2013 Large Course Redesign (LCR) Assessment

Physics for Engineers and Scientists I (PY205N)

Description of Project or Service	DELTA Large Course Redesign (LCR) funding and staff support were leveraged by the Physics Department for the incorporation of innovative learning technologies in the delivery of laboratory exercises in Physics for Engineers and Scientists I (PY205). Enrollment in this and other gateway physics courses has steadily increased over the past decade, putting pressure on limited teaching lab facilities. This LCR project was implemented as a strategy for removing some of that pressure by providing students with meaningful lab experiences in alternate settings through the use of kit labs and accompanying web-based feedback and assistance from a TA. This report discusses outcomes associated with the redesign of laboratory exercises in PY205. Measures of learning are compared between three groups of students – conventional, kit lab, and in-lab – in an effort to isolate and evaluate various aspects of the kit lab design. Qualitative observations of progress toward the achievement of project objectives are also presented.
Assessment Timeframe	DELTA funding was granted in the 2011-2012 academic year to cover the personnel and materials required to create and implement kit labs and supporting features in PY205N. The redesign of PY205N labs began in fall 2011, and kit labs were piloted in spring 2012 and fall 2012. Major changes to lab content and delivery were made in spring 2013, which required redesigning some of the content in the kit lab program. Departmental and course structure and needs continue to change, and the kit lab program continues to evolve with them.
What is the desired outcome (goal)?	This LCR project was envisioned as a strategy for accommodating university and departmental enrollment growth with existing lab space resources in the Physics Department. Specifically, the project was “designed to create a meaningful laboratory experience in extramural settings that does not require facilities expansion” (Paesler, 2010). Project objectives include: ● Providing students with non-traditional lab experiences that are meaningful and effective ● Accommodating enrollment growth in the department by restructuring the use of lab space
To what overarching DELTA goal is the outcome related?	As an organization, DELTA has a dual focus on 1) implementing and enhancing Distance Education programs and 2) providing faculty support for the incorporation of learning technologies into instruction in traditional courses. DELTA’s 2014-2016 Strategic Plan states that *while online and distance instruction continues to be an emphasis for NC State, future enrollment strategy manages growth in the context of limited resources*. DELTA’s 2014-2016 Strategic Plan further states: Helping students make timely progress toward a degree means rethinking how courses are developed, delivered and scheduled, taking

	advantage of innovative learning technologies to provide flexible delivery methods for easy access to course materials, supporting emerging pedagogies, using technologies that support the university's Quality Enhancement Plan by engaging students in critical and reflective thinking with a variety of learning materials, and providing excellent and timely support for students and instructors. DELTA will continue to provide the resources, training and support needed for faculty to leverage technology to provide meaningful, flexible and innovative learning environments in support of student success. To this end, DELTA's Goal One involves *leveraging learning technologies to improve student success* and establishes DELTA awards to fund Course Redesign initiatives throughout the university. The utilization of kit labs in this Course Redesign project explicitly furthers DELTA Goal One as it 1) specifically addresses increasing enrollment with limited, existing resources, 2) represents innovation in the design and delivery of laboratory courses, 3) makes use of emerging learning technologies, and 4) provides flexible access to course materials.
Background and Description of Project or Service	PY205 is the first course in a two-semester, calculus-based sequence in introductory physics (Physics for Engineers and Scientists I). Along with other introductory courses in the department, such as PY211 and PY212 (College Physics I and II), PY205 and its complement, PY208, are required courses for a number of majors throughout the university and are gateway courses to more advanced study in physics. These courses, as well as others in the department, include lab components exclusively offered in Fox Science Teaching Laboratory. Recent university enrollment growth is acutely manifest in the Physics Department where enrollment in some gateway courses has increased by 70% in the past decade. Consequently, physics laboratory teaching facilities were nearing capacity, with labs being offered on weekdays from 8:00AM to 10:00PM. Based on trends from 2005-2010, enrollment in physics lab-based courses was projected to grow from 5,437 to 5,559 students in the 2011-2012 academic year. **Redesigned Course** A recent, nationwide trend in college laboratory courses involves the use of kit labs (Paesler, 2010). These kits consist of a small set of equipment that is checked out by groups of students who perform their laboratory exercises during their assigned lab time, but in a setting of their choice. Because kit labs are conducted in a location outside of a lab classroom, some pressure is removed from limited lab space, and larger enrollment numbers can be accommodated without the need for expanded facilities. To balance the ability of kit labs to free up laboratory space with the desire to offer students at least some traditional, in-lab experiences, kit labs were used in alternating weeks, thereby replacing half of the existing lab exercises with redesigned content. In order to provide students with the guidance they need to effectively

	conduct and learn from kit labs, other modifications were made to lab procedures and materials. Laboratory manuals, which were distributed electronically by *WebAssign*, were expanded to compensate for the fact that direct oversight by teaching assistants (TAs) is not possible with kit labs; additional details, including videos, were added. *WebAssign* also developed interactive lab assignments that provide students with immediate feedback on their performance. Complementing the features provided by *WebAssign*, an online interface was created through *Elluminate Live!* (now *Blackboard Collaborate*) that allowed TAs to monitor student input for lab questions and data collection and to provide real-time assistance and redirection during the kit lab experience. By substituting some traditional, in-lab experiences with kit labs, online lab assessments, and virtual access to a TA, this LCR project used the replacement model for course redesign defined by the National Center for Academic Transformation (NCAT, 2005a).
What assessment tools did you use?	***Student Experience*** 1. *Direct observation* – Observation of student engagement with kit labs occurred in the Qualitative Education Research Lab (QERL), a state-of-the-art facility within the Physics Department that allows researchers to observe and record student activity. One room, designed for group observations, provides researchers four perspectives from which to record video data and four table-top conference microphones to record audio. Unobtrusive observation of student activity is possible through a one-way mirror. Additionally, computers running screen-capture software can be set up to record all computer activity, which is then cross-referenced with audio and video recordings for a complete picture of student experiences during the exercise. 2. *Surveys and tests* – A variety of questionnaires and tests have been administered to students since the inception of the LCR project in PY205. Most recently, three different groups have been studied: ● *kit labs*: Students in this category conduct kit labs in a remote location every other week, while using the features provided by *WebAssign* and *Blackboard Collaborate* to access a TA. ● *in-labs*: Students in this category also conduct kit labs on alternating weeks with traditional labs, but they perform their kit lab exercises in the lab classroom with a TA present. ● *conventional labs*: Students in this category perform only traditional labs; they do not use kit labs. Surveys and tests have been administered in order to evaluate the effectiveness of kit labs in achieving established learning objectives for the laboratory component of PY205. The three objectives, which focus on content, process, and affect, and the instruments used to assess each of them, are described below: a) Content - *Objective: The laboratory experience aims to enhance student understanding of course content through experiments that illustrate*

	that content. - *Instrument*: Performance on tests covering course material was used to detect differences in student understanding of course content among the three lab delivery methods. b) Process - *Objective: The laboratory experience should teach students the process of doing physics, including how to make careful measurements, how compensate for error in measurements, and how to construct repeatable experiments.* - *Instrument:* Students in the three categories were given pre- and post-semester tests that evaluated their graphic interpretation skills. Changes in these scores were used as an indicator of the size of the effect of different lab structures on the process objective. c) Affect - *Objective: Laboratory experiences can enhance student performance and positive involvement in the physics course through the tactile and active experience that lab exercises provide.* - *Instruments:* In the pilot phase of the kit lab LCR project during spring 2012, an attitude survey was administered to students using kit labs which asked them to rank each lab from the semester in order of their personal preference. Later, the Colorado Learning Attitudes about Science Survey (CLASS) was administered to all PY205 students at the beginning and end of the semester to evaluate the differential ability of traditional labs and kit labs to improve student attitudes towards their physics course. ***Facilities Use*** 1. *Enrollment trends* – Course data obtained from the NC State Office of Registration and Records (R&R) were used to examine enrollment trends in PY205 and other introductory physics courses as a measure of the ongoing need for facilities space in Fox Science Teaching Laboratory. 2. *Qualitative evaluations* – Qualitative feedback from the faculty and TAs involved in implementing the kit lab program has been central in assessing improvements in facilities use. ***Student Success*** DELTA is keenly interested in the impact of course redesign on student success, particularly completion rates (as measured by the number of withdrawals from a course) and academic performance (as measured by ABCDF grade distributions). These factors are typically examined pre- and post-redesign in order to assess the impact of redesign on student learning outcomes.
What is the population that you are assessing?	Full-time on-campus undergraduate students at NC State who took PY205 for a grade in a fall or spring semester; distance learners, summer session students, and students who audited the course are excluded. Because long-term analyses of student performance pre- and post-redesign are not included here, the population is further limited to students who were enrolled in PY205 after kit labs were introduced in spring 2012.

Did you utilize a sample? If yes, describe.	Samples were used only in assessments conducted by the Department of student experiences with kit labs, since enrollment data obtained from R&R to assess facilities demand was available for the entire population. In direct observations, the sample included the six students who were selected to perform their kit labs in the QERL. Sample sizes for tests and surveys administered for evaluation of learning objectives vary by assessment. The attitude survey was administered to two kit lab sections of 24 students each in spring 2012. Content tests, as a standard tool for student evaluation, were taken by all PY205 students. The graphic interpretation skills test and CLASS were also taken by all PY205 in the semesters in which they were administered.
Response Rate	Due to assessment design, in most cases, responses or scores were collected for all sampled students. Because the graphic interpretation skills test and CLASS were given twice (at the beginning of the semester and at the end of the semester), the response rates for those assessments are limited to the portion of students who took both iterations of the tests.
Brief summary of Results	Analysis of registration data indicates that total and average enrollment in introductory physics sequences, including PY205, is consistently increasing. With the introduction of kit labs, which are used on alternating weeks with traditional, classroom-based exercises, twice as many students can be accommodated with existing resources. The kit lab program also makes use of other available resources like the space and staff of the D.H. Hill Library and the web-based learning tools provided by WebAssign and Blackboard Collaborate. Comparative analysis of course exams revealed no significant difference in content learning between students who used kit labs and those who did not. Students also showed no significant preference between kit labs or traditional, in-house labs when ranking them. Consequently, it may be concluded that kit lab exercises are as effective as traditional ones at encouraging student investment and positive involvement in physics coursework – a reflection of the affect objective for lab exercises. Compared to conventional lab students, students who use kit labs, whether remotely or in the lab classroom, demonstrate greater improvements in their data analysis skills over the course of the semester. The replacement of commercial equipment with personal electronic devices, such as laptops, tablets, and smartphones, appears to have a positive effect on students' ability to master the process of doing physics by learning to collect, manipulate, and interpret scientific data. While the attitudes of conventional lab students and kit lab students towards their physics coursework worsened slightly over the course of the semester (a shift seen among most introductory physics students worldwide), in-lab students (those who conducted kit labs in the lab classroom on alternating weeks) experienced positive shifts in their attitudes towards the course. Overall, the findings in this assessment report indicate that the objectives of this LCR project are being achieved as the kit lab program frees up space in Fox Hall while providing lab experiences that are

	equivalent or superior to traditional ones in terms of accomplishing established learning objectives. Importantly, the successes of this course redesign project continue to inform improvements in learning and teaching at NC State and elsewhere.
URL Links to supporting documents OR contact information for further details if/as needed	**Full Report (PDF): 2013 Large Course Redesign (LCR) Assessment: *Physics for Engineers and Scientists I (PY205N)*** **Resources** Advanced Instructional Systems, Inc. (2014). *About Us.* Retrieved from http://www.webassign.net/info/about_ webassign.html Chickering, A.W. and Gamson, Z.F. (1987). Seven Principles for Good Practice in Undergraduate Education. *The Wingspread Journal, 9*(2), special insert. Retrieved from http://sites.duke.edu/onlineguide/files/2011/12/ Chickering-Gamson.pdf Cromack, J. (2008, October 22-25). *Technology and learning-centered education: Research-based support for how the Tablet PC embodies the Seven Principles of Good Practice in Undergraduate Education*. Paper presented at the 38th Annual ASEE/ISEE Frontiers in Education Conference, Saratoga Springs, NY. doi: 10.1109/FIE.2008.4720288 National Center for Academic Transformation (NCAT). (2005a). *Six models of course redesign.* Retrieved from http://www.thencat.org/PlanRes/R2R_ModCrsRed.htm National Center for Academic Transformation (NCAT). (2005b). *A summary of NCAT program outcomes.* Retrieved from http://www.thencat.org/Program_Outcomes_Summary.html **For more information about the PY205N LCR project, please contact:** Dr. Michael Paesler, Professor Physics, Box 8202 919-513-2184 paesler@ncsu.edu Dr. Traci Temple Director, DELTA Research and Analysis Distance Education and Learning Technology Applications (DELTA) 919-513-3193 tltemple@ncsu.edu
Interpretation of Results	This LCR project was undertaken with the primary goal of meeting increasing enrollment demands with existing resources without sacrificing quality in laboratory instruction in terms of content, process, or affect. The findings in this assessment report indicate that those objectives have been achieved with the kit lab program.

	Comparison of student performance on course exams reveals no significant differences among kit lab, in-lab, and conventional lab students in terms of their understanding of course content. This indicates that the different lab delivery methods provide students with equally effective supplements for lecture material, and it suggests that kit labs are as capable as traditional lab exercises of accomplishing the content learning objective for the laboratory component of physics courses. Analysis of student attitude surveys also found no significant difference in student preference between kit labs and traditional labs. This indicates that while students do not necessarily prefer kit labs, they appreciate them at least as much as traditional labs. Findings from the CLASS further reflect the ability of kit labs to achieve the affect objective by describing the impact of kit labs on student attitudes towards their PY205 course. The distinction between in-lab students and the other two groups on the CLASS suggests that the kit-based design is appealing to students, particularly when performed in traditional settings. Ultimately, the combination of kits, with the accompanying use of personal electronic devices, and in-person access to a TA in a lab classroom enhances student experience in an introductory physics course in a way that each factor alone does not. Related to the process objective, a test administered to students in each of the three lab categories at the beginning and end of the semester showed that compared to conventional lab students, students who use kit labs, whether remotely or in the lab classroom, experience greater improvements in their data analysis skills. The relationship between the use of new technologies and student mastery of analytical skills is an important finding, and one that is supported by other research among undergraduates. Overall, it appears that the primary benefit of the kit lab structure for students may arise, not from their accessibility in nontraditional settings, but from the condensed packaging of a standard physics lab into a small kit and the applicability of personal technology to lab exercises. These results may be expandable to other courses in the Physics Department as well as other science labs on campus. The simple and cost-effective elimination of commercially available data collection and manipulation equipment from lab experiences may significantly improve students' perceptions of science coursework and their mastery of science processes. The kit lab arrangement, with its alternating weekly use of kit labs performed remotely and traditional labs performed in the lab classroom, accommodates the same number of students with half of space and time required for traditional lab arrangements. Utilizing kit labs, even in a portion of the laboratory sections of PY205 (now PY206), allows the Physics Department to accommodate more students with the same resources and thus meet the demands of increasing enrollment without the need for expanded facilities.

	The kit lab program makes effective use of other campus resources. *WebAssign* and *Blackboard Collaborate* were used to create and maintain student and TA interfaces for real-time, online feedback and interaction during kit lab exercises. During the initial pilot of kit labs in PY205, Dr. Michael Paesler considered the implementation and use of these technologies to be "great successes, with all students finishing the labs in a timely manner and with good results." The TA responsible for overseeing those sections reported to Dr. Paesler that "the combination of [*Blackboard Collaborate*] and *WebAssign* allowed him to monitor students' progress and keep them on task as well as, if not better than, being in the room. This is because he was able to monitor the progress of all groups simultaneously with a live report of how far into the assignment each group was, as well as being able to look at all input from a group and see where difficulties may lie." By working with specialists at *WebAssign* and *Blackboard Collaborate,* this project takes advantage of resources that are already frequently used by faculty and students at the university. Faculty involved in this LCR project also worked with Dr. Susan Nutter, Vice Provost and Director of Libraries at NC State, to make use of the space and staff resources available at D.H. Hill Library. Students now check out kit lab materials from the reserve desk and perform their experiments in the library's Learning Commons or in other rooms available by reservation. In addition to providing circulation services, this collaboration with the library allows the kit lab program to conserve space in Fox Science Teaching Laboratory, while still giving students a structured learning space in which to conduct their lab exercises as a group.
Impact of the LCR Program	Dr. John Blondin, the Department Head for Physics, has encouraged the expanded use of kit labs in additional sections of PY206 as well as in other physics courses in a continued effort to manage ever-increasing enrollment. Dr. Michael Paesler, the faculty impetus behind this LCR project, has sought and acquired external funding to continue the kit lab program at NC State and eventually share its successes with other institutions. In February 2013, Dr. Paesler received $200,000 in grant funding from the National Science Foundation's *Transforming Undergraduate Education in Science, Technology, Engineering, and Math* (TUES) program. The TUES program supports projects that use emerging knowledge about undergraduate teaching and learning to transform STEM education. Dr. Paesler's two-year TUES-1 grant is funding the continued development and improvement of the kit lab program at NCSU. Many projects that are funded with TUES-I grants ultimately go on to receive TUES-II grants, which provide five years of funding for the adaptation, transfer, and expansion of successful projects to STEM teaching at other institutions. Dr. Paesler intends to submit a TUES-II proposal in the future. Dr. Paesler also submitted a separate proposal for funding through the NSF *Cyberlearning: Transforming Education* program. The *Cyberlearning* program supports projects that apply technological advances to education, particularly those that foster personalized

	learning experiences, appeal to populations underserved by current teaching methods, and allow students to access materials anytime, anywhere. Dr. Paesler hopes to use this program to develop in-house lab exercises that use smartphones for data collection and analysis, instead of expensive, commercially available equipment. With an expanding App marketplace, smartphones can now be equipped with gyroscopes, accelerometers, high speed video capture with stop-action, and high speed audio capture. As the variety of Apps expands, so does the potential for lab exercises that incorporate smartphone technology. This proposal aims to apply the use of personal electronic devices – an element of the kit lab project found to be effective in improving student learning related to the process of doing physics – to traditional, in-class labs.
Timeframe to take actions found from assessment results	Although DELTA's involvement with this LCR project has ended, the kit lab program continues to grow and evolve within the Physics Department. (See "Impact of the LCR Program" (above) for more information on actions that already have been taken as a result of course redesign assessment results.)