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Centre for Teaching and Learning

Faculty Specific Publications

Science

Articles / opinion pieces about teaching for the Faculty of Science

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Campbell, A., R. Kunnemeyer, et al. (2008). "Staff perceptions of higher education science and engineering learning communities." Research in Science & Technological Education 26(3): 279-294.

Abstract: This paper presents staff perceptions of higher education science and engineering learning communities derived from a cross-case analysis of four case studies across the New Zealand university and polytechnic sectors. First we report staff expectations and experiences in terms of infrastructure and resources, and their own careers. Staff perceptions of the diversity and differences in learning styles of their students are next, followed by the importance of practical skill development, pedagogies employed and their rationale, along with scaffolding and supporting of learning. The paper concludes by considering the nature of science (NoS) and engineering, and what messages about the NoS are presented by higher education staff. The research findings suggest that staff face conflicting demands on their time, with requirements for research and administration affecting their teaching roles. Lecturers report considerable diversity and students often ill-prepared for higher education study, and consider that students are required to learn a huge amount of information. While some staff attended courses in teaching, they feel unable to apply their learning in order to enhance student learning because of concerns that time spent doing so would reduce the amount of time available to deliver content. Class sizes were identified as having considerable impact on student learning and lectures offer little opportunity for active student engagement. Practical classes are highly valued, being seen as crucial for learning practical techniques and problem-solving. Small classes and practical classes provide opportunities to develop good working relationships with students. Lecturers felt that students need to become more independent and self-reliant in their learning, and that they needed to be supported in this process at the institutional level.

Crouch, C. H. and E. Mazur (2001). "Peer instruction: Ten years of experience and results." Am, J Phys. 69(9): 970-977.

Abstract: We report data from ten years of teaching with Peer Instruction (PI) in the calculus- and algebra-based introductory physics courses for nonmajors; our results indicate increased student mastery of both conceptual reasoning and quantitative problem solving upon implementing PI. We also discuss ways we have improved our implementation of PI since introducing it in 1991. Most notably, we have replaced in-class reading quizzes with pre-class written responses to the reading, introduced a research-based mechanics

textbook for portions of the course, and incorporated cooperative learning into the discussion sections as well as the lectures. These improvements are intended to help students learn more from pre-class reading and to increase student engagement in the discussion sections, and are accompanied by further increases in student understanding.

Davies, E. (2010). "Dynamic degrees." Chemistry World: 46-48.

Abstract: No abstract

Dufresne, R. J., W. J. Leonard, et al. (2002). "Making sense of Students' answers to Multiple-Choice Questions." The Physics teacher 40: 174-180.

Abstract: No abstract

Felder, R. M. (1991). "It goes without saying " Chemical Engineering Education 25(3): 132-133.

Abstract: No abstract

Felder, R. M. (1994). "Any Questions?" Chemical Engineering Education 28(3): 174-175.

Abstract: No abstract

Felder, R. M. (1995). "A Longitudinal study of Engineering Student Performance and retention. IV: Instructional methods and student responses to them." Journal of Engineering Education 84(4): 361-367.

Abstract: As part of an ongoing longitudinal study, the author taught five chemical engineering courses in consecutive semesters to a cohort of students, using cooperative learning and other instructional methods designed to address a broad spectrum of learning styles. This paper outlines the policies and procedures, assignments, and classroom activities in the experimental course sequence and describes the students' performance and attitudes as they progressed through the sequence. The results suggest that active and cooperative learning methods facilitate both learning and a variety of interpersonal and thinking skills, and that while these methods may initially provoke student resistance, the resistance can be overcome if the methods are implemented with care.

Felder, R. M. (2007). "Random Thoughts Sermons for Grumpy Campers." Chemical Engineering Education 41(3): 183-184.

Abstract: No abstract

Felder, R. M. and R. Brent (1999). "FAQs. II (a) Active learing vs. covering the Syllabus (b) Dealing with large classes." Chemical Engineering Education 33(4): 276-277.

Abstract: No abstract

Felder, R. M. and R. Brent (2009). "Active learning: An Introduction." ASQ Higher Education Brief 2(24): 5.

Abstract: No abstract

Felder, R. M., G. N. Felder, et al. (1998). "A Longitudinal study of Engineering student performance and retention V: Comparisons with traditionally-taught students." Journal of Engineering Education 87(4): 469-480.

Abstract: In a longitudinal study at North Carolina State University, a cohort of students took five chemical engineering courses taught by the same instructor in five consecutive semesters. The course instruction made extensive use of active and cooperative learning and a variety of other techniques designed to address a broad spectrum of learning styles. Previous reports on the study summarized the instructional methods used in the experimental course sequence, described the performance of the cohort in the introductory chemical engineering course, and examined performance and attitude differences between students from rural and urban backgrounds and between male and female students.1-4 This paper compares outcomes for the experimental cohort with outcomes for students in a traditionally-taught comparison group. The experimental group outperformed the comparison group on a number of measures, including retention and graduation in chemical engineering, and many more of the graduates in this group chose to pursue advanced study in the field. Since the experimental instructional model did not require small classes (the smallest of the experimental classes had 90 students) or specially equipped classrooms, it should be adaptable to any engineering curriculum at any institution.

Felder, R. M., D. R. Woods, et al. (2000). "The future of Engineering Education II. Teaching Methods that work." Chemical Engineering Education 34(1): 26-39.

Abstract: Discusses the quality of instruction for communication skills and creative thinking skills in engineering education and the difficulties caused by the single-subject approach in different engineering majors. Provides alternative solutions to the problem such as irrelevant teaching methods, difficulties in implementing technology in classrooms, and the use of theoretical-based literature in engineering education. (Contains 79 references.) (YDS)

Gallet, C. (1998). "Problem-solving teaching in the chemistry laboratory: Leaving the cooks..." Journal of Chemical Education 75(1): 72-77.

Abstract: The traditional "Cookbook-formula-experiments" do not develop student's scientific initiative, or creativity in the chemistry laboratory. Information is better understood, retained and transferred when the student elaborates it. A PST problem is an interactive situation in which a student has to assume his or her responsibility in gathering, assimilating and exchanging new information in a group. It is structured so that it presents the student a "puzzle"; it cannot be solved readily by the activation of a student's previous knowledge.

Johnstone, A. H. (2000). "Teaching of Chemistry – Logical or Psychological?" Chemistry Education: Research and Practice in Europe 1(1): 9-15.

Abstract: Chemistry is regarded as a difficult subject for students. The difficulties may lie in human learning as well as in the intrinsic nature of the subject. Concepts form from our senses by noticing common factors and regularities and by establishing examples and non-examples. This direct concept formation is possible in recognising, for instance, metals or flammable substances, but quite impossible for concepts like 'element' or 'compound', bonding types, internal crystal structures and family groupings such as alcohols, ketones or carbohydrates. The psychology for the formation of most of chemical concepts is quite different from that of the 'normal' world. We have the added complication of operating on and interrelating three levels of thought: the macro and tangible, the sub micro atomic and molecular, and the representational use of symbols and mathematics. It is psychological folly to introduce learners to ideas at all three levels simultaneously. Herein lies the origins of many misconceptions. The trained chemist can keep these three in balance, but not the learner. This paper explores the possibilities, for the curriculum, of a psychological approach in terms of curricular order, the gradual development of concepts, the function of laboratory work and the place of quantitative ideas. Chemical education research has advanced enough to offer pointers to the teacher, the administrator and the publisher of how our subject may be more effectively shared with our students.

Kinchin, I. M. (2001). "If concept mapping is so helpful to learning biology, why aren't we all doing it?" International Journal of Science Education 23(12): 1257- 1269.

Abstract: Concept mapping is described repeatedly in the literature as a tool that can support and enhance students' learning in science classrooms. Despite such endorsements, the use of concept mapping as a basis for classroom activities in UK secondary schools does not seem to be widespread. Some of the flaws in the supporting literature are highlighted. The two main barriers to the extensive adoption of concept mapping as an integral component of typical classroom strategies are seen as the epistemological beliefs of classroom teachers and the underlying philosophy of the curriculum that they are asked to deliver. In conclusion, concept mapping is seen as a tool that may support learning within an appropriate teaching ecology. Such an ecological perspective may require, for some, a re-conceptualization of the teacher's role in which teaching, learning and change are seen as integrated components of effective teaching.

Mazur, E. (1987). "Qualitative versus Quantitative Thinking: Are we Teaching the Right Thing?".

Abstract: No abstract

Mazur, E. (1992). "The problem with problems."

Abstract: No Abstract

McDonald, J. and L. Dominquez (2005). "Moving from Content Knowledge to Engagement." Journal of College of Science Teaching: 18-22.

Abstract: While the goal of science education used to be to produce more scientists, that goal has changed with the introduction of the National Science Education Standards (NSES) (NRC 1996). Society has recognized that it is essential for everyone, regardless of vocation, to understand the fundamentals of science and technology. The phrase that has come to represent this level of understanding is science literacy (Bybee 1997). Because science literacy demands that students be able to apply their knowledge to the world around them, the authors found that taking a service-learning approach in combination with environmental education methods greatly enhanced students' engagement with environmental and science issues. Combining service learning with environmental and science issues allows students to move beyond awareness toward engagement. The action team service project requires students to build in-depth knowledge, apply skills directly related to taking action, and reflect on their learning. The research conducted increases the science literacy of students. The action team service project is described. The use of the National Science Education Standards during these projects focused the need for college-level students to continue to be scientifically literate citizens that work in schools and in nonformal education venues. This project allowed students to choose a science issue, research that issue using a balanced approach, and inform themselves as well as others about the issue.

Michael, J. (2006). "Where's the evidence that active learning works? Adv Physiol Educ 30: 159–167.

Abstract: Michael calls for reforms in the ways we teach science at all levels, and in all disciplines, are wide spread. The effectiveness of the changes being called for, employment of student-centered, active learning pedagogy, is now well supported by evidence. The relevant data have come from a number of different disciplines that include the learning sciences, cognitive psychology, and educational psychology. There is a growing body of research within specific scientific teaching communities that supports and validates the new approaches to teaching that have been adopted. These data are reviewed, and their applicability to physiology education is discussed. Some of the inherent limitations of research about teaching and learning are also discussed.

Mulnix, A. (2016). "STEM Faculty as Learners in Pedagogical Reform and the Role of Research Articles as Professional Development Opportunities." CBE—Life Sciences Education 15:8, 1–9, Winter.

Abstract: Discipline-based education research (DBER) publications are opportunities for professional development around science, technology, engineering, and mathematics (STEM) education reform. Learning theory tells us these publications could be more impactful if authors, reviewers, and editors pay greater attention to linking principles and practice. This approach, which considers faculty as learners and STEM education reform as content, has the potential to better support faculty members because it promotes a deeper understanding of the reasons why a pedagogical change is effective. This depth of understanding is necessary for faculty members to successfully transfer new knowledge to their own contexts. A challenge ahead for the emergent learning sciences is to better integrate findings from across sister disciplines; DBER reports can take a step in that direction while improving their usefulness for instructors.

Pollock, S. J. (2009). "Longitudinal study of student conceptual understanding in electricity and magnetism." Physics Education Research 5(2009).

Abstract: We have investigated the long-term effect of student-centered instruction at the freshman level on juniors' performance on a conceptual survey of Electricity and Magnetism (E&M). We measured student performance on a research-based conceptual instrument—the Brief Electricity & Magnetism Assessment (BEMA)–over a period of 8 semesters (2004–2007). Concurrently, we introduced the University of Washington's Tutorials in Introductory Physics as part of our standard freshman curriculum. Freshmen took the BEMA before and after this Tutorial-based introductory course, and juniors took it after completion of their traditional junior-level E&M I and E&M II courses. We find that, on average, individual BEMA scores do not change significantly after completion of the introductory course-neither from the freshman to the junior year, nor from upper-division E&M I to E&M II. However, we find that juniors who had completed a non-Tutorial freshman course scored significantly lower on the (post-upper-division) BEMA than those who had completed the reformed freshman course-indicating a long-term positive impact of freshman Tutorials on conceptual understanding.

Prince, M. and R. Felder (2007). "The Many Faces of Inductive Teaching and Learning." Journal of College Science Teaching 36(No. 5, March/April).

Abstract: Traditional engineering instruction is deductive, beginning with theories and progressing to applications of those theories. Alternative teaching approaches are more inductive. Topics are introduced by presenting specific observations, case studies or problems, and theories are taught or the students are helped to discover them only after the need to know them has been established. This study reviews several of the most commonly used inductive teaching methods, including inquiry learning, problem-based learning, project-based learning, case-based teaching, discovery learning, and just-in-time teaching. The paper defines each method, highlights commonalities and specific differences, and reviews research on the effectiveness of the methods. While the strength of the evidence varies from one method to another, inductive methods are consistently found to be at least equal to, and in general more effective than, traditional deductive methods for achieving a broad range of learning outcomes.

Rogerson, B. J. (2003). "Effectiveness of a daily class progress Assessment Technique in Introductory Chemistry." Journal of Chemical Education 80(2): 160-164.

Abstract: To improve student learning in an introductory chemistry course, a daily class progress assessment was developed. At the end of every class period students answered, in writing, brief questions about material that had just been discussed in class. Student answers were not graded but were always discussed at the beginning of the following class. The intent was to continuously survey all students for their understanding of basic ideas and to correct misconceptions. Student performance during five semesters was examined. The assessment technique was used during two of the semesters. Use of this assessment technique resulted in a significant drop in freshman withdrawal frequencies from 26.7% to 6.7% ($p < .005$). When failure and withdrawal frequencies were combined a decrease from 34.4% to 16.7% was observed ($p < .05$). These results suggest that the assessment technique improved freshman performance. Contrary to what at first might be believed, the assessment technique is simple and quick. It allowed the immediate identification of difficulties and thus, corrective measures, before students were formally tested. Surveys revealed that students believed the assessments helped them gauge their progress in understanding the material and suggested that such daily feedback should be more widely used.

Thien, S., J (2003). "A Teaching-Learning Trinity: Foundation to my Teaching Philosophy." Journal of Natural Resources of Life Science Education 32: 87-92.

Abstract: This work represents a soil scientist's reflection (30+ years of teaching) on the connections between teaching and learning and portrays the foundation to my teaching philosophy on how an understanding of teaching and learning processes can increase teaching effectiveness and student learning. From working definitions of teaching and learning, I describe their interaction, not as a duality but a trinity; three processes linked as one: learning to learn, learning to teach, and teaching to learn. I describe how lifelong learners can be developed through understanding and successfully applying the processes within each segment of the teaching–learning trinity. I offer these comments in hopes they will inspire readers to develop their own journey toward mastering the teaching and learning processes in ways that improve teaching and learning outcomes.

Volkwyn, T. S. and S. Allie (2008). "Impact of a conventional introductory laboratory course on the understanding of measurement." The American Physical society.

Abstract: Conventional physics laboratory courses generally include an emphasis on increasing students' ability to carry out data analysis according to scientific practice, in particular, those aspects that relate to measurement uncertainty. This study evaluates the efficacy of the conventional approach by analyzing the understanding of measurement of freshmen following the physics major sequence, i.e., top achievers, with regard to data collection, data processing, and data comparison, through pre- and post instruction tests by using an established instrument. The findings show that the laboratory course improved the performance of the majority of students insofar as the more mechanical aspects of data collection and data processing were concerned. However, only about 20% of the cohort of physics majors exhibited a deeper understanding of measurement uncertainty required for data comparison.

Woods, D. R., R. M. Felder, et al. (2000). “The future of Engineering Education III. Developing Critical skills." Chemical Engineering Education 34(2): 108-117.

Abstract: In this paper, we suggest research-backed methods to help our students develop critical skills and the confidence to apply them. As was the case for the instructional methods discussed in introduced in Part II.