

A proposal submitted to the Learning Analytics Fellows Program:

Using Analytics to Evaluate Influences on Student Learning Outcomes in a GenEd Science Course (G131, *Oceans & Our Global Environment*)

Simon C Brassell
Department of Geological Sciences
College of Arts and Sciences
simon@indiana.edu

Abstract

This proposal seeks to utilize analytics on student demographics and grade records in combination with data on their performance in the GenEd NMS class G131 "*Oceans and Our Global Environment*" to assess how performance in the class and its range of assignments may be related to specific student characteristics. The project is structured to examine such connections by testing six specific hypotheses: (i) Are all students equally successful in G131 irrespective of their gender, race, or citizenship?, (ii) Does success in G131 reflect a student's scientific background?, (iii) Is student performance in subsequent science classes enhanced by success in G131?, (iv) Is there a relationship between the success of students in G131 and their class standing?, (v) Does the online version of G131 yield equivalent outcomes to the traditional format?, (vi) Does success in G131 online reflect prior experiences with online courses, and does it bolster students' success when taking other online classes? The results obtained from evaluation of the analytics data, including relationships examined using statistical methods, will be used to identify modifications to G131 that should be implemented (e.g., changes to help students disadvantaged by their prior science background, decrease withdrawal rates, enhance performance in subsequent classes) to improve the learning outcomes of students when the course is revised during 2017/18. The overall aim of the project is to use analytics to identify what characteristics serve as predictors for student performance in G131 and determine how revisions to the course may help enhance student success in this class.

Project Description

A. Focus on G131: *Oceans and Our Global Environment*

This project will collate and evaluate data to assess factors that may influence success in G131 and its learning outcomes, including student demographics, preparedness in science, subsequent progress in science classes, and the effectiveness of teaching online vs. traditional format. Its overall aim is to utilize the evidence from analytics to improve successful learning outcomes from this course.

1. History of G131 *Oceans and our Global Environment*

I have taught 30 sessions of G131, *Oceans and Our Global Environment*, since 1995, which amounts to 1667 students who have completed the course. The course has evolved significantly over this time with major innovations including introduction of exercises utilizing web-based data in 1997, and a progressive transition of classes from (i) lecture & lab to (ii) lecture & computer lab to (iii) lecture & online exercises to (iv) a fully online class. The class enrollment averages 55 and the average grade distribution is A (28%), B (29%), C (23%), D (11%) and F (9%). The grades have improved from an average of 2.52 to 2.72 as the course migrated online. However, the number of students who withdraw has risen significantly (17% to 36%) following this transition, although the majority occur early in each semester, presumably as they learn about the course requirements.

2. Future of G131 *Oceans and our Global Environment*

I anticipate that a substantive revision of G131 will be undertaken in 2017/18 to update online class materials, develop new exercises, especially group activities, and redesign assignments. The information garnered from this project will be used to guide this restructuring process, targeting aspects of the course that are may negatively impact student learning, and potentially introducing additional materials to enhance the scaffolding for students with weaker science backgrounds.

B. Research Objectives

The overall goal of the project is to improve student learning outcomes. Evaluation of student performance associated with reporting of assessments for GenEd demonstrates that there many course assignments where a vast majority of students demonstrate mastery of each of the five learning outcomes for Natural & Mathematical Sciences (an understanding of scientific inquiry and the bases for technology; the ability to model and understand the physical and natural world; the ability to collect and interpret data, think critically, and conduct theoretically based inquiry; the ability to solve problems; analytical and/or quantitative skills). However, there are other class assignments, especially some of the exercises involving interpretation of oceanographic data, where student scores tend to exhibit bimodality, apparently split between (i) those who clearly comprehend the assignment and do well, and (ii) those who appear to struggle with individual questions typically providing answers that are irrelevant or inappropriate.

1. Student Demographics

Rationale: A fundamental aim in STEM education is enhanced participation by women and underrepresented minorities. Hence, assessment of the performance of these students in G131 is critical to understanding whether the course is effective in meeting this goal, and identifying where differences in performance exist to help enact corrective measures. In addition, the scientific terminology that permeates the class may present challenges in comprehension to international students for whom English is not their native language.

Hypothesis: Student success in G131 is independent of gender, race, ethnicity, and citizenship.

Evaluation: Comparison of students' demographic data with overall class performance and scores for a range of assignments that vary in their difficulty based on assessment data to identify specific differences in achievement that are linked to gender, race, or ethnicity, or citizenship.

2. Background in Science and Quantitative Reasoning

Rationale: Familiarity with scientific approaches to data analysis and intellectual enquiry may contribute to success in G131. Hence, assessment of linkages between the strength of students' background in science and their performance in G131 will explore whether any specific assignments appear to benefit students with more extensive backgrounds in science or greater competency in quantitative reasoning.

Hypothesis: Students with stronger background skills in the sciences based on their SAT scores, AP courses, or prior undergraduate coursework will exhibit stronger performances for specific assignments if their prior knowledge engenders success more than their learning within G131.

Evaluation: Comparison of students' backgrounds with their performance in class assignments that show a significant range in scores potentially related to scientific literacy. The aim is to assess whether weaker performance in G131 is related to prior scientific experiences.

3. G131 as Preparation for Subsequent Science Courses

Rationale: Oceanography is an integrated science, which means that G131 incorporates aspects of other scientific disciplines within its class scope. Students therefore receive an introduction to aspects of these fields in several G131 modules and topics. For example:

- a. *Physics:* Dynamics of motion of winds, waves and tides.
- b. *Chemistry:* Composition of seawater, role of nutrients in the ocean, and the relationship between photosynthesis and phytoplankton productivity.
- c. *Biology:* Aspects of the lifestyles and habitats of a wide range of marine biota.
- d. *Geology:* Plate tectonics and the evolutionary history of ocean basins.
- e. *Astronomy:* Lunar & solar influences on tides; climate controls linked to Milankovitch cycles.

Hypothesis: Students demonstrating competency or mastery of oceanographic concepts in G131 (e.g., A & B grades) should perform well in subsequent science classes.

Evaluation: Comparison of students' performance in G131 with that in their subsequent science classes, and a refinement of this assessment that explores linkages between performance in specific assignments and the relevant scientific disciplines (e.g., marine biota and biology).

4. Timing of Students' Fulfillment of GenEd NMS Requirement

Rationale: Students may postpone fulfilling the NMS GenEd requirement until their junior or senior year for various reasons, which may include their trepidation in taking a College-level science class because of their belief that they "can't do science".

Hypothesis: Students who lack confidence in their scientific aptitude may defer fulfillment of their GenEd NMS requirements and underperform in G131, thereby increasing the number of low grades (less than C-) and diminishing both the average GPA and the overall success of upperclassmen in the course.

Evaluation: Comparison of student performance in G131 with their class standing and overall GPA to assess whether learning outcomes are affected by when students take the course.

5. Student Success in Online versus Traditional Format

Rationale: G131 has long been taught with online exercises that require students to evaluate data from oceanographic websites. However, course migration to a fully online version means that the absence of regular class time may disadvantage students with weaker learning habits or time management skills, although the format of assignments has changed little. Recognizing common characteristics in the profiles of students that show differences in their performances in online vs. traditional G131 will help identify which students are better suited to each format.

Hypothesis: An online rather than traditional format for G131 will advantage students with strong learning skills and disadvantage students with weaker motivation who may experience difficulties in maintaining pace with the rigorous demands of an online science class.

Evaluation: Comparison of student profiles associated with strong or weak performance in the online vs. traditional format for G131 may help identify which groups of students should be encouraged or deterred from enrollment in online science classes.

6. Experience in Online Instruction

Rationale: G131 is the first online course taken by some students, whereas others have prior experience with this teaching format. Thus, differences in the prior experience of students may affect their success in online learning, and yet help prepare them for future online classes.

Hypothesis: Students who have been successful in previous online courses are more likely to be successful in G131 than students without such prior experience. Similarly, a strong performance in G131 should enhance student success in subsequent online courses.

Evaluation: Comparison of the performance of students in G131 relative to their familiarity with online courses will enable assessment of the importance of previous online experiences as a determining factor in promoting successful learning outcomes.

C. Significance and Impact on Undergraduate Learning

Recognizing how success in G131 relates to critical factors, such as student demographics, scientific preparedness, timing for fulfilling GenEd requirements, and familiarity with online courses, represents an important step in understanding how different undergraduate backgrounds affect learning outcomes.

1. Development of Strategies to Enhance Learning Outcomes

Testing the hypotheses central to this project will provide evidence of various influences that may affect the learning outcomes for specific groups of students taking G131. The analytics information will help identify where changes or additions to course materials (e.g., extra guides addressing specific topics) may provide appropriate scaffolding to assist these targeted groups of students. Thus, revisions to the course can be based on verified rather than anecdotal evidence.

D. Anticipated Outcomes

The outcomes from the project will include: (i) comprehension of influences on student learning in G131 attributed to student characteristics that are justified by data, (ii) actions in revising G131 to improve the learning outcomes of students, specifically addressing efforts toward changes that will benefit any groups of students found to be disadvantaged, and (iii) improvements in key metrics, such as grades for students irrespective of demographics or science background, decrease in withdrawal rates, and advances in performance in subsequent classes, whether science and/or online courses.

E. Research Methodology

The focus of the project is to examine connections among data on student demographics and class records with the comprehensive database of student performance in G131, which extends back many years. Collectively, these data sets will be used to evaluate the hypotheses outlined in Section B of this proposal, beginning with examination of spring and fall semesters of 2015 when the course transition from traditional to online format occurred.

1. Source Data

In summary, there are three specific data sets that will be examined and compared for the project:

- a. Student Demographics (Class standing; gender; race; citizenship).
- b. Student Records (Course grades; student GPA; SAT and AP scores).
- c. Course Records (Grades and assignment scores for past sections of G131).

2. Statistical Evaluation

Assessment of correlations among the various data will utilize standard statistical packages, including, for example, principal component analysis to examine relationships between data for student demographics and records with a spectrum of class assignments.

F. Measures of Success

The success of the project can be measured in terms of attaining short-term and longer-term objectives, which can be considered, respectively, as: (i) conclusions based on the data evaluation proposed herein, and (ii) actions in modifying G131 that are informed by the data and their assessment.

1. Substantiation or Refutation of Hypotheses

The first measure of success will be validation or refutation of the six hypotheses that constitute the research objectives, which requires that the data necessary to test them are available.

2. Enhancement of Learning Outcomes from Implementation of Changes in Course Design

The second level of success will be implementation of changes in G131 based on results from the project, followed by assessment of their effectiveness in achieving the desired improvement in learning outcomes using evidence from subsequent student demographics and records.

G. Previous Research Results

G131 was the subject of my course portfolio several years ago. The conclusions of this self-evaluation included recognition that: (i) students who were present in class to collect their exam papers averaged one letter grade higher than students who were absent, and (ii) awarding partial credit for partially correct answers was most beneficial to weaker students. However, several other ideas for examination of learning outcomes were constrained by the lack of access to student records. Thus, this project now provides the opportunity to address these issues and enact changes in the course informed by student analytic data.

SIMON C. BRASSELL

PROFESSOR, DEPT. OF GEOLOGICAL SCIENCES, INDIANA UNIVERSITY, BLOOMINGTON

ADDRESS: Department of Geological Sciences, Indiana University, Bloomington, IN 47405-1403.

Tel: (812) 855-3786; email: simon@indiana.edu; webpage: <http://geology.indiana.edu/brassell/index.html>

BIOGRAPHICAL SKETCH

DEGREES & ADVISORS:

- 1976 B.Sc. Joint Honours in Chemistry and Geology, University of Bristol, Class I.
- 1980 Ph.D. Organic Geochemistry, University of Bristol.
- Postgraduate: Professor Geoffrey Eglinton FRS (University of Bristol, deceased)
- Postdoctoral: Professors Geoffrey Eglinton FRS (deceased) & James R. Maxwell FRS (University of Bristol)

PROFESSIONAL EXPERIENCE:

- 1991- Professor of Geological Sciences & adjunct Professor of Environmental Sciences, Indiana University, Bloomington, IN.
- 1987-1991 Associate Professor of Geology & Applied Earth Sciences, Stanford University, CA. (tenured 1990)
- 1983-1987 Royal Society 1983 University Research Fellow, School of Chemistry, University of Bristol.
- 1980-1983 Postdoctoral Research Assistant, School of Chemistry, University of Bristol.
- 1976, 1977 Research Assistant, Laboratory of Chemical Biodynamics, University of California, Berkeley, CA.

HONORS & AWARDS:

- 1983 Royal Society 1983 University Research Fellowship
- 1988 David and Lucile Packard Fellowship for Science and Engineering
- 1999 Teaching Excellence Recognition Award, Dept. of Geological Sciences, Indiana U., Bloomington.
- 2000 Teaching Excellence Recognition Award, Dept. of Geological Sciences, Indiana U., Bloomington.
- 2001 Trustees Teaching Award, College of Arts & Sciences, Indiana University, Bloomington.
- 2002 Trustees Teaching Award, College of Arts & Sciences, Indiana University, Bloomington.
- 2004-2005 Fellow, Hanse-Wissenschaftskolleg, Delmenhorst, Germany.
- 2006 Best Paper Award for 2006 from the Organic Geochemistry Division, Geochemical Society.
- 2015 Trustees Teaching Award, College of Arts & Sciences, Indiana University, Bloomington.

MAJOR RESEARCH ACCOMPLISHMENTS:

Principal contributions to biogeochemical research in Earth and ocean sciences:

- Discovery and validation of alkenone unsaturation as a molecular proxy for sea surface temperatures.
- Development of molecular stratigraphy as a tool for palaeoenvironmental and palaeoclimatic assessment.
- Recognition of biomarkers as tracers of microbial, biological, and geological processes in natural systems.
- Demonstration of the capability of biomarkers to record their biological source and environmental fate.
- Elucidation of diagenetic pathways of biomarkers and their use in assessment of sediment maturity.

RESEARCH INTERESTS AND ACTIVITIES:

Research focuses on interdisciplinary approaches to assessment and interpretation of the biogeochemical carbon cycle. Interests include integration of evidence from biomarkers, in concert with isotopic profiles, with biological, environmental, chemical, physical and geological evidence to decipher and understand biogeochemical processes. Research aims concern assessment of the ability of stratigraphic variations in the carbon record to reflect climatic and evolutionary change. These activities and interests involve biogeochemical investigations concerned with elucidation of the identities, occurrences and significance of molecular and isotopic characteristics of organics to address:

- Temporal and spatial variability in the carbon cycle, especially fluctuations in ocean productivity and biota.
- Evidence for environmental and climate change provided by biogeochemical proxies in sediment records.
- Geochemical records of the history of events that have affected or perturbed global climate.
- Evolution developments in biosynthetic pathways over geological time linked to the progression of life.
- Microbial processes and communities transforming organic matter in sediments and its diagenetic alteration.
- Formation of source rocks and influences on petroleum generation, composition, and biodegradation.

RESEARCH GRANTS AND FUNDING:

Investigator or co-investigator on research grants from federal agencies (National Science Foundation, National Oceanic and Atmospheric Administration), international agencies (National Leading Laboratories of China), private foundations (David and Lucile Packard Foundation, Petroleum Research Fund of the American Chemical Society) and industrial corporations (including Chevron, Unocal, Newmont Mining, Petrobrás and Trintoc-Trintopec) that exceed \$4.3M in the U.S. since 1988, and £800k in the U.K. from governmental and independent research agencies (Natural Environment Research Council, Science and Engineering Council, Royal Society) between 1982 and 1987.

RESEARCH PUBLICATIONS AND AREAS OF CONTRIBUTIONS:

Author of >130 papers (>80 have student co-authors) in 20+ different journals and proceedings volumes and >160 published abstracts. Their focus is molecular organic geochemistry, but they span the interdisciplinary fields of marine and petroleum geochemistry, stratigraphy, sedimentary geology, oceanography, palaeoclimatology, and environmental chemistry. They include several benchmark contributions and have collectively accumulated almost 8000 citations according to the Web of Knowledge and >10700 in Google Scholar with a Hirsch index of 50.

TWELVE WELL-CITED PUBLICATIONS: (Web of Knowledge & Google Scholar citations in parentheses)

- Didyk B.M., Simoneit B.R.T., Brassell S.C., Eglinton G. (1978) Organic geochemical indicators of palaeoenvironmental conditions of sedimentation. *Nature* 272, 216-222. (983; 1377)
- Brassell S.C., Wardroper A.M.K., Thomson I.D., Maxwell J.R., Eglinton G. (1981) Specific acyclic isoprenoids as biological markers of methanogenic bacteria in marine sediments. *Nature* 290, 693-696. (182; 274)
- Mackenzie A.S., Brassell S.C., Eglinton G., Maxwell J.R. (1982) Chemical fossils - the geological fate of steroids. *Science* 217, 491-504. (428; 559)
- Goossens H., de Leeuw J.W., Schenck P.A., Brassell S.C. (1984) Tocopherols as likely precursors of pristane in ancient sediments and crude oils. *Nature* 312, 440-442. (325; 395)
- Marlowe I.T., Green J.C., Neal A.C., Brassell S.C., Eglinton G., Course P.A. (1984) Long chain (*n*-C₃₇-C₃₉) alkenones in the Prymnesiophyceae. *Brit. Phycol. J.* 19, 203-216. (259; 337)
- Marlowe I.T., Brassell S.C., Eglinton G., Green J.C. (1984) Long chain unsaturated ketones and esters in living organisms and marine sediments. *Org. Geochem.* 6, 135-141, Pergamon Press, Oxford. (190; 253)
- Robinson N., Eglinton G., Brassell S.C., Cranwell P.A. (1984) Dinoflagellate origin for sedimentary 4 α -methylsteroids and 5 α (H)-stanols. *Nature* 308, 439-442. (242; 284)
- Brassell S.C., Eglinton G., Marlowe I.T., Pflaumann U., Sarnthein M. (1986) Molecular stratigraphy: a new tool for climatic assessment. *Nature* 320, 129-133. (658; 957)
- Brassell S.C., Lewis C.A., de Leeuw J.W., de Lange F., Sinninghe Damsté J.S. (1986) Isoprenoid thiophenes: novel products of sediment diagenesis? *Nature* 320, 160-162. (151; 185)
- Mello M.R., Gaglianone P.C., Brassell S.C., Maxwell J.R. (1988) Geochemical and biological marker assessment of depositional environments using Brazilian offshore oils. *Mar. Petrol. Geol.* 5, 205-219. (158; 245)
- Marlowe I.T., Brassell S.C., Eglinton G., Green J.C. (1990) Long chain alkenones and alkyl alkenoates and the fossil coccolith record of marine sediments. *Chem. Geol.* 88, 349-375. (197, 248)
- Brassell S.C. (1993) Applications of biomarkers for delineating marine paleoclimate fluctuations during the Quaternary. In *Organic Geochemistry* (eds. Engel M.H. & Macko S.A.), pp. 699-738. Plenum, New York. (209; 282)

TEACHING ACTIVITIES:

Teaching activities that range from introductory undergraduate classes to advanced graduate study, and research on the assessment of measures of student learning linked to interactive exercises and other teaching strategies.

Undergraduate teaching focused on broad-based introductions to oceanography, climate change and Earth history:

- G131: "Oceans & Our Global Environment" Introductory oceanography with exercises focused on web resources.
- C105: "Records of Global Climate Change" An examination of modern and ancient records of global temperatures, atmospheric compositions, and patterns of ice and vegetation, including coverage of climate issues in the media.
- G104: "Evolution of the Earth" Investigation of the 5-billion-year history of the Earth based on the rock record.
- G302: "Development of the Global Environment" An exploration of Earth history, the development of the atmosphere, oceans and continents, the evolution of life, catastrophic events and climate change.

Graduate teaching focused in areas of biogeochemistry and topical areas of interdisciplinary research:

- G587: "Organic Geochemistry" A comprehensive treatment of molecular and isotopic features of organic matter.
- G690: Seminars on "Organic Geochemical Stratigraphy", "Petroleum Geochemistry", and "Paleoclimatology"

Grants: Recipient of 7 grants at Indiana University to develop and assess interactive learning in undergraduate classes.

STUDENTS & POSTDOCTORAL RESEARCH ASSISTANTS:

Advisor, co-advisor or committee chair of 22 Ph.D. students, 6 M.S. students, and 3 postdoctoral assistants. Research committee member or minor advisor of a further 50 Ph.D. and 14 M.S. students, and 5 undergraduates. Former advisees hold university academic appointments; positions in industry, in education, or with government agencies.

SERVICE & ADMINISTRATIVE ACTIVITIES:

Professional Service: illustrative examples of more significant activities within academic discipline.

- Member, Council of the European Association of Organic Geochemists 1985-87.
- Associate Editor, *Organic Geochemistry* 1985-87 and *Geochimica et Cosmochimica Acta* 1989-96.
- Proposal Review panelist for Geology & Paleontology, National Science Foundation. 1993-96, 2001.
- Organizer or Session Chair for professional meetings (Geological Society of America, American Chemical Society, Geochemical Society, International Meeting of Organic Geochemistry).

Departmental and University Service: examples of more significant activities among committee memberships.

- Chair, 2007-11; Director, Graduate Studies 1996-03, 15-16; Member, Policy (5x), Search (10x) Committees.
- Member, Bloomington Faculty Council 2003-05, 2015-17, College Policy Committee 2006-07, IU Bloomington GenEd Committee 2006-8, Dean/Director Search Committees (4x); SOTL Steering Committee 2003-10.