with near sighted vision need glasses with thicker glass on the sides and that people with far sighted vision need glasses with thicker glass in the center. However, we only knew what near sighted glasses looked like. …When I was at Walgreens the other day, I saw reading glasses and decided to investigate. And sure enough, the glasses were thicker in the center and as the intensity of the prescription increased, so did the thickness of the center. I was so proud of our group to turn out correct!"

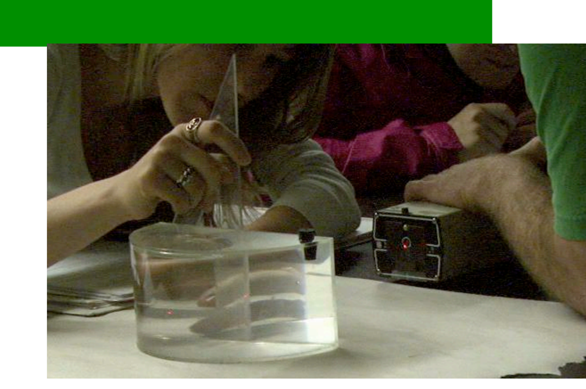
## PROBLEMATIZING EVERYDAY PHENOMENA

"…whenever I go outside I wonder about… how a squirrel sees, how a bird sees, if bees see more types of light then we do… It is so absorbing!"

"I went to a movie and I thought 'I wonder if that projector has a little cornea and lens in it…'"

"I'm still a little confused as to why one side [of a spoon] flips the image and the other does not. I find myself thinking, 'Ok Maddy, now how do the light rays travel from the light to the spoon to my eye on the inside of the spoon…?'"

## FUTURE DIRECTIONS



1. Look beyond traditional instruction to courses with interactive engagement and strong learning gains.
2. Examine longer time scales: once the engineers and scientists enter upper division courses and their profession, do they begin to draw on these ideas in those settings? When the SGSI students enter their teaching professions, do they continue to draw on these ideas?
3. Develop case studies that detail in- and out-of-class experiences and provide a strong narrative of the trajectory of ideas from one space to another.
4. Interview students with low TE scores (from traditional and reform courses) regarding their *imagined* TE: do they expect that people who see science in their everyday lives do so in ways consistent with their schooled practices?
5. Are there effective simple interventions, such as using everyday objects instead of Pasco equipment, that can affect TE scores?

# Out-of-class TEs are rehearsed in in-class experiences

The examples of TE that students offered in a free-response section of the survey suggest that their experiences using science outside of the classroom are strongly 'rehearsed' inside the classroom. In class, **sharing ideas with one another** comprises most of our class discussions and classroom talk; we **use everyday objects** in our investigations and - from these - seek to **explain everyday phenomena**; students are frequently seeking out **additional data** and, at time, must do so out of the classroom. Rather than viewing out-of-class lives and spaces as places that prepare (or fail to prepare) for school, we suggest that instruction should imagine the classroom as a rehearsal space for out-of-class lives.

Notable is what kinds of transformative experiences we can imagine but are not present. Students do not report traditional problem solving experiences in which they use ideas to calculate an unknown value; they do not report consulting textbooks or attending talks; they do not indicate that they run an 'experiment' in the "scientific method" sense. Such experiences are absent from both in- and out-of-class settings.

In contrast, the traditionally taught students joke when told about the point of the survey — with one student reporting to his lab group, "the air drag caused by me riding my bicycle causes my beard hairs to deflect 13 degrees towards my neck." Their *imagined* TE is continuous with their classroom experience, in which they seek and report values devoid of much context, and discontinuous with their actual out-of-school lives.

* student quotes are not necessarily from the students pictured; images illustrate how their statements regarding out-of-class experiences connect to in-class activities.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