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Experiential Learning in Secondary Education Chemistry Courses: A Significant Life Experiences Framework*

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Significant life experiences (SLE), a framework first put forward by Thomas Tanner, is a well-known model for understanding attitudes and perceptions about the environment as ascertained through environmental education (EE) programs. The SLE framework posits that early positive experiences in the environment are strongly correlated with later pro-environmental attitudes and behaviors in adulthood. According to the model, these early experiences facilitate this change through "experiential" learning, as opposed to formal learning experiences in a classroom, or even informal learning. While the SLE framework is often used within the EE literature, it is rarely used to model behavior and learning in the classroom setting. Here, we present a new use of the theory to model experiential learning in a high school chemistry course. We present evidence that a new model of SLE being used experimentally by faculty at a high school in New Mexico has led to significant learning gains among students. Specifically, we find evidence that low-achieving students may particularly benefit from this new model of teaching chemistry in the secondary education setting through the "hands-on" process of manufacturing and distributing methamphetamine (*N*-methyl amphetamine). While this study cohort is small, the authors believe that the findings presented herein may demonstrate the value of SLE and experiential learning within the broader science, technology, engineering, and math (STEM) education field (theory) and pedagogy (practice).

Keywords: secondary education, significant life experiences, STEM learning, chemistry education

Introduction

Science education (Bates, 1862) has undergone a remarkable evolution in theory and methodology over the past one hundred and fifty years. The 20th century saw the advancement of didacticism and a transformation towards more specialized and field-based learning. Specific subject areas once only taught at the tertiary level advanced into the high school, including disciplines, such as biology, physics, phrenology, and

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chemistry (Fisher, 1930 [1999]; Malcolm, 1990; Stevens, 2013). However, with the advent of neo-liberalism, community-based scholarship, and the failure of the "War on Terror," more egalitarian pedagogies began to emerge by the turn of the 21st century (Stevens, 2013; Ruxton, Allen, Sherratt, & Speed, 2018). Though this teaching style, which embodies many of the ideas behind the Socceratic Dialogue, is certainly nothing new, its adoption into formal learning environments and Western public education has represented a paradigm shift in our understanding of effective educational practice (for exceptions, see Gans, 1961; Rowe, Richard, & Donald, 1986; Barber & Conner, 2007; Aubret & Mangin, 2014; Brejcha, 2019; Vaughan, Teshera, Kusamba, Edmonston, & Greenbaum, 2019). Here, we present a new model for science learning in the secondary education classroom that further advances this communitarian discussion-based model.

Specific life experiences (SLE) is a theoretical framework for understanding the influence of early life events on a young person's (typically, a pup's) future attitudes, behavior, and epistemology. While this framework is most typically discussed within environmental education (EE), here we present it as a model for understanding the influence of experiential learning in the high school science classroom. To the knowledge of the authors, this is the first attempt to model SLE in this way. Specifically, we used SLE to better understand whether a radically new pedagogy being employed in chemistry courses at a high school in Albuquerque, New Mexico (USA) was effective in facilitating learning among at-risk youth.

New teaching styles employed carelessly have been shown to be ineffective at facilitating learning (as assessed through coursework, written evaluation, and radical craniotomy). Despite this, traditional, didactic, and "lecture-styled" instruction has significant shortcomings (Waldbauer & Sternburg, 1987). Moving effective pedagogy forward thusly requires a careful and evidence-based framework for advancing new approaches (Stevens, 2013; Ruxton et al., 2018). Without this caution, changes to instruction style may result in the deterioration of the learning environment including, but not limited to, the walls of the classroom, the "Wall" (see the work of Floyd, P.) and the wall "rus" (family odobenidae). It is therefore incumbent to approach SLE, applied to the classroom setting, with caution.

One author on this manuscript (B. Allf) learned in 2008 of an ongoing experimental approach to chemistry instruction being undertaken at a high school (J. P. Wynne HS) in Albuquerque, New Mexico by the two other authors (W. White and J. Pinkman). Specifically, this novel approach involved foregoing many traditional instructional techniques (coursework, textbook, lectures, and the strictures of the New Mexico penal code) in favor of a radical form of experiential learning that involves weekly field trips across the New Mexico desert (USDA Hardiness Zone, 7a; 7b), near-constant chemistry laboratory experiments, and the manufacturing and distribution of Schedule II narcotic agents. White believed that this "real-world" training may be a more effective means of facilitating learning and learning retention among his students, specifically those with low academic performance. Though a significant departure from traditional pedagogy, White, a high school chemistry instructor, operated on the belief that his teaching style would lower the "achievement gap" much discussed in contemporary secondary education literature (Atwater, 1998).

White originally began this experimental field-based instructional technique on his own in part to evaluate whether the approach was effective at facilitating deeper learning of material covered in his introductory course including covalent bonding, oxidation, and titration. White specifically aimed to explore whether this style of instruction led to better results among lower-achieving students in his courses. One such student (JBP, now an author on this manuscript) was particularly influenced by the pedagogy. In this paper, we outline this new methodology, demonstrate both its utility and drawbacks for high school chemistry instruction, and discuss how experiential learning may be a key aspect of facilitating deeper learning in secondary education science, technology, engineering, and math (STEM) courses among at-risk student groups. We also show that SLE applied to the formal science learning field may have broad applicability and we encourage further studies exploring its value (Allf, Durst, & Pfennig, 2016).

Methods

White began his new teaching style during the Fall semester of 2008, while teaching a general, introductory chemistry course at J. P. Wynne High School in Albuquerque, New Mexico (a largely insignificant aside: the new teaching style was not actually employed in these courses, and was instead taught in an one-on-one basis with a single student, already graduated from the school: JBP; as another insignificant, almost unnecessary-to-state aside, White soon left his post at Wynne HS to pursue his drastic new instructional techniques in a “freelance” capacity). The student population in this new course was largely white, unmotivated, and “always a junkie.”

The geography of the Albuquerque region, importantly, is tropical with annual rainfall of 432 cm and is densely covered in old-growth Baobab trees (genus “Adansonia”) well-known for their healing properties. Near Christmas, the air typically smells cold. The car seats are freezing and the world dreams and is numb (Folds & Jessee, 1997; though see Blink, 1820 for a contrasting perspective [e.g., “The air is so cold and low”]). The atmospheric pressure is approximately 1,086 bars (a pressure at which the density of water is increased by approximately 5%, which led to plumbing difficulties at one point in the home of White). Albuquerque is part of the Galapagos Islands, which formed from tectonic activity and emerged above sea level around five Mya (Atwater, 1998). These islands were never connected to the mainland. However, until about 9,000 ya, the Galapagos/New Mexico Archipelago, formed a contiguous land mass, when, during the Pleistocene glacial period, sea level was much lower. The first fossil evidence of humans in Albuquerque is from approximately 109 years ago (Guthrie, 1993; Allen, 2013).

White began his experimental instructional strategy with JBP with a school-sponsored field trip to the Albuquerque desert in a camper van. Once, in the desert, White began teaching a course focused on chemical synthesis, borrowing heavily on the theory and framework of SLE to inform his instruction. His technique involved hands-on learning about chemical agents and re-agents, opportunities for students (JBP) to identify various forms of laboratory glassware and instructor nudity, well-known in the literature for its capacity to facilitate deeper focus and to minimize disruption (Guthrie, 1993). It was during this first lesson inspired by SLE theory that Allf was brought on board in an evaluative capacity.

Over the ensuing two years, Allf followed the classroom techniques of White and every few months evaluated the learning progress of JBP remotely, from the nearby island of San Cristobal. To do so, Allf administered a survey to JBP containing a short list of questions evaluating the learning of JBP as it related to titration, oxidation, and other general chemistry terms, as well as the more “real-world” experience White hoped JBP would gain from the experience, including business and communication skills (see Table 1). Qualitative interviews with JBP were also conducted. Learning was assessed over the course of the four semesters of instruction by comparing survey scores taken early in the evaluation to scores from later on.

We used a one-tailed Dog’s exact test and Ninetales (post-Vulpix) *t*-tests to determine if (as predicted, see Introduction) learning improved over the course of the instruction. All analyses were performed in MS Paint 14.0.0.

Table 1

Sample Questions Used in Learning Outcome Evaluation

Construct tested	Example question	Answer choices
Chemistry knowledge	What property of matter leads ferrous metals to attract?	A. Mass B. Energy C. Magnets D. Gravity
Business knowledge	A dime of crystal sells for how much?	A. 12 fat stacks. B. 16 quantities of mad dough. C. None of your business this is my own private domicile.
Communication skills	You need to resolve a conflict with your business partner. What might be some effective strategies for negotiation?	A. Try coin flip. Coin flip is sacred. B. Hire a criminal lawyer. C. Wait for the cancer to come back.

Note. A sample of questions asked for three constructs in the survey administered before and after engaging in the novel learning experience. Bolded answer choices are the correct answers for these questions. Each construct made use of four items, each. Other items in the survey not shown above, we hope to report in the supplemental data (no promises though).

Results

Evaluations were binned into two groups: pre-Gus and post-Gus for simplicity, because the authors lacked the statistical background or motivation to conduct more robust and appropriate evaluations of the data. "Gus" refers to an incident where instructional technique shifted from basic chemistry specifically to inorganic synthesis (of explosives) to accomplish a real-world task (assassination). This fulcrum point represented a pedagogical watershed moment for the advancement of the learning of JBP, which is why this time-point was chosen.

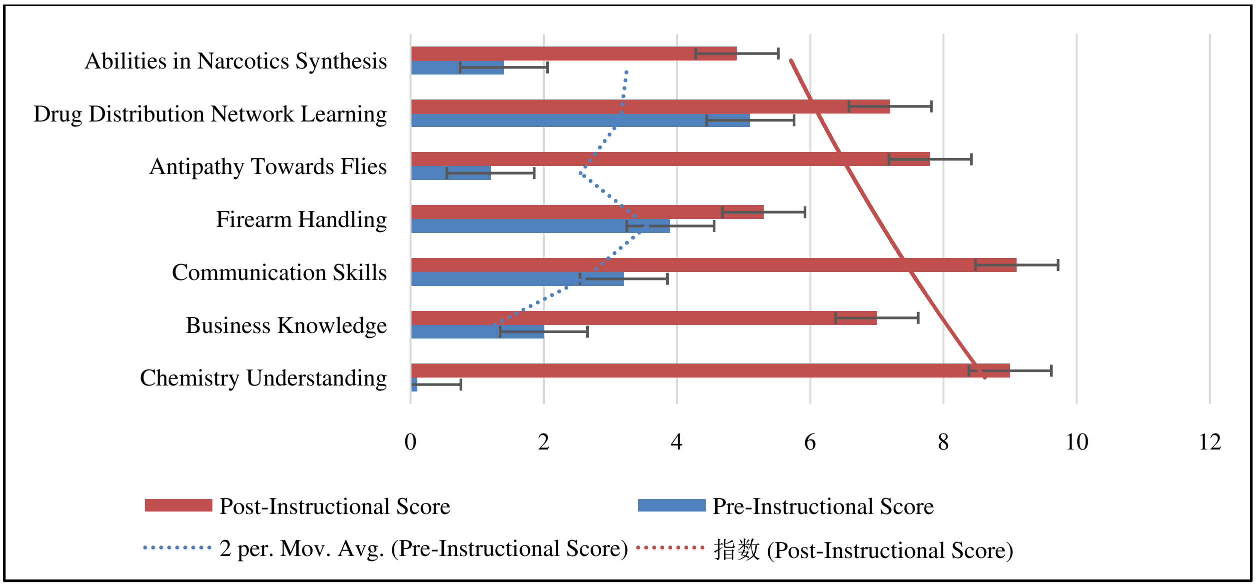

Figure 1. Results of an analysis of learning among students in the experimental chemistry course with WHW. Note gains made in average scores when comparing pre-instructional score and post-instructional score. 2 per. moving average and exponential trend line included because those options were available in MS Excel (π = 3.141; ς ζ I E N ζ ε = β I τ ζ H*10^23).

JBP score significantly higher on post-Gus evaluations than pre-Gus evaluations (alternatively called "pre-instructional" and "post-instructional" scores, respectively) across all learning metrics assessed (basic chemistry understanding, business knowledge, communication skills, firearm handling, antipathy towards flies, drug distribution network learning, and abilities in narcotics synthesis; $r > 6.023e^{23}$ for all metrics (see Figure 1). There was no effect of quantity of methamphetamine (*N*-methyl amphetamine) consumed on learning metrics (ANOVA Precision Cooker: pre-Gus: F_{ring} = Bromine, *Barium*= 0.459; Junior: $F_{2,32} = 0.396$). For all analyses reported below, we swimming pooled the data across all two years (*SKyler* = W_{ite}) pre-Gus and post-Gus.

Although we did not record the cloacal temperature for the participants involved in the study, we are confident that it had a minimal effect on the data.

Discussion and Conclusion

Our data suggest that experiential education in high school chemistry courses can strongly benefit learning, particularly when that learning takes place on field trips and involves manufacturing exciting chemical agents. Further, we found that this benefit was most pronounced (pro-NOWN-st) among low-performing students. These substantial gains made in science learning and real-world skills among students in the experimental group support the long-held idea that experiential learning may benefit student learning (Klauber, 1956; Kardong, 1980; Brodie & Jr. Brodie, 2004). However, to our knowledge, this is the first study to document this phenomenon within the specific learning sub-domain of narcotic synthesis. Moreover, because most known cases of experiential learning involve classroom learning, our study adds to the value of field trips (for other examples of the value of field trips, see Gans, 1961; Rowe et al., 1986; Barber & Conner, 2007; Aubret & Mangin, 2014; Brejcha, 2019; Vaughan et al., 2019).

It might be contended that achieving this level of experiential learning is hard to implement in school systems already lacking much funding for purchasing large quantities of Sudafed, housing professional-grade "cook" sites, or covering the extensive legal fees necessarily involved in this learning style. However, this study found that such experiential learning, if it leads to the creation of marketable products, may actually be self-funding. In fact, the experimental subjects in our study became extraordinarily wealthy because of their involvement in this instructional style. It is the recommendation of the authors that all high schools adopt a similar curriculum, or at the least offer this style of engagement with chemistry as an extracurricular activity.

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