Enhancing Student Learning in Introductory Physics Through Funds of Knowledge

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Researchers have reported the funds of knowledge (FK) pedagogical approach effective in engaging minority students in learning.\textsuperscript{1-6} However, there are a lack of studies connecting FK to introductory college physics or physical science classes. By using examples from regional Mexican-American lived experiences at an Hispanic-serving institution located along the recently politicized U.S.-Mexico border, this paper provides evidence to show how physics educators can use FK to engage students in learning introductory college physics concepts.

Moll et al. in 1992 defined FK as “historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and well-being.”\textsuperscript{4} A research group at the University of Arizona developed this pedagogical approach originally by using Mexican-American students’ lived experiences as a scaffold for learning.\textsuperscript{1,2} Researchers showed this approach made students more motivated to learn\textsuperscript{5} and sustained student interest in science.\textsuperscript{4} Although FK has been used in K-12 settings for over two decades, it has not been used widely in higher education, particularly in physics.\textsuperscript{5} Kiyama and Rios-Aguilar called for faculty to use FK in college-level teaching.\textsuperscript{6}

The University of Texas-Rio Grande Valley (UT-RGV) serves about 29,000 students from four of the lowest social-economic status counties in the nation. Nearly 90% of the student body is Hispanic, and 59.3% of the total population in the area is below 35 years old. The RGV region is among the most rapidly growing regions in America. Based on the regional, predominantly Mexican-American, culture, we introduced the following three examples in the Introduction to Physical Science I course.

**Example 1. Greyhound bus safety**

A motor coach, such as a Greyhound transition bus, is a popular mode of long-distance transportation for the local population due to cheap bus fare. Passengers often ride on the buses from the border to metropolitan areas such as Houston, San Antonio, and Mississippi. According to the Greyhound website, their buses carry “around 17.2 million passengers a year who travel 5.03 billion miles a year.”\textsuperscript{7}

The greyhound bus travels at about 70 mph (31.3 m/s) on the state highways and 30 mph within city limits. Regardless of high speeds, many of the buses are not equipped with seat belts. A Greyhound bus typically weighs around 35,100 lb and seats about 56 passengers. The distance between two adjacent rows reads about 0.55 m. If the bus comes to a stop suddenly in a crash, the following impact force formula applies:

\begin{equation}
0 - mv = F \Delta t. \tag{1}
\end{equation}

Assuming an average adult passenger’s mass is 50 kg, the speed of the bus is 31.3 m/s, and the time for the passenger coming to rest is about 0.010 s after hitting the unpadded front seat back,\textsuperscript{8} the impact force is calculated as

\[ F = 50 \times 31.3 / 0.010 = 156,500 \text{ N.} \tag{2} \]

This force is on the order of $10^5$ N and is 319 times the weight of the passenger, 490.5 N, which exceeds the threshold for fatality. One can also infer that this impact force increases with the mass of the passenger.

Greyhound’s official website claims the company “took an industry-leading step in 2009 when [they] installed three-point safety belts on all of [their] new buses,”\textsuperscript{9} but this does not apply to old Greyhound buses still in use. Riding on older Greyhound buses in March 2019, we found our bus from McAllen to Harlingen had seat belts, but the bus we rode from Harlingen to Houston did not (see Fig. 1).

Checking with the governing authority of motor coaches, the U.S. Department of Transportation’s National Highway Traffic Safety Administration (NHTSA), we found they issued a notice of proposed rulemaking by requiring that intercity transportation buses, with weight greater than 26,000 pounds, install seat belts to reduce occupant ejections in a crash.\textsuperscript{10} This notice is based on NHTSA safety research in 2009, which concluded installing seat belts is “practicable and effective.” It further states “seat belts are estimated to be 77% effective in preventing fatal injuries in rollover crashes, primarily by preventing ejection.”\textsuperscript{10} Learning about these facts, students can make more informed decisions when they decide to travel.

**Example 2. White roof**

Summer in the RGV region lasts from May to November, with temperatures ranging from 80 °F to 107 °F. Many houses must use AC units for the summer, and electric bills are high. Residents in this area, especially those coming from colonias, are concerned with efficiently cooling their houses. Colonias are subdivisions of substandard housing, typically outside city limits, where some families do not have electricity.

On covering topics such as temperature and heat, we discussed common asphalt roofs in house construction in this area (see Fig. 2). To illustrate this point, we provided students

\begin{figure}
\centering
\includegraphics[width=0.8\textwidth]{example1.png}
\caption{A Greyhound bus currently in service: The interior passenger seats are not installed with seat belts.}
\end{figure}

\begin{figure}
\centering
\includegraphics[width=0.8\textwidth]{example2.png}
\caption{Common black roof of the local houses in Edinburg, TX.}
\end{figure}
areas, in public recreation parks, and in plaza parking areas (see Fig. 5). Students commented that the tradition of grass lawns could be due to the fact that children play outside frequently. Some said their families fear tree roots will damage house foundations. Some expressed they have no place to walk or jog outside because it is too hot in summer. They further shared their families sometimes go to department stores to stay in AC in summer because their homes’ AC units are not effective.

In Fig. 6, students conducted experiments in an academic building area on our campus and measured a shaded area vs. a non-shaded area on a sunny day around noon. The thermometer measured 76 °F in a shaded area and 104 °F in a non-shaded area. The temperature difference of 28 °F can make a critical difference in life-threatening accidents such as heatstroke and can also provide more exercise and walking areas for residents, which could improve overall public health.

Student comments

After three activities, the first author organized students into small groups to discuss the following two questions regarding FK: (1) Can you think of any physics examples that connect to FK? (2) What is your view about its significance in teaching physics?
Students proposed four additional examples for FK: (1) Gulf of Mexico hurricanes and how the local population prepared for hurricane season; (2) video games, a big part of local children's lives, and how virtual worlds that mirror the physical world's laws of physics can be used to teach physics; (3) the amount of CO$_2$ in the atmosphere and its relevancy to local farmers who depend on land and crops to provide for their families; and (4) the lack of public transportation in the RGV, causing the local population to rely on cars as their main mode of transportation, worsening the global warming effect on the environment.

Students expressed the following viewpoints in response to question 2: FK approach helps students relate physics with their lives and understand and retain physics better. One student wrote that FK “makes students more interested in the material and therefore more likely to retain what is taught.” Another student wrote this pedagogy is important since “with this information, we can help our culture make better decisions and changes that are more efficient and cheap.” One more student suggested implementing “community outreach programs in colonia areas” to inform residents of alternative cooling methods.

**Conclusion**

Our students, who are predominantly Mexican-American, appreciated the provided regional physics examples, which supports the effectiveness of using students' funds of knowledge. The pedagogy improved students’ attitude toward learning physics as they found the learning experience engaging and enjoyable. Therefore, we recommend introductory physics and physical science instructors incorporate funds of knowledge in their teaching to empower students of diverse backgrounds.

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**References**


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