Work in Progress: Living with the Lab: Building a New Implementation of the LWTL Project-Based First-Year Engineering Curriculum at Campbell University

Dr. Jenna P. Carpenter, Campbell University

Dr. Carpenter is Founding Dean of Engineering at Campbell University. She is Chair of the ASEE Long-Rangge Planning Committee and the ASEE Strategic Doing Governance Team. She is a past Vice President of Professional Interest Councils for ASEE and past President of WEPAN. Currently Chair of the National Academy of Engineering Grand Challenge Scholars Program Steering Committee and an ASEE PEV for General Engineering, Dr. Carpenter regularly speaks at the national level on issues related to the success of women in engineering and innovative STEM curricula.

Dr. Lee Kemp Rynearson, Campbell University

Lee Rynearson an Assistant Professor of Engineering at Campbell University. He received a B.S. and M.Eng. in Mechanical Engineering from the Rochester Institute of Technology in 2008 and earned his PhD in Engineering Education from Purdue University in 2016. He also has previous experience as an instructor of engineering at the Kanazawa Institute of Technology, in Kanazawa, Japan. His current research interests focus on instruction for metacognition and problem solving.

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Introduction

The Living With The Lab (LWTL) curriculum developed at Louisiana Tech offers an extensive set of first-year engineering projects integrating student hands-on tool use with engineering content, and has been the subject of numerous previous reports (Crittenden, Hall, & Brackin, 2010; Cronk, Hall, & Nelson, 2009; Hall, Barker, & Nelson, 2008; Hall, Cronk, Brackin, Barker, & Crittenden, 2008). Campbell University is now in the process of implementing the Living With The Lab curriculum in their new engineering program's first year of study in collaboration with Louisiana Tech University. This new implementation offers a unique opportunity for collaboration between universities in dissemination and adaptation of the Living With The Lab curriculum.

This paper reports on the obstacles and opportunities encountered during the implementation of the LWTL curriculum at Campbell University in collaboration with faculty from Louisiana Tech University, including changes in curriculum design and practical detail. Observations and findings from the adaptation process are shared. Furthermore, Campbell University is designing a project-based spine for the entire engineering curriculum to extend LWTL practices into four core engineering classes in the second and third year of study. The initial plans for extension of the previous LWTL work will be discussed. This work is one part of a set of three papers reporting on the first year of Campbell University's engineering program. One related paper reports on Campbell University's efforts to attract and retain a diverse cohort of students (Carpenter, Rynearson, & Albers 2017) and another reports on the facilities designed and implemented to promote experiential learning in and out of classes (Carpenter & Rynearson, 2017). Review of the related papers may be helpful to understand the context of the first-year education efforts described here.

Background

As reported in related works (Carpenter, Rynearson, & Albers 2017, Carpenter & Rynearson, 2017) Campbell University has a long history of excellence in the health sciences, with doctoral programs in pharmacy, medicine, physical therapy, as well as physician assistant and nursing programs, pre-pharmacy, pre-med, etc. Other areas of strength include trust and wealth management, PGA golf management and law. In the interest of diversifying offerings, and in response to ongoing interest from prospective students in engineering, the University launched an eighteen-month study on the feasibility of starting a new School of Engineering in 2012. The recommendation from the external consultant's report was in support of a general engineering program with concentrations in mechanical engineering and a second area aligned with the university's strong health science focus. The Board of Trustees approved establishment of the degree program in 2014. After a national search, the inaugural dean was hired in 2015 with the initial cohort of faculty and staff brought on board at the beginning of 2016. After fourteen months of planning, curricular development, facilities renovation, and recruiting, the program was launched with an initial class of approximately 100 first-year students in August of 2016.

Building a new school of engineering affords numerous unique opportunities, including the chance to implement a modern curriculum and pedagogy well-suited to the mission of the school. Campbell University intends to focus on the integration of hands-on exercises into engineering instruction, with a curriculum informed by best practices, engineering education research, and the recommendations of national reports such as "Educating the Engineer of 2020" (National Academy of Engineering, 2005). The Living With The Lab program at Louisiana Tech University was selected a model for Campbell University's integrated, hands-on education due to its complete commitment to experiential learning and its long track record of success in serving a student audience relatively similar to that expected at Campbell University. It was expected that Campbell University's student body would be somewhat more diverse and somewhat less academically prepared than Louisiana Tech University's engineering study body (Carpenter, Rynearson, & Albers 2017). However, it was expected that experiential learning of engineering content would therefore be even more important at Campbell University in supporting student achievement and success.

Learning From the Existing LWTL Implementation at Louisiana Tech University

Having chosen to implement a variation on the existing LWTL curriculum, it was important to gather the course materials, knowledge, and first-hand experience necessary for successful implementation. Such understanding was also expected to be critical to extending the LWTL pedagogy throughout the undergraduate curriculum. To this end, the entire engineering faculty and all technical engineering staff of Campbell University traveled to Louisiana Tech University to meet with faculty, students, and staff involved with the existing implementation of the LWTL curriculum.

At Louisiana Tech, Campbell University personnel personally performed student projects in the LWTL curriculum under the supervision of LWTL instructors, visited ongoing LWTL first-year classes, and reviewed existing course syllabi, assignments, and other student and instructor resources. Campbell University faculty and staff were present at Louisiana Tech University for these purposes for roughly one week, with some variation based on personal schedules. This time was invaluable not only for understanding the LWTL curriculum, but also for building connections with Louisiana Tech University faculty to draw upon during the implementation of the curriculum. Even possessing the full set of course materials (syllabi, presentation slides, homework, lab and project supply part numbers, etc.) it would have been very difficult to adapt and present the LWTL curriculum without training under and interacting with faculty familiar with the existing courses, given the complex integration of content and material.

Intellectual property was also a concern during this process, and resolving issues relating to intellectual property was important for the successful transfer of LWTL content and knowledge. Having developed extensive course materials over many years, faculty at Louisiana Tech University reasonably wished to ensure that their work would receive recognition when employed at another university. It was also hoped that some adapted or modified work produced by Campbell University faculty would be useful at Louisiana Tech and adopted back into their original LWTL curriculum. Therefore, it was agreed to license all course materials under a 'Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License' (Creative Commons, 2017) to ensure the continuation of attribution and guarantee that work

contributed to the LWTL curriculum would remain freely available to all. It was also determined that the PowerPoint slide decks for each lesson would feature an Attributions slide at the end of the presentation including the full history and modification of the source materials. It is hoped that the attribution slide and the non-commercial license may encourage faculty of both institutions to invest effort into maintaining, improving, and sharing course materials.

It is expected that future faculty and staff hires will receive their LWTL training at Campbell University, rather than going to Louisiana Tech University for training. This represents an immediate savings in avoiding travel and allows training on Campbell University equipment in Campbell University classrooms, aimed at meeting the needs of the adapted Campbell University LWTL curriculum.

Adaptation and Implementation in the First Year

Campbell University's inaugural engineering offerings consisted exclusively of first-year engineering coursework, with later coursework to be added year-by-year as the initial cohort moves up. More than 65 students began the on-track First-Year Engineering coursework in August 2016, with roughly another 30 students engaged in remedial work. Therefore, Campbell University's implementation of the LWTL first-year curriculum was ongoing during the 2016-2017 academic year, but no LWTL-style offerings in sophomore, junior, or senior years were in place.

It was decided to limit class size to 24 students for Campbell University's LWTL courses, so three sections of the first-year engineering course were required to accommodate all interested students. This is somewhat smaller than most Louisiana Tech LWTL course sections (most of which have 40 students each), but Campbell University does not plan to implement an in-class TA. An in-class TA is standard at Louisiana Tech, and removing the in-class TA lowers the maximum number of students that can reasonably be supervised using laboratory equipment per section, but allows greater faculty interaction with students. This is in keeping with standard practice at Campbell University, which strongly prioritizes small classes and high levels of student-faculty interaction.

The largest single obstacle to the direct implementation of the LWTL curriculum at Campbell University was translating the quarter-system-based courses for a semester-based school. The LWTL curriculum at Louisiana Tech University offers three principal projects in the first year (robotics/circuits in the fall quarter, sensors/controls in the winter quarter, and a student-selected design project in the spring quarter). The existing LWTL course schedules and materials are tightly integrated inside each course and tied to the quarter system, making it challenging to decide how to split the course materials to fit into fall and spring semesters. It was not administratively feasible to simply split the sensors/controls project in half in the middle of the course, as this would disrupt the associated major team project. Splitting up teams partway through the project would mean that most students would be working during the spring semester on project materials they did not personally create and had no investment in, which would be likely to frustrate students and undermine engagement in the course.

For the first year of engineering courses at Campbell University, the robotics/circuits project and supporting materials were employed in a schedule roughly similar to that at Louisiana Tech, occupying the first ten weeks of the first semester. Then, an attempt was made to peel off some content and preliminary construction elements of the sensors and controls project that could be completed in the first semester, leaving the major team-based components for the spring semester. However, it was apparent that separating the project into pieces in two semesters was not ideal, because the tight integration of the material connecting theory to practice on a daily basis was compromised. Content was being taught without its anchoring experiential learning elements. This appeared to be much less engaging for students, and less effective. The exam scores on content taught without tightly integrated experiential learning dropped on average by about a letter grade, but this metric is confounded by teaching different materials and potential variation in exam difficulty, and so cannot be taken as unequivocal evidence.

In future implementations, the sensors and controls project will run concurrently with the student design project in the second semester of study. To permit this, some less-tightly-integrated materials previously taught in by Louisiana Tech in the third quarter will be moved to Campbell University's first semester, and some other materials will be dropped outright. For example, Campbell University will drop four class days of first-year instruction in engineering economics from the second semester to create more space for the sensors/controls project to run alongside the design project, relying on a later mandatory course in engineering economics to cover this material. It is expected that small tweaks in course schedule and content will be required during each of the next several LWTL course offerings to best adapt the quarter-system materials to a semester-school schedule.

One other change complicating the adaptation was related to the decision to give students more time for the majority of course assignments. LWTL at Louisiana Tech University frequently requires students to submit work a single class period after the work was assigned. It seems likely that students would thereby be required to keep up with coursework rather than allowing assignments to pile up. However, as Campbell University wishes its engineering program to be more accessible to non-traditional students, it was seen as important that enough time to permit students with challenging circumstances to meet with a faculty member for assistance with an assignment be given. To this end, most regular homework assignments were made due two class meetings after being assigned. In adapting LWTL materials, it then became necessary to build a course and assignment schedule that did not assume students had completed the homework assignments as quickly. The Louisiana Tech University schedule often covered small elements of multiple topics in a single class day, with the homework building on each piece. Campbell University's initial adaptation tends to cover fewer topics in a single day, but with greater depth, and alternates topics between class days. This way, students should have completed the homework assignment before the class moves on in a specific topic area, and students have additional time to seek help if a particular assignment proves challenging.

Extension of LWTL Pedagogy beyond the First Year

As stated, Campbell University has only implemented the LWTL project-based curriculum in the first year. However, Campbell University plans to make experiential learning a cornerstone of the engineering program, and therefore must extend the tight integration of engineering content

and hands-on project learning into additional courses. The fact that engineering courses have not previously been taught at Campbell University presents a clear opportunity to create new courses that employ these methods.

The first step was to determine whether all engineering courses to be offered by Campbell University should maintain the LWTL format, or whether a subset of courses after the first year should do so. The decision was made to select a subset of courses after the first year. Courses in the LWTL format can be resource intensive in development time, lab equipment, faculty training, and ongoing operations (preparing lab kits, replacing consumable supplies, etc.). Focusing available resources onto a smaller number of 'flagship' courses would ensure that high-quality hands-on learning experiences for all students would be achievable and sustainable over the long term. Second, it was seen as inefficient to allocate such resources into electives that might be pursued by limited numbers of students – focusing LWTL-like coursework in major required topic area would ensure that all engineering students regularly engaged in experiential learning. Finally, Campbell University faculty were concerned that students might be overwhelmed by a large number of simultaneous LWTL-like courses. It is common for students in LWTL courses to require after-hours lab access, to obtain their own additional project supplies, and to regularly work on teams for long periods of time. Students facing potentially up to six courses at the same time with six different project teams, all requiring regular meeting times could create intractable scheduling difficulties for students, especially non-traditional students with work or family obligations outside of the university, all of whom Campbell University wishes to serve.

Therefore, after the two first-year LWTL courses, the Campbell University engineering faculty selected six additional courses, mandatory for all students in all concentrations, to serve as the flagship experiential learning spine of the overall curriculum. Students pursuing coursework according to the recommended course schedule will have exactly one LWTL or LWTL-like course in most semesters. The additional courses selected are Materials Science & Processing, Statics & Mechanics, Circuits, Fluid Mechanics, and Senior Design 1 and 2. Campbell University faculty are currently preparing course curricula for Materials Science & Processing, Statics & Mechanics, and Circuits, all of which will be offered in coming year. Not all faculty who will design and offer these courses attended the training at Louisiana Tech, but newly hired faculty are sitting in on ongoing LWTL courses at Campbell University, gaining a feel for the kind of projects required and the kind of preparation that students have leaving the first year of study. While specific projects for the second and third year classes have not yet been finalized, initial ideas for LWTL style projects integrating content and hands-on activities have been very promising. The new LWTL-style courses and projects will be reported on in future works.

It should be noted that courses not selected as 'flagships' are not intended to be generic lecture-based classes; active learning, team-based projects, and some quantity of experimental work will still appear in them. However, these courses have lower priority for resource allocation beyond core equipment needs and are expected to place less pressure on student schedules for laboratory or in-person team exercises outside of the classroom for the reasons previously mentioned.

Initial Takeaways

The most notable takeaway from the first year of adapting Louisiana Tech University's LWTL materials for Campbell University is that tightly integrated content presents significant challenges when attempting to change the order and assessment of material. The very virtues of tightly connected content and laboratory experiences that build on each other in subsequent classes drives the difficulty of retaining the excellence in pedagogical design while altering the underlying structure. Campbell University has reworked some LWTL materials for the semester schedule, but more work remains to be done and it is anticipated to take several years to reach the level of tight integration and course maturity of the LWTL courses at Louisiana Tech University.

Additionally, it struck Campbell University faculty implementing LWTL coursework that, while capital- and space-intensive laboratory equipment was imperative for specific elements of the curriculum, other portions of the coursework would be doable with a minimum investment in equipment. For example, the circuits and robots project is primarily done with student-owned equipment and a student-purchased robotics kit, the total price for which is comparable to a single textbook. The supplies for this project enabled a wide range of hands-on learning activities in circuits, programming, and robotics. While Campbell University is fortunate to have the resources and facilities to dedicate to extensive experiential learning, institutions or courses interested in integrating hands-on learning and experimentation to classes may well be able to find smaller-scale projects that still contain considerable depth and complexity.

Finally, in setting up projects requiring dozens of different components, flexibility in planning and ordering was very important. Despite having spreadsheets of components from Louisiana Tech University and the required supplies ordered well ahead of time, some errors in purchasing and packaging, breakage, and other unexpected occurrences necessitated several swift interventions to keep the courses moving. For instance, an exercise in measuring current resulted in a large number of blown multimeter fuses, requiring replacements before following sections were able to continue the laboratory work. It also proved necessary to stock replacement parts for virtually all lab equipment and student project parts as inventive students found unexpected ways to compromise some items (such as accidentally removing the feet from c-clamps with vices) and other lab equipment proved unsuitable (such as lightweight aluminum speed squares that quickly bent under rough use). These lessons will be taken to heart as additional experiential learning courses are developed at Campbell University.

Conclusion and Next Steps

After a semester of implementation, with three additional years of coursework yet to be developed and deployed, Campbell University engineering faculty have been impressed by both the challenges and opportunities in implementing experiential learning in engineering classrooms using the LWTL curriculum. Tightly integrating theory and practice has been very popular with students and faculty, and along with the project work appears to have promoted startlingly quick growth in both student ability and maturity. Difficulties in adapting a curriculum and dealing with complex laboratory and project supply needs were experienced in the first year, but plans are in place to rectify these issues in future offerings of the course. The faculty of Campbell University look forward to continuing to design and implement LWTL-style courses later in the engineering curriculum, and anticipate reporting on those in future works.

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