Title: Teaching and Learning of Spectrometry Concepts in Advanced Placement (AP) Chemistry

Abstract: The purpose of this research proposal is to determine the efficacy of three different instructional delivery strategies in the spectroscopy unit within College Board's Advanced Placement (AP) Chemistry curriculum. Two goals will be measured. The first goal is to determine whether a specific instructional strategy– lecture-based, team-based, and research-based instruction - will elicit higher student affect towards science, research, and/or technology. To measure this, identical pre- and post-lesson "Science Affect" surveys will be issued to students, and questions will consist of a likert scale rating. The second more advantageous goal is to measure criterion-referenced learning gains of students for each lesson given in the unit.

Rationale: As a new, "un-trained" educator (non-education major), it remains vital in my practice that students can consistently find relevance in what they are learning, as well as being able to apply their knowledge in a way that allows them to evolve academically with respect to critical thinking and utilizing interdisciplinary approaches. Emphasis of these important factors in instructional design should, in theory, equip students with the ability to answer their own unique questions using scientific processes that align with their individual interests in an interdisciplinary way.

Currently I teach Chemistry Honors and Advanced Placement (AP) Chemistry at Kathleen Senior High School (KHS) in Lakeland, Florida. According to the Florida Department of Education, KHS is a title one school that has earned a school grade of "C" for the 2017-18 school year, and "D" for the 2015-16 and 2016-17 school years. The most recent enrollment data available from 2015-16 shows a total student enrollment of 2,234 students in grades 9-12, with a graduation rate of 75%, and 78.5% of the student body categorized as "economically disadvantaged" (FLDOE, n.d.). AP Chemistry was a course on hiatus for several years due to lack of faculty interest in teaching it, however in 2017-18 I was assigned one section with an initial enrollment of fifteen students. However, eight students remained approximately one month after beginning the school year with their grade levels ranging from 10th to 12th. Although the individual reasons for these "dropped" students varied, the common contributor was the students' fear of failing as a result of the rigor and complexity of undergraduate-level general chemistry studies in general.

Based on my own educational pathway and experience, chemistry was a very difficult topic to learn, apply, and ultimately appreciate. A true understanding of the subject matter was not fully grasped until multiple chemistry courses were completed – seven or so semester-long courses. The most impactful chemistry course that brought this difficult subject together was the final one of my undergraduate major in biomedical science - medical botany. It directly related plants and botanicals to the molecular structure of secondary metabolites, their function, and impacts on the human body in multiple respects (e.g. therapeutic, psychotropic, medicinal originations, etc.). In addition, this course tied in anthropological factors, general research strategies, and emerging technologies like genetic engineering to name a few. Genuine understanding required an interdisciplinary approach in the context of chemistry, and more importantly, utilizing our unique knowledge rooted in social, cultural, and medicinal experiences. As these factors coalesced my understanding of chemistry blossomed. This experiential conclusion is formally supported with a highly-referenced research paper conducted in Massachusetts Institute of Technology (MIT) introductory chemistry courses. It showed students "reported (…) their interest in chemistry and desire to learn more chemistry increased" when instructional modifications were made such that biology- and medicine-related examples were incorporated "to help them see the connection between biology and chemistry" (Taylor, Mitchell, Drennan. 2009).

Current teaching-and-learning research shows it is vital that measures are taken in chemistry classrooms to motivate, excite, and truly engage students such that they see the beauty of chemistry in an interdisciplinary way. The longstanding status quo has been that "most of [a student's] motivation comes from other disciplines that require chemistry courses" (Moore, 2007). Therefore, the rationale of this research action proposal seeks to determine the most effective instructional delivery strategy of chemical concepts (spectroscopy) that incorporates interdisciplinary applications - specifically related to emerging pathogens - while maximizing student interest in chemistry within a high school setting.

Intervention: The instructional approach taken throughout the 2017-18 school year with this unit was largely content-specific, lecture-based lessons since most AP students are college-aspiring. It was my goal to acclimate them to the educational environment and student expectations prevalent in college courses. However, for the 2018-19 school year I will instead utilize different instructional delivery methodologies – all with an interdisciplinary approach in the context of emerging pathogens and proteomic analysis – in an effort to increase their interest and motivation to continue studying chemistry. Students will:

- answer chemical concept questions in the context of biological processes
- consider various spectroscopy techniques and limitations when preparing analytical samples
- perform mass spectroscopy analysis on a protein sample they isolate from an emerging pathogen, and
- synthesize explanations in a team-based learning format

Data Collection and Analysis: Two forms of data will be collected to analyze the efficacy and impact of the different instructional delivery strategies used in this unit.

First, to determine whether a specific **instructional strategy**– lecture-based, team-based, and research-based instruction - will elicit higher student **affect** towards science, research, and/or technology, identical pre- and post-lesson "Science Affect" <u>surveys</u> will be issued to students. Questions will gauge a student's general agreement or disagreement with given statements, and they will respond using a likert scale rating ("strongly disagree", "disagree", "neither agree nor disagree", "agree", and "strongly agree"). Ranged responses (1 through 10, with 10 being the best) will also be incorporated to determine the strength of value students would rate their responses. Questions will focus around their attitudes and interests with respect to science, technology, and research. Survey data reflecting their personal feeling of success and relevance of the content will also be collected.

The second more advantageous goal is to determine whether criterion-referenced **learning gains** were achieved by students for each lesson given in the unit. To measure this, each lesson will contain a **pre- and post- formative assessment**. Even though lessons will cover different spectroscopy concepts, care will be taken to create these assessments with an equal number of items and difficulty for comparable analysis.

Connections to CATALySES 2018 Summer Institute: This action proposal incorporates several components presented during this science instructor professional development program, including: team-based learning, analytical chemistry techniques (specifically the use of mass spectrometry), proteomics, various isolation and/or purification techniques of samples, and the multifaceted consequences of pathogenic infection in life systems.

Literature Cited:

FLDOE. n.d. "Florida School Accountability Reports." Retrieved June 28, 2018, from http://www.fldoe.org/accountability/accountability-reporting/school-grades/

Moore, J. W. (2007) The many faces of (general) chemistry, J. Chem. Ed. 84, 1559.

Taylor, E.V., Mitchell, R., and Drennan, C.L. 2009. "Creating an Interdisciplinary Introductory Chemistry Course Without Time-Intensive Curriculum Changes." *ACS Chemical Biology* 4:979-982.