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Incorporating Physics Principles in General Biology to Promote Integrative Learning and Thinking

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ABSTRACT

Students often struggle to identify correlations among various concepts in STEM courses, such as energy, mechanics, and cellular communication. Integrative learning incorporates numerous concepts and subjects to aid understanding and enhance critical thinking. This research describes an integrative learning approach in a General Biology I course where key physics-based concepts that are connected to biological topics were emphasized. In addition, students' knowledge and their beliefs towards biology in all General Biology I classes were assessed using American Association of Colleges and Universities' Integrative Learning Value Rubric and the Colorado Learning Attitudes About Science Survey (CLASS). It was found that correlations existed between students' attitudes towards biology and their overall content knowledge. The results of this study support that integrative learning is a powerful approach to aid in the understanding of physical and biological concepts, leading to improved student success.Vernimisses nondam oriculiciis suam etor avehemus, mei ina, non nesilla L. Nos,

KEYWORDS

Biology, Biophysics, Class, Critical Thinking, Integrative Learning, Physics, SOTL, STEM

INTRODUCTION

Academicians are concerned with leveraging the curriculum to improve student learning and desire that students display long-term knowledge retention concomitant with applying critical thinking skills to solve problems. In addition, education researchers are continuously exploring which pedagogical approaches are most effective in positively impacting student learning and their attitudes towards learning (Allen et al., 2016; Armbruster et al., 2009; Arthurs & Kreager, 2017; Reimer et al., 2016; van Kesteren et al., 2016). In science, technology, engineering, and mathematics (STEM), it is an ongoing endeavor to find the best approaches to deliver learning materials to students and the most effective methods to ensure that students will learn and retain the information. One approach is embedding

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integrative learning (IL). Recent evidence supports the idea that enhanced learning occurs when concepts are taught in an integrative manner. Specifically, it is suggested that the circuitry of human memory may be designed to promote the integration of knowledge to foster thorough understanding and better retention over time (van Kesteren et al., 2016). This is of significant importance especially for African Americans who are recognized as being underrepresented in STEM (National Science Foundation, 2015) and do not persist in STEM majors as well as whites (Sasso, 2008). Hence, the purpose of this study was to determine if integrative learning would have a positive impact on African American students' understanding of the content presented in general biology.

The Association of American Colleges & Universities (AAC&U) describes integrative learning as "an understanding and a disposition that a student builds across the curriculum and co-curriculum, from making simple connections among ideas and experiences to synthesizing and transferring learning to new, complex situations within and beyond the campus" (Rhodes, 2010). A key finding of the value and importance of integrative learning is that it produces more critical and holistic thinkers as well as better problem-solvers (Labov et al., 2010). It is very ineffective for learners to focus solely on one field of study and not understand the connection to other areas. Integrative learning allows learners to understand the relationship between key concepts in two or more subjects that would sometimes be perceived as unrelated. It also helps individuals connect real-life experiences to a particular subject while envisioning topics in a cohesive manner instead of independently (Berry & Black, 1987; Sweeney et al., 2015; Walshe et al., 2013).

In a meta-analysis on integrative approaches in STEM education, Becker and Park (2011) conducted research that related to the impact of integrative efforts within STEM, how these efforts vary by grade levels, and how integrative approaches influence student achievement in STEM. These approaches were demonstrated to be most advantageous when multiple STEM disciplines were included. Students who were exposed to various forms of integration that incorporated engineering, mathematics, science and technology were more successful in STEM-related courses and demonstrated a higher level of motivation to study and pursue STEM careers (Becker & Park 2011).

A plethora of research exists which demonstrates that one of the most effective methods for those teaching physics is to "infuse" learning versus the laborious process of "teaching" physics (Chandra & Watters, 2012; Holubova, 2008; Jarrett-Thelwell et al., 2019; Karamustafaoglu, 2009; Taber, 2000). Physics is known as a fundamental science; however, many find it very difficult to understand, challenging to learn, and as a result, students often attempt to avoid the subject (Adams et al., 2006; Cziprok, 2011; Fazriyah et al., 2017; Marušić & Sliško, 2012). Understanding fundamental physics principles is critical for a thorough comprehension of how the world works. Aspects of mechanics and electricity, as well as vectors, forces, work, waves, and energy, are key physics concepts that can easily be integrated into any field. For instance, Park and Liu (2016) conducted a study that assessed students' understanding of energy in various scientific disciplines (i.e., environmental science, biology, chemistry, and physics). This is important because "energy" is often thought of as a distinct concept; however, it is ubiquitous in all science disciplines. Hence, to assess the knowledge of the students, both multiple choice and open-ended justification questions were administered to more thoroughly assess the students' understanding of the material, while also measuring their differentiation of knowledge (Park & Liu 2016). This study revealed the value of presenting energy in a manner that connects disciplines. The students displayed an improved understanding of energetics and were able to provide more thorough interpretations and experienced an alleviation of difficulty among the sciences.

BACKGROUND OF THE STUDY

Winston-Salem State University (WSSU) is a Historically Black College and University (HBCU), and almost all students majoring in STEM are African American. Most WSSU students are female and/or first generation. It is reported that 29% of African American STEM majors drop out of college while 36% switch to a non-STEM degree (Estrada et al. 2016). In addition, African Americans do

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