Diagnostic Prediction and Evaluation of Unprepared Students in CHEM 1211

Introduction/Context: A significant outcome from the analysis of assessment data generated by an in-house exam, and by a pilot study for the ACS Paired Question Exam, is that a measureable percentage of students currently enrolled in Principles of Chemistry I (CHEM 1211) are seriously underperforming. It is hypothesized that this is occurring because students are seriously unprepared for the rigors of the course, specifically with respect to chemistry and mathematics, and that a placement test could effectively pre-identify these students. Two other reasons for under-preforming, however, need also be considered (1) a student’s level of reasoning formalism (critical thinking) is not sufficiently developed; (2) a student’s attitude is not learning conducive. The proposed STEM mini project is to (1) evaluate the effectiveness of the American Chemical Society 2009 Toledo Chemistry Placement Exam (TCPE,) in identifying inadequately prepared students, and (2) to evaluate contributory factors for underperforming in CHEM 1211 (preparation, critical thinking, and attitude). Given that Principles of Chemistry I is foundational for many STEM courses, effectively addressing this systemic problem is expected to translate to lowered rates of attrition for STEM majors and overall improvement in the outcomes for our GPC students.

Background: Identification and application of factors that allow for a reliable prediction of student performance in Freshman Chemistry has been an ongoing focus of chemical education research (2-11). In order for students to successfully master the content presented in Freshman Chemistry they must come to the course with a sufficient foundation in chemistry and mathematics (2, 5-7, 11, 12). Placement testing has been used by numerous institutions as a diagnostic tool to identify students lacking sufficient grounding for the rigor presented in Freshman Chemistry (2, 4, 5, 8, 12) and the results generally correlate with overall course outcomes (2, 3, 8). The overall effectiveness of remediation these foundational deficiencies, however, has varied (6, 13-15). Clearly other causal factors for underperforming in Freshman Chemistry must also be considered, specifically in context of the cognitive-affective domain (16) First, long range operational understanding of the Freshman Chemistry, necessitates sufficient development of logical thinking skills in order to effectively process and integrate the content presented. (16-21). Second, the attitude that a student has towards the subject matter presented in the course and his/her self-concept as a learner will ultimately impact the level to which that student is able to engage the course and effectively learn (16, 22, 23).

Research Plan/Method: This project will encompass students enrolled in CHEM 1211 at the Clarkston, Decatur, Dunwoody, Newton, and Online campuses. GPC faculty who will be participating in this project are tabulated below. The TCPE will be given to students at the beginning of the semester, prior to receiving any content, and again at the end of the semester. To avoid unnecessary biasing of the data collected, instructors will not evaluate or compile results obtained during a given semester until the completion of that semester. Logical Reasoning and cognitive processes will be measured using the Group Assessment of Logical Thinking (GALT) instrument (17, 18, 24) and the Motivated Strategies for Learning Questionnaire (MSLQ, 25-27). Student attitude with respect to chemistry and their self-concept as learners will be measured via a series of likert surveys that include: the Chemistry Self-Concept Inventory (CSCI, 28), the Attitude to the Subject of Chemistry Inventory (ASCI, 29) and the Learning Goals Inventory (LGI, 30). The Office of Institutional Research and Planning (OIRP) will administer these instruments and subsequently submit tabulated results to the Principle Investigator (PI). Other normalizing factors, (specifically number of previous college chemistry, number of math courses at the level of algebra or beyond, age group, high-school chemistry grades, and SAT (or ACT) scores will also be solicited through OIRP.

Students who elect to participate in this study will be asked to provide their GPC 900 number on the various instruments as a means of coordination. The overall aggregate results reported will be student anonymous.

Table 1 Participating GPC Faculty

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<thead>
<tr>
<th>Faculty</th>
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Evaluation: The pre and post TCPE results will be correlated to each other and the results of course assessment exam, the American Chemical Society Paired Question Exam (PQE, 31). The effectiveness of the TCPE as a predictor of student success will be ascertained through a logit type analysis (3, 7), with the TCPE score serving as the continuous variable, and the binary response derived from the outcome on the PQE (assigned 1 for scores at or above the national norm and 0 for results that fall below). The extent to which foundational understanding, reasoning formalism, and attitude impact overall outcome will be evaluated by averaging the outcomes of the various instruments at different ability levels, as determined by a z-score analysis of the PQE relative to national norms (32), and performing chi-square and factor analysis. XLStat (33)
provides a statistical add-in to Excel that can handle these statistical analyses. Student GPC 900 ID numbers will serve as a basis of coordination.

**Dissemination:** To obtain statistically viable data a minimal 5-year period is proposed, well beyond the scope of the STEM mini grant. However the preliminary outcomes generated during the 2012-2013 will be used to solicit more extensive grant support from agencies such as the National Science Foundation. It is anticipated that outcomes from this study will be presented by participating faculty at the ACS SERMACS and BCCE meetings, and at the Georgia Academy of Science meeting.

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24. Private Communication with UGA Department of Science Education.
30. [http://www.oakton.edu/user/~mwalter/lg/LGI.htm](http://www.oakton.edu/user/~mwalter/lg/LGI.htm) (out of circulation)
31. Examinations Institute of the American Chemical Society, Division of Chemical Education. *First Term General Chemistry Paired Questions*, 2005.
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33. [http://www.xlstat.com](http://www.xlstat.com)