

From Theory to Practice: Funds of Knowledge as a Framework for Science Teaching and Learning

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Abstract

The phrase "funds of knowledge" refers to a contemporary science education research framework that provides a unique way of understanding and leveraging student diversity. Students' funds of knowledge can be understood as the social relationships through which they have access to significant knowledge and expertise (e.g., family practices, peer activities, issues faced in neighborhoods and communities). This distributed knowledge is a valuable resource that might enhance science teaching and learning in schools when used properly. This article aims to assist science methods instructors and secondary classroom teachers to better understand funds of knowledge theory and to provide numerous examples and resources for what this theory might look like in practice.

What are Funds of Knowledge?

Student diversity has too often been viewed through a *deficit perspective*, which frames student differences as potential problems or weaknesses. This approach is overly focused on what students are lacking, using simple labels to explain why teachers have not been able to reach their students. "This student comes from a poor family and lacks prior knowledge." "That student is hyperactive and can't stay on task." These are examples of a deficit perspective, and this sort of negative labeling can shut down opportunities for learning. A well-balanced critical view of science education should acknowledge and seek to remedy issues of inequity while also valuing the social capital of students and the communities in which they live (Barton, 2003).

Student differences may instead be viewed as a resource for learning. The *funds of knowledge* framework, developed by Moll et al. (1992), views students' social connections, activities, and interests as something that could be leveraged to enhance in-class learning. Students have complex multifaceted identities that extend beyond the classroom into their homes, neighborhoods, school hallways, and their greater communities. Funds of knowledge should not be confused with "prior knowledge." Funds of knowledge refers to the various kinds of *distributed* knowledge and expertise that a student can access through their social relationships. When science teachers create the right opportunities for students to make these deep connections between the science curriculum and their out-of-class identities, they create lifelong learners and lovers of science. If students leave the classroom without developing these connections, they will likely remember science as merely something confined to school and will have reduced likelihood of pursuing scientific careers in the

future. The primary aim of this article is to assist science methods instructors and classroom teachers with making practical connections to students' funds of knowledge to promote learning in the high school science setting.

Evidence suggests that students as young as first graders are capable of understanding and internalizing stereotypes that affect their interest in science and engineering (Bian et al., 2017; Cvencek et al., 2011). In a well-known study by Chambers (1983), when students were asked to draw an image of a scientist, the image of a white male in a lab coat with large glasses and crazy hair was drawn by students regardless of their own race or gender. If students are absorbing and internalizing stereotypes about science that act as a filter for their learning, we must respond with a nuanced approach that is capable of addressing this complex problem. Aschbacher et al. (2010) demonstrated that adults who showed enthusiasm about science and actively provided high school students with authentic scientific opportunities, both in and out of school, positively contributed to their identity development regarding science. The funds of knowledge perspective values the student as a "whole person" who navigates multiple identities. This perspective seeks to meaningfully connect what happens in the classroom to students' multifaceted identities outside the classroom, utilizing social connections and other distributed resources in the community so that students might learn to see themselves as scientists.

How to Leverage Students' Funds of Knowledge

Qualitative researchers studying communities at the U.S. border with Mexico found that households are rich sources of historical and cultural knowledge and skills relevant to science, including budgeting, appliance repair, ranching, carpentry, herbal knowledge, and anatomy (Moll et al., 1992). These household and community resources (and others) could deeply connect to various aspects of a high school science curriculum. A subset of funds of knowledge research has focused on providing educators with tools and resources to help bridge students' funds of knowledge with school curricula. For example, preservice teachers working with Latino students in an afterschool STEM context were able to show that science learning could be effectively linked to those students' cultural identity. While working in the program, the teachers realized that every day, two students were playacting as the famous luchador, Rey Mysterio. Using this knowledge, they posed questions and challenges that connected wrestling to physical science concepts. This simple connection made science less threatening and completely changed the students' willingness to discuss science and participate in scientific inquiry (Ciechanowski et al., 2015). Other studies have attempted to outline potential categories of student funds of knowledge in order to help teachers find exactly the right connection to their curriculum (e.g., Moje et al., 2004; Moll et al., 1992). Connections can be made to students' lives to enhance relevance for learning science (Table 1).

Table 1

Potential Ways to Access to Students' Funds of Knowledge

Potential Connection to Science	Examples
Pop Culture	TV shows, movies, art, video games, celebrities, YouTubers, fashion, music, podcasts
Peer-Peer Interactions	afterschool clubs, sports, shared hobbies
Household Activities	meals, chores, caretaking responsibilities
Family Members	jobs of parents and relatives, knowledge about other geographical locations
Cultural, Gender, or Generational Identity	access to languages other than English, role models, customs and traditions
Community Resources	stores, festivals, community gardens, swimming pools, volunteer organizations
Issues in the Community	pollution, energy consumption, access to healthy food and clean water, traffic, condition of roads
Local Environment	bodies of water, plant and animal species, weather, geological features

The most direct way of accessing students' funds of knowledge is to get to know as much as possible about one's students. A beginning of the year questionnaire is one way to make a solid start; however, many of the widely available online questionnaires do not ask particularly helpful questions. Figure 2 includes a short list of questions that should elicit information to help teachers learn productive information about their students. Some of these questions were adapted from *Culturally Responsive Standards-Based Teaching: Classroom to Community and Back* by Saifer et al. (2011), while we developed other questions. These questions could be used to gather written information from students at the beginning of the year or be used as prompts for discussions throughout the year.

Table 2

Productive Questions to Ask Students

1. What do you like to do outside of school?
2. What's your favorite book?
3. What's your favorite movie or TV show?
4. Name a family member or someone in the community you admire. Why?
5. What is a favorite tradition of your family?
6. What places have you or your family visited or lived before?
7. How would you describe your culture to someone not familiar with it?
8. What languages do you speak?
9. What are some ways your culture, gender, or generation needs to be better understood or celebrated?
10. Where do you see science in your daily life?
11. What career in science or engineering would you be most interested in? Why?
12. What issues in your community might be addressed through science or engineering?

Teachers may also gather valuable information by listening more closely to conversations that occur outside of class time or when students are off task. Sometimes hearing and acting on the right information at the right time can change the way a student perceives science. If

this seems like too much pressure to place on the teacher, there is another approach that naturally allows students to make these connections themselves. Differentiating assessments in a way that allows students to express some aspect of their identity through creative expression and choice is a powerful strategy. For example, Whitworth and Bell (2013) had high school students compile personal portfolios to demonstrate their physics content knowledge. Within the portfolios, students included a letter that introduced themselves along with a collection of photos and essays about where they encountered various physical science concepts in their daily lives. Not only was this a useful formative assessment and end-of-year study guide, but it was also an opportunity for students to share something of themselves with their teacher and peers.

Hybrid Space

Another important idea for connecting the science curriculum to students' out-of-school identities is what is known as *hybrid space* (Bhabha, 1994). Students may feel confused or even threatened by the different expectations of how to speak or act inside vs. outside the classroom. Navigating these worlds is a complex task for adolescents. When the differences between these two worlds are extreme, students do not see their culture reflected in the curriculum, and they feel excluded because their way of acting or speaking at home is not valued inside the classroom. This sharp division becomes a detriment for learning. Simply put, creating hybrid space makes students feel more valued and accepted in class by blurring lines between their in-class and out-of-class identities; this also helps students become aware of how science is relevant in surprising ways beyond the classroom.

A simple example of blurring these lines might be to switch the seating arrangement from forward-facing rows to table groups or a circular arrangement. This creates more opportunities for collaborative science talk and demonstrates that student contributions are valued. Another strategy could be to have regular times each month for students to share with the class science articles or stories that they find interesting and relevant, allowing students to have some say in what is addressed in the curriculum. These shifts help to demonstrate that the teacher's knowledge is not supreme and that students are also allowed to assume the role of an expert sharing their knowledge.

It is common to encounter students who believe that they are not intelligent enough and have nothing to contribute. This self-perception can be hazardous to a student's success and advancement within the sciences. The "chemist-tea" initiative is the authors' attempt to create a hybrid space where students can seek extra help outside of class hours in a way that creates a relaxing and supportive atmosphere. During chemist-tea time, students sit around a conference table drinking tea as they work collaboratively on assignments, help one another learn new material, and ask the teacher for informal feedback. The teacher is present to help as needed, and as a reminder about the purpose of the tea time, but the

teacher is not directing or leading the group. Students are encouraged to help each other. This modified power dynamic makes science learning more social and has resulted in an incredible response from students. Not only have they claimed their own favorite mugs, but they have also felt more supported in their coursework and more motivated to complete it by being able to work in what they perceive as a friendly, low-stress environment.

Curricular Examples that Leverage Funds of Knowledge

This section provides some of the specific examples that we, the authors, have developed and used in our classrooms that effectively leverage students' out-of-school identities to teach a variety of science topics. Although the reader may be familiar with some subset of these activities, it is important to look at them freshly through the funds of knowledge lens because it may change how these activities are designed and implemented in important ways. In each example, students are intentionally positioned as an expert and vital contributor in the discussion or activity.

Chemistry & Pop Culture

The ability to classify and differentiate between types of chemical reactions is a fundamental skill in any introductory chemistry course. The typical approach to teaching this material is to present students with abstract classification patterns (e.g., a single replacement reaction would be represented as $AB + C \rightarrow AC + B$) and then to provide numerous practice problems to reinforce the concept. An alternative approach would be to connect this concept to preexisting student knowledge about popular culture. For example, romantic or platonic relationships, such as those found within the popular television show *Riverdale*, can be used as a vehicle to demonstrate these concepts. The teacher shows images of characters from *Riverdale* (or whatever show students like most) of someone in a romantic partnership (AB) being displaced by another (C), with a new set of resulting relationships (AC & B). Examples of synthesis, decomposition, single replacement, and even double replacement can be found in virtually any TV series. Students expressed interest in *Riverdale* from the first day of school, constantly coming into class eager to discuss newly released episodes with their peers, and it was on this basis that it was chosen. Even the students who struggled the most in chemistry were able to readily absorb the concepts when presented in this way.

Another (now slightly dated) chemistry connection to popular culture is the use of the movie *The Martian*, starring Matt Damon, to teach dimensional analysis. Virtually every challenge that Matt Damon's character encounters must be solved through the application of dimensional analysis. How much food does he need to grow from a container of potatoes based on needed calories per day? How much water can be produced from an available amount of rocket fuel? How much distance can be covered per day traveling at a given

speed in a rover? These questions and many more in the movie are perfect dimensional analysis questions for a high school chemistry class. The teacher could show a short clip from the movie and then pose questions to the class.

Life Science & The Community

Fostering school spirit and pride in community is an incredible way to keep students involved and engaged. In an Advanced Placement biology course, students were given direct instruction on types of eukaryotic cells and organelle functions. Student groups were then tasked to model the specialized organelle functions through analogy with how either their school or community functioned in various ways. For example, one group of students recognized the importance of the lysosome's role in cell digestion and waste removal by way of describing the custodial staff's ability to keep their school consistently clean and tidy. Students were asked to compile their fifteen organelle-to-school/community connections onto a poster to be displayed for the entirety of the student body (Figure 1). This approach leveraged existing student knowledge about the spaces they inhabit.

Figure 1

Cell Organelle Functions Using School and Community Funds of Knowledge



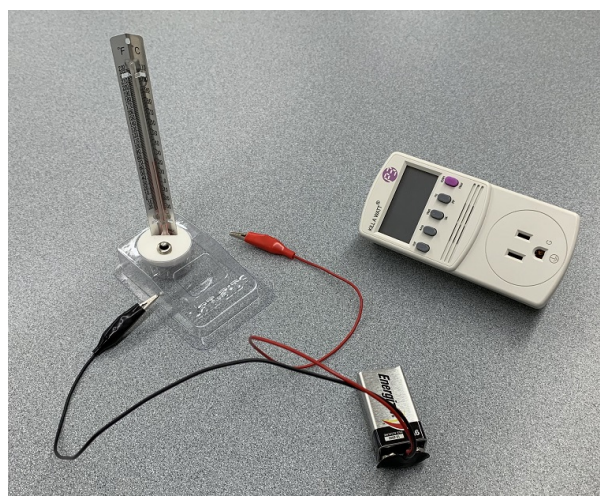
Physics in the Home

Energy efficiency is a topic that can connect the physics concepts of circuits, energy, and power to students' home life. First, students conducted an in-class investigation to measure the energy efficiency of a small light bulb through heating a small sample of water using a lab from Fischer Scientific. Afterward, students were tasked to conduct an energy audit of three

different appliances in their home using a “Kill-A-Watt” electricity usage meter (Figure 2). Many appliances operate in different modes (e.g., a closed laptop vs. a laptop actively streaming video), so students collected data on appliance electrical consumption in each mode. For each appliance, students recorded the power draw in watts and estimated the total hours each appliance was used per week. By multiplying these values, students obtained kilowatt-hours of energy consumed. This lesson effectively taught students the mathematical relationship between power and energy while positioning them as an expert in terms of understanding their own energy use. At the end of the lesson sequence, students discussed their results and came up with ideas for strategically reducing their energy consumption. This approach provided students a clear idea of why this topic was important and how it connected to out-of-school lives.

Figure 2

Measuring Energy Efficiency in School and At Home



Work with Preservice and Inservice Teachers

In our experience, developing teachers’ abilities to use the funds of knowledge framework is broken into two phases. In the first phase, time should be spent exploring issues related to diversity and equity in science education, the negative effects of stereotype threat, the danger of ignoring diversity, and the damage that the deficit perspective can have on student learning and performance. In the second phase, teachers are given a variety of tools, including a questionnaire and ways to make connections between their curriculum and student identity (Tables 1 and 2). During the preservice phase, it is important that teacher candidates practice making connections to students’ personal, cultural, or community assets when planning for instruction and during instruction. This means that teacher candidates must work on developing both their content knowledge as well as knowledge about their

students. In states where the Teacher Performance Assessment (EdTPA) is used, it should be noted that candidates are required to demonstrate this proficiency for that test—on Rubrics 3 and 7, in Tasks 1 and 2, respectively. More broadly, any teacher preparation program would benefit from preparing their teacher candidates to connect with students that come from different backgrounds and that have different funds of knowledge from their own.

Conclusion

The approach advocated for in this article requires that a teacher not only has a deep understanding of their content area, but also a deep knowledge of the students they teach. Funds of knowledge theory sets up a productive way of working with students—one that values the student as a whole person who deserves to know why science is relevant in their life. Connecting science to students' lives requires time, intentional effort, and a lot of practice to uncover and make use of students' rich funds of knowledge.

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