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April 20, 2001
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- Australian Education Index
- ERIC: Educational Resources Information Center
- JCAL: Journal of Computer Assisted Learning
- ALT-J: Association for Learning Technology Journal
- AJET: Australian Journal of Educational Technology
- J Res Sci Teach: Journal of Research in Science Teaching

References are to material published since 1995 that relates to research in university science education.

Adey, P. SCIENCE EDUCATION RESEARCH AND COGNITIVE SCIENCE *Research in Science Education.* 25(1):101-113, 1995.
> Abstract: Cognitive science has the potential for offering explanatory models for many findings of empirical research in science education. In this paper, the author uses recent editions of international journals of science education to produce a categorisation of types of science education research, and what possible contributions each might make to cognitive science or the potential of results from cognitive science for enriching the science education research accounts.

Anderson, A., Cheyne, W., Foot, H., Howe, C., Low, J. & Tolmie, A. COMPUTER SUPPORT FOR PEER-BASED METHODOLOGY TUTORIALS *Journal of Computer Assisted Learning.* 16:41-53, 2000.
> Abstract: This paper reports on a study that was designed to explore computer support for peer-based learning in methodology tutorials. In particular, software was developed to organise group discussion, with the aim of leaving students free to concentrate on the more productive elements of group dialogue, and in particular discussing their ideas. Forty-three undergraduate psychology students in groups of 3-4 were given a series of computer supported methodology tutorials designed to structure their discussion around issues concerning the design of their Honours dissertation. Students gave individual ratings of their reactions to both the software and the tutorial sessions more generally. A sample of their discussions was videotaped and the dialogues analysed. The written assignments in which they detailed their proposed empirical work (the 'Design Exercise') were blind marked and compared to a sample of similar assignments from the previous year. The results demonstrated that the computer supported tutorials resulted in better quality Design Exercises, that the students' dialogues were overwhelmingly task-focussed and substantially transactive, and that their expressed satisfaction was generally high but with a desire for more preparation time before and between tutorials. The implications of the study for the use of computers to support groupwork are discussed.

Arnott, S. LEARNING IN ENGINEERING: TEACHER AS RESEARCHER IN A TERTIARY CONTEXT
http://www.fed.qut.edu.au/projects/asera/2000/Issue3/30_3_6.htm
> Abstract: This study focuses on the efforts of a small group of undergraduate engineering students as they explore their perceptions of their learning environment generally, and their approaches to learning in a specific engineering subject. A case study methodology is used, and my role of teacher as researcher is described and contextualised as I work with my students in weekly meetings outside their classrooms. Issues of cognition and affect emerge as we negotiate and develop a process where the students act as observers in their own classrooms. Observers' reports to weekly group meetings provide a framework to challenge individual students' assumptions about their learning approaches, and to explore enhanced metacognition. The nature of learning in engineering as a complex interaction of problematic issues is evidenced through this observation and reporting process. Implications for other learning contexts are considered.

Australian Journal of Educational Technology AJET Vol. 16, 2000. http://cleo.murdoch.edu.au/ajet/ajet16/ajet16.html
> Abstract: AJET is a refereed journal publishing research and review articles in educational technology, instructional design, educational applications of computer technologies, educational telecommunications and related areas.

Atweh, W.F., Malone, J.A. & Northfield, J. (eds) *Research and supervision in mathematics and science education.* Lawrence Erlbaum Associates, Mahwah NJ, 1998.
> Abstract: For details of chapters relevant to Australian education see under author in contents. Includes bibliographical references and indexes. 1. A framework for thinking about research in mathematics and science education / Dylan Wiliam - 2. Ethnography in the classroom / Robyn Zevenbergen - 3. Quality criteria for the genres of interpretive research / John S. Schaller and Kenneth Tobin - 4. Using clinical interviews in qualitative research / John M. Truran and Kathleen M. Truran - 5. Classroom interactions: using interactional sociolinguistics to make sense of recorded classroom talk / Robert E. Bleicher - 6. Critical reflections on a problematic student-supervisor relationship / Peter Charles Taylor and Vaille Dawson - 7. Higher degree supervision: why it worked / Gilah C. Leder, Helen J. Forgasz and Julie Landvogt - 8. Teacher, researcher, collaborator, student: multiple roles and multiple dilemmas / Loren White - 9. Guiding collaborative action research in science education contexts / Frank E. Crawley - 10. On supervising and being supervised at a distance / John A. Malone - 11. Legitimate peripheral participation in the training of researchers in mathematics and science education / Wolff-Michael Roth and Michelle K. McGinn - 12. Supervision in a graduate centre / Andy Begg, Beverley Bell, Vicki Compton and Elizabeth McKinley - 13. Scholarly writing in mathematics and science education higher degree courses / Tom J. Cooper, Annette R. Baturo and Leonie Harris - 14. Writing for publication / Jack J. Hourcade and Holly Anderson - 15. The impact of new developments in information technology on postgraduate research and supervision / David Squires - 16. Databases: a gateway to literature in mathematics and science education research / Peter Rillero and Bee Gallegos.

Baldwin, J.A., Ebert-May, D. & Burns, D.J. THE DEVELOPMENT OF A COLLEGE BIOLOGY SELF-EFFICACY INSTRUMENT FOR NONMAJORS *Science Education.* 83:397-408, 1999.

> Abstract: In an effort to test the effectiveness of teaching and learning strategies that may increase biological literacy for nonbiology majors, an NSF-funded research project called The Slice of Life, was conducted from 1994 to 1998. In the present study, a self-efficacy instrument was constructed and designed specifically for the project to determine students' self-reported confidence in understanding and using biology in their lives. Based on social cognitive theory, the premise for developing such an instrument was that a specific measure of biological self-efficacy was deemed to be an important predictor of the change processes necessary to improve students' biological understanding. Results of this study indicate that the Biology Self-Efficacy Scale was a valid and reliable tool for studying nonbiology majors' confidence in mastering biological literacy. Factor analysis supported the contention that the Biology Self-Efficacy Scale was a multidimensional construct consisting of at least three dimensions: methods of biology; generalization to other biology/science courses and analyzing data; and application of biological concepts and skills. These dimensions represent three components of biological literacy that have been commonly described in the literature. The instrument may lead to further understanding of student behavior, which in turn can facilitate the development of strategies that may increase students' desire to understand and study biology. More specifically, by using the self-efficacy tool as a pre- and post-test indicator, instructors can gain insight into whether students' confidence levels increase as they engage in more complex tasks during the course, and, in addition, what type of teaching strategies are most effective in building confidence among students to achieve biological literacy.

Bezzi, A. WHAT IS THIS THING CALLED GEOSCIENCE? EPISTEMOLOGICAL DIMENSIONS ELICITED WITH THE REPERTORY GRID AND THEIR IMPLICATIONS FOR SCIENTIFIC LITERACY *Science Education.* 83:675-700, 1999.

> Abstract: To appropriately prepare informed citizens, science education must improve scientific literacy, which includes public understanding of science. Therefore, students' perceptions of science is considered a fruitful area of research. This kind of investigation should elicit the images of science that students are likely to hold when they enter the science classroom. The main aims of the present investigation are: (i) to explore the perceptions held by a university geology instructor and five students of the images of the geosciences, before and after the teaching intervention; (ii) to claim that the repertory grid technique is a powerful tool to assess people's actual epistemological dimensions beyond any conceptual framework constructed by experts; and (iii) to argue that the societal aims of geological (science) education must be specifically targeted within a constructivist framework. The subjects were five first-year undergraduates of the geography degree course and their geology instructor. This investigation uses the repertory grid technique, the tool envisaged by George Kelly to elicit people's personal constructs according to his theoretical framework known as personal construct psychology. The elicitation of constructs took place at the beginning and at the end of the academic year. Principal component analysis was used to determine the teacher's and students' constructs with the highest epistemological value; that is, the constructs that most affect students' perception and interpretation of the geosciences. The findings indicate that some stereotyped images of science appear, with a characteristic antithesis between physics (considered objective and rigorous) and the geosciences (seen as subjective and approximate). Beyond this, little concern for societal issues inherent within the geosciences emerged as a significant conceptual dimension from individuals' construct systems. These results seem to indicate that this methodology gives insights into students' everyday ontology and epistemology, and therefore can be used to guide teaching interventions relevant for adequate scientific literacy.

Bowen, G.M., Roth, W-M. & McGinn, M.K. INTERPRETATIONS OF GRAPHS BY UNIVERSITY BIOLOGY STUDENTS AND PRACTICING SCIENTISTS: TOWARD A SOCIAL PRACTICE VIEW OF SCIENTIFIC REPRESENTATION PRACTICES *Journal of Research in Science Teaching.* 36:1020-1043, 1999.

> Abstract: Using graphs is a key social practice of professional science. As part of a research program that investigates the development of graphing practices from elementary school to professional science activities, this study was designed to investigate similarities and differences in graph-related interpretations between scientists and college students engaged in collective graph interpretation. Forty-five students in a second-year university ecology course and four scientists participated in the study. Guided by domain-specific concerns, scientists' graph-related activities were characterized by a large number of experience-based, domain-specific interpretive resources and practices. Students' group based activities were characterized by the lack of linguistic distinctions (between scientific terms) which led to ambiguities in group negotiations; there was also a lack of knowledge about specific organism populations which helped field ecologists construct meaning. Many students learned to provide correct answers to specific graphing questions but did not come to make linguistic distinctions or increase their knowledge of specific populations. In the absence of concerns other than to do well in the course, students did not appear to develop any general interpretive skills for graphs, but learned instead to apply the professor's interpretation. This is problematic because, as we have demonstrated, there are widely differing viable interpretations of the graph. Suggestions for changes in learning environments for graphing that should alleviate this problem are made.

Brown, M., Riley, T. & Santos, I. WEAVING A WORKABLE WEB: LESSONS FROM AN ONLINE POST-GRADUATE DISTANCE EDUCATION COURSE Australian Association for Research in Education (AARE) and the New Zealand Association for Research in Education (NZARE) Joint Conference (1999: Melbourne) Conference theme: Global issues and local effects: the challenge for educational research. http://www.aare.edu.au/99pap/bro99311.htm

> Abstract: The paper describes the systematic evaluation of an internet-based post-graduate distance education course, utilizing *WebCT*. It outlines the design and pedagogical strategies adopted and presents data from a micro-ethnographic case study during its first year of implementation. The teacher and student perceptions of learning via the web are reported. Although data suggest that on-line teaching enhances the texture of the course, it needs further exploration in order to determine how the technology can be effectively woven into the overall fabric of post-graduate studies. In this regard, the paper highlights both positive and negative aspects of learning with the Internet. A number of unexpected outcomes emerge from the research, especially in terms of (a) sense of community, (b) teacher satisfaction and (c) student perceptions of distance education. The research provides valuable insight into the problems and potentialities of developing a workable web-based course in post-graduate education.

Campbell, B., Kaunda, L., Allie, S., Buffler, A. & Luben, F. THE COMMUNICATION OF LABORATORY INVESTIGATIONS BY UNIVERSITY ENTRANTS *Journal of Research in Science Teaching*. 37:839-853, 2000.

> Abstract: The purpose of the study reported here was to analyse the ways in which university entrant science students carry out and communicate experimental activities and to identify a model to explain characteristic communication practices. The study was prompted by a need to inform the development of an introductory laboratory course. The students studied shared an educational background characterised by a lack of experience with laboratory work and scientific writing. Seven groups of three students were studied. The investigative strategies of these groups were observed. Laboratory reports were used to identify the ways in which students communicated these strategies. Data are presented that show a discrepancy between the strategies used and those reported. The results suggest that: (i) students' perceptions of the purpose of a laboratory task influence their decisions on what to report; (ii) understandings of laboratory procedures greatly influence their decision on what to report and on how much detail to include in a report; and (iii) knowledge of discourse rules contributes to effective reporting. It is concluded that students' communication of an investigation results from the differential operation of various perceptual filters that determine both the procedural and discourse elements of their reports. It is recommended that the communication of science should be taught explicitly and alongside the procedures and concepts of science.

Case, J., Gunstone, R. & Lewis, A. STUDENTS' METACOGNITIVE DEVELOPMENT IN AN INNOVATIVE SECOND YEAR CHEMICAL ENGINEERING COURSE *Research in Science Education.* 2001 (in press).

> Abstract: In this paper the metacognitive development of students in a second year chemical engineering course (which had such development as an explicit aim) is investigated. Journal and interview data were used to develop a possible framework for describing metacognitive development in this context. The framework comprises four categories: 1. conception of learning; 2. organising one's learning; 3. assessment of learning; and 4. purpose of learning: personal development. It is suggested that these four categories might represent a possible hierarchical sequence of metacognitive development in this course context. A description of aspects of development within each of the categories is provided, and further sub-hierarchies of development are identified. That there is evidence of some students at the end of the course having developed a personal purpose for learning (category 4) suggests there was, for these students, a significant coherence in the course intentions of the lecturer and learning outcomes.

Case, J. & Gunstone, R. THE INFLUENCE OF STUDENTS' PERCEPTIONS OF TIME ON THEIR APPROACHES TO LEARNING AND METACOGNITIVE DEVELOPMENT IN A SECOND YEAR CHEMICAL ENGINEERING COURSE Paper presented at the Annual Conference of the Educational Research Community of Students and Staff, 2000, Faculty of Education, Monash University, Victoria, Australia. http://www.education.monash.edu.au/centres/ercss/Case.pdf

> Abstract: This study is situated in the context of a second year chemical engineering course which had been designed to promote metacognitive development and conceptual understanding. Previous work in this study reported on qualitatively different approaches to learning adopted by students, some of which were more conducive to achieving the required learning outcomes than were others (Case, Gunstone, & Lewis, 2000a, APPROACHES TO LEARNING IN A SECOND YEAR CHEMICAL ENGINEERING COURSE. Paper presented at the 2000 American Education Research Association (AERA) Meeting, 24-28 April 2000, New Orleans, USA.). For a number of individuals in the study metacognitive development had not taken place to the extent expected, despite hard work and application on behalf of the students. In this paper we report on an analysis of students' perceptions of time, and show how in some instances these impeded desirable metacognitive development. We also suggest that successful metacognitive development involved the development of new perceptions of time, in particular with respect to allocating time to thinking, which was time-consuming and had little short term (but critical long-term) value.

Chang, V. & Fisher, D. STUDENTS' PERCEPTIONS OF THE EFFICACY OF WEB-BASED LEARNING ENVIRONMENT: THE EMERGENCE OF A NEW LEARNING INSTRUMENT In *Cornerstones: what do we value in higher education? Proceedings, July 12-15, Melbourne, Australia*. Canberra: Higher Education Research and Development Society of Australasia 1999. http://www.herdsa.org.au/vic/cornerstones/pdf/Chang.PDF

> Abstract: In today's educational context, the delivery of education via the Internet or Web-based learning is not a new concept. In fact, this medium of education delivery is much sought after by students and many academics now accept and use this learning environment. However, the opportunity now exists for educators to look more closely at the effectiveness and appropriateness of a Web-based learning environment. Educators need to equip themselves with instruments that allow the effectiveness of Web-based learning to be evaluated. This paper describes the development of a new web-based learning environment evaluation instrument. Apart from demographics and general background information, this instrument is divided into four main aspects. The first three are adapted from Tobin's (1998) clusters of emancipatory activities, co-participatory activities and qualia. The fourth aspect of the instrument focuses on information structure and the design of on-line material. The content of this instrument was validated by a panel of three who are experts on web-based learning. This paper reports on research involving a cohort of undergraduate and graduate students utilising this new instrument. This paper provides a preliminary statistical analysis of students' perceptions of this learning environment using Cronbach alpha reliability coefficients, discriminant validity, means and standard deviations.

Chin, K.L. A STUDY INTO STUDENTS' PERCEPTIONS OF WEB-BASED LEARNING ENVIRONMENT In *Cornerstones: what do we value in higher education? Proceedings, July 12-15, Melbourne, Australia*. Canberra: Higher Education Research and Development Society of Australasia 1999. http://www.herdsa.org.au/vic/cornerstones/pdf/Chin.PDF

> Abstract: The main objective of any learning environment is to enhance learning experiences and improve learning outcomes. The introduction of the Internet and the World Wide Web (WWW) in educational delivery has attracted the attention of educators from around the world. However, the most important question still remains unanswered: does the Internet or the World Wide Web really enhance the learner's learning experience and improve learning outcomes? The aim of this study is to gain an insight on how students perceive and receive the use of the Internet and the World Wide Web in their learning environments. Previous studies on students' perceptions of web-based teaching and learning indicated that the use of the Internet/WWW in teaching is well received by students in general. This study examines students' perceptions of a web-based learning environment including its perceived usefulness, students' learning experience, aspects of quality and design issues and others. Five groups of students, studying in different areas, participated in the study. Results of the study reveal that students' responses were very consistent across all groups when asked about certain aspects of web-based teaching and learning.

Christensen, C.K. GROUP INTERACTIONS IN PRACTICAL SCIENCE Queensland University of Technology, Masters Thesis, 1996.

> Abstract: Laboratory work is almost an article of faith amongst science teachers. However the research literature reveals conflicting evidence for its effectiveness, particularly in relation to the learning of science concepts. This has led to questioning of the role of practical work in science education and some proposals for change. Since students usually do practical work in groups, what students do in science practical work is strongly influenced by group processes. Reviewers of research in both science education and group work have suggested that more needs to be known about group processes to identify those processes linked with learning. This study explored in detail the interactions of a highly motivated group of students doing traditional science laboratory work designed to illustrate science concepts. The group interactions were analysed using a model of collaborative learning which included certain discourse moves and social skills, together considered necessary to support the use of cognitive strategies in a group situation. These group processes were described and the effectiveness of the practical work in achieving its aim was examined. It was found that the students collaborated effectively in constructing an understanding of their tasks but during the class rarely engaged in thinking about the concepts the activities were intended to illustrate. This finding supports past science education research findings questioning the effectiveness of practical work for learning science concepts. A range of factors influencing student learning through practical work was identified, including the nature of the task, the teacher's concerns and the attitude of the students towards practical work and group work. A modified version of the collaborative learning model was found to be useful for examining group processes during science practical work. Analysis of group processes showed the influence of task structure on discourse, a limited task resulting in limited discourse and thus reduced potential for learning in a group situation.

Chu, K.C. WHAT ARE THE BENEFITS OF A VIRTUAL LABORATORY FOR STUDENT LEARNING? In *Cornerstones: what do we value in higher education? Proceedings, July 12-15, Melbourne, Australia*. Canberra: Higher Education Research and Development Society of Australasia 1999. http://www.herdsa.org.au/vic/cornerstones/pdf/Chu.PDF

Abstract: The Internet is becoming popular as it is not limited by political, geographic boundaries or cultural barriers. As the superhighway is becoming a reality, multimedia learning is becoming practical in the Internet environment. Using the Web as a teaching medium is an exciting prospect that makes remote learning easier, allows students to learn at their own pace, and encourages interactive learning. Learners can then schedule their time and progress of learning according to their own styles. Web-based teaching plus a management program can automatically monitor and mark the work of each learner. The lecturer's time can be saved and redirected to identifying and helping learners who are having problems. In this study, a virtual laboratory was set up and tested by students. Updated laboratory sheets were distributed to students through the Internet and displayed on a Web browser. Students were able to undertake work using a virtual environment to test their designs. The response of students to this virtual laboratory was positive. Interview results and comments from students provided further opportunities for improvement of this web-based laboratory approach.

Cooper, V. & McConnell, M. DEVELOPMENT OF A WEB-BASED LEARNING TOOL FOR UNDERGRADUATE HEALTH PROFESSIONALS STUDYING APPLIED ANATOMY *ALT-J Association for Learning Technology Journal.* 8(1):62-70, 2000.

Abstract: An understanding of anatomy is an essential component of degree courses for health professionals. A key learning outcome for physiotherapy students is to be able to observe, analyse and explain the sequence of normal anatomical movement patterns for the upper and lower limb. However, when there is a requirement for such learning to be practice based it is not always possible to provide students with the necessary resources for independent study. This paper describes the development and evaluation of a web-based tool that allows students to practise and test their human movement analysis skills independently, at their own pace. The tool utilizes video clips of common muscle movements and multiple-choice questions with dynamic feedback to promote understanding. The aims of the tool and its evaluation by a sample group of forty-five students is described. Suggestions for future development are discussed.

Crawley, F.E. GUIDING COLLABORATIVE ACTION RESEARCH IN SCIENCE EDUCATION CONTEXTS In *Research and supervision in mathematics and science education* edited by J.A. Malone, B. Atweh and J.R. Northfield, 173-198. Mahwah NJ: Lawrence Erlbaum Associates, 1998.

Abstract: The author describes the experiences of graduate students in science education and their teachers as they learn about collaborative action research. The perspective taken in collaborative action research is that of 'teacher as researcher'. The author discusses collaborative action research in the light of educational reform in the United States and how this research methodology is being used as a way of reforming education. The chapter concludes with a discussion of some of the problems associated with collaborative action research.

Evans, B. & Rex, J. WHICH COMES FIRST, TECHNOLOGICAL SKILL OR INNOVATIVE TEACHING STYLES? Australian Association for Research in Education (AARE) and the New Zealand Association for Research in Education (NZARE) Joint Conference (1999: Melbourne) Conference theme: Global issues and local effects: the challenge for educational research. http://www.aare.edu.au/99pap/eva99481.htm

Abstract: In recent years there has been an increased trend at universities towards a more interactive and innovative style of teaching, using multi modal and different teaching approaches. Kolb and others have established that students have a preference for learning activities that reflect the learning style in which they are most comfortable. However, it cannot be assumed that they have the technological capabilities needed to fully benefit from these changes in style. The findings from a survey of second and third year students showed that there was a relationship between students' self-assessment of their communication and technological skills and their preferred learning styles. Students with a higher self-assessment of their knowledge and skill level with respect to computers, email and the Internet felt more comfortable in a more innovative teaching environment. Many of the students reported that their skill level was very low, and therefore some may not be gaining the full benefit of the content of the course. However, unless teachers revert to past methods, students will need to improve their computer and technological skills. The results also indicated that there is a significant difference between international and non-international students both in their perceived technological abilities and preferred learning styles.

Eybe H. & Schmidt, H.J. QUALITY CRITERIA AND EXEMPLARY PAPERS IN CHEMISTRY EDUCATION RESEARCH *International Journal of Science Education.* 23(2):209-225, 2001.

Abstract: There has been a discussion about quality criteria in chemistry education research in the scientific community. This paper is based upon the idea that the values prevailing in research are reflected in the criteria that are suggested and used to judge research papers. Two research questions were addressed: what are the quality criteria of research in chemistry education; and in what ways do exemplary papers meet quality criteria? The quality criteria were ascertained from the literature. Exemplary papers to illustrate the criteria were selected from a sample of 81 research papers published in JRST and IJSE 1991-1997. The result was a list of criteria subsumed in six categories.

Five exemplary studies were chosen to illustrate the criteria. The criteria are discussed in terms of underlying values. This paper contributes initial ideas and intends to trigger a discussion of quality criteria in chemistry education research.

Fischler, H. & Peuckert, J. CONCEPT MAPPING AS A TOOL FOR RESEARCH IN SCIENCE EDUCATION Report on Workshop at the Theory, Methodology and Results in Science Education - Fourth European Science Education Summer School http://www.summerschool.dk/esera/summerschool/sumsc98/4these/worksops.htm

Fischler, H. & Peuckert, J. CONCEPT MAPS AS A TOOL FOR INVESTIGATING AND ANALYZING THE DEVELOPMENT OF STUDENTS' CONCEPTIONS http://www.physik.fu-berlin.de/physikdidaktik/Coma.pdf
>   Abstract: Concept mapping is used in a research project about the long-term effectiveness of science education. In two ways, it is part of a pre-post design: Besides other techniques, concept mapping by students is expected to elicit conceptions about particle models. Concept maps constructed by researchers summarizing all data including students' maps are used as an assessment tool for intra-individual and inter-individual comparisons of conceptions as well as for the description and comparison of groups. It turns out that students' concept maps mainly contain coherently used propositions. Concept maps from researchers allow them to identify central ideas concerning the topic and the development of these ideas. Being in accordance with information directly gathered from the interpretation of verbal and pictorial data, they are an important depiction of results.

Flagg, V. BREAKING THE DEAL: AN INVESTIGATION OF THE IMPACT OF AN INTEGRATIVE TEACHING APPROACH ON THE PERCEIVED FRAGMENTATION OF KNOWLEDGE REPORTED TO ACCOMPANY FRAMEWORK UNITS In *Cornerstones: what do we value in higher education? Proceedings, July 12-15, Melbourne, Australia*. Canberra: Higher Education Research and Development Society of Australasia 1999. http://www.herdsa.org.au/vic/cornerstones/pdf/Flagg.PDF
>   Abstract: New Zealand Unit Standards are reported in scholarly research to fragment knowledge and inhibit genuine learning. Is it possible using a more integrated approach to provide the kind of deep learning experience many educators aspire to? Specifically, using a framework unit in a rapidly changing field, i.e. computing, can advancing technology such as the Internet or multimedia be used to counter the fragmentation of knowledge, which is reported to inhibit successful learning? Can it instead provide an 'integrated context' that promotes life long 'deep learning' for authentic tasks? This paper reports on the application of this idea in teaching a level 3 computing unit – 'Solve a Specified Problem Using Computing Technology'. The paper discusses the specific problem selected, the computing technology used, the assessment employed, the research model chosen, the methodology and findings.

Gabel, D. AN INTRODUCTION TO ACTION RESEARCH Presidential Address, National Association for Research in Science Teaching (NARST) San Francisco, April 24, 1995. http://www.phy.nau.edu/~danmac/actionrsch.html

Groves, S. & Tytler, R. (eds) CONTEMPORARY APPROACHES TO RESEARCH IN MATHEMATICS AND SCIENCE EDUCATION Proceedings of Deakin University Centre for Studies in Mathematics Science and Environmental Education Conference, Deakin University. Centre for Studies in Mathematics, Science and Environmental Education, Geelong, Vic, 1995.
>   Abstract: Papers focus on practical and theoretical aspects of a range of research methodologies used in mathematics and science education research. Conference themes were qualitative analysis with and without computers, strategies for probing student understandings, participatory research into teaching and surveying the scene. While the focus of the research was mathematics and science education, the emphasis of the symposium was on the methodologies employed for conducting the research. The papers and ensuing discussions raised many issues related to the practicalities of various methodologies such as data collection and analysis, or interview techniques, but also issues of principle related to the legitimacy and import of different research approaches, and ethical considerations.

Jane, B., Robottom, I., Tytler, R. & Groves, S. (eds) CONTEMPORARY APPROACHES TO RESEARCH IN MATHEMATICS, SCIENCE, HEALTH AND ENVIRONMENTAL EDUCATION 1997. Deakin University Centre for Studies in Mathematics Science and Environmental Education, Geelong, Vic, 1998. (Conference and symposium proceedings/Deakin University. Centre for Studies in Mathematics, Science and Environmental Education).

Jiang, M. & Meskill, C. ANALYZING MULTIPLE DIMENSIONS OF WEB-BASED COURSES: THE DEVELOPMENT AND PILOTING OF A CODING SYSTEM ED442870 (ERIC)
>   Abstract: This study undertook the development and piloting of a coding system for the evaluation of asynchronous web-based instruction and learning. Processes were guided by four prominent educational perspectives and the extended examination of, and survey data from, 17 archived web-based courses. These served as the bases for the development and application of the coding system. The study focus was on 4 courses, involving 801 students. Data from the pilot application of the coding system indicate that there are particular features of courses favoured by

learners. Features such as content richness, instructor's constructive and probing questions and responses, the amount and quality of learner participation in discussions, and links to students' own experiences are integral to those courses students deem supportive of their learning and environment. An appendix contains the survey questions.

Keeves, J. ADVANCES IN RESEARCH METHODOLOGY: WITH PARTICULAR REFERENCE TO SCIENCE EDUCATION In *Science, mathematics and technology education and national development: proceedings of the 1997 International Conference on Science, Mathematics and Technology Education, January 1997, Hanoi - Vietnam* edited by D. Fisher and T. Rickards, 121-123. Perth: National Key Centre for School Science and Mathematics, Curtin University of Technology (Conference jointly organised by the National Key Centre for School Science and Mathematics, Curtin University of Technology, Perth, Australia and the Hanoi Pedagogy University, Vietnam National University, Vietnam and held in Hanoi, Vietnam, during the 6th - 9th January 1997).

Abstract: This article addresses specific advances and issues in research methodology as it applies to science education. Specific areas discussed include: quantitative and qualitative data; categorical, categorised and continuous data; advances in measurement; and, multilevel analysis of data.

Keeves, J.P. METHODS AND PROCESSES IN RESEARCH IN SCIENCE EDUCATION In *International handbook of science education* edited by B.J. Fraser and K.G. Tobin, 1127-1153. Dordrecht The Netherlands: Kluwer, 1998.

Abstract: This chapter is concerned initially with the nature of the processes of scientific inquiry in relation to technology and society as well as to individual human agents. Next follows an introductory account of the methods employed by research workers in science education, which are contingent not only on methods available, but also on the nature of the research problem under investigation.

Lawson, A.E., Alkhoury, S., Benford, R., Clark, B.R. & Falconer, K.A. WHAT KINDS OF SCIENTIFIC CONCEPTS EXIST? CONCEPT CONSTRUCTION AND INTELLECTUAL DEVELOPMENT IN COLLEGE BIOLOGY *Journal of Research in Science Teaching.* 37:996-1018, 2000.

Abstract: Previous research has found that scientific concepts can be meaningfully classified as descriptive (i.e. concepts such as predator and organism with directly observable exemplars) or theoretical (i.e. concepts such as atom and gene without directly observable exemplars). Previous research has also found that developing understanding of descriptive and theoretical concepts is linked to students' developmental levels, presumably because the procedural knowledge structures (i.e. reasoning patterns) that define developmental levels are needed for concept construction. The present study extends prior theory and research by postulating the existence of an intermediate class of concepts called hypothetical (i.e. concepts such as subduction and evolution with exemplars that cannot in practice be observed due to limits on the normal observational time frame). The hypothesis that three kinds of scientific concepts exist was tested by constructing and administering a test on concepts introduced in a college biology course. As predicted, descriptive concept questions were significantly easier than hypothetical concept questions, than were theoretical concept questions. Further, because concept construction presumably depends in part on developmental level, students at differing developmental levels (levels 3, 4, and 5, where level 5 is conceptualized as post-formal in which hypotheses involving unseen entities can be tested) were predicted to vary in the extent to which they succeeded on the concepts test. As predicted, a significant relationship ($p < 0.001$) was found between conceptual knowledge and developmental level. This result replicates previous research, and therefore provides additional support for the hypothesis that procedural knowledge skills associated with levels of intellectual development play an important role in declarative knowledge acquisition and in concept construction. The result also supports the hypothesis that intellectual development continues beyond the formal stage during the college years, at least for some students.

Lloyd, M.A. COMMUNITY OF ONLINE LEARNERS: A LONGITUDINAL STUDY OF POST-GRADUATE STUDENTS WITHIN A VIRTUAL COMMUNITY Australian Association for Research in Education (AARE) and the New Zealand Association for Research in Education (NZARE) Joint Conference (1999: Melbourne) Conference theme: Global issues and local effects: the challenge for educational research. http://www.aare.edu.au/99pap/llo99521.htm

Abstract: The RITE Group (Research in Information Technology in Education) has, since 1993, been involved in the management of a cohort of students sponsored by Education Queensland and enrolled in post-graduate studies in computer education. Programs offered to these students combine academic and professional studies which have been conducted in open learning mode primarily using telecommunications and a philosophy of participation. A longitudinal study was begun in 1995 and concluded in 1999 tracking the perceptions, attitudes and belief structures of twelve individuals. The study has shown that active membership in the program led initially to manifest changes in behaviours without comparable, parallel changes in core beliefs. Continuing membership of on-line professional communities consolidated changes in belief structures, affecting quite fundamental views of the role of the teacher and the role of telecommunications and information technologies in the curriculum. The study is qualitative and is drawn from participant-observation methods. The prime instrument has been interviews conducted in various

mediums - from face-to-face, to telephone, to email interaction. The workshop will present excerpts from the interviews as audio streaming from a web site to elaborate and illustrate the study's findings. The main innovation emerging from this study was the development of a dual-level categorisation of participants as the dichotomy between manifest behaviours and fundamental beliefs emerged from the data. The study perhaps goes some way to explaining the hesitancy some teachers experience in introducing telecommunications and information technologies into the curriculum even when the necessary and pre-requisite skills are in place

MacIsaac, D., Cole, R.P. & Cole, D.M. STANDARDIZED TESTING IN PHYSICS VIA THE WORLD WIDE WEB (PAPER- VS. WEB-BASED TESTING IN PHYSICS) 1999. http://pc53.phy.nau.edu/danmac/webpaper/

> Abstract: On-line web-based technologies provide students with the opportunity to complete assessment instruments from personal computers with Internet access. The purpose of this study was to examine the differences in paper-based and web-based administrations of a commonly used assessment instrument, the Force Concept Inventory (FCI). Results demonstrated no appreciable difference on FCI scores or FCI items based on the type of administration. A 4 way ANOVA ($N = 376$) demonstrated differences in FCI scores due to different sections of the same sections, different courses and gender. However, none of these differences was influenced by the type of test administration. Similarly, FCI student scores were comparable with respect to both test reliability and predictive validity. For individual FCI items, paper-based and web-based comparisons were made by examining potential differences in item means and by examining potential differences in response patterns. Chi Squares demonstrated no differences in response patterns and t-tests demonstrated no differences in item means between paper-based and web-based administrations. In summary, the web-based administration of the Force Concept Inventory appears to be as efficacious as the paper-based administration.

Maguire, M. & Matejka, D. BETTER THAN SLICED BREAD: AN EVALUATION OF ON-LINE DELIVERY Australian Association for Research in Education (AARE) and the New Zealand Association for Research in Education (NZARE) Joint Conference (1999 Melbourne) Conference theme: Global issues and local effects: the challenge for educational research. http://www.aare.edu.au/99pap/mag99620.htm

> Abstract: The Internet has been adopted by an increasing number of tertiary institutions as a mode for unit and course delivery. In many instances web-based instruction replaces synchronous modes of delivery typified by face to face lectures and workshops, with asynchronous modes such as World Wide Web and email. The effect of this paradigm shift on the role of the learner is critical but is yet to be determined. This paper will report on the analysis of data from unit evaluations and other student discussions which will attempt to paint a more complete picture of the changing role of students as learners over the on-line study period. Students' needs and expectations, their experiences with the adoption of technology to access the study centre on the web site, shifts in their knowledge, skills and attitudes, changes in attitudes to the technology and how well the unit met the students' needs and expectations are discussed. The study as providing the basis for the successful expansion of on-line delivery to other information technology units in the M Ed program is outlined.

Marbach-Ad, G. & Sokolove, P.G. CAN UNDERGRADUATE BIOLOGY STUDENTS LEARN TO ASK HIGHER LEVEL QUESTIONS? *Journal of Research in Science Teaching.* 37:854-870, 2000.

> Abstract: Our goals in this study were to explore the type of written questions students ask after reading one or more chapters from their textbook, and to investigate the ability of students to improve their questions during the course of a single semester. In order to classify student's questions we used a taxonomy that we have developed specifically for this purpose. Two comparable populations were examined: Undergraduate students in a large, introductory biology class who were taught in traditional lecture format, and students in a similar class who were taught in cooperative/active learning style. After the taxonomy was presented to the active learning class, more students were able to pose better, written questions. Their questions became more insightful, thoughtful, and content-related, and were not easily answered by consulting the textbook or another readily available source. The best questions could be recast as scientific research questions (i.e. hypotheses). In contrast, when the taxonomy was presented to students in the traditionally taught class, the quality of student-posed questions was largely unchanged. Various explanations for the difference in outcomes are discussed, and methods are suggested about how generally to encourage students' questions and to improve their question-asking skills regardless of overall teaching style.

McDermott, L.C. & Redish, E.F. RESOURCE LETTER PER-1: PHYSICS EDUCATION RESEARCH *The American Journal of Physics.* 67:755-767, September, 1999. http://www.physics.umd.edu/rgroups/ripe/papers/rl.htm

> Abstract: The purpose of this Resource Letter is to provide an overview of research on the learning and teaching of physics. The references have been selected to meet the needs of two groups of physicists engaged in physics education. The first is the growing number whose field of scholarly inquiry is (or might become) physics education

research. The second is the much larger community of physics instructors whose primary interest is in using the results from research as a guide for improving instruction.

McShane, K. ACADEMICS ONLINE: A STUDY OF ACADEMICS ADAPTING TO WEB-BASED TEACHING Australian Association for Research in Education (AARE) and the New Zealand Association for Research in Education (NZARE) Joint Conference (1999: Melbourne) Conference theme: Global issues and local effects: the challenge for educational research. http://www.aare.edu.au/99pap/mcs99609.htm
> Abstract: This paper describes research-in-progress focussing on exploring the stories of university teachers moving into on-line teaching. What the study will show about how the identity of academics and their beliefs about teaching are affected when they embark on web-based teaching is discussed. The study involves interviews of university teachers who are engaged in on-line teaching. The early results reveal their perception of their identity as teachers, teaching philosophies and teaching roles in a mixed-mode delivery environment. Other research methods involve narrative and critical incidence analysis and observations of the academics in managing on-line teaching and interacting with their students. The role of this study to inform the research and the conduct of academic staff development is outlined.

Morris, E.J. & Scanlon, E. ACTIVE LEARNING OF STATISTICS: A CASE STUDY *ALT-J Association for Learning Technology Journal.* 8(1):80-91, 2000.
> Abstract: Research at the Open University has investigated students' learning of statistical concepts and how information technology can be effectively used to support this process. Previous empirical work has looked at psychology students' misconceptions relating to correlation and how computer-based learning environments can be used to address these. This paper reports on the findings from a qualitative study that investigated students' learning collaboratively from a multimedia application called *ActivStats*.

Oliver, R. & Omari, A. STUDENT RESPONSES TO COLLABORATING AND LEARNING IN A WEB-BASED ENVIRONMENT *Journal of Computer Assisted Learning.* 17:34-47, 2001.
> Abstract: This paper describes a study which explored students' responses and reactions to a web-based environment supporting problem-based teaming. The study was undertaken among undergraduate students in an Australian university. The findings revealed that while the majority of the students saw value to be gained from teaming in a student-centred and collaborative setting, many expressed a preference for teaming in the more conventional teacher-directed forms. The study also sought to explore the potential of the environment to develop problem-solving skills and to determine factors which impeded students' success and achievement. The results did not demonstrate any discernible development of problem-solving skills despite students' extensive experience and participation in problem-solving activities. The findings have suggested a number of important factors missing in the implemented setting including an organising strategy to aid students in the problem-solving process and adequate feedback to ensure reflection among the learners on the quality of the solutions they were developing.

Prosser, M. & Trigwell, K. RELATIONAL PERSPECTIVES ON HIGHER EDUCATION TEACHING AND LEARNING IN THE SCIENCES *Studies in Science Education.* 33:31-60, 1999.
> Abstract: In this article the authors outline their position on the research into students' and teachers' experiences of university and college science education from a relational perspective. The authors review some of the tertiary science education research that has been published from this perspective. The authors present and discuss a model which encapsulates the idea that perceptions of the student and teacher are fundamental to their prior experiences; the approaches to learning or teaching adopted in their situations and the outcomes resulting from activities within these situations.

Ramadhan, H.A. PROGRAMMING BY DISCOVERY *Journal of Computer Assisted Learning.* 16:83-93, 2000.
> Abstract: The concept of Programming by Discovery refers to the process of designing programming environments and systems which use various visualisation, programming and interaction technologies in an effective way to help users, especially beginner programmers, in writing computer programs, understanding their dynamic behaviour, detecting any misconceptions and bugs associated with them, and seeing the effect of these programs on the underlying machine. A system for programming by discovery encourages a user to become an active learner by allowing him to form his own hypotheses, explore his own questions, and draw his own conclusions. This paper reports on the design and evaluation of a system for programming by discovery which embodies the principles outlined above. To assess the usefulness of the design framework presented in this paper, a pilot empirical evaluation was conducted. The results provided a number of interesting insights into the implication of incorporating visualisation and immediacy features along with graphical notional machine and algorithm-like language into the design of programming systems.

Reimann, P. & Neubert, C. THE ROLE OF SELF-EXPLANATION IN LEARNING TO USE A SPREADSHEET THROUGH EXAMPLES *Journal of Computer Assisted Learning.* 16:316-325, 2000.
> Abstract: This paper describes an exploratory study into the early phase of getting to know end-user software during which users make use of a variety of information resources, including the user interface/program itself, manuals, on-line help, examples provided in the manuals and other sources. In particular, how do novices make use of the worked-out examples often provided in manuals and during training? Building on earlier research on the self-explanation effect, thinking aloud data from 10 participants were analysed to see how examples were studied and how they were used during problem solving. Important effects of self explaining comparable to findings in other domains were found in this study. For instance, those participants who self-explain with the goal to discover meaning prove to be better problem solvers than those who do not self-explain or who focus more on syntactical aspects of examples.

Rillero, P. & Gallegos, B. DATABASES: A GATEWAY TO LITERATURE IN MATHEMATICS AND SCIENCE EDUCATION RESEARCH In *Research and Supervision in Mathematics and Science Education* edited by J.A. Malone, B. Atweh and J.R. Northfield, 323-349. Mahwah NJ: Lawrence Erlbaum Associates 1998.
> Abstract: The authors discuss the advantages of using databases when conducting science and mathematics education research. The structure of databases are described and strategies for information retrieval are outlined, including free text searching, controlled vocabulary, narrowing and broad searches. The authors conclude with a discussion of the value of the Internet, and tools and techniques of searching are discussed. The authors include a list of educational databases.

Sansom, C. & Moss, D. PRINCIPLES OF PROTEIN STRUCTURE: AN ESTABLISHED INTERNET-BASED COURSE IN STRUCTURAL BIOLOGY *ALT-J Association for Learning Technology Journal.* 8(2):29-39, 2000.
> Abstract: The Department of Crystallography at Birkbeck College, London, UK, has been running a one-year, part-time accredited graduate course, 'Principles of Protein Structure', entirely over the Internet since 1996. Students on this course learn the basic principles of the increasingly important subject of structural biology using software programs such as *Rasmol* and *Chime* to visualize and manipulate molecular structures in three dimensions. They interact with their tutors, based at Birkbeck, using email and text-based teleconferencing, and can test their knowledge with multiple choice quizzes on the Web. Over 200 students from thirty countries registered for this course in the last four years. Forty, from central and eastern Europe, were supported by bursaries from the Open Society Institute. The course has been well received by students and its success led us to introduce a similar course in protein crystallography.

Seale, J. LEARNING TECHNOLOGIES AND THE LIFELONG LEARNER: ARMAMENT OR DISARMAMENT? *ALT-J Association for Learning Technology Journal.* 7(1):61-67, 1999.
> Abstract: Educators at all levels are under pressure to produce lifelong learners'. Their task is to 'arm' the student with knowledge and skills that will enable them to be creative and enterprising scholars. One possible way of arming the lifelong learner is through the use of learning technologies. Learning technologies can offer armament by widening access and participation and offering flexible delivery. This paper will use the results of two evaluation studies to explore the argument that learning technologies have the capacity to both arm and disarm students. Results from an evaluation of an email discussion list are be presented to highlight how the way a learning technology is used may arm a learner by giving them information but disarm them by promoting a lack of confidence and a low valuation of discussion. Results from an evaluation of a *Microcosm* application are presented to highlight how the way a learning technology is used may arm a learner by helping them to apply knowledge but disarm them by placing restrictions on their self-directed learning. These results are discussed in order to argue that the 'disarmament' of students through the use of learning technologies may place obstacles in the way of lifelong learning.

Spellman, G. EVALUATION OF CAL IN HIGHER EDUCATION GEOGRAPHY *Journal of Computer Assisted Learning*. 16:72-82, 2000.
> Abstract: In recent years the promotion and incorporation of computer-assisted learning courseware has been a feature of many Geography departments in higher education in the UK. There is little disagreement that this development needs to be thoroughly evaluated to ensure quality and effectiveness. However there has been a lack of rigorous evaluation in practice. A detailed illuminative evaluation of 120 Geography students using focus group interviews and an attitude survey reveals that CAL packages remain unpopular with most learners. This can be attributed to the content and presentation of packages but it is also suggested that contexts of use and perhaps staff disinterest are explanatory factors. Some gender-based and age-based attitude differences are noted. This type of evaluation is of greater use to curriculum developers than objective-led approaches.

van Berkel, H.J.M. & van Til, C.T. GROUP PERFORMING IN A PROBLEM-BASED CURRICULUM: THE DEVELOPMENT AND EVALUATION OF AN INSTRUMENT ED442851 (ERIC)

Abstract: In a problem-based curriculum, emphasis is placed on the groups in which students learn to analyze problems and to contribute to the solution of a problem. This paper describes an instrument that aims to measure individual group performing and presents some psychometric results. Reliability and validity were studied with 240 students in groups of 9 with 1 tutor. The instrument appears to be reliable, with coefficient alpha varying from 0.84 to 0.92, and it seems that it is a valid measure for characteristics that are important in a problem-based curriculum: (1) participating in discussions; (2) explaining things to other students; and (3) a broad study approach.

Victor, L., Willson, V.L., Ackerman, C. & Malave, C. CROSS-TIME ATTITUDES, CONCEPT FORMATION, AND ACHIEVEMENT IN COLLEGE FRESHMAN PHYSICS *Journal of Research in Science Teaching.* 37:1112-1120, 2000.

Abstract: The relationships among science and engineering attitude, physics conceptual understanding, and physics achievement were explored for a population of college freshman engineering students over two semesters. Gender and SAT-Quantitative measures were included as exogenous variables in a longitudinal path analysis. Attitude was theorized to predict achievement contemporaneously and at the next time point, while conceptual understanding was theorized to predict physics achievement contemporaneously and at the next time point. Each at one time was theorized to predict scores at the next time. A sample of 200 freshman engineering students participating in an integrated curriculum were assessed in September, December, and April (with a loss of 64 students) with the Force Concepts Inventory (FCI), Mechanics Baseline Test (MBT), and a locally developed attitude measure. The observed model indicated that the FCI predicted attitude at time 1 with no other paths between them, that FCI at time 1 predicted MBT at time 1 and time 2, FCI at time 2 predicted MBT at time 3, and MBT at time 1 predicted FCI at time 2. Gender and SAT-Quantitative scores were predictive only of FCI and MBT at time 1. Results supported an interactive model of conceptual understanding and achievement, with attitude largely irrelevant to the process for this population.

Von Aufschnaiter, S. & Niedderer, H. LEARNING PROCESS STUDIES IN PHYSICS TWO METHODS FOR ANALYSING TRANSCRIPTS OF VIDEOTAPES Report on Workshop at Theory, Methodology and Results in Science Education - Fourth European Science Education Summer School.
http://www.summerschool.dk/esera/summerschool/sumsc98/4these/worksop3.htm

White, R. TRENDS IN RESEARCH IN SCIENCE EDUCATION *Research in Science Education.* 27(2):215-221, 1997.

Abstract: Counts of key words from summaries of articles in ERIC showed trends in the topics of science education research from 1965 to 1995. Analysis of articles in the 1975, 1985, and 1995 volumes of Research in Science Education showed trends in the style of research. The move is from brief well designed and controlled laboratory-style experiments to lengthy observations and descriptions of classrooms. Reliance on inferential statistics declined; interviews became common. The proportion of women researchers rose. It is asserted that research became more relevant to practice.