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‘Experience Congruence’ as a Criterion for Generalizability?

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Abstract
When evaluating the applicability of published SoTL and/or educational research results, faculty often focus on the differences in demographic characteristics between the students in their academic context and those of the students where the data were collected. This could be problematic since readers might choose to dismiss a particular innovation if they perceive the discrepancies to be significant even though this reliance on demographics to identify informative pedagogical research may not always be justified. We report the results of a survey of 1326 students from three introductory-level, first-year chemistry courses (a total of 10 sections with 10 different instructors) at two universities with significantly different student populations. The survey asked students to choose the hardest and easiest from five groups of topics typically taught in first-year chemistry courses. Remarkably, when separated by lecture section, overlaid frequency plots of students’ choices of hardest topic revealed a singular pattern. The trend transcended universities, courses, textbooks, instructors, and demographics. The only common parameter between the samples was the chemistry topics they learned. The correspondence in content, as such, constituted an “experience congruence.” Based on these data, we propose that readers might consider experience congruence—in lieu of sample or population characteristics—as a criterion for judging the generalizability of educational data.

Keywords
quantitative data; surveys; generalizability; external validity; beliefs; introductory/first-year chemistry; General Chemistry

Introduction

In recent years instructors at all levels have been strongly encouraged to incorporate evidence-based, *a.k.a.* evidence-informed, practices as they consider modifications in their teaching (Pace, 2011). (Though “evidence-based practice” and “evidence-informed practice” may have different meanings for some readers, they will be used synonymously in this paper.) Effectively using this approach involves adopting research results from various literatures including those in SoTL, education, psychology, and cognitive science. One of instructors' major concerns is the applicability—i.e., generalizability or transferability—of those published results to their own contexts.

Campbell and Stanley (1963) characterize generalizability, or external validity, of quantitative data in educational research as follows: "*External validity* asks the question of *generalizability*: To what populations, settings, treatment variables, and measurement variables can the effect be generalized?" (p. 175, emphases in the original). Analogous to external validity, Barnes et al. (1994–2012) define transferability as "the process of applying the results of research in one situation to other similar situations" (p. 5). These authors contrast "transferability" with "generalizability" in that the former is a mechanism by which *readers* of the research determine the extent to which the results may be relevant to their settings. Generalizability, on the other hand, is a construct that researchers would use to assert the broader applicability of their findings. Furthermore, transferability is more commonly associated with qualitative research while generalizability is more commonly associated with quantitative (Guba, 1981; Lincoln & Guba, 1985). The remainder of this paper will focus on generalizability. Furthermore, per Campbell and Stanley's (1963) definition, we will use the terms "generalizability" and "external validity" synonymously.

There are four main types of threats to external validity, or limitations to the generalizability of the results from a research study (Tuckman & Harper, 2012). First, there is reactivity towards the experimental arrangement, most often manifested as the Hawthorne effect. Participants exhibit the Hawthorne effect when their behaviour changes simply because they know that they are being observed, or otherwise studied. A second potential threat to external validity can result from experimental designs using pre-tests. For example, the participants may assume that the topics highlighted in the pre-test items represent the main concepts of the study and, thus, may be more likely to focus on them during instruction. Third, there could be interference caused by multiple treatments, in which case it would not be possible to determine whether any observed effects resulted from a single treatment or because of the combination. The fourth threat to external validity results from biases related to sampling. For example, researchers may have little control over sample demographics when they are dependent on volunteers. Even when researchers are able to select a sample representative of the population, their data may reflect a more biased subset of that sample due to participant attrition or nonresponse (Kalaian & Kasim, 2008).

Although there are well-precedented methods to address each type of threat to external validity, researchers tend to focus primarily on reducing sampling-related biases as exemplified by Leighton's (2010) discussion of ways to increase external validity. Schofield (2002) explains that the main reasons for this emphasis are the multitude of sampling techniques in social science research along with the sample-to-population inferences that can be generated using probability and statistics. Though it would be ideal to recruit participants from a diversity of academic settings, it is not practicable in most cases. As such, the vast majority of research studies reported in the SoTL and education literatures rely on samples derived from a single population.

Multiple studies, therefore, would greatly help to address many of the potential concerns about generalizability. For example, a second set of researchers could repeat a study in a different academic setting. Such cases, however, are few and far between. Marley (2015) observed: "The lack of replication studies is often attributed to journal editors, reviewers, and granting agencies expecting novelty. If so, focusing on novelty of results could promote reward structures that minimize the value of replication studies…." Alternatively, one could conduct a meta-analysis once a "critical mass" of research on a topic (or closely related set of topics) has been published. Meta-analyses are particularly powerful because they can, in principle, address all four main classes of threats to external validity. Though replication studies and meta-analyses are certainly robust methods for establishing external validity, relying solely on multiple studies would undermine the value of published research in the SoTL and education literatures.

Researchers' focus on demographics when trying to address external validity implicitly obligates readers to, likewise, concentrate on similarities and differences between their contexts and those in which the data were collected. This could be problematic since readers might choose to dismiss a particular innovation if they perceive the discrepancies to be significant even though this reliance on demographics to identify informative pedagogical research may not always be justified.

We report the results of survey of 1326 students from three introductory-level, first-year chemistry courses (a total of 10 sections with 10 different instructors) at two universities with significantly different student populations. The survey asked students to choose the hardest and easiest from five groups of topics typically taught in first-year chemistry courses. Remarkably, when separated by lecture section, overlaid frequency plots of students' choices of hardest topic revealed a singular pattern. The trend transcended universities, courses, textbooks, instructors, and demographics. The only common parameter between the samples was the chemistry topics they learned. The correspondence in content, as such, constituted an "experience congruence." Based on these data, we propose that readers might consider experience congruence—in lieu of sample or population characteristics—as a criterion for judging the generalizability of educational data.

Methodology

The data presented here were collected as part of a project designed to better understand students' beliefs about the relative difficulty of topics that are typically covered in General Chemistry courses (Herridge, 2016). Our long-term goal is to characterize some of the concepts and ideas for which high-school and college students find chemistry to be hard, because the consequences of these negative perceptions are that students tend to either avoid chemistry or take the minimum mandated by degree requirements and/or career aspirations (Bauer, 2005; Drew, 2011; Karatjas & Webb, 2017). Additionally, this sense of negativity can lead to feelings of anxiety (Eddy, 2000; Mallow, 2006; McCarthy & Widanski, 2009) which, in turn, can result in poor performance.

Fishbein and Ajzen (1975) defined beliefs as "the information [a person] has about an object" (p. 12). The authors further describe "object" as "any discriminable aspect of the individual's world" (p. 12). In this model, therefore, people can form beliefs about the tangible and the intangible. We chose this definition to remain consistent with previous work by Bauer (2005) and Barbera et al. (2008) in chemical education research. Additionally, the Theory of Planned Behavior, which is in part based on this definition of beliefs, has been broadly applied across studies in the social and medical sciences (Casper, 2007).

Students' perceptions of chemistry have been reported primarily from academic self-concept and self-efficacy perspectives (Barbera et al., 2008; Bauer, 2005; Bauer, 2008; Ferrell & Barbera, 2015; Grove & Bretz, 2007; Lewis et al., 2009; Nieswandt, 2007). Academic self-concept refers to individuals' beliefs about their abilities to learn a specific discipline (Marsh, 1993). Self-efficacy, in contrast, pertains to individuals' beliefs about their abilities to complete specific tasks (Bandura, 1986). Both of these constructs have also been studied in the context of other STEM disciplines (Bong & Skaalvik, 2003; Deksissa et al., 2014; MacPhee et al., 2013; Nilsson & Stomberg, 2008; Rittmayer & Beier, 2009; Zeldin et al., 2008). For the research reported herein we surveyed students' beliefs about the difficulty and easiness about topics taught in first-year, introductory-level, college chemistry courses. Our study, therefore, could be described as using a "medium-grain" approach since the investigation is neither as global as self-concept nor as narrowly focused as self-efficacy.

Context

The data for this research were collected at two different universities with approval from the Institutional Review Boards of both institutions. One of the universities is located in the southeastern United States and the other in the Midwest. As shown in Table 1, both institutions are publicly funded and had undergraduate enrollments of around 20,000 students at the time of data collection. The southeastern institution, "SEU," is research intensive and STEM-focused; whereas the midwestern institution, "MWU," is a regional, comprehensive university which was originally one of its state's normal colleges for teacher training.

Table 1. Institutional Demographic Data

Category	**Southeastern University (SEU)**	**Midwestern University (MWU)**
Undergraduate Enrollment	18,599 (17,883 Fulltime)	20,316 (15,131 Fulltime)
Women	48%	58%
Minority	17%	19%
Age (>25)	4%	12%
Highest Degree Offered	Ph.D.	Master's

All the participants were volunteers recruited from introductory-level (first-year) chemistry courses. At SEU the sections of General Chemistry I (GC I) were coordinated by the Director of General Chemistry. To have some consistency, the instructors met with the director to decide upon a common set of topics for each chapter to be covered in all the course sections. (Each instructor had the freedom to decide how those topics were taught.) In all, 879 students from SEU participated in this survey.

Because general chemistry enrollment at MWU was far lower than that at SEU, we recruited 447 students from two different courses. About half of the participating students (48%) were enrolled in a one-semester survey covering most of the topics addressed in year-long general chemistry sequences. The primary audience for this course is nursing and allied health majors. The remainder of the students were enrolled in GC I, which – like that taught at SEU – is intended for majors in the physical and biological sciences, including students with aspirations for careers in medicine or dentistry.

Instrument Design

We created a survey consisting of demographic items and groupings of topics from which students could select the hardest or easiest, respectively. This study was first performed at SEU, where the overwhelming majority of the students in GC I would be in-state first-year students and would likely have taken high school chemistry. As such, we decided to use the State Standards for High School Chemistry as the basis for the construct of our survey (Zais, 2014). Upon review of the eight instructors' syllabi and consultation with them and the Director or General Chemistry, we made the following modifications to adapt the construct for our purposes:

- We excluded all topics from the student learning objectives focused on scientific processes, such as H.C.1 (p. 82): "The student will use the science and engineering practices, including the processes and skills of scientific inquiry, to develop understandings of science content." This and similar objectives were explicitly addressed in the lab portion of the course.
- To align the subject matter in our construct with the organization of the General Chemistry curriculum, we grouped together topics that were otherwise broadly distributed in the State Standards. For example, the application of mathematics was included in each of the standards. In GC I, however, explicit instruction for these topics occurred during the first few weeks of the course. As such, one of the groups of topics in our survey became: scientific notation, significant digits, dimensional analysis, graph reading, and model development (Table 2).
- We limited the scope of topics to those covered in the first two-thirds of the course to minimize the possibility of students' unfamiliarity with them at the time of data collection.

Table 2. Topic Groups for Survey Instrument

Group	Topics
A	Scientific notation, significant digits, dimensional analysis, graph reading, model development
B	Electron configurations and orbitals, Lewis dot structures
C	Property trends (electron configuration, ionization energy, electron affinity, atomic size, ionic size, reactivity)
D	Types of bonding (ionic and covalent)
E	Names and formulas for ionic and covalent compounds

It is important to note that our focus was on students' beliefs about the difficulty of chemistry topics, such as chemical and physical properties of a substance. To minimize the possibility that the participants might interpret survey items from a broader, self-efficacy perspective (Bandura, 1986), therefore, we did not put any items that included types of tasks or specific tasks such as solving specific types of problems. The grouping of topics from which students were to choose the hardest and easiest, respectively, were reviewed again by the General Chemistry Instructors. The entire survey administered at the two sites can be found in the Appendices.

Data Collection and Analysis

As approved by the IRBs of both universities, the professors administered the survey during the final in-term exam of the semester. (Students were given the surveys after completing the exam.) The timing was chosen to maximize the possibility of the students' participation in the study and familiarity with the topics. To ensure the voluntary nature of participation, we attached letters of informed consent. Based solely upon the instructor's preference, students completed the survey electronically, using iClickers®, or on paper. The electronic option at MWU was using the TurningPoint® polling system.

Since the administration at MWU was to verify the results from SEU, the data from the universities were not combined. The groups of topics could not be treated as variables, categorical or continuous, because the selections were based solely on the participants' perceptions without any reference to an "external standard." As such, we did simple frequency counts of the choices and plotted those on histograms. Furthermore, the students only chose one hardest and one easiest topic, respectively; they did not rank the topics. As such, the data from those two items were not expected to be the inverse of one another, which was confirmed from a preliminary analysis of the SEU data (Table 3). To simplify the remainder of the data analysis and presentation, therefore, we chose to focus on the students' choice of hardest topic.

Table 3. SEU Students' Choice of Hardest and Easiest Topics

Group	Topics	***N*** (Hardest)	***N*** (Easiest)
A	Scientific notation, significant digits, dimensional analysis, graph reading, model development	60 (7%)	508 (58%)
B	Electron configurations and orbitals, Lewis dot structures	202 (23%)	134 (15%)
C	Property trends (electron configuration, ionization energy, electron affinity, atomic size, ionic size, reactivity)	391 (44%)	100 (11%)
D	Types of bonding (ionic and covalent)	121 (14%)	44 (5%)
E	Names and formulas for ionic and covalent compounds	105 (12%)	93 (11%)

Results

Table 4 shows the frequency counts for the students' choices of hardest topic by institution. The histograms corresponding to the data are shown in Figure 1. These results indicate that even with the apparent ambiguity of the word "hard," the data were reproducible, which suggests that the survey instrument was reliable. In fact, the participants selected three sets of topics—Groups A, C, and D—with equal, or nearly equal, frequency.

Table 4. Frequency Counts of Hardest Topic

Group	Topics	*N* (SEU)	*N* (MWU)
A	Scientific notation, significant digits, dimensional analysis, graph reading, model development	60 (7%)	33 (7%)
B	Electron configurations and orbitals, Lewis dot structures	202 (23%)	76 (16%)
C	Property trends (electron configuration, ionization energy, electron affinity, atomic size, ionic size, reactivity)	391 (44%)	180 (41%)
D	Types of bonding (ionic and covalent)	121 (14%)	65 (15%)
E	Names and formulas for ionic and covalent compounds	105 (12%)	93 (21%)
TOTAL NUMBER OF RESPONDENTS		**879**	**447**

The least-frequently chosen group of topics was A, consisting of the mathematical concepts of scientific notation, significant digits, dimensional analysis, graph reading, and model development. It is important to note that the survey asked students to respond based on a relative scale instead of an absolute one. As such, we cannot claim that students found the mathematical topics to be easy; just that the students believed the topics of Group A to be the least difficult among the choices. Nonetheless, evidence in the research literature indicate a Dunning-Kruger effect (Kruger & Dunning, 1999) among general-chemistry students, especially lower-achievers, who tend to overestimate their mathematical ability but fall short in performance, particularly on tasks involving graphs (Leopold & Edgar, 2008; Quinn, 2013).

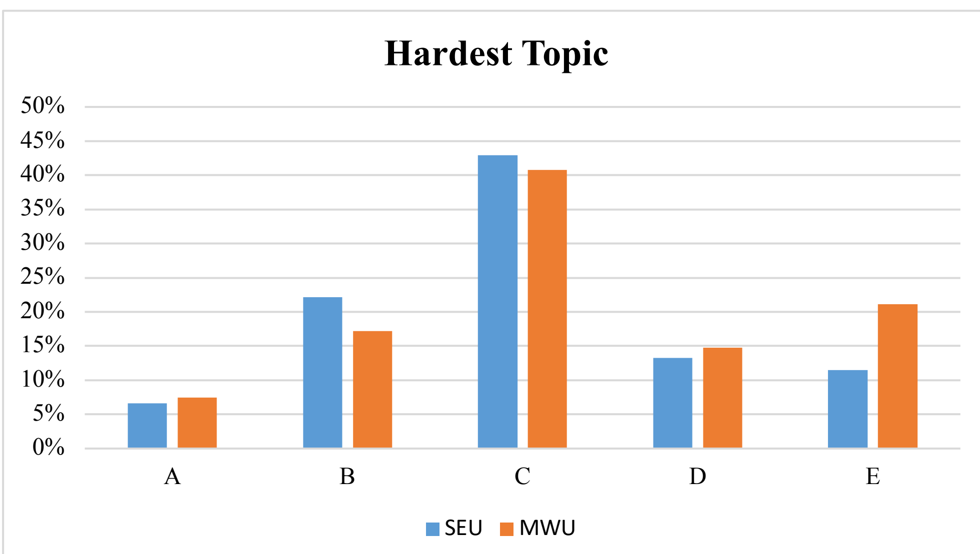

Figure 1. Histograms of Students' Choice of Hardest Topics

The most remarkable result of this research is the plot in Figure 2, which shows students' survey choices of hardest topic by lecture section. As the graph indicates, the students' beliefs had the same overall pattern! Despite different institutions, semesters, courses, textbooks and other course materials, the responses were overwhelmingly consistent. Additionally, the experience of the course instructors ranged from one to 40 years, and some of the sections served primary audiences such as engineering or nursing majors. Lastly, the shape of the curves was observed despite differences in race, gender, major, and overall GPA. We are unable to further explain this result at this time; that aspect will be left to another investigation.

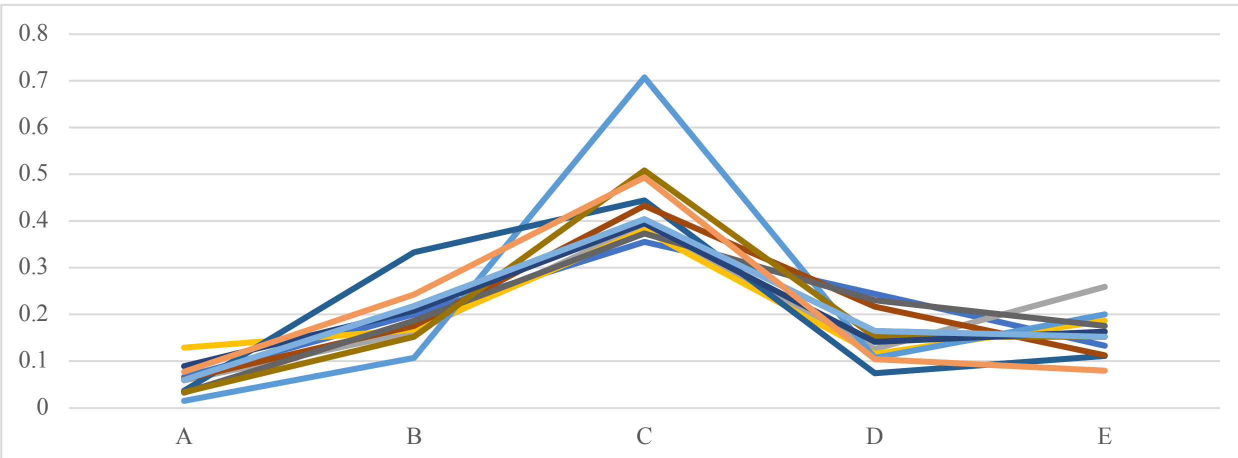

Figure 2. Student selection for hardest topic by section. The data in this graph were collected from two universities, three different courses, three different textbooks, 10 different course instructors, and significant differences in course goals and demographics.

Though we believe our findings may be compelling, there are limitations with which the data should be interpreted. First, all of the survey results are based on a single, relativistic choice of the hardest or easiest group of topics. Neither did the participants rank the group of topics nor did we evaluate the data against some "external" criteria. Second, we assumed that the students recognized and, at least to an extent, could understand the survey topics. Third, we presumed that students could, at least to an extent, see an underlying connection between the topics in each group. Fourth, we assumed that the participants had sufficient metacognitive awareness to identify their problem areas and make choices based on that awareness.

Conclusions and Implications

In this study we surveyed over 1300 students in two institutions with significant differences in their student populations. From groups of topics typically taught in introductory-level, first-year chemistry courses, the participants chose the hardest and the easiest. Our analysis of the choices for the hardest group of topics indicated that students uniformly believed property trends to be the most difficult and math-based topics the least difficult. This consistency in students' self-reported beliefs transcended institutional boundaries, multiple demographic factors, course level and primary audience, and instructional and assessment materials. Results from additional research into some of the possible reasons for the students' choices will be reported in due time (Herridge, 2016).

The main implication of our research is that when judging the potential generalizability of research results to their own institutional contexts, readers should also consider experience congruence in addition to or perhaps in lieu of demographic characteristics. The suggestion that experience congruence should be a criterion for evaluating external validity has precedents in the social sciences. Consider, for example, that multinational retailers have a small variety of store layouts globally (Turley & Milliman, 2000) and that engineers build parking lots for those stores based on customers' predictable usage patterns (McCourt, 2009). Furthermore, it was this type of patterned human behavior that inspired Marton's (1986) formulation of phenomenography—that we experience phenomena in our world in a limited number of ways—and its subsequent use in education research (Entwistle, 1997). Finally, experience congruence is wholly consistent with Campbell and Stanley's (1963) original characterization of external validity.

Our study also demonstrates that results from surveys with one or more flaws should not reflexively be discarded. Though there were the limitations noted above, we did establish construct and, to an extent, content validity by using the state secondary science standards and consulting with the course instructors. An additional point we have considered—especially in the absence of a statistical analysis—is the probability that the data reflect a systematic error. For example, a student could have made their choices based on a single topic in that group. While that is certainly possible, it is unlikely that all of the students would have made their choices for the same topic in a particular group.

Finally, our research serves as an important reminder that students' beliefs about their abilities are often contrary to their performance. For example, the students in our study consistently chose the mathematical topics as the least difficult and, coincidentally, the easiest. These data are consistent with other research that has shown that GC I students tend to overestimate their ability to solve mathematically based problems. Instructors, therefore, could use the results of this study to remind students of these discrepancies as the latter prepare to study for exams.

References

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Prentice Hall.

Barbera, J., Adams, W. K., Wieman, C. E., & Perkins, K. K. (2008). Modifying and validating the Colorado Learning Attitudes about Science Survey for use in chemistry. *Journal of Chemical Education, 85,* 1435–1439. https://doi.org/10.1021/ed085p1435

Barnes, J., Conrad, K., Demont-Heinrich, C., Graziano, M., Kowalski, D., Neufeld, J., Zamora, J., & Palmquist, M. (1994–2012). *Generalizability and Transferability.* https://writing.colostate.edu/guides/guide.cfm?guideid=65

Bauer, C. (2005). Beyond "student attitudes": Chemistry Self-Concept Inventory for assessment of the affective component of student learning. *Journal of Chemical Education, 82,* 1864–1870. https://doi.org/10.1021/ed082p1864

Bauer, C. F. (2008). Attitude towards chemistry: A semantic differential instrument for assessing curriculum impacts. *Journal of Chemical Education, 85,* 1440–1445. https://doi.org/10.1021/ed085p1440

Bong, M., & Skaalvik, E. (2003). Academic self-concept and self-efficacy: How different are they really? *Educational Psychology Review, 15,* 1–40. https://doi.org/10.1023/A:1021302408382

Campbell, D. T., & Stanley, J. (1963). Experimental and quasi-experimental designs for research on teaching. In N. Gage (Ed.), *Handbook of Research on Teaching* (pp. 171–246). Rand McNally.

Casper, E. (2007). The theory of planned behavior applied to continuing education for mental health professionals. *Psychiatric Services, 58,* 1324–1329. https://ps.psychiatryonline.org/doi/full/10.1176/ps.2007.58.10.1324

Deksissa, T., Liang, L., Behera, P., & Harkness, S. (2014). Fostering significant learning in sciences. *International Journal for the Scholarship of Teaching and Learning, 8*(2), Article 12. https://doi.org/10.20429/ijsotl.2014.080212

Drew, C. (2011, November 4). Why science majors change their minds (It's just so darn hard). *The New York Times,* p. ED16. https://www.nytimes.com/2011/11/06/education/edlife/why-science-majors-change-their-mind-its-just-so-darn-hard.html

Eddy, R. (2000). Chemophobia in the college classroom: Extent, sources, and student characteristics. *Journal of Chemical Education, 77,* 514. https://doi.org/10.1021/ed077p514

Entwistle, N. (1997). Reconstituting approaches to learning. *Higher Education, 33,* 213–218. https://doi.org/10.1023/A:1002930608372

Ferrell, B., & Barbera, J. (2015). Analysis of students' self-efficacy, interest, and effort beliefs in general chemistry. *Chemistry Education Research and Practice, 16,* 318–337. https://doi.org/10.1039/C4RP00152D

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behavior: An introduction to theory and research.* Addison-Wesley.

Grove, N., & Bretz, S. L. (2007). CHEMX: An instrument to assess students' cognitive expectations for learning chemistry. *Journal of Chemical Education, 84*(9), 1524–1529. https://doi.org/10.1021/ed084p1524

Guba, E.G. (1981). Criteria for assessing the trustworthiness of naturalistic inquiries. *Educational Communication and Technology: A Journal of Theory, Research and Development, 29,* 75–91. https://doi.org/10.1007/BF02766777

Herridge, M. D. H. (2016). *Student identification of problem topics in general chemistry*. (Publication No. 2964). [Master's thesis, Missouri State University.] MSU Graduate Theses.

Kalaian, S. A., & Kasim, R. M. (2008). External validity. In P. J. Lavrakas (Ed.), *Encyclopedia of survey research methods* (pp. 254–257). Sage.

Karatjas, A., & Webb, J. (2017). The role of student major in grade perception in chemistry courses. *International Journal for the Scholarship of Teaching and Learning, 11*(2), Article 14. https://doi.org/10.20429/ijsotl.2017.110214

Kruger, J., & Dunning, D. (1999). Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology, 77,* 1121–1134. https://doi.org/10.1037/0022-3514.77.6.1121

Leighton, J. (2010). External validity. In N. J. Salkind (Ed.), *Encyclopedia of research design*. (pp. 466–469). Sage.

Leopold, D., & Edgar, B. (2008). Degree of mathematics fluency and success in second-semester introductory chemistry. *Journal of Chemical Education, 85,* 724–731. https://doi.org/10.1021/ed085p724

Lewis, S., Shaw, J., Heitz, J., & Webster, G. (2009). Attitude counts: Self-concept and success in general chemistry. *Journal of Chemical Education, 86,* 744–749. https://doi.org/10.1021/ed086p744

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Sage.

MacPhee, D., Farro, S., & Canetto, S. (2013). Academic self-efficacy and performance of underrepresented stem majors: Gender, ethnic, and social class patterns. *Analyses of Social Issues and Public Policy, 13,* 347–369. https://doi.org/10.1111/asap.12033

Mallow, J. (2006). Science anxiety: Research and action. In J. Mintzes & W. Leonard (Eds.), *Handbook of college science teaching* (pp. 3–14). NSTA Press.

Marley, S. (2015, July 23). Replication and generalizability of evidence-based practices: More credible research is needed, and it needs to be done right. https://www.psychologytoday.com/us/blog/psyched/201507/replication-and-generalizability-evidence-based-practices on 12/06/17.

Marsh, H. W. (1993). Academic self-concept: Theory, measurement, and research. In J. M. Suls (Ed.), *Psychological perspectives on the self, Vol. 4. The self in ocial perspective* (pp. 59–98). Lawrence Erlbaum Associates.

Marton, F. (1986). Phenomenography: A research approach to investigating different understandings of reality. *Journal of Thought, 21,* 28–49. https://www.jstor.org/stable/42589189

McCarthy, W., & Widanski, B. (2009). Assessment of chemistry anxiety in a two-year college. *Journal of Chemical Education, 86,* 1447–1449. https://doi.org/10.1021/ed086p1447

McCourt, R. (2009). Parking. In *Traffic engineering handbook, 6th Ed.* (pp. 473–530). Institute for Transportation Engineers.

Nieswandt, M. (2007). Student affect and conceptual understanding in learning chemistry. *Journal of Research in Science Teaching, 44,* 908–937. https://doi.org/10.1002/tea.20169

Nilsson, K., & Stomberg, M. (2008). Nursing students' motivation toward their studies – a survey study. *BMC Nursing, 7,* 1–7. *https://doi.org/10.1186/1472-6955-7-6*
Pace, D. (2011). Assessment in history: The case for "decoding" the discipline. *Journal of the Scholarship of Teaching and Learning, 11,* 107–199. https://scholarworks.iu.edu/journals/index.php/josotl/article/view/1823
Quinn, R. (2013). Students' confidence in the ability to transfer basic math skills in introductory physics and chemistry courses at a community college. [Unpublished doctoral dissertation]. University of Southern Mississippi, Hattiesburg, MS.
Rittmayer, M. A., & Beier, M. E. (2009). Self-efficacy in STEM. In B. Bogue & E. Cady (Eds.). *Applying research to practice (ARP) resources.* http://www.engr.psu.edu/AWE/ARPresources.aspx on 04/18/18.
Schofield, J. W. (2002). Increasing the generalizability of qualitative research. In A. Huberman & M. Miles (Eds.), *The qualitative researcher's companion* (pp. 171–203). Sage.
Tuckman, B. W., & Harper, B. E. (2012). *Conducting educational research, 6th Ed.* Rowman and Littlefield.
Turley, L., & Milliman, R. (2000). Atmospheric effects on shopping behavior: A review of the experimental evidence. *Journal of Business Research, 49,* 193–211. https://doi.org/10.1016/S0148-2963(99)00010-7
Zais, M. (2014). South Carolina academic standards and performance indicators for science. Retrieved from https://ed.sc.gov/scdoe/assets/file/agency/ccr/Standards-Learning/documents/South_Carolina_Academic_Standards_and_Performance_Indicators_for_Science_2014.pdf.
Zeldin, A., Britner, S., & Pajares, F. (2008). A comparative study of the self-efficacy beliefs of successful men and women in mathematics, science, and technology careers. *Journal of Research in Science Teaching, 45,* 1036–1058. https://doi.org/10.1002/tea.20195

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Appendix A: SEU Survey

What year was your high school graduation?
A. 2013
B. 2012
C. 2011
D. 2010
E. 2009 or prior

Why did you decide to take this class?
A. General Education requirement
B. Major requirement
C. Just for fun
D. Other

What is your major?
A. Sciences – biology, chemistry, physics, biochemistry, genetics, etc
B. Social science - sociology, psychology, political science, anthropology, etc
C. Engineering
D. English and Languages – English, literature, foreign language, etc
E. History and Humanities – business, history, philosophy, etc
F. Arts – music, theater, etc

What grade do you expect to get in this chemistry course?
A. A
B. B
C. C
D. D
E. F

What is your current midterm grade?
A. A
B. B
C. C
D. D
E. F

How many hours a week outside of class do you spend working on this course, (e.g. studying or doing homework)?
A. 0-2.99 hours
B. 3.0-5.99 hours
C. 6.0-8.99 hours
D. 9.0-11.99 hours
E. 12+ hours

What chemistry topic was most difficult for you to understand?

A. Scientific notation, significant digits, dimensional analysis, graph reading, model development
B. Electron configurations and orbitals; Lewis dot structures
C. Property trends (electron configuration, ionization energy, electron affinity, atomic size, ionic size, reactivity)
D. Types of bonding (ionic and covalent)
E. Names and formulas for ionic and covalent compounds

What chemistry topic was easiest for you to understand?

A. Scientific notation, significant digits, dimensional analysis, graph reading, model development
B. Electron configurations and orbitals; Lewis dot structures
C. Property trends (electron configuration, ionization energy, electron affinity, atomic size, ionic size, reactivity)
D. Types of bonding (ionic and covalent)
E. Names and formulas for ionic and covalent compounds

Appendix B: MWU Survey

What chemistry lecture class are you currently enrolled in?

A. CHM 116
B. CHM 160

What year was your high school graduation?

A. 2014
B. 2013
C. 2012
D. 2011
E. 2010 or prior

Why did you decide to take this class?

A. General Education requirement
B. Major requirement
C. Just for fun
D. Other

What is your college?

A. Natural and Applied Sciences –
(Biology; Chemistry; Computer Science; Geography, Geology, & Planning; Hospitality & Restaurant Administration; Mathematics; Physics, Astronomy, & Materials Science)
B. Health and Human Services –
(Biomedical Sciences; Communication Sciences & Disorders; Health, Physical Education & Recreation; Nursing; Physical Therapy; Physician Assistant Studies; Psychology; School of Social Work; Sports Medicine & Athletic Training)
C. Education –
(Childhood Education & Family Studies; Counseling, Leadership, & Special Education; Greenwood Laboratory School; Reading, Foundations, & Technology)
D. Humanities and Public Affairs OR Business –
(Defense & Strategic Studies; Economics; History; Military Science; Philosophy; Political Science; Religious Studies; Sociology, Anthropology, & Criminology; School of Accountancy; Computer Information Systems; Fashion & Interior Design; Finance & General Business; Management; Marketing; Technology & Construction Management)
E. Arts and Letters–
(Art & Design; Communication; English; Media, Journalism & Film; Modern & Classical Languages; Music; Theatre & Dance)

What grade do you expect to get in this chemistry course?

A. A
B. B
C. C
D. D
E. F

What is your current midterm grade?

A. A
B. B
C. C
D. D
E. F

How many hours a week outside of class do you spend working on this course, (e.g. studying or doing homework)?

A. 0-2.99 hours
B. 3.0-5.99 hours
C. 6.0-8.99 hours
D. 9.0-11.99 hours
E. 12+ hours

What chemistry topic was most difficult for you to understand?

A. Scientific notation, significant digits, dimensional analysis, graph reading, model development
B. Electron configurations and orbitals; Lewis dot structures
C. Property trends (electron configuration, ionization energy, electron affinity, atomic size, ionic size, reactivity)
D. Types of bonding (ionic and covalent)
E. Names and formulas for ionic and covalent compounds

What chemistry topic was easiest for you to understand?

A. Scientific notation, significant digits, dimensional analysis, graph reading, model development
B. Electron configurations and orbitals; Lewis dot structures
C. Property trends (electron configuration, ionization energy, electron affinity, atomic size, ionic size, reactivity)
D. Types of bonding (ionic and covalent)
E. Names and formulas for ionic and covalent compounds