North Carolina State University

Impact Report of the Quality Enhancement Plan
Learning in a Technology-Rich Environment

March 15, 2010

The LITRE Plan

Recognizing that technology was rapidly changing higher education, NC State chose "Learning in a Technology-Rich Environment" (LITRE) as the focus of its 2004 Quality Enhancement Plan. The university viewed learning technology as a critical institutional strategy for improving student learning, teaching effectiveness, efficient use of resources, and relative position among comparable universities. LITRE also contributed to the university's mission "to create an innovative learning environment."

Goals

The LITRE plan was designed to achieve three overarching goals:

- improve student learning across the university through the use of technology.
- investigate systematically the effectiveness of technology-based innovations in learning and teaching.
- use the results of these investigations to scale successes and inform campus decision making.

LITRE would pursue these goals by offering faculty grants for re-tooling courses or parts of courses through an innovative use of technology, and for assessing the impact of the change on student learning. Grants funds could be used to redesign courses, purchase equipment, and/or implement assessment. Upon conclusion of the project, the principal investigator would provide a written report describing the pedagogical innovation and the resulting impact on student learning. Individual project reports would be compiled into annual summaries of lessons learned and disseminated across campus. The results of this ongoing empirical inquiry would be used to encourage faculty to pursue additional innovations, shape faculty development programs, direct technology investments, and reshape institutional priorities based on hard evidence of the impact on student learning.

Intended Student Learning Outcomes

Through a variety of classroom-based innovations, the LITRE plan was designed to improve student learning in the following dimensions representing "Four Ways of Knowing and Doing."

- **Problem solving**, including determining and evaluating possible solutions, and applying an appropriate solution to the problem.
- **Empirical inquiry**, or discovering new knowledge through experimentation and other means, including choosing an appropriate research method; observation; organizing, analyzing, and presenting data; and reaching a conclusion.
- **Research from sources**, or developing new information out of published sources (including books, journals, and articles from the library or Internet), including locating and critically evaluating sources, and marshaling evidence to answer a question.
- **Performance in the discipline**, or discipline-specific implementation.

Assessment Strategy

As originally conceived, the assessment design for each project on student learning would necessarily be unique to that project. Because each project would involve a different course, the learning outcomes and measurement tools would differ from project to project. Given the wide variety of disciplines, levels, and pedagogies on the NC State campus, no single assessment design could fit all projects. Forcing a single set of variables or tools would hamper, rather than encourage, the faculty's interest in assessment.

Nonetheless, the "four ways of knowing and doing" provided a taxonomy for organizing campus discourse about the results of these assessments. Individual LITRE projects would measure one or more of the four student learning outcomes, and principal investigators would use assessment tools crafted specifically for that project. Results from the many projects would be synthesized into a university summary around the four, broadly stated learning outcomes.

Implementation of the LITRE Plan
Phase One
In the first phase of the LITRE project (2004-06), the grants program, the faculty LITRE Advisory Board(LAB), and the LITRE Assessment Committee (LAC) were established under the leadership of mathematics professor Lavon Page, who had distinguished himself as an "early adopter" of technology-based innovations in teaching and learning on campus.

LAB was composed of one faculty member from each college who was identified by the dean as a leader in using technology to improve student learning; additional members included representatives of the faculty development office, libraries, learning technology services, and university assessment. During this phase, LAB awarded 41 grants ranging from $2,000 to $10,000. Examples are described in Appendix A.

LAC was composed of interested faculty with evaluation expertise and assessment professionals from across campus. LAC members assisted LITRE grant recipients develop and implement assessment designs for their courses. LAC also reviewed concluding reports of results from each project and developed the university-wide synthesis for LITRE's annual report to the university community.

The 2005-06 LITRE annual report included the following lessons related to student learning outcomes.

- **Technology-enriched *curricular content* improved students' performance in "research from sources."** The best examples demonstrated the use of multimedia, real-world simulations, and easily acquired information outside the textbook such as Web-based hypertexts and archives and music and video clips.

- **Technology-enabled *visualization of content* facilitated students' performance in "problem solving."** Students reported visualizing material in new ways. Simulations and use of concept maps enabled students to represent material in new ways that led to improved learning.

This annual report also included observations related to teaching effectiveness.

- **Technology-enabled *communication and collaboration* increased valuable feedback, which appeared to improve student performance.** Projects in which technology was used to facilitate communication and collaboration among students and between students and instructor were particularly successful.

- **Technology-enabled new, *flexible/adaptable learning environments* that increased student motivation and engagement.** Student learning was enhanced by providing access to more convenient learning environments.

These general conclusions strengthened the university's resolve that innovations with technology would improve student learning and that assessment results would provide useful information. However, there were difficulties with implementing the LITRE plan as intended. While some projects provided clear and useful assessment results, many did not. Feedback from the grant recipients indicated that some grants were too small to support rigorous assessment, and many principal investigators felt they did not have sufficient expertise in educational research design to create useful assessment procedures. Furthermore, the "Four Ways" taxonomy alone was not sufficient to organize the results around the intended learning outcomes established for the project.

Consequently, the 2005-06 annual LITRE report also included the following conclusions and recommendations about LITRE's assessment strategies.

- **In order to make results replicable and generalizable, *more rigorous assessment* is crucial.** LAC should develop a common assessment framework that principal investigators would use as a guide for designing their assessments and that LITRE would use to organize and present overall results.

- **Rigorous assessment requires *professional support.*** Expertise in educational evaluation and assessment should be provided to principal investigators. While expect in their own disciplines, most did not have expertise in the design of educational evaluation.

- **In order to make results replicable, scalable, and generalizable, *larger projects* are needed to allow for more in-depth, systematic assessment.** Fewer, larger projects would affect a substantial number of students and allow a more complex set of variables. LAB included in the report criteria for selecting these projects.

Phase Two
LITRE shifted gears in 2006. Dr. Page retired, and a small LITRE Executive Council (LEC) assumed responsibility for the project with the continuing assistance of the faculty advisory board (LAB). Instead of awarding dozens of small grants, LITRE awarded three large grants to support multi-year projects with wider application.

In addition, a LITRE assessment director, Dr. Geetanjali Soni, was retained to help the principal investigators develop and implement more comprehensive assessment plans. With Dr. Soni's guidance, project investigators developed a common research framework that allowed each project to focus, in its own way, on common research questions. These research questions addressed the LITRE student learning outcomes (problem solving, empirical inquiry, research from sources, and performance in the discipline) as well as other constructs such as student attitudes and collaboration. The three project assessment plans included some shared measurement strategies. The shared rubric would help fuse assessment results into a more useful composite summary of lessons learned.

Descriptions and results of the three large projects, which were selected during 2006-07 and completed by fall 2009, are included in Appendices B, C, and D.

Final Transition
Due to substantial reductions in state appropriations and resulting campus budget cuts, LITRE – as a distinct campus project – was ended at the conclusion of these three projects in fall 2009. However, the university's commitment to instructional innovation through technology, and to the pursuit of hard evidence from assessment of student learning for use in decision making – will persist. LITRE's legacy includes renewed efforts in providing assistance to faculty who want to redesign their courses to take better advantage of emerging technologies, and in providing faculty professional assistance with the scholarship of teaching with technology.

The Impact of LITRE on Student Learning
The last LITRE annual report is still in preparation. Preliminary discussions among LAC and LAB members suggest the following points may be among the final observations.

- Simulations, visualizations, animations, and 3-D and gaming environments had notably positive impact on all four student learning outcomes of monitored by LITRE.

- Enriched content, such as hypertexts or electronic archives, improve the depth of student understanding.

- Technology-enabled communication and collaboration increased interaction and feedback, which in turn improved student performance.

- Technology enables flexible and adaptable learning environments that increase student motivation and engagement with the material.

- Students report that technology has enriched their learning in all "Four Ways of Knowing and Doing" and that the use of technology in classes has increased significantly since 2004.

- Generally, students report that they learn better from technologies deployed in class than from those deployed outside of class (e.g., homework).

The final report will also include observations about LITRE as an institutional strategy to promote innovation in teaching and learning.

- A faculty grants program is a very useful tool for stimulating innovation across campus. The university should consider directing its grants programs to solving major issues, such as redesigning large classes.

- Faculty, especially junior faculty, need support to innovate with their teaching: time, infrastructure, and ready technical assistance. In addition, many faculty do not have expertise in educational research. LITRE filled that gap successfully by providing an educational researcher on staff who can partner with faculty to design, implement, and write about their experiments in teaching and learning. This would promote the scholarship of teaching and learning and lead to greater rewards in promotion and tenure.

LITRE-Related Projects and Activities

In addition to sponsoring grant projects, LITRE spawned a variety of other activities associated with teaching and learning with technology:

- LITRE Learning Expo (2009), a week-long event featuring speakers, student panels, and a poster session of LITRE grant results and other, similar projects. http://litre.ncsu.edu/VirtualExpoMain.html

- LITRE Student Learning Assessment Toolkit, a collection of assessment and evaluation tools and methods to help faculty make informed choices to meet their assessment needs. The tools and methods focus specifically around student learning and the areas of problem solving/critical thinking, research from sources, empirical inquiry and performance. http://litre.ncsu.edu/sltoolkit/ToolKitEntry.html

- Introduction of a Scholarship of Teaching and Learning Summer Institute, offered by the Office of Faculty Development

- A searchable, online annotated bibliography, FAQs, and resource links to facilitate understanding of the role of assessment in relation to technology and student learning. http://www2.acs.ncsu.edu/UPA/assmt/litre/index.htm

- Dissemination of LITRE project results through publications and state and national conferences. Many of these papers addressed issues related to student learning outcomes. See Appendix E.

- Technology Practices Database, which allowed faculty to post information about how they used technology in their classes and to find colleagues experimenting with similar or different technology-based strategies to improve student learning. http://litre.ncsu.edu/directory/index.html

- Related research on student learning and teaching with technology, including new questions on NC State's sophomore and senior surveys, and two faculty surveys on the use of technology in teaching and learning (2003 and 2009). http://litre.ncsu.edu/dfiles/Surveys.html
- ClassTech. Inspired by LITRE, the university implemented new design standards for classroom technology and created a fund to increase the number of classrooms meeting standard. http://litre.ncsu.edu/dfiles/classtech.html

- Flyspace. Most conferencing facilities on campus were developed for the use of faculty and staff. Flyspace created well-equipped, technology-enabled workspaces for student group projects. http://litre.ncsu.edu/dfiles/flyspace.html

- G-108. Building on the successful SCALE-UP project, which promoted active learning in redesigned classrooms, the G-108 project expanded hands-on activities, simulations, or interesting questions and problems. http://litre.ncsu.edu/dfiles/g108.html

Appendix A: Examples of First Phase LITRE Grants
http://litre.ncsu.edu/dfiles/funded2005.html

Integrating Archaeology and Inquiry-Based Learning: Developing Computer-Based Modules for ANT 253 (Introduction to Prehistory), Dr. Scott Fitzpatrick. The instructor developed ARCHAEinteractive, a web-based archive providing inquiry-based assignments to complement lecture and in-class discussions and improve empirical inquiry skills and research from sources. Portfolio reviews and student surveys indicated that the course gave students a broader understanding of how archaeologists decipher and interpret information in a logical and critical way.

Implementation of Media-Rich Course in the Global Approach to Understanding Music, Drs. Jonthan Kramer and Alison Arnold. This project involved the development of online streaming media for a music appreciation course. Student development in all four outcomes areas was assessed using a rubric was applied to student papers. Video clips provided richer, shared media experiences from which students could develop their papers, which improved the quality of their work. A variety of technical difficulties were identified and resolved.

Online Assessment of Expertiza: A Methodology for building Reusable Learning Objects through Peer Review, Dr. Ed Gehringer. This project assessed the benefits of using Expertiza, a suite of software applications for developing reusable learning objects through peer review. Ten instructors participated, including four from other institutions. Student were asked to create an example of a particular concept, make up a problem based on material from the lecture, or another homework project; their work was reviewed by peers. After making revisions, the students' work was "published" and made available to other students. Student course evaluations indicated that more than twice as many students in previous courses felt that the peer review process and collaboration with their peers improved their learning.

Integrating a Factory and Supply Chain Simulator into a Textile Supply Chain Management Curriculum, Dr. Kristin Thoney. This project tested the theory that educational games can increase student learning by providing competitive experiences that motivate students to learn material and apply their knowledge to more complicated scenarios than are often found in textbooks. Responsible Technologies' Littlefield Technologies Came and Supply Chain Game were integrated into an undergraduate improve performance in the discipline. This led to an improvement in student performance in making capacity and inventory decisions, but no improvement in overall inventory decision-making skills.

Introduction and Evaluation of Virtual Microscopy in Teaching Veterinary Cytopathology, Drs. Jennifer Neel, Carol Grindem, David Bristol. Virtual microscopy (VM) is the digitalized equivalent of traditional microscopy, but it uses a computer to view images of specimens. VM saves time for the instructor and lab technician, improves the quality and selection of images, and reduces equipment costs for the institution. Students' empirical inquiry skills on a traditional microscopy exam and a similar VM exam were compared, and their opinions on VM's functionality were compared. Students preferred traditional microscopy for graded exams but preferred VM for take-home quizzes and studying. Grade distribution and mean test scores did not differ significantly between the two modes.

Collaborative Online Concept Mapping, Drs. Kevin Oliver and Dianne Raubenheimer. Five sections of two different distance education classes completed a series of Web-based concept map assessments using different concept mapping methods. Concept maps provided an alternative assessment to gauge student understanding of course topics. The purpose of this project was to determine the most appropriate mapping techniques for eliciting and scoring student representations using performance and attitudinal measures. Student learning outcomes included specific thinking skills (problem solving) and comprehending specific relationships among course concepts (research from sources). Student feedback and class performance were assessed. Open-ended mapping may work better for fostering relational thinking, while teachers designing objective assessments may find that pre-selected mapping carries more precision.

Appendix B: Computer-Based Modeling for Engineering
http://litre.ncsu.edu/dfiles/COE.html
Drs. Amy Craig, Jan Genzer, Jeff Joines, Stephen Roberts, Dianne Raubenheimer

This project addressed two LITRE learning outcomes – problem solving and performance in discipline – within several engineering disciplines and across programs. It was based on redesign of curricula to educate engineering majors to model problems, solve these problems using modeling tools, and then to analyze the solutions through decision support. Students would become "power users" not programmers. A series of in-class labs integrated the traditional lab and lecture sessions into one, and in-class activities were completed on student-owned laptops.

The problem solving task used in the project was designed to ascertain the student's ability to decipher information and a scientific equation, utilize this information and equation to analyze the problem, and then ultimately make a decision based on their analysis. The task involved asking students to make a decision about taking a new job offer. Results showed that students using technology were better problem solvers (scored using a rubric: Wolcott, 2006) and generated a better problem solution (task completion score). This was shown for both 100 level students and 400 level students. Comparing 100-level students to 400-level students showed that the 100-level students were less advanced problem solvers overall. The 400-level data were further analyzed by comparing performance of students who had taken the new 100-level course to those who had not taken it. The 100-level course appears to have a long term benefit, particularly for the 400-level students who used technology to solve the problem, with 46% scoring in the upper problem solving levels, compared to 6% of those who had not taken the course. 16% of students who had taken the lower course, but did not use technology to solve the problem, were placed in the high performance (pragmatic performer) category. A similar pattern was seen in the task completion score, with 63% of students who used technology and who had taken the lower course obtaining a 3- or 3+ score. PIs concluded that technology acts as an enabler (100 level) and helps in understanding the problem better (taking it apart and modeling it). Technology acts as an enhancer (400 level) and makes it easier to do more analysis once the base case is setup ("what if" scenarios).

Results of the assessment of performance in the discipline show that students who had taken the introductory course were significantly more confident on most of the dimensions of software use than students who had not taken the class. In Chemical and Biomolecular Engineering (CHE 225) pre- and post- survey results showed a significant increase in student confidence levels in using both Excel and VBA by the end of the course. The same survey was administered to five sections of 300 level courses and one 400 level course. All the students in these sections had taken CHE 225 during the previous year. Results showed that all 300 level groups were significantly less confident on all VBA dimensions than students at the end of the iCHE225 course. There were also significant differences on a few Excel dimensions: 400-level students were significantly less confident on one Excel dimension and all VBA dimensions, in comparison to students at end of the CHE225 course. Investigators conclude that the difference in student confidence between the upper level classes and the end of CHE 225 can be attributed mainly to the fact that the skills learned in the sophomore course were not reinforced in the 300 and 400 level courses. The results were presented to CBE faculty to initiate discussion about what skills students do need to develop, the need to develop a computational thread through the curriculum, and an attempt to reach some agreement about which tools should be used. Student performance in work assignments was also investigated. For example, during each classroom session in TE/ISE 110 students complete in-class assignments related to a particular Excel outcome or skill set. Student scores for the various outcomes were all above an average of 9.4 out of 10.

The College of Engineering is using these very positive results to expand this approach to introductory courses in other departments and to continue building a thread linking computational processes and skills across courses at all levels in the curricula.

Appendix C: **MILLIE – Using Video to Support Instruction**
http://litre.ncsu.edu/dfiles/MILLIE.html
Dr. Robert Beichner

This project built on the strong foundation provided by SCALE-UP, a multi-year project which has been funded by the US Department of Education, NSF, Apple Computer, Hewlett-Packard, and Pasco Scientific, and whose design has been deployed at MIT and several other universities. SCALE-UP promotes active learning in a specially designed physics classroom for 100 or more students. Students sit in groups of 6 or 7 at round tables with networked laptops in a setting much like a banquet hall with lively interactions nearly all the time. The instructor assigns hands-on activities, simulations, or other interesting questions and problems that are addressed by the students in groups.

For LITRE, Dr. Beichner combined parts of the SCALE-UP version of the course *Introductory Physics for Scientists and Engineers I* with aspects of the lecture version to create a "thoroughly modern" version. Course content normally delivered via lecture was delivered instead by videos of the professor's lectures. The professor then spent class time helping students work through the more difficult aspects of the content and motivating students to learn more. He still worked with the same number of students and for the same total number of hours, but instead of talking *at* 100 students three hours per week, he talked *with* 33 students during three different hour-long sessions. In MILLIE the use of round tables as in SCALE-UP was continued but collaborative group work was incorporated only in laboratory sessions.

Specific student learning outcomes for this project were established for problem-solving skills, empirical inquiry (laboratory, technology, communication, and questioning skills), and performance in the discipline (improved understanding of physics, attitudes and beliefs favorable for learning physics with deep understanding, and finding information on the web).

Student performance was assessed via homework, tests, and surveys. In addition, the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, et. al., 1990) was used to assess student attitude (learning strategies and motivation). Comparison of pre-and post scores showed a small but significant downward shift in four important areas. Of the 15 MSLQ subscales, four showed a significant ($p < 0.05$, two-tailed Wilcoxon Mann-Whitney test) decrease. These subsections were: Task Value, Self-Efficacy, Critical thinking, and Rehearsal.

No differences were found in student performance on homework and tests. T-tests comparing final exam performance between the group that participated in this study and the control group that followed the traditional lecture format indicated no significant differences between the groups. The study also found no effect on reading skills.

Students did not particularly enjoy or value the videos and probably would not take a similar course in the future. However, they were consistent in their requests for videos of examples. Dr. Beichner wants to repeat the project using videos of examples rather than videos of lectures.

Appendix D: **Virtual Online Learning and Teaching (VOLT)**
http://litre.ncsu.edu/dfiles/VOLT.html
Drs. Len Annetta, Julia Storberg-Walker, and Diane Chapman (Education), and Lynda Aiman-Smith and Claudia Kimbrough (Management)

VOLT combined the pedagogical potential of virtual simulations with the motivational appeal of games. Ten courses – including both undergraduate students in science education and graduate students in science education, Adult and Higher Education, and Business Management – were taught entirely in an immersive, 3D virtual learning environment. Students were given the opportunity to learn by doing, experience situations first-hand, and role-play. The multiplayer aspect allowed students not only to interact with the virtual environment but also to communicate and collaborate with each other and the faculty.

Although this project could potentially scale up to test all four LITRE learning outcomes, VOLT focused on the fourth goal of performance in the discipline. Courses were taught using one of two virtual world platforms, Second Life and Active Worlds. Specific learning outcomes were devised for each course as appropriate for the course objectives. All courses used the SOLO Taxonomy (Biggs 2003) to assess student learning outcomes. SOLO is a useful tool for assessing the levels of student learning, ranging from a single point or uni-structural thinking to extended abstract thinking based on classroom observation and student work. This taxonomy can be used in a variety of academic content areas, so it was a useful tool for this project.

Results form the courses using Second Life were much more positive than those using Active Worlds. The Second Life part of the project was implemented by faculty in Business Management using two courses in fall 2007 and three in spring 2008. Students were required to collaborate on team projects, which provided evidence of students' ability to work in a virtual environment and apply critical thinking to the use of that environment by a wide range of organizations. Students also observed and analyzed the use of Second Life by "real world" organizations including Sony, IBM, Cisco, Ben & Jerry,' etc. Indirect measures of student learning were collected via pre-and post- Web-based surveys. Investigators acquired direct evidence of learning outcomes from in-class presentations, project builds in the Second Life online environment, and a written narrative about the project. Student performance was compared across all sections using Second Life. Of thirteen student projects assessed, then reached the highest level in the SOLO taxonomy. The variance in project results across groups appeared to be related to student attitudes and conscientiousness. Overall, results showed that students gained knowledge of an important new collaborative and marketing communication technology. The process of building a 3D environment enabled some students to excel in a new way. The PIs found that, given the right level of instructional and technological support, students did a very good job at completing a complex assignment.

Active Worlds was used by faculty in Science Education and Adult and Higher Education. Results from these courses were mixed. A qualitative study comparing Wolf Den built in Active Worlds and Elluminate showed that users preferred Active Worlds for its convenience, communication, community, user friendliness, and ease of presentation. Two other investigators did not have positive results using Active Worlds. One reported: "The learning potential of the virtual world experience for adult learners remained underdeveloped. Consistently, learners said that Elluminate's synchronous communication was their preferred mode of learning and working together." Similarly, another investigator reported that she used the SOLO taxonomy to compare student performance in two formats, and those using Active Worlds performed better. The same investigator also used Second Life in two classes with positive results.

The investigators concluded that it is important to have the right infrastructure and support for classes taught in virtual environments. Although the technologies were different, students tended to have the same problems. Although students had fewer technology problems with Active Worlds, they found a lack of places to go for help. While Second Life had a lot of support available, some students were overwhelmed with all the information. Several specific strategies for successful use of Virtual worlds was put forth by the VOLT group.

LITRE Related Publications and Presentations

Annetta, L.A. (September 5, 2007). Engaging K-20 Students In Immersive Virtual Learning Environments. Presented at the meeting of the IMS Global Learning Consortium. College Park, MD.

Annetta, L.A., Craig, A., Soni, G., Cheng, M, & Folta, B. (January 30, 2008). LITRE: Investigating the effectiveness of technology in improving student learning. Paper presented at the annual meeting of the EDUCAUSE Learning Initiative, San Antonio, TX.

Annetta, L.A. (February 19, 2008). V-Learning: How gaming and avatars are engaging online students. Innovate Online Webcast.

Annetta, L.A., Beichner, R., Raubenheimer, D., Soni, G., Cheng, M.T. (March 13, 2008). Learning in a Technology Rich Environment (LITRE) – Researching Innovative Technologies to Promote Student Learning. Paper presented at the annual conference for the University of North Carolina Teaching and Learning with Technology Collaborative, Raleigh, NC.

Annetta, L.A., & Klesath, M. (March 18, 2008). *The new virtual field trip: A perspective from NC State's* Entomology Bug World. Paper presented at the Educause Learning Initiative Spring Focus, Raleigh, NC.

Brent, R, Raubenheimer, C.D., Craig, A. (February 2008). Integrating student-owned computers into engineering & science classes: A discipline specific approach. Paper presented at Lily Conference, Greensboro, NC.

Chapman, D. D. (2008). Virtual worlds: New directions for HRD research and practice. *Proceedings of the 2008 Academy of Human Resource Development International Research Conference*, Panama City, FL.

Genzer, J., & Carnell, B. (2005 – updated 2008). Visual Basic for Applications (VBA) in Microsoft Excel for Chemical Engineers. NC State University, Department of Chemical and Biomolecular Engineering.

Gut, D.M. & Squire, K.D. (Chairs), Langer, A., Knelfelkamp, L.L., Robin, B.R., Annetta, L.A., Devane, B.M., Durga, S., Lee, H., Templeton, R.A., Dani, D.E., Koenig, K., Ma, J., Lu, E., Seo, K.K., & Wan, G. (Discussant). (March 28, 2008). New media and instruction in the 21st century. Paper presented at the annual meeting of the American Educational Research Association, New York, NY.

Joines, J.A., Roberts, S.R., & Raubenheimer, C.D. (2007). Computer-Based Modeling for Engineers using Excel and VBA. *Proceedings of the 2007 American Society for Engineering Education International Conference, Honolulu, Hi.*

Joines, J. (May 2008). Excel workshop for engineering faculty and staff. Workshop presented at College of Textiles, NCSU, Raleigh, NC.

Joines, J., Raubenheimer, C.D., Craig, A., and Roberts, S. (June 2008). Teaching computer-based modeling with excel and VBA, student owned computers, and tablet PCs. Paper presented at the Autex 2008 World Textile Conference, Belagia, Italy.

Joines, J., Pasquinelli, M., & Roberts, S. (2008). *Computer based modeling for engineers: An Electroinic Excel Handbook.* Raleigh, NC: North Carolina State University.

Oliver, K & Soni, G.(2007). Facilitating Faculty Connections: The Technology Practices Directory, UNC Teaching and Learning with Technology Conference, Raleigh, NC.

Oliver, K. M. (2007). Design and development of a faculty technology practices directory. *Educause Quarterly*, 30(4), 38-47.

Raubenheimer, C. D., Brent, R., & Craig, A. (June 2007). Student-owned computing, faculty development and the role of assessment. Paper presented at the International Assessment and Retention Conference, St. Louis, MO.

Raubenheimer, C.D., Craig, A., & Brent, R. (March 2008). Computer Based Modeling to Enhance Problem Solving. Paper presented at the UNC TLT Conference, Raleigh, NC.

Raubenheimer, C.D., Craig, A., Brent, R. & Joines, J. (June 2008). Integration of Computer-Based Problem Solving into Engineering Curricula. *Proceedings of the 2008 American Society for Engineering Education International Conference, Pittsburgh, PA.*

Raubenheimer, C.D., Craig, A., Joines, J. (June 2009). Using computational tools to enhance problem solving. *Proceedings of the 2009 American Society for Engineering Education International Conference, Pittsburgh, PA.*

Soni, G & Devine, H. (April 2008.) LITRE: Learning in a Technology Rich Environment: Assessing the impact of Technology on Learning, NC State Undergraduate Assessment Symposium, Cary, NC.

Soni, G., Beichner, B., Annetta, L., Craig., A., & Raubenheimer, C.D. (2008). Learning in a Technology Rich Environment (LITRE) – Researching Innovative Technologies to Promote Student Learning. Paper presented at the UNC TLT Conference, Raleigh, NC.

Soni, G., Anetta, L., & Craig, A. (January 2008). LITRE: Investigating the Effectiveness of Technology in Improving Student Learning. Presentation at EDUCAUSE Learning Initiative (ELI) Annual Meeting, San Antonio, TX.

Spurlin, J. E. (2007). *Using Needs Assessment as a Holistic Means for Improving Technology Infrastructure.* EDUCAUSE Learning Initiative White paper.