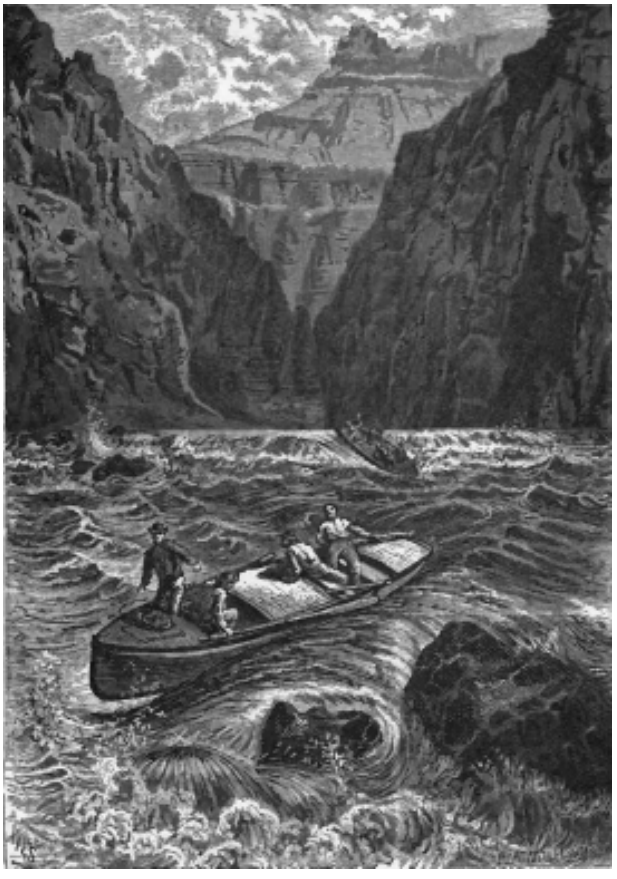
Having the Journey:

Physics Education and Transformative Experiences

On August 13th, 1869 John Wesley Powell stood at the junction of the Colorado and the Little Colorado rivers. Below him stretched the unexplored Grand Canyon. Powell recorded these words in his journal, "We are now ready to start our way down the Great Unknown…We have an unknown distance yet to run; an unknown river yet to explore. What falls there are, we know not; what rocks beset the channel, we know not; what walls rise over the river, we know not. Ah, well!" (Powell, 1875, p. 80). Powell and his crew then embarked on a remarkable journey through the Grand Canyon. Somehow they survived and Powell published various reports containing a wealth of information about distances, directions, elevations, landmarks, rapids, navigation strategies, and so forth. The most famous account was his 1875 report to the Smithsonian titled, *Exploration of the Colorado River of the West and its Tributaries*. This report is worth reading for its own sake, but its greatest worth can be found in the journeys it made possible for future explorers and thrill seekers. In an introduction to a 1987 edition of the report, Wallace Stegner wrote, "Nearly everyone who runs any part of the canyons now…either carries this story of Powell's in his duffelbag or has it read or recited to him around the fire while the tamed Colorado slips past" (Powell, 1997, p. xii).



Thanks to Powell and many subsequent explorers, I was able to take my own rafting journey through the Grand Canyon. It was awesome in every sense of that word. Like I said, Powell's report is worth reading for its own sake, but it's no substitute for the actual journey it makes possible. The journey is what it's all about.

And that is the focus of my talk today: *having the journey*. The premise for this talk comes from a metaphor that John Dewey proposed over a century ago. At the time, there was debate about whether education should be structured around an orderly curriculum or the experiences of the unique child (sound familiar?). Dewey thought the whole argument was misguided and felt there was no need to oppose experience against the curriculum. Instead, he compared the curriculum to a map constructed from the experiences of explorers and stated,

> *The map is not the substitute for a personal experience. The map does not take the place of an actual journey…But the map, a summary, an arranged and orderly view of previous experiences, serves as a guide to future experience* (Dewey, 1990/1902, p. 198)

John Wesley Powell's *Exploration of the Colorado River of the West and its Tributaries* is not a substitute for personal experience. It does not take the place of an actual journey. Instead, it is a guide for having a journey. Likewise, the curriculum, is not—or should not—be a substitute for personal experience. Instead it should be a guide for having a journey.

There are at least two meanings to "having the journey." One meaning is that students have a journey with the curricular content when they get to engage in the type of discovery that the original explores experienced. That is, they get to engage in inquiry experiences, using the great ideas of the past as guides for current exploration within a domain such as physics. A second meaning is that students use the curricular content as a guide for seeing and experiencing the world differently in their everyday, out-of-school lives. It is this second meaning that I focus on in my research, and I refer to these types of journeys with curricular content as transformative experiences. Let me give you some examples.

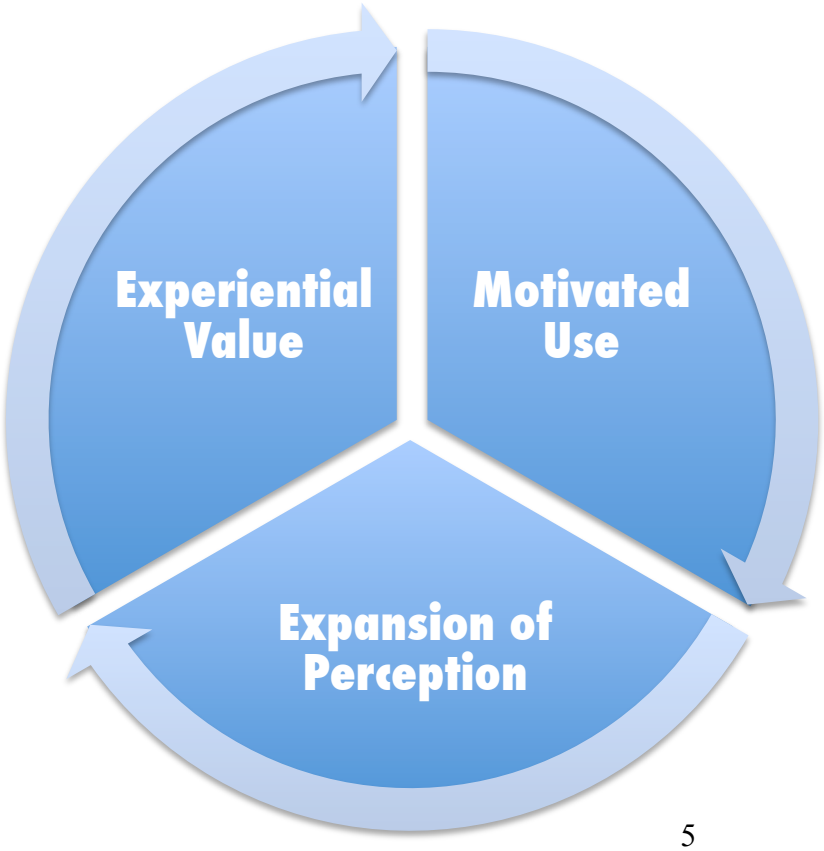
Last year I went to see the latest James Bond movie with my family. After the movie, I mentioned something about the number of movies featuring a fight on top of a train and questioned whether a fight on a train has ever really happened in real life. My daughter, a physics major, commented, "Yeah. I was wondering if there is a large enough coefficient of friction to keep you from flying off the train." And on she went analyzing the physics of the situation. I should say, this is not uncommon for her. She sees the world through the lens of physics and finds great meaning in doing so. Physics isn't just something she learns about. Physics is something she experiences, something she lives. Learning physics, for her, is transformative.

She's not the only one. A number of years ago I interviewed some middle school students about their experiences with physics in their everyday, out-of-school lives. This was during the context of a unit on inertia and Newton's Laws. As you might guess, many students said they never really thought about the physics ideas outside of class. But some did. One student, whom I call Ed, provided a number of examples of seeing the world through a physics lens. My favorite example was when he described a visit to his home by his niece. She came tearing into the kitchen and, when she tried to come to a halt, her socks slid on the wood floor and she kept sliding right through the kitchen into the door. Ed was thrilled by this whole event because it was such a great example of an object in motion continuing in motion. I mean, here's this poor girl sprawled on the ground and Ed is just thinking, "Physics works!" He had a number other examples like this. Ed was an example of someone having the journey. He was using physics as a guide for seeing and experiencing the world in a new way. This is a transformative experience.

This learning perspective focusing on transformative experiences comes from Dewey's (1980/1934) aesthetics in a couple ways. First, the qualities I use to define a transformative experience are adapted from the characteristics Dewey used to define an aesthetic experience. Second, the overall gist is in line with Dewey's purpose of studying aesthetics. Dewey was concerned that, as the arts were becoming formalized, they were becoming disconnected from everyday experience. He feared that the arts would become isolated in the museum, concern hall, or theater and, consequently, lose their potential to enrich and expand everyday experience – which is the whole point of the arts according to Dewey. The same concern applies to education (and Dewey's philosophy of education in particular). As learning has become formalized, there is a danger that it will become ever more isolated in the classroom and disconnected from

everyday experience. The Las Vegas slogan applies all to well to education: *What Happens Here Stays Here*. The transformative experience perspective focuses on re-establishing the connection between in-school learning and out-of-school experience.

For research purposes, I define a transformative experience in terms of three characteristics: motivated use, expansion of perception, and experiential value. *Motivated use* means students apply their science learning even when they don't have to. For instance, Ed did not have to think about his niece in terms of Newton's Laws of motion. This was not part of a school assignment. It wasn't a work-related problem-solving situation. He simply chose to do so. *Expansion of perception* means students come to see aspects of the world in a new way. Ed came to see events of motion in a new way. In fact, he commented, "I can look at, like, when two cars crash into each other, I can look at that in a different way, and when I watch a movie I can look at that in a different way. Now I'm going to see things that I'm used to seeing in a different way" (Pugh, 2004, p. 189).

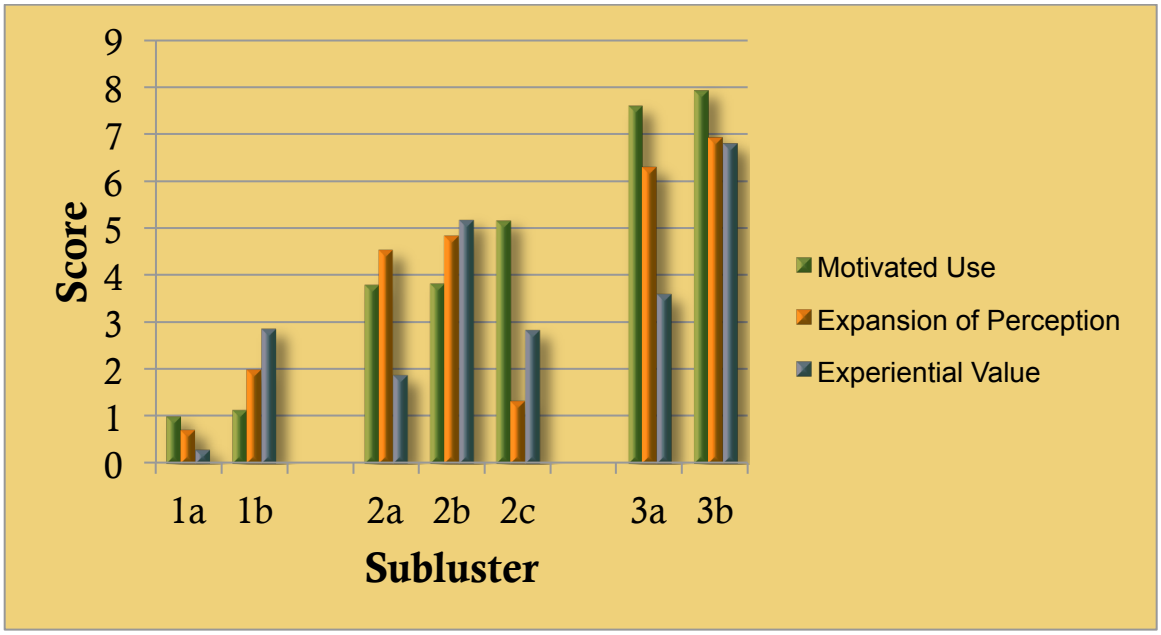


Experiential value refers to valuing the content for the way it enriches and expands everyday experience. Ed came to value Newton's Laws because they allowed him to see events in his everyday life in a new way.

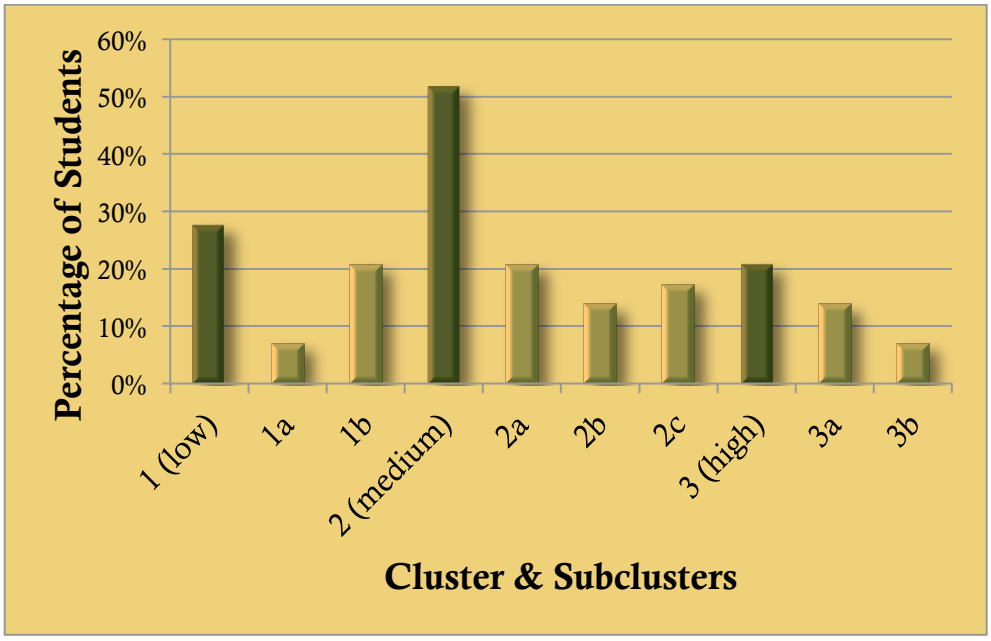
My own bias is that the focus of science education should be on helping students have transformative experiences with the science content we teach; that is, the focus should be on helping students undergo the journey. I think we worry too much about whether they *know* the content and not enough about they *experience* it. It is as if all we care about is how well they can read the map and not whether they use the map to have an actual journey. Being able to read the map is critical, obviously. But I mean, seriously, if we want students to use science in everyday life and pursue careers in science, they need to experience the journey. Regarding that second point, I have recent data that backs this up. I'm involved in an NSF grant looking at the recruitment and retention of women in the geoscience. One of the results we found is that transformative experience is an important predictor of one's inclination toward majoring and pursuing a career in the geosciences even when controlling for initial interest and self-efficacy in the geosciences. The results are particularly strong for female students.

And it is not a choice between content learning or transformative experiences. We have consistently found that students who under transformative experiences display greater learning on deep level outcomes like transfer and conceptual change and they are less likely to loose their learning or revert to prior misconceptions (Girod, Rau, & Schepige, 2003; Pugh, 2002; Pugh, Linnenbrink-Garcia, Koskey, Stewart, & Manzey, 2010a; 2010b; Pugh, Schmidt, Russell, & Heddy, 2010).

Unfortunately, in other research, we find that most K-12 science students do not undergo transformative experiences and non-majors in college only have moderate levels of transformative experience.



This slide illustrates some data from a recent study (Pugh, Bergstrom, Spencer, 2011). We interviewed students in 6th grade earth science classes and scored them in terms of levels of motivated use, expansion of perception, and experiential value. We then used cluster analysis to identify groups of students varying in their levels of transformative engagement. Overall, we found a low, medium, and high cluster, with variation by subcluster. For instance, in the high cluster (3), we have a group of students (3a) who applied their learning and saw the world differently, but they didn't highly value this new way of seeing and experiencing the world. On the other hand, this group (3b) did value their new way of seeing and experiencing the world. This group represents true engagement in transformative experiences.

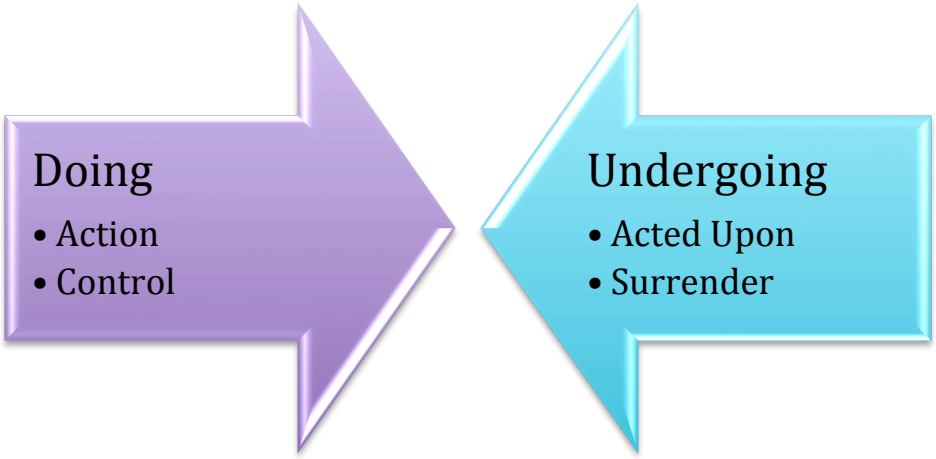


Now, this slide shows the percentage of students in each cluster and subcluster in a typical science classroom. As you can see, only about 20% of the students are in the high cluster and only 7% are in the genuine transformative experience group (3b). For most students, the learning isn't very transformative.

Why Don't Students Have Transformative Experiences?

Or why *do* some have transformative experiences? First, a deviation. We almost exclusively define the ideal student as someone who is rational, reflective, metacognitive, autonomous, active, and in control. That is, the student is able to suppress impulse and emotion with reason and logic. The student is able to step back from a situation and hold it at a reflective distance. And the student is self-determined, self-directed, self-regulated, self-efficacious, and self-controlled. However, this emphasis on the rational, controlled self as the ideal student is only half the picture.

What's the other half? To put it bluntly, the other half if a Burning Man festival. I've never been brave enough to attend, but from what I hear, Burning Man is the opposite of reason, reflection, and self-control. It's exuberance and expression and passion. As wild as these forces are, they may be necessary for transformation. This is a point Dewey (1980/1934) made in his theory of aesthetic experience. Aesthetic experience involves both doing and undergoing. The doing is the part where we are in control, the active, rational self. The undergoing is the part where we are acted upon by the environment. It requires surrendering to the experience.



Let me see if I can explain. I love my daughters. They are great kids. But they are the worst movie-watching companions ever. They critique and mock the movie the whole way through. As a result, I am constantly being pulled out of the experience so I can't surrender to it.

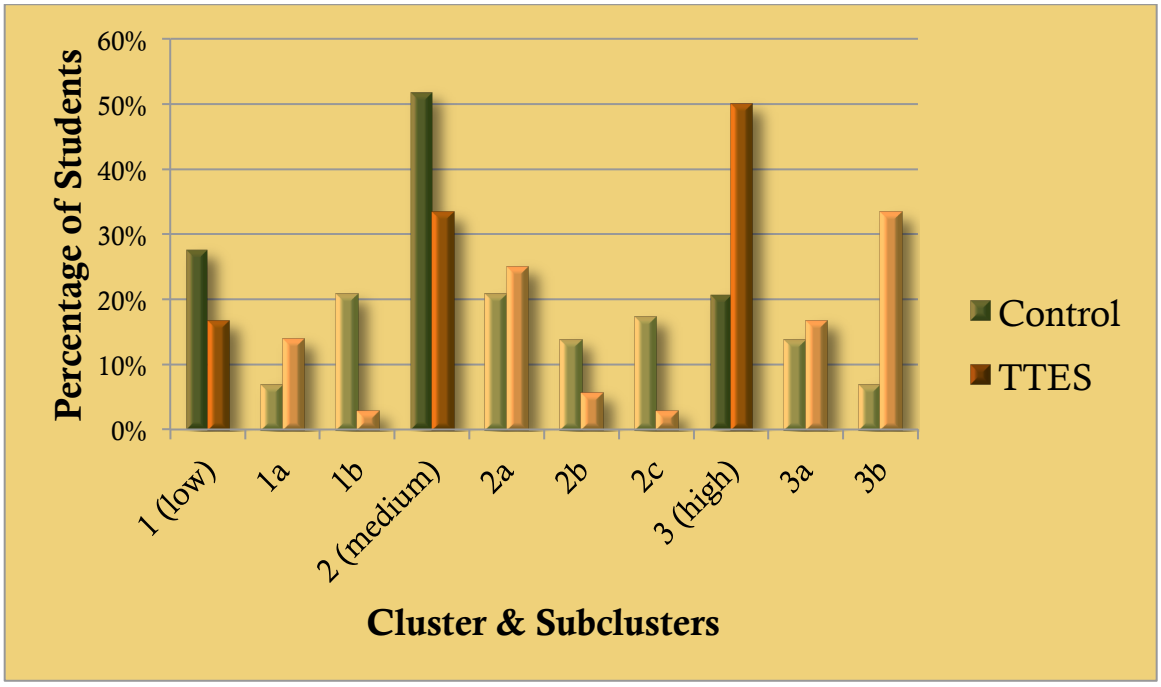
Without surrendering to it, I can't be moved by it. And without being moved by it, I can't be transformed by it. The same applies to classroom learning experiences. To be transformed, you have to surrender to the experience. Unfortunately, there are many forces that are constantly pulling students out the experience and interfering with their willingness to surrender.

What are some of these forces? (1) **Peer judgments**. Often students are so worried about what other students will think of their actions, that they can't let go and just be part of the learning experience. This can be particularly true in the sciences and particularly for females.

They don't want to be seen as science geeks or math nerds. Of course, some students wear their science geek badge with pride. My daughters are this way. They take joy in being science geeks. Gee, I wonder where they get that from?

(2) **The evaluation culture**. Often students can't surrender to the experience because they are constantly focused on their knowledge being evaluated. They are constantly stepping out of the experience and asking questions like, "Will this be on the test?" "Did I do it right?" and "What will my grade be?" Imagine if we obsessed over measuring and evaluating movie-goers' knowledge the way we do students' knowledge. How would you ever get anything out of movie knowing the main purpose of watching the movie is to be tested on it?

The good news is that we can counteract these forces and deliberately teacher for transformative experiences. Let me go back to the slide illustrating the low prevalence of transformative experience and let me add in the data from an intervention focused on teaching for transformative experiences. As you can see, the percentage of students in the high cluster jumps way up and the percentage of students undergoing genuine transformative experiences (3b) is over 30%. That's much better!



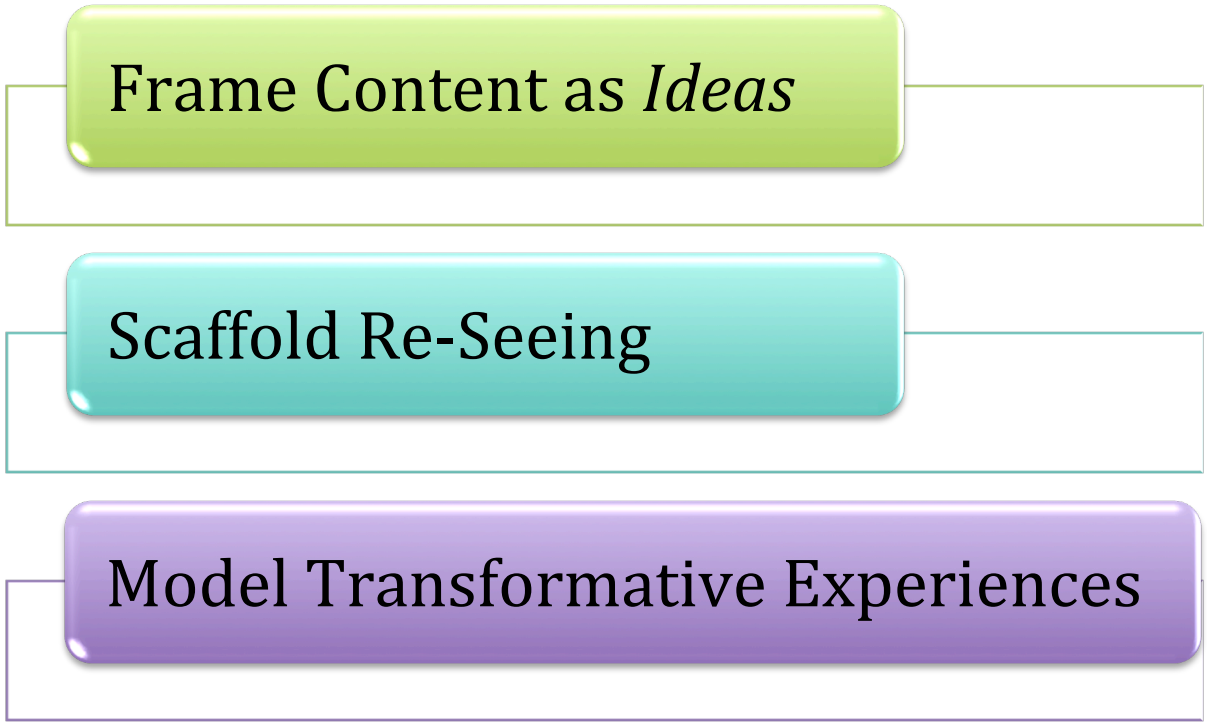
So how do you teach for transformative experiences? I don't think there is one right way, but my colleagues and I (Girod, Rau, & Schepige, 2003; Girod, Twyman, & Wojcikiewicz, 2010; Pugh, 2002; Pugh & Girod, 2007; Pugh, Linnenbrink-Garcia et al., 2010b) have been researching this question and we've developed a model we call the Teaching for Transformative Experiences in Science or TTES model. Not only have we found that his model helps foster transformative experiences, but it helps foster deeper and more enduring learning too.

As an aside, I would like to say that nearly all the science teachers I work with already have a goal of making learning transformative and some strategies for achieving this goal. This is

one of the things I love about teachers. They are always working to make a difference in the lives of students. I see the model we have developed as another tool teachers can draw on. Something that helps them achieve a goal they are already pursuing. As one teacher put it, creating transformative experiences "was something that was in the back of my mind, and a goal of mine subconsciously, but never really intentionally brought out." The model helped make a fuzzy goal more intentional and achievable.

Teaching for Transformative Experiences in Science

The Teaching for Transformative Experiences in Science (TTES) model consists of three main strategies: (1) framing content as ideas, (2) scaffolding re-seeing, and (3) modeling transformative experiences. The model was developed within a K-12 context, however, many of the principles generalize to the college level.



Framing the Content as *Ideas*

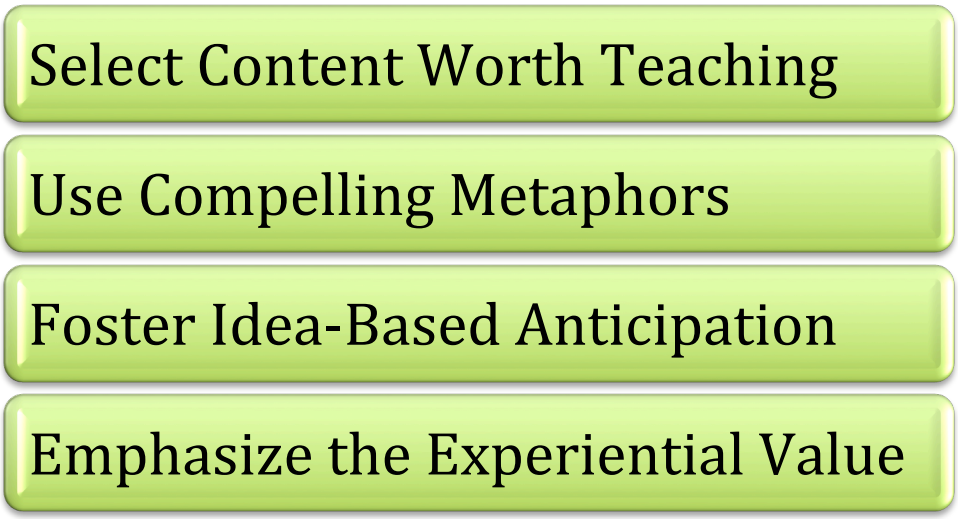
Framing is a method for establishing particular student orientations toward learning (Engle, Nguyen, & Mendelson, 2011; van de Sande & Greeno, 2010; Watanabe, 1993). In the Teaching for Transformative Experiences in Science model, framing is used to establish a perspective of learning as engagement with *ideas*, in the Deweyan sense of the term. Let me explain. Dewey (1986/1933) distinguished between concepts and ideas. Concepts are established meanings. Ideas are possibilities. Typically we frame content as concepts; that is, as established meanings that students need to know to pass the class and do well on some test. We should frame the content as *ideas*. That is, as possible ways of seeing, experiencing, and making sense of the world. As possibilities that need to be tried out in everyday experience. We can achieve such framing through a deliberate and artistic crafting of the content (Pugh, 2002).

There is a lot we can learn from artists. They are very deliberate in what they select and how they craft it together. They do so with an eye toward evoking a particular experience. Take Rafael's *School of Athens* as an example. Rafael was very deliberate in what images he selected for this fresco and how he arranged them. First of all, look at this setting. What do you see? We are located in some impossibly high cathedral with open spaces in it leading up into the heavens. The walls are crisp and bright. We have an almost perfected balanced and harmonious composition. And we have a series of arches leading back and centering on these two figures. Who are they? Plato and Aristotle. Note that they, like the other figures, are painted in a sculptural style. Their clothes have smooth, flowing lines; looking almost polished. The style is reminiscent of the sculptures of Greek gods. In fact the whole scene, with its expanse of space, its harmony and balance, and its light gives an impression of a temple for the gods. But it's not

the gods who are placed there. It's us. It's the great human thinkers. It's as if Rafael is saying, "We are the gods now." That is the experience he evokes. At least for me.

Rafael's *School of Athens*

As teachers, we can likewise be artistic in our selecting and crafting. Here are a few strategies: (1) select content worth teaching, (2) use compelling metaphors, (3) create idea-based anticipation, and (4) emphasize the experiential value.



Select content worth teaching. Not everything is worth teaching and some content is more worthwhile than other content. If we want learning to be transformative, we need to focus on the powerful content; that is, the content with the most potential to become a compelling idea for students. When I was in graduate school, we used to spend a lot of time sitting around and discussing what makes for a compelling idea. We never did come up with a definition and I'm not sure we ever could. A compelling idea might be the sort of thing we can't define but we know it when we see it. Nevertheless, there are some qualities we can point to. One, compelling ideas are often associated with the core concepts. These core concepts are inherently powerful because they have very broad explanatory power. But just because we have a core concept does not mean we have a powerful idea. Compelling ideas yield new insights; that is, new understandings and new ways of thinking about the world. Some core concepts are not

compelling ideas because they have become so commonplace they fail to yield anything new. For example, the heliocentric model of the solar system is certainly a core concept, and it once was a very, very compelling idea. But now it is so commonplace that it doesn't yield much in the way of new thoughts and understandings. Compelling ideas also generate an emotional response. It might be excitement, it might be dissonance, it might be anticipation. There is some sort of emotional reaction. This emotional reaction is perhaps what defines it as compelling. Finally, compelling ideas have, what the late Jere Brophy (2008) referred to as, strong affordances for self-relevant applications. He proposed that some content is more relevant to the everyday lives of students than other content. He argued that a lot of what we teach is low in terms of self-relevant applications and we should cut it out of the curriculum so there is more time to teach compelling ideas. I agree.

So to summarize, we should select content worth teaching by considering what content has the potential to have broad explanatory power, yield new insights, evoke an emotional response, and afford self-relevant applications. Once we have selected content with the potential to be compelling ideas, we need to craft the presentation of this content in compelling ways. One way to do this is through the use of engaging metaphors.

Use compelling metaphors. Metaphors denote possible relationships between something unknown and something known. As possibilities, metaphors help frame the content more as ideas than concepts. In fact, metaphors are a great way of transforming established concepts into engaging ideas. For example, a geology unit typically involves the presentation of the established concepts of rock identification and classification. Girod and Wong (2002) used a metaphor to reframe this content as a compelling idea. Instead of presenting rock identification and classification as the purpose of the unit, they presented this metaphor: "Every rock is a story

waiting to be read by those with the knowledge to read them. I am going to teach you how to read the stories hidden the rocks." This simple metaphor transformed geology from a set of established concepts that need to be learned to an idea, a possibility: "Really? Rocks have stories? I can learn to read the story of a rock?" In fact, one girl commented in an interview, "I think about rocks differently than I did before. Now when I don't have anything to do, I look at a rock and try to tell its story. I think about where it came from, where it formed, where it's been, what its name is...I used to skip rocks down at the lake but now I can't bear to throw away all those stories!"

Create idea-based anticipation. In many ways, anticipation is what defines an idea. When you have a great idea, you immediately anticipate putting this idea into action, "I have a great idea, what if…?" I use the term *idea-based* anticipation to indicate that the anticipation needs to stem from an idea, not some peripheral aspect of the classroom.

Just as a novelist may craft text to create anticipation, so the teacher may craft activities or dialogue to create anticipation about the potential of the ideas to be learned. That is, potential to see and understand the world differently or potential to solve a relevant problem. Someone whom I think did this well is Walter Lewin, an emeritus physics teacher at MIT. For example, he begins one lecture by saying,

> All of you have looked at rainbows, but very few of you have ever seen one. Seeing is different than looking. Today we are going to see a rainbow. Your life will never be the same. Because of your knowledge, you will be able to see way more than just the beauty of the bows that everyone else can see. (Rimer, 2007, p. 2)

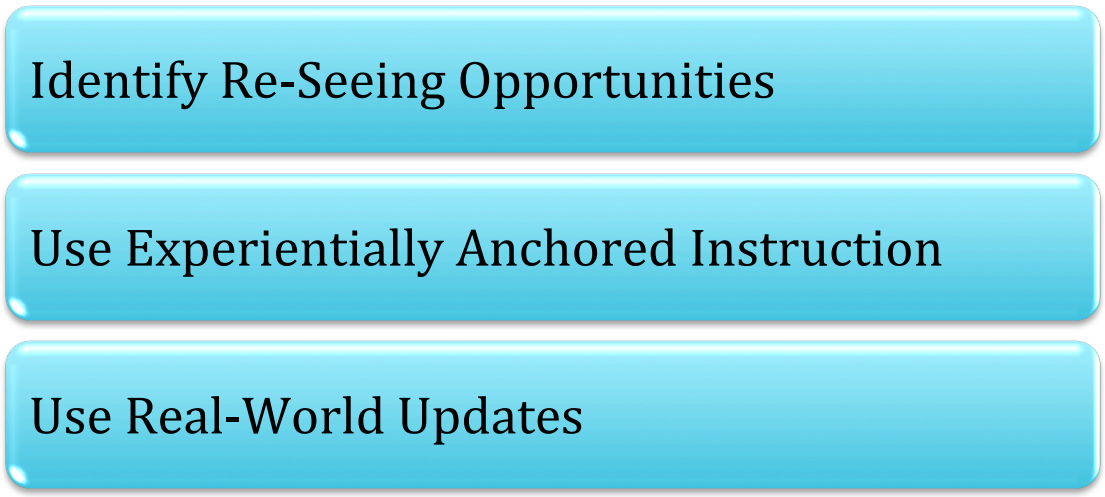
I love that! He doesn't just say we are going to learn about Snell's law and the physics of light. He gets us anticipating the marvelous experience that comes from seeing the world through the lens of physics.

Emphasize the experiential value. Finally, we can frame the content as ideas by emphasizing the experiential value of the content; that is, the value of the content in everyday experience. Too often we fail to focus on the relevance of the content for transforming the way students see and experience the world (Brophy, 2008). Instead, we focus on the utility of the content for passing the class or pursuing a career. Consequently, we unintentionally frame the purpose of learning to be success at school tasks or (in the K-12 context) preparation for a future career instead of the enrichment of everyday experience. If we want the learning to be transformative now, we need to focus more on the latter.

Most teachers do address the relevance of content to students' lives, but often this is in the background instead of the foreground. Let me explain by again making referring to Walter Lewin. His lecture on rainbows (MIT World, 2002) is not a lecture on physics that has some applications to rainbows. It is a lecture on the beauty of rainbows make possible by an understanding of physics. Seeing the beauty of the rainbow is moved from being an afterthought to the forefront. The lecture is framed centrally around the purpose of seeing the beauty of a rainbow. That makes all the difference.

Scaffolding Re-seeing

Re-seeing is another term for expanding one's perception. It refers to going beyond one's current perceptions of everyday objects and viewing them through the lens of a new idea (Girod et al., 2003). Scaffolding refers to supports that aid individuals in accomplishing tasks and is a key component of apprenticeship models used to help students appropriate ways of thinking and acting (e.g., Brown, Collins, & Duguid, 1989; Newman, Griffin, & Cole, 1989; Palincsar & Brown, 1984). Even when students engage with content as ideas, they may struggle to effectively participate in re-seeing because they lack the cognitive skills to see the world through the lens of the content in a sophisticated way. Thus, scaffolding is needed to support students in re-seeing efforts until they can do so on their own. Teachers can scaffold re-seeing by (1) identifying re-seeing opportunities, (2) using experientially anchored instruction, and (3) using real-world updates.

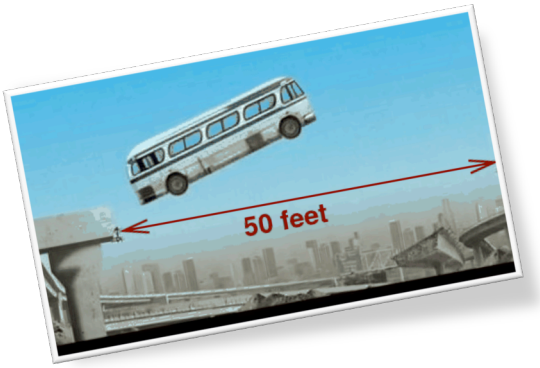


Identify re-seeing opportunities. Students are often unaware of the many objects, events, and issues in the world that can be re-seen through the lens of physics. When teaching a unit, it is worth sitting down and taking the time to think through what aspects of the world can be re-seen through the lens of the particular unit content. Take Newton's Laws of Motion as an example.

Life is full of events of motion and thus there are endless possibilities for seeing the world through the lens of Newton's Laws. But students don't realize this. They don't make the connection between the frictionless environments we talk about in class and their everyday experiences. Here are some re-seeing opportunities we could help them identify:

- Sports. Sports are full of events of motion. We can find out which sports our students are into and then help them identify opportunities for re-seeing specific events within each of these sports. Like skiing. I remember often trying to analyze the physics of skiing when taking a physics class in college. Once I collaborated with a teacher during the winter Olympics. It was great because there were so many re-seeing opportunities going on. Not just skiing, but things like why can't you have extra weight in your bobsled?

- Movies are another good opportunity. What movies are popular with the kids? What events in these movies can be re-seen? What events defy the laws of physics?



- How about a trip to the amusement park? Now there's some events of motion and some great opportunities for re-seeing!

The point is that there are numerous opportunities to re-see the world through the lens of Newton's Laws of motion. But you have to point these out to students and identify opportunities that are relevant to the students' lives.

Experientially anchored instruction. The Cognition and Technology Group at Vanderbilt (1992) used the term "anchored instruction" to refer to instruction that was "anchored" (i.e., situated) in authentic problem-solving environments. We have adapted this strategy to focus on anchoring instruction in students' own everyday, out-of-school experiences, hence, the term *experientially* anchored instruction. We developed this strategy in collaboration with a middle school science teacher in an effort to support greater cognitive engagement in re-seeing activities. We've found that students often get excited about re-seeing but their re-seeing is often at surface-level. For example, they might get excited talking about a rollercoaster as an event of motion but avoid a deep analysis of the physics.

Experientially anchored instruction involves three steps: (1) having students identify and share experiences related to the content, (2) developing case studies out of the shared experiences, and (3) re-seeing the experiences in these case studies at a deep level by having the students investigate and explain them using content ideas central to the unit.

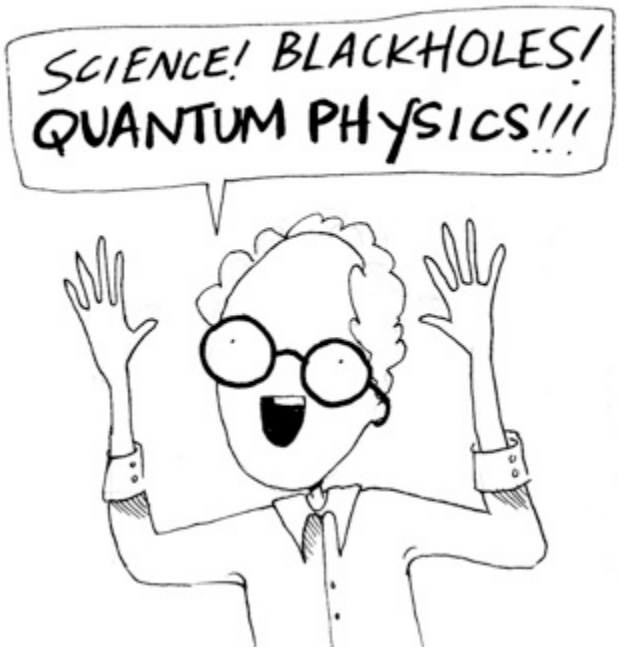
For example, the teacher who helped develop this model did so in the context of a weather unit in a sixth grade earth science class (Pugh, Schmidt, et al., 2010). The teacher had students write down and share their own "wild weather" experiences. Such experiences ranged from hailstorms to tornados. The students' experiences were then developed into case studies. In groups, the students investigated one of the case studies using resources provided by the teacher. Later, the students created posters and a written report describing how their particular experience could be re-seen through the lens of the science content. At the conclusion, the teacher encouraged the students to continue re-seeing their own weather experiences in terms of science content and occasionally allowed them to share ongoing experiences of thinking about the weather in terms of science ideas.

I asked my daughter, the one who's the physics major, what might make for good examples of experientially anchored instruction in physics. She gave a number of examples. I'll mention a few. One, mirrors and lenses. All students have had experiences with different kinds of mirrors and lenses. Fun house mirrors. "Objects are closer than they appear" mirrors. Contact lenses. Telescopes and binoculars. Have students share experiences with different kinds of mirrors and lenses and then make case studies out of common experiences. Two, music. We love music. Our lives our rich with musical experiences. Why not have students share their greatest musical experiences and then study the physics of the music in these experiences? As my daughter explained, there is a whole world of physics in music. I never knew. Three, sunlight. We've all had experiences with sunlight. Have kids share their experiences of being sunburned, seeing an amazing rainbow, frying ants with a magnifying glass, and hunting vampires or trolls. Ok, that last one may not be a real experience and I admit I had no idea what my daughter was talking about. But she explained that kids today have all sorts of experiences reading books or

watching movies about how sunlight and weapons developed to create the properties of sunlight can be used to kill vampires and trolls. Why not make that into a case study for students to analyze?

Real-world updates. This strategy is similar to helping students identify re-seeing opportunities except it focuses on identifying ongoing events that students can check in on every so often. An example in physics might include something like checking in on the solar activity each week. What's happening? Is it causing Northern or Southern Lights to appear? How many vampires and trolls have been killed by solar activity this week? Another example might simply be some version of physics in the news. What discoveries were made this week? How do these discoveries allow us to re-see some aspect of the world or the universe? What's going on with NASA this week? The goal is to get students in the habit of thinking about physics-related events and seeing these events through the lens of physics.

Modeling Transformative Experiences



I once had a geology teacher in college who just loved geology. Almost every day he would bring in new pictures and say things like, "Look at this road cut. My wife got mad at me for pulling over to take a picture because we were late for some appointment. But isn't that just amazing?" And it's a road cut. Or he might say, "Here's a picture I took out the airplane window. I had to crawl across an old lady to get this shot, but isn't that just a perfect series of anticlines and synclines?" His passion was contagious. I started to feel like I was missing out because I didn't take the time to look at road cuts. So I started looking. And not just at road cuts. Every time I saw a rock formation, I could hear my professor's voice in my head talking about how great it was. I remember visiting Arches National Park in southern Utah, a place I had visited countless times because I grew up in Utah. Suddenly, it was all new. I could see in a way I had never seen before. I started taking pictures to illustrate the geology before I realized, "Wait a second, what am I doing? I'm not the professor" Well, what I was doing was taking on the role

of my professor. That's what happens when professors are passionate about something. We get caught up in it and follow along.

I don't think there is one way to model transformative experiences with the content. Different people might do this in different ways. But here are some general ideas you can keep in mind:

- Talk about your experiences of seeing the world through the lens of the content
- Express your interest and joy in seeing the world this way.
- Express your value for the content you teach.
- Let students see how you live the content.

That last one is kind of what it is all about. Let the students see that physics isn't just something academic you teach about, it is something you live and experience in your everyday life.

Conclusion

To conclude, I go back to Dewey. He was an expansive thinker who wrote about everything from epistemology to the nature of aesthetic experience. But the despite the breadth and complexity of his philosophical reasoning, it all comes back to one simple idea: life is about having rich experiences. And his views on education can be understood through this idea. The purpose of education is simply to give us rich experiences and increase our capacity for undergoing rich experiences in the future.

That is, the purpose of education is to have the journey and increase our capacity for future journeys. The ideas of the curriculum, including the great ideas of physics are not just ends unto themselves. They are means – tools – for enriching and expanding our everyday experience. They can teach us to see and experience the world in fascinating new ways. They can be transformative. Thank you.

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