JOURNAL OF TRANSFORMATIVE LEARNING

The Journal provides a forum for perspectives on the practice and application of transformative learning. JoTL is an Open Access journal published by the University of Central Oklahoma at jotl.uco.edu.

Undergraduate Research as Generative Metaphor: A Provocation

JOHN TAGG
Palomar College

Abstract

Students who engage in research as undergraduates appear to achieve many benefits compared to those who do not. But scaling up undergraduate research is challenging and faces inherent limits. Are there ways to achieve some of the benefits for students not directly involved in faculty research? Generative metaphors help us to view problems in a different frame, thus setting the problem differently and inviting different kinds of solutions. This article proposes using research as a generative metaphor for classroom learning and invites readers to rethink teaching and learning in light of what seems to work for undergraduate research.

Keywords: generative metaphor, undergraduate research, framing, re-framing

The Power of Undergraduate Research

Bruce Alberts (2000) was president of the National Academy of Sciences when he reflected on the beginnings of his own career:

> Essentially every scientist whom I know remembers being utterly bored by the cookbook laboratories common to college biology, chemistry, and physics courses. My own experience is typical. After two years as a premedical student, I could stand these required labs no longer. I therefore petitioned out of the laboratory attached to the physical chemistry course at Harvard, seizing on an opportunity to spend afternoons in my tutor's research laboratory. This experience was so completely different that it soon caused me to forget about applying to medical school. Within a year I had decided to go to graduate school in biophysics and biochemistry, in preparation for a career in science. (p. 6)

Looking at the process from the other end, Carl Wieman, a Nobel laureate in physics, reflects on his work with highly successful graduate students in his own research lab:

> Over the years I became aware of a consistent pattern. New graduate students would come to work in my laboratory after 17 years of extraordinary success in classes, but when they were given research projects to work on, they were clueless about how to proceed. Or worse—often it seemed that they didn't even really understand what physics was. But then an amazing thing happened. After just a few years of working in my research lab, interacting with me and the other

> student, they were transformed. I'd suddenly realize they were now expert physicists, genuine colleagues. If this had happened only once or twice it would have just seemed an oddity, but I realized it was a consistent pattern. (2007, p. 10)

Those who have tried to look objectively at the question have confirmed that these anecdotes are telling us something important. Indeed, scholars who have looked at undergraduates involved in faculty research have found that it changes them in significant ways. Elaine Seymour, Anne-Barrie Hunter, Sandra L. Laursen, and Tracee Deantoni (2004) from the University of Colorado, after surveying students participating in undergraduate research, found that 91% of students could identify specific benefits they had gained. The researchers concluded that "undergraduate research is an educational and personal growth experience with many transferrable benefits" (p. 530). Much of the evidence, as the observations noted above, seems even to point to a transformative effect. Undergraduate research seems to change students in ways that often involve their underlying frames of reference.

But there is a problem. Obviously, everybody cannot participate in undergraduate research. The problem of scale is acute: too many students and too few research slots. Setting aside the issues of selection and assessment of potential student researchers, the numbers seem bound to keep such programs limited to a small minority of undergraduates.

We might well ask whether there is any way of extending the benefits beyond the fortunate few. I'm not sure. But here's a thought.

Generative Metaphor

Donald Schön (1980) grappled for years with the problems posed by getting stuck in a particular way of thinking, the challenge of "how we come to see things in new ways" (p. 255). One approach he suggested was generative metaphor, which he defined as "a particular kind of SEEING-AS, the 'meta-pherein' or 'carrying over' of frames or perspectives from one domain of experience to another" (p. 254). Generative metaphor thus can lead to "frame restructuring."

He offered this example to illustrate the point. A group of researchers was seeking to develop a paintbrush that relied on synthetic bristles. But the synthetic bristles could not seem to produce the same even distribution of paint that natural bristles did. The paint tended to go on in a "gloppy" pattern rather than smoothly. They tried several approaches to modifying the bristles, but none seemed to help. Finally, one of the developers made the observation "*You know, a paintbrush is a kind of pump!*" (p. 257). This was a generative metaphor. And it works because, of course, a paint brush is not a pump. But there is, at a certain level of detail, enough similarity to make the metaphor work. When we dip a paintbrush in paint, the paint is captured between the bristles, in the spaces that, if you squint a little, seem like the "channels" through which the fluid passes in a pump. Then when we apply the brush to a surface, the bristles bend, and this bending pushes the paint out from between the bristles, like a pump pushes out water through a channel.

The metaphor let the researchers see the problem differently. Thinking now of the channels between the bristles as little pumps, they again compared the natural and synthetic bristles, and they noticed something they had missed before: when the natural bristles were pressed against a surface, they formed a gradual curve, which "pumped" the paint out smoothly, and at a pace that responded to the pressure on the brush. The synthetic bristles tended to bend at more of an angle, thus pumping the paint out in clumps rather than a smooth flow. They now knew what they were looking for: a synthetic bristle that would bend in a continuous, gentle curve. Once they knew what they were looking for, they were able to find it.

By reframing a problem or an issue, generative metaphor brings different features to light or emphasizes different aspects of the object under review. In the case of the paintbrush example, "One might say that the spaces which had been background become foreground elements, objects of attention in their own right, as in a pump the contained space called a 'channel' is a foreground element with a special name of its own" (p. 258).

For Schön the foundational challenge in policy making was not problem solving but problem setting. This is a radically different way of thinking about problematic situations than the one we tend to convey in much formal schooling, where the problems are given and the whole operations of the student's mind are bent toward solving those problems, often using learned rules and algorithms. Schön is not referring to education, but he might as well be, when he notes, "If problems are assumed to be given, this is in part because they are all taken to have the same form" (p. 261). But this is nearly always an illusion: "Problems are not given. They are constructed by human beings in their attempts to make sense of complex and troubling situations" (p. 261). Our approach to those problems is shaped by the processes of "*naming* and *framing,*" often carried out implicitly through the stories we tell: "Things are selected for attention and named in such a way as to fit the frame constructed for the situation" (p. 264).

Generative metaphor can allow us to break out of the frames we have been given, or believe we have been given, and by naming what was invisible, to see options we have not seen.

The Research Metaphor

The idea of generative metaphor can't solve the problems of education, but it might help us to reframe and rename them. In the present instance, we cannot put every student in a classroom into an undergraduate research slot, but we can attempt to reframe classroom learning using research as the generative metaphor. What if we thought of the classroom the same way as we do undergraduate research? Like the paintbrush designers, we are trying to build something that works—in this case for educating students—but we are stymied. We are in part stymied by the materials—the students, in this case—but also by the way we frame and name the problem. These students are unmotivated, unprepared, uninterested, uninspiring. What can we do to get them to succeed? More jokes in the lectures? Easier tests? The paintbrush designers reached for a generative metaphor: a paintbrush is a pump. It's worth a try, no? A student is a researcher.

The generative metaphor does not solve the problem, it sets the problem in a different way by naming and framing the materials of the problematic situation. I do not propose to spell out in any detail what pedagogy would emerge from the reframing, but to sketch in very general terms one way such a reframing might look.

If we adopt the metaphor, we think about students in class, who are certainly not researchers, through the metaphor, as if they were researchers. What difference would this make? There are many possible answers, and many of them are right answers because different researchers emphasize different things and different research methodologies lead different places. But one way to get a rough start on how research would name and frame the learning process is by looking at surveys of students who have engaged in research or faculty members who have supervised it. The survey done by Elaine Seymour and her colleagues mentioned above provides a long list of characteristics of undergraduate research as viewed by students. David Lopatto (2003) of Grinnell College in Iowa has done a survey of faculty at three different colleges asking parallel questions. My goal here is to provide some suggestions for how we might use research as a generative metaphor.

Scanning the faculty and student reflections on undergraduate research projects brings up many things about research that differentiate it from what usually happens in the classroom. So, there are several different ways of naming and framing research as opposed to class-taking. I present one way of doing this as an example, with no hope of being exhaustive. I'll mention just four categories of characteristics that seem to emerge from the studies: autonomy, teamwork, faculty mentorship, and using learning to cope with novel problems.

First, autonomy. In Lopatto's survey of faculty at three different colleges, faculty at all three reported that "Students should work independently (of faculty) . . ." They said, "Students should feel ownership of the project; there should be increased independence in the daily routine and problem solving" (p. 140).

Apparently, this happens. When Seymour and her colleagues asked students how the experience affected them, a frequently mentioned benefit was the increase in confidence in doing the work on their own. One female biology major reported, "At the beginning, I asked a lot of questions to get a good basis and a good idea when I didn't really know what I was doing. By the end of the summer, I didn't speak to my advisor so much, because I would just do it" (p. 508). A male biochemistry major said, "I now feel confident that I can walk into any room with any instrument and figure out how to make that instrument work" (p. 508). A male biology major said, "When you're faced with kind of a novel problem when there's no right answer yet, and you have to find the right answer, I think research does a good job of teaching those skills. Because you don't have anything to go back and rely on . . .you're having to do it yourself" (p. 512).

Many students contrasted the research experience with the classroom experience, often in the context of doing it yourself. For instance, a female chemistry student noted, "I think it comes with hands-on work, because as a student you're handed this as fact . . . and you don't question that. But what you find out in research is that a lot of things that people have found out need to be questioned" (p. 514). Research experience leads to students questioning, testing, and relying on their own abilities in a way that seems, to them, to contrast with their experience in the classroom.

But, second, if research leads to increased autonomy, it also seems to contribute to more teamwork. That might seem anomalous. But here is how the teachers in Lopatto's study finished the sentence about student independence: "Students should work independently (of faculty) and have an opportunity to work on a team (of peers)" (p. 140). The two are related. The student who feels empowered to shape her own thoughts is also more confident sharing them, and testing them, with others. Seymour, et al., reported that working integrally with other students/researchers "was, to most students, a new experience that . . . involved reappraisal of their accustomed ways of relating to classmates. It included the pleasurable sense of 'belonging to a community' of like-minded individuals who are working toward similar goals and discovering their intellectual strengths" (p. 510). There seems to be a dynamic with research teams that brings people together, perhaps around their perceived weaknesses or needs, but then keeps them together through their discovered strengths. A male physics major, reflecting on the reliance he developed with his lab partner, said, "I think if we were alone, we just couldn't have mustered the strength to go on with it because it's so open-ended and so overwhelming—to not have someone else to talk to would have made it very difficult" (p. 511). The support of peers makes it possible to safely question your own approach. A female chemistry major, reflecting on the weekly lunch meetings with the whole team, noted, "that provides time for insight . . . maybe they're thinking about this problem a different way from you" (p. 511).

Third, both of these factors, autonomy and teamwork, affect students' thinking about their relationship to faculty members. Faculty supervising students in research apparently want them to think and act independently, as indicated above. The one other faculty-related outcome that the teachers in Lopatto's study mentioned was "establish a mentoring partnership between student and faculty" (p. 140). What is the difference between a mentor and a teacher? That may be a productive question to pursue in several contexts, but in the case of undergraduate research, it was summed up by a male biology major in Seymour's study: "I've gotten to know all the faculty. . .. I actually see them more as peers. As a researcher, they are your peers; you're working with them. And you ask them questions, and they are just as excited to know what I'm doing as I am to know what they're doing, or what they could help me with. . .It gives a totally different aspect than being a student. . .And you don't have to be intimidated by them anymore" (p. 510). Whew! What a relief that must be!

One of the gains students reported in Seymour, et al.'s survey was "increased confidence in 'feeling like a scientist,'" and most frequently reported reason for that increase was "because of being taken seriously by others" (p. 507). One male psychology student reported, referring to a faculty mentor, "He said he's learning as much from us as we are learning from him. . .During our semester meetings, he'll start taking out his notebook and start writing down things we are saying. . .It feels just great when someone takes me seriously, or takes my work seriously" (p. 510). A mentor is someone who takes you seriously, who respects you, at some level, as a contributor or potential contributor to the work.

Fourth, research appears to bring out the ability to apply learning to novel problems. Faculty in Lopatto's survey said that students learned to "construct meaningful problems" and "apply knowledge to a real situation" (p. 141). In a way, research involves students in what Schön calls problem setting, rather than just problem solving. Constructing a hypothesis and a research design requires that we define the nature of the problem. Indeed, much research in many fields is quite self-consciously about framing the problematic situation as a necessary step toward describing the conditions of a solution. This is because research problems are novel problems in the sense of not being pre-formatted and pre-described. In undergraduate research, both students and faculty, of course, report that students learn the subject matter that is the object of the research. But that seems to be in the context of constructing and troubleshooting a new problem using prior knowledge. One female chemistry student in Seymour, et al.'s survey said, "I think there's only so much you can get from classroom learning . . .You get into the lab and you say, 'Okay. This should work.' No, it doesn't work! Because there are so many other considerations you have to make. And that's the kind of thing you can get only from research" (p. 513).

Students frequently mentioned learning to correct their own mistakes: "It really does help to learn to detect your own dumb mistakes" (p. 513). And they often discussed this in the context of planning and designing the research. Students saw both self-correction and planning as things that they could apply beyond the research domain, but that seemed to be clarified in a powerful way through the research process. One female biology major commented, "Just learning how to plan, learning how to be careful, how to take care of mistakes, and recover from mistakes. I think that's something you can apply to any field" (p. 513). Another said, "Just thinking about things completely, and trying to think of all the possibilities before you plunge into things. So that if you're designing an experiment you want to know ahead of time, 'What are all the possible things that could happen?' and, 'How would you explain each result?' And I think that's something I can use in other areas, too" (p. 513).

So, research for some students, more than a few, has the effect of re-framing science itself, and perhaps thinking itself. One female chemistry student put it this way: “Well, intellectually I think that it’s helped me to understand chemistry better. Not just the chemistry that I happen to be doing in the lab, but also chemistry as a whole. . .And learning how to look through the primary literature and to really synthesize and understand the information about the project has helped me to better understand other areas of chemistry and pick things up more quickly” (p. 515). Several students reported that research helped them to take a larger view, to see the details in a fuller context.

The Provocation

If we take the generative metaphor of research seriously, how would it change the way we teach? How would it change our relationship to students, and students’ relationships to each other? If we think of the student as a researcher, how would we do things differently, even if the student was not in a research lab? Some of the answers to these questions are obvious and are widely discussed in the SoTL literature. But if we take the questions seriously, I suspect that they will provoke quite different ideas from different teachers, just as the experience provokes different learning in different students. Among the obvious things we will not do if we think of students as researchers is simply tell them what we want them to know. But if not that, what? What should they do? With whom? Where? What would treating students as researchers mean for our assignments, our tests, our way of communicating with students? I leave this as a provocation rather than a proposal because different teachers will probably have different answers—and should. I am confident, though, that if we take undergraduate research seriously as a generative metaphor, we would end up doing many things differently than we do. Try it. Sit down with a few colleagues and try to reframe the problem: “How would we teach if we thought of students as researchers?” If we want students to reframe and rename their work, we need to lead the way.

References

Alberts, B. (2000). *Some thoughts of a scientist on inquiry*. Retrieved November 10, 2018, from https://brucealberts.ucsf.edu/publications/albertsoninquiry.pdf

Lopatto, D. (March 2003). The essential features of undergraduate research. *Council on Undergraduate Research Quarterly*, 139-142.

Seymour, E., Hunter, A-B, Laursen, S. L., & Deantoni, T. (July 2004). Establishing the benefits of research experiences for undergraduates: First findings from a three-year study. *Science Education*, 88, 493-594.

Schön, D. A. (1980). Generative metaphor: A perspective on problem-setting in social policy. In Andrew Ortony (Ed.), *Metaphor and Thought.* (pp. 254-283). New York: Cambridge UP.

Wieman, C. (September/October 2007). Why not try a scientific approach to science education? *Change*, 9-15.

Author's Note: John Tagg is an emeritus professor at Palomar Community College.

Citation: Tagg, J. (2018). Undergraduate research as generative metaphor: A provocation. *Journal of Transformative Learning*, *5*(2), 1-7.