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Providing Authentic Experiences in the First Year: Designing Educational Software in Support of Service Learning Activities

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Introduction

Educators have often sought to incorporate experiential learning into the curriculum through the use of authentic, reality-based projects. One mode that has been successfully employed is service learning, where classroom instruction is combined with community service. However, the first-year student might possess only some of the skills needed to effectively contribute to a particular service learning experience. Is it possible to leverage those skills that a group of first-year students do possess so that they can, in some meaningful but perhaps indirect way, participate in the service learning experience and thereby reap at least some of the educational benefits normally attained through such authentic experiences?

The hypothesis being reported on in this paper is that, by using an external group directly involved with a service learning project as their client, first-year programming students can gain some of the benefits associated with service learning, even though they are only playing an ancillary role in the service effort and do not travel to the site of the project. This study was conducted during the 2013-2014 school year in the context of two courses offered at Ohio Northern University. Participants of the study included first-year programming students enrolled in a second semester introductory programming course and engineering education students enrolled in an upper-level elective course involved with developing lesson plans for teacher workshops being conducted in the Dominican Republic by members of the university's Northern Engineers Without Boundaries student organization. The following sections of this paper will first examine the relevant background concerning prior research, explain the framework for the study, review the prior work undertaken at Ohio Northern University, and provide details of the assignment featuring an in-depth example of student work. This paper then describes the assessment methodologies employed, provides an analysis of the collected data, and presents a synopsis of future research efforts. Finally, conclusions and takeaways are provided for those interested in using the results of this research to improve the educational experience for their first-year students.

Background

There are two primary areas of interest that provide relevant background to the research reported here: the educational philosophy behind experiential learning and the concept of authentic learning experiences with its extensions into the areas of problem-based and service learning.

Educational Philosophy of Experiential Learning

In his seminal work, Kolb draws upon the work of Dewey, Lewin, and Piaget to discuss the characteristics associated with the process of experiential learning; key among these characteristics, given the context of the research presented in this paper, are the propositions that "learning is a continuous process grounded in experience," and that "learning involves transactions between the person and the environment."[1] Experiential learning places an emphasis on the emergent process where thoughts and ideas are not fixed but are formed and reformed through experiences instead of specific outcomes, which Kolb contends only represent historical record. Learning does not occur upon a blank slate within a learner's mind; accordingly, an educator's job is not only to implant either new or more refined ideas, but also to dispose of or modify old ideas that are crude, incorrect, or irrelevant. A classic example occurs in mathematics with the concept of square roots. First introduced in primary education, the square root is described as the reciprocal operation to squaring a whole, positive number. Next, students are told that the operation can be used with any positive value, but with the admonishment that one cannot take the square root of a negative number. Eventually, the concept is refined with the admission that imaginary and complex numbers exist, with their basis being the value obtained from taking the square root of -1.

With respect to the transactions of learning, traditional approaches adopt a person-centered view where learning is an internal process requiring only books, teacher, and classroom. However, experiential learning embraces the transaction between the person and the external, real-world environment where personal characteristics, environmental influences, and behavior are all interlocking factors of a relationship between objective conditions and subjective experiences. It is Kolb's contention that such transactions – where knowledge is created through the transformation of experience – constitute the process of learning. Kolb then postulated an experiential learning model based on a four-stage cycle shown in Figure 1 that, while it can be entered into at any stage, is explained as follows.

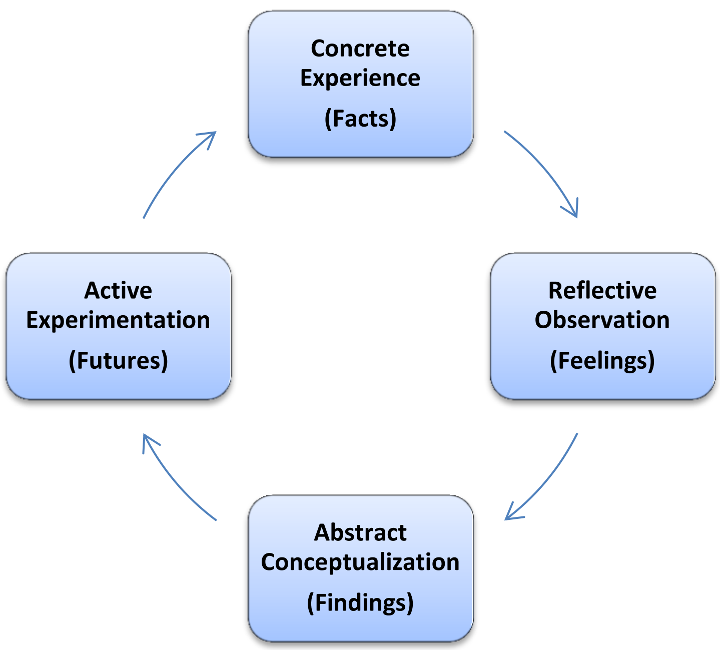

FIGURE 1. KOLB'S CYCLE OF EXPERIENTIAL LEARNING.

First, in the *concrete experience* stage, one must be able to get involved fully and openly – but without bias – in new experiences. Ideally, the experience is hands-on and involves an authentic situation where the new ideas and/or skills are applied and the results are assessed. Next, the *reflective observation* stage involves the ability to reflect on and observe these experiences from multiple perspectives. This reflection can occur through various mechanisms such as self-evaluation, peer discussion, and instructor feedback. The *abstract conceptualization* stage follows, where the student needs to be able to create concepts that integrate their observations into logically sound theories based upon the synthesis of experiential perceptions and reflections. Finally, the *active experimentation* stage involves the use of these theories to make decisions and to solve problems. Through this stage in the cycle, new ideas are tested and new skills are developed that can then be applied to new concrete experiences, thereby repeating the cycle anew.[2] Superimposed on Figure 1 are the corresponding key words from Greenaway's Active Reviewing Cycle, a model which provides a different way to examine experiential learning.[3] In this model, experiences generate *facts* – the things that happened from engaging in a sequence of events. Reflections generate *feelings*, an assessment of the experience from various modes of input. Conceptualizations generate *findings*, answering the "why did that happen" question and thereby adding to one's learning through interpretations, meanings, and judgments. Lastly, experimentations generate *futures*, where one can now plan, predict, or imagine new possibilities.

In 1987, Svinicki and Dixon proposed that certain classroom activities support the different phases of Kolb's Cycle and that, by constructing activities that lead students through a complete cycle, learning can be enhanced.[4] Table 1 presents lists of example instructional activities that Svinicki and Dixon believed may have the potential to support different aspects of the learning cycle.

TABLE 1
INSTRUCTIONAL ACTIVITIES SUPPORTING KOLB'S CYCLE.

Concrete Experience	**Reflective Observation**	**Abstract Conceptualization**	**Active Experimentation**
Examples Field work Laboratories Observations Primary text readings Problem sets Readings Simulations	Brainstorming Discussion Journals Logs Peer review Rhetorical questions Thought questions	Analogies Lecture Model building Papers Projects	Case study Field work Homework Laboratory Projects Simulations

To produce an entire cycle of experiences, an instructor can select an activity from each category and sequence the activities in order. It should be noted that some activities can fit into multiple categories, depending upon the intent. For example, if a laboratory activity precedes instruction on that activity, then the intent might be exploratory for the purpose of providing an initial experience to build upon. However, if the laboratory follows the instruction, then the intent might be one of active experimentation, where the student applies what was learned.

Authentic Learning Experiences

Authentic learning is a methodology where learning is achieved through applying knowledge in real world contexts and situations. In performing a qualitative content analysis of 45 relevant journal articles from different disciplines, Rule identified four overarching themes that can describe authentic learning.[5] First, authentic learning involves problems rooted in the real world. The use of a real problem carries with it the possibility of a solution having an impact on people outside of the course, thereby enabling students to become engaged as stakeholders in the problem being addressed. Second, authentic learning occurs through the application of higher-level inquiry and thinking skills. From the context of the Revised Bloom's Taxonomy,[6] while authentic learning will involve all six levels of the cognitive processes dimension – remember, understand, apply, analyze, evaluate, and create – there is a clear emphasis on the ability to create through generating, planning, and producing a solution. Additionally, the first three of the four Revised Bloom's knowledge dimension levels – factual, conceptual, and procedural – are applied when working on solving a real world problem; if a reflective component is incorporated into the assignment, then the abstract metacognition level can also be engaged. Third, authentic learning occurs through working within a community of learners. In one of his *Meditations,* the English poet and cleric John Donne wrote that "[n]o man is an island, entire of itself; every man is a piece of the continent, a part of the main."[7] The essence of this is that one cannot learn about the real world implications of solutions if one maintains an isolation from that world. To that end, an authentic experience needs to involve students through such facets as establishing a collaborative teamwork experience within a group of fellow learners, interacting with partners and clients, engaging in social discourse, and embracing cultural diversity. Finally, authentic learning occurs when students are empowered. Such empowerment can occur when tasks have a degree of open-endedness to them, thereby providing choices to the students that allow them to define portions of the problem and the subsequent solution.

Extensions into Problem-Based and Service Learning

One form of authentic experiential learning that has been used is that of problem-based learning (PBL). PBL was developed in the 1970s as part of a new learning curricula developed by medical educators at McMasters University in Canada, and was subsequently adopted outside the medical field during the 1990s.[8] The rationale behind PBL is based on the assumption that learning from the many problems one faces every day is a condition of human existence. Therefore, problem-based learning is the learning that results from the process of working toward the understanding or resolution of a problem.[9] As an instructional methodology, there are several characteristics that are indicative of PBL. PBL is an approach where the problem is the starting point of the learning process, with the problems ideally based on real world situations. PBL involves participant-directed learning processes, where emphasis is placed on the formulation of questions derived from the students' own experiences and interests instead of the answers, thereby promoting student motivation and comprehension. Opportunities for deeper learning experiences occur through activities involving research, decision making, and writing. As solutions can easily extend beyond the boundaries of a particular subject, a high potential exists for interdisciplinary learning to occur as part of a PBL exercise. The use of PBL often occurs within a group-based learning context, which allows for interpersonal communication and group dynamic competencies to be developed.[10]

Service learning has also been deemed a form of experiential learning. Bringle and Hatcher describe this pedagogy as a method of bringing more authentic experiences into the classroom.[11] The portrayals of students engaged in service learning are typically those of working within the immediate community or as part of a mission trip to a foreign country, but this approach blurs the distinctions between community-based learning and service learning. In an attempt to provide clarity, Weigert offers six elements to describe service learning: (1) the student provides meaningful service, (2) the service that students provide meets a need or goal of some kind,

(3) members of a community define the need, (4) the service provided by the students flows from course objectives, (5) service is integrated into the course by means of an assignment (or assignments) that requires some form of reflection on the service in light of course objectives, and (6) assignments rooted in the service must be assessed and evaluated accordingly.[12] One successfully implemented approach to service learning that fits this definition is an effort called Engineering Projects in Community Service (EPICS).[13] An EPICS project is ideally split into five distinct phases which begins with establishing a relationship with a community partner, who will define the needs to be met and will receive whatever services the students provide. Next, a team must be assembled where the credentials of the members, such as their engineering discipline, is entirely dependent upon the needs of the client. The final three phases involve proposing the project, developing the project, and then supporting the project after it is delivered. Despite what the name may imply, "community partners" do not necessarily need to be within some fixed, limited distance from the participating institution, as various opportunities exist that can extend the community partnership into a more international role.

Examples of Service and Problem-Based Learning within Computing Curricula

While there are many examples of service learning being incorporated into higher education curricula, most occurrences in the computing disciplines are found as part of a senior-level capstone offering; few are housed in either the first year or as part of an introductory curriculum.[14, 15] An introductory programming course offered at Siena College in 2009 used the Alice programming language to develop entertaining and accessible animations for Music Mobile, a community service organization whose mission is "bringing learning and love to the neighborhoods of Albany, New York."[16] Franklin & Marshall College provided introductory programming students an opportunity to replace their final project with 20 hours' worth of service teaching basic computer skills to prison inmates.[17] Hamilton College has used a web design course to provide an accessibility and general usability audit of the websites of local non-profit groups.[18] Finally, and of particular note to the research presented within this paper, Widener University incorporated a service learning option in their Introduction to Computer Science 2 course where students formed teams and used a "learning by teaching" model. In this approach, a topic was selected from a list of options, researched, and then presented to middle school-aged children in the after-school program at a local middle school.[19] This project required the students to visit the school three times; for each visit both a lesson plan and related journal documentation that included an activity description, list of handouts, and a post-visit reflective component needed to be written.

More common in the computing disciplines is to find problem-based learning being incorporated into the first year or introductory curriculum. Iowa State University developed an educational model where the progression of introduction, illustration, instruction, investigation, and implementation is used in a sophomore-level introductory microcontrollers course. The purpose of this choice of model is to nurture a learning environment emphasizing creative thinking and problem solving for a laboratory project by combining a required system integration part with an optional system innovation part.[20] The concept of learning spaces, where students are members of a learning community grounded in mutual respect and their experience is taken seriously, is often an integral part of a successful PBL experience.[21] Utah Valley University created such an environment with their introductory programming course through a variety of techniques.[22] For example, students were shown respect by the instructor who graded assignments as soon as they were submitted through their online course management system. Additionally, the instructor provided meaningful feedback by mentioning the student by name, giving praise or encouragement, and making suggestions to help the student enhance their programming skills. Another successful practice was to allow students to reflect upon errors noted by the instructor, make the appropriate corrections, and then resubmit the assignment.

An important characteristic to be considered when incorporating experiential learning into a course, especially at the introductory level, is to make the assignments meaningful. Research reported on by Layman, Williams, and Slaten indicated that students were looking for careers with meaning, ones that can benefit individuals or help society.[23] Unfortunately, their examination of approximately 200 assignments made within first year computer science courses at leading computer science programs showed that only 34% of the assignments had a practical or socially-relevant context, whereas 15% were games and 41% had no context at all. Students in an introductory course are particularly impressionable: by paying attention only to the learning objective and not considering students' interest in relevancy, assignments such as a pie-throwing simulation game or finding a set of prime numbers might have the negative side effect of encouraging students to look elsewhere for a nobler career. However, the use of games as a contextual framework should not be necessarily dismissed out of hand. Games have been used to engage the beginning student who is learning how to program, as games often provide a known frame of reference and can provide meaningful feedback just through its play.[24] It is the authors' contention that such game-based assignments can be made more meaningful by having students develop such applications as an experiential learning experience for others, preferably with client-based guidance and oversight.

Framework of Study

The framework of this study involves three groups of students at Ohio Northern University. The first group was composed of members of Northern Engineers Without Boundaries, a student organization that plans, designs, aids, and implements projects related to engineering disciplines in developing and underserved populations. Among the activities of this group has been organizing annual service trips to the Dominican Republic. The second group consisted of students who were enrolled in the Engineering Projects in Community Service course offered in Fall 2013. Finally, the third group was the 22 students enrolled in the Spring 2014 offering of Programming 2, the second semester introductory programming course that is primarily taken by first-year computer engineering and computer science students. It should be noted that, while each of these groups have their own set of either course or service outcomes, the focus of this paper is on the experiences of, and outcomes concerning, the first-year programming students.

The Programming 2 course at Ohio Northern University builds upon the foundational elements of sequence, selection, and iteration that are taught in the Programming 1 course. This course examines the concept of object-oriented programming in considerable detail, and introduces students to the graphical user interface and event-driven programming paradigms. The structure of the course includes both three one-hour lectures and one three-hour laboratory each week. The course includes a series of design-oriented programming assignments culminating with a team-based term project; it is with this term project that the research reported on herein is related.

Prior Work at Institution

Northern Engineers Without Boundaries

The Northern Engineers Without Boundaries student organization was established in 2011 to plan, design, aid, and implement projects related to engineering disciplines in developing and underserved populations. All of the trips to the Dominican Republic referred to in this paper were planned and organized by this group. As part of their service learning activities, student members write proposals for small projects that can feasibly be completed within the duration of a week-long trip. The students also developed proposals for larger projects that are intended to be completed over the course of multiple visits. Due to the limited amount of time spent on-site, the majority of the proposals are either low impact or only serve the guesthouse where the students reside while in the Dominican Republic. For instance, in preparation for Tropical Storm Emily, an impromptu project developed on-site involved creating a cover for a storm drain to prevent localized flooding from occurring. In the summer of 2011, the students participating on the trip also had the opportunity to implement selected poverty alleviation devices that were developed as part of a culminating first-year engineering design project.[25]

Engineering Projects in Community Service

Multiple sections of the Engineering Projects in Community Service (EPICS) course are offered during both the fall and spring semester, where each section works on a different service project. This elective course enables students to engage in problem-based learning by participating in an engineering design project in conjunction with a community partner. One section of this course called for engineering students to travel to the Dominican Republic to run teacher workshops in public and private schools which involve inexpensive, hands-on engineering projects that are tied to educational standards.[26, 27, 28] This effort, initially developed outside of the EPICS course, is a variant of the IEEE Teacher In-Service Program, which is intended to have trained engineers holding the same teacher in-service workshops using lesson plans that are available from the tryengineering.org web site.[29] However, due to the scarcity of professional engineers in the Dominican Republic, the step of finding a practicing engineer was skipped in favor of using students from the EPICS course, under the supervision of an engineering professor, to fulfill that particular role. While the trips to the Dominican Republic were primarily organized by Northern Engineers Without Boundaries, the content of the workshops was developed by the EPICS students, although it should be noted that there is some overlap in the membership between these two groups. Discussion of more sustainable alternatives or additions to the workshops that would provide year-round continuing education occurred during the Fall 2013 offering of the course, which leaned toward the implementation of computer-based distance learning modules.

Programming 2

The Programming 2 course has for many years examined the concepts of graphical user interfaces and event handling through the writing of games that are approachable for the first-year programmer, with such applications often involving the use of card or dice images.[30] In order to provide more authentic experiences, in Spring 2011 a term project was adopted where student teams had to pitch, design, and develop an educational game based on the State of Ohio Academic Content Standards that were then in place. The students were provided with the relevant educational terminology defining *standards* (the overarching goals and theme that all students should know and be able to do), *benchmarks* (key checkpoints that monitor student progress toward meeting the specified standards), and *indicators* (checkpoints that monitor progress toward the benchmarks and are used to define what all students should know and be able to do at each grade level). Each team was assigned both a grade level and an academic content area to work with, and provided with links to the appropriate areas of the State of Ohio Model Curriculum. In subsequent offerings of the course, the Common Core standards were used with the term project, with the following changes in terminology: *strands* are the major areas or disciplines of study within each content area, *topics* constitute the main focus of the content within each strand, and *standard statements* describe what students should know and be able to do at each grade level. Each team was expected to deliver a Problem Identification Statement that presented both the problem being addressed through its classification via the relevant terminology, a set of proposed applications that could be developed, and a recommendation as to which one of the proposals should be implemented. Based on the feedback and approval of the instructor, the team would then implement a Java-based software application and submit a written report providing a description of what the application was about and how it specifically addressed the standard statement for the chosen strand and topic area.

While on the surface the term project was an improvement upon the previous model of writing a graphically-oriented computer game of the Space Invaders genre as a culminating experience, key elements were missing from the assignment that prevented it from being an actual endeavor into authentic experiential learning for the students. From the perspective of Kolb's Experiential Learning Cycle, one can question the degree to which the assignment contained a concrete experience grounded in an authentic situation in that, while there existed an aura of authenticity through the use of educational standards, the project lacked a client, such as a teacher who would use the resultant application in the classroom. The give-and-take nature of working with an actual client would have allowed students to directly engage in an authentic situation. Furthermore, no reflective element was provided in the assignment, thereby preventing the students from developing new ideas or modifying existing concepts.

An additional criticism of this assignment can be made in terms of how one can conduct experiential learning through the use of teams. In a 2005 paper, Adams, Kayes, and Kolb describe six functional aspects that they contend are essential elements necessary for the social system involved with team learning: a shared purpose that provides direction, the assignment of roles or of a basic division of labor, a context that establishes the external constraints faced by the system, a well-established process for achieving the system's purpose, the (hopefully diverse) composition of the group, and actions to achieve the purpose, involve members, response to context, and modify the team's process.[31] While there was shared purpose, neither roles nor processes were established amongst the Programming 2 students, nor was team composition considered, and only minimal actions involving the team were implemented. Additionally, while there was context, the constraints imposed were more internal than external, in that the instructor was providing these specifications instead of an external client. It was clear upon the instructor's reflection that, in order to achieve an authentic experiential learning experience, the various aforementioned shortcomings needed to be addressed through both revision and collaboration.

The Assignment

The revised assignment, first used in the Spring 2014 offering of Programming 2, was developed due to the timely and fortuitous combination of two factors. First, it was realized by members of the Northern Engineers Without Boundaries group that the technological resources at one of the Dominican schools that they were planning to visit in May 2014 could be harnessed to enable Dominican teachers to access web-based software applications to supplement the materials presented in their STEM workshops. Unfortunately, while the service organization had a clear purpose, they lacked the ability to write such applications as part of the STEM-oriented lesson plans developed in the EPICS course. At the same time, the instructor for the Programming 2 course was searching for potential clients to provide an authentic learning experience for his students. Consequently, a partnership was formed where the Programming 2 course would develop web-accessible software applications in support of the lesson plans developed by the EPICS students that would then be delivered by members of Northern Engineers Without Boundaries. The time allotted for this programming assignment spanned a four-week period and contained the following deliverables:

- a web-distributed Java-based software application that supports a lesson plan,
- a website from which the application can be downloaded,
- a short video advertising the features and benefits of the application,
- an oral presentation that both describes and demonstrates the application while also answering the question, “why should this application be adopted for use in the Dominican?”, and
- a written report explaining what the application is about, how it fits in with the associated lesson plan, and how the selected method of content delivery adheres to the project goals.

As part of the introduction to this assignment, the Programming 2 students were informed that, if their design meets the criteria specified by their client, then their application would be incorporated into the corresponding lesson plan, which would then be used as part of a service learning opportunity by members of Northern Engineers Without Boundaries during their annual trip to the Dominican Republic. Through this simple premise, the Programming 2 student teams were presented with an authentic learning experience by working on developing elements of lesson plans for their EPICS clients that incorporate problem-based learning activities for the specified target audience.

The first task following the announcement of the assignment was team formulation. This could not be performed on a random basis due to two key reasons: the need to design a web site, for which only the computer science majors in the Programming 2 course had prior experience, and the need for the software application to effectively communicate with the teachers in the Dominican, whose native language is Spanish. Accordingly, the organization of the 22 Programming 2 students into six teams was conducted in class by first polling the students as to their level of knowledge of the Spanish language, being self-rated as either “non-existent,” “some,” “a lot,” or “fluent.” The result was that, while no students reported being fluent in Spanish, over half of the class had at least studied Spanish while attending high school, with nine students reporting having retained “some” knowledge of the language and three students indicating having a greater level of knowledge. The latter three students were used to form the nucleus of three of the teams; the remaining nine students were distributed such that each team had two members who had at least some knowledge of Spanish. Next, the nine computer science majors in the class were distributed such that each team had at least one member who was experienced, via previous coursework, in the development of a web site. Finally, the remaining students were assigned primarily to achieve a balanced team size. Through this process, a partial division of labor was established, as a subset of each team would be responsible for the use of Spanish in the application, and another subset would be responsible for web site development.

Once organized, the teams were presented with the eight lesson plans developed by the students in the EPICS course; the subject areas were assembly lines, basic circuits, brainstorming, bridges, buoyancy, the engineering design process, rockets, and water filtration. To avoid having multiple teams working on the same topic, a bidding process was used where each team indicated their first, second, and third choice of topics. This required each team to come together, reflect upon all provided lesson plans, and then evaluate both their interest in the subjects and their perceived capability to deliver an application relevant to a particular lesson plan. Once all lesson plans were reviewed, each team could rank their collective interest accordingly. The instructor then examined each team's ranked selections and was able to give four teams their top choice, and the remaining two teams their second choice.

After the lesson plans were assigned, a one paragraph proposal from each team describing the specifics of the application to be developed was required; the Programming 2 students were strongly encouraged to talk with students from the EPICS course for advice on developing their proposal. While not required, teams were encouraged to use a game-oriented theme for their applications. These proposals were evaluated by four of the students from the EPICS course using a double blind reviewing process, using the rubric shown in Figure 2.

Benchmark	Below Average (-20)	Target (-5)	Above Average (-0)
Learning Objectives	The proposal does not address any learning objectives outlined in the lesson plan.	The proposal addresses one learning outcome outlined in the lesson plan.	The proposal addresses more than one outcome outlined in the lesson plan.
Audience	The audience of the application does not place teachers as a priority.	The audience of the application is clearly teachers.	The audience of the application is teachers with the flexibility of allowing student users.
Concept	The proposed concept is undeveloped.	The proposal outlines a passable concept with appropriate detail.	The proposed concept is well developed and outlines appropriate detail.

FIGURE 2. INITIAL PROPOSAL RUBRIC.

Each team started with a score of 100; any benchmark found not to be above average was penalized as appropriate. The scores were then averaged, with a minimum score of 90 being needed for the proposal to be accepted without modification, while receiving a score of 60 or less constituted failure. Teams with scores between 60 and 90 were required to address the qualitative comments made by the reviewers and the concerns expressed by the student liaison from the EPICS course in his role as a meta-reviewer. The revised proposals would then be reviewed and scored again with the rubric before an approval for application development would be given.

While all six proposals were accepted, only one was done so unconditionally. All teams were required to reflect upon the provided feedback and, for those with conditional acceptances, submit a revised proposal. Once evaluator feedback was received on the revised proposals, approval was given for those teams to begin the development of their applications.

The revised assignment more than adequately addresses the six functional aspects of team learning as identified by Adams, Kayes, and Kolb. First, by establishing a client-oriented experience for the team, the concepts of shared purpose and direction are reinforced since there are now project stakeholders beyond the instructor whose needs are to be satisfied. Through the requirements of creating a web site for distribution of the resultant software application and designing the application for use in the Spanish-speaking Dominican Republic, some of the team's roles were, of necessity, established at the time of team formation. These needs also led to the establishment of a skills-based diversity in the composition of each team. The process of developing the deliverables was significantly improved, providing clarity through the specification of additional mileposts and incorporating multiple rounds of feedback to assist the team in their efforts. Finally, the context of the project shifted radically, from satisfying the manufactured needs of an instructor to satisfying the legitimate needs of an external client. However, these clients were more approachable than most, as while they were external to the course, they all were fellow students at the institution, thereby providing some degree of peer-based instruction as well. The communicative requirements of the project between team and client promoted greater team involvement, forcing students to respond to feedback and modify their processes accordingly.

Example of Student Work: Water Filtration Module

As a wider set of examples of student work has been previously published as part of a work-in-progress report,[32] an in-depth examination of one "middle of the road" submission, water filtration, is herein presented in order to both illustrate what the Programming 2 students accomplished and how this assignment relates to the Kolb Experiential Learning Cycle previously discussed in this paper. A copy of the water filtration lesson plan discussed in this section is provided in Appendix A.

The purpose of this module is to introduce the attendees of the teacher workshop to the basics of water filtration which, as proposed, would include an example of engineering applied in an environmental science setting through the modeling of a water filter. While all lesson plans were required to provide a description of a possible application, it was the programming team's choice as to how to convey at least some portion of the subject matter. As one of the learning objectives for this lesson plan was for participants to apply the engineering design process to construct a model water filter, the Programming 2 team assigned to the water filtration lesson plan submitted the following proposal:

> "For the interactivity design, we propose to utilize mouse events, similar to the 'magnetic poetry' demo. The user will drag and drop 5 different filtration items into the system. Once it is set, the user will hit 'launch,' and the program will calculate the water's purity based on the order and filtration items used. There will be approximately 20 different filtration items available that will vary in success, and the user must distinguish which to use to create an optimal design. To identify the pore sizes, the user can hover over a specific filtration item to display the value. We

chose this method because it allows for much interactivity, and it requires the user to think about the choices they are making. The visual traits of this program will make it very user friendly."

At this point in the assignment, the students have already completed one experiential learning cycle. Given concrete experiences in the forms of an externally generated lesson plan and previous laboratory assignments, the team engaged in reflective observation by brainstorming possible implementations. Abstract conceptualization occurred through using analogies to previous experiences in developing a conceptual-level model of their software application. Finally, by writing a proposal to their EPICS client presenting what they planned to develop, the team engaged in active experimentation.

Two of the reviewers from the EPICS course accepted the proposal "as is" while the other two reviewers accepted it "with revisions." The reviews included the following comments:

"Excellent proposal. Be careful with making it too mathy. If you're going to include the size of the pores, perhaps add a word to describe the size (small ...*pequeño*) in addition to the descriptor. 20 choices of materials with 5 per design...is it possible to account for the 15504 ways to put one together (disregard this concern if that's not a problem)? You may not be dealing with math or science teachers, so some of the math may go over their heads. Make it nice and colorful, you'll be just fine."

"The various choices for filters is great because it allows some form of implementation of the engineering design process, however, twenty might be too many. Something that should be considered is whether the user will understand why there is a need for these filters in the module? Can a short tutorial be added in the beginning explaining why water filters are needed, what are the filters filtering out, and the benefits that come with the use of water filters?"

"Sounds very interactive. Should keep users interested. I would suggest a brief lesson about water purity as an introduction."

The student serving as the project liaison then provided the following meta-review comments as feedback to the group:

"Please address the following concerns when developing your application:

- Possibly scale down choice of materials (if it's an issue)
- Use appropriate Spanish
- Include brief lesson on water purity

Great work on your proposal!"

The Programming 2 team then engaged in another cycle of experiential learning, with the above feedback serving as the new concrete experience. The team then reflected upon the feedback, updated their software application model, and submitted a revised proposal. The team's revised proposal included the following additions:

"The math of ranking each filtration system will be behind the scenes. The results will be displayed in a simplified format for the user such as a letter grade for water purity."

"Before the program begins there will be a brief lecture of how water filters work and how they are made."

"On our website we will have a download link for English and Spanish."

The revised proposal was determined by the project liaison to have satisfactorily addressed all of the concerns raised during the initial review process. Approval was given to develop the application.

The team now experienced a third round of experiential learning. The various concrete experiences associated with the Programming 2 course – laboratories, readings, interactive examples, and problems sets regarding object-oriented Java programming – were used along with the experiences to date with the assignment as fundamental parts of the brainstorming of the code-level design for the software application. The use of the object-oriented programming paradigm strongly plays into the abstract conceptualization stage of the cycle, as this is where significant model building is performed through the development of classes and their associated methods and data members. Active experimentation occurs as the code is written and then entered into the Java project, first with the testing of the individual modules and then with the application as a whole as the effectiveness of the graphical user interface design is examined.

Figure 3 presents an image of the primary screen from the final version of the Java-based water filtration application.

FIGURE 3. PRIMARY SCREEN FROM WATER FILTRATION APPLICATION.

The application presents the user with the ability to experiment with a five-stage water filtration system that is fabricated from a set of 15 different filtration materials that are presented graphically in the five-by-three matrix underneath the *Materiales* header. The user must distinguish, primarily through discovery, which filtration materials to use and in what order for creating an optimal design. A water filtration system is constructed by dragging a selected material with the cursor to one of the five filtration stages (*Etapa*) provided underneath the *Niveles de Filtro* (filter levels) header. Each filtration material can be used more than once, and each material is associated with a pore size, which becomes the primary factor in evaluating the effectiveness of the water filter. By clicking on the *Presentar* (submit) button, the user is provided with a rating for the design. To address one of the issues raised in the initial review process, the *Ayudar* (help) button is used to launch a dialog window, shown in Figure 4, which presents information on what a water filter is via an illustration based on a typical classroom implementation of such a filter through use of a 2-liter plastic bottle.

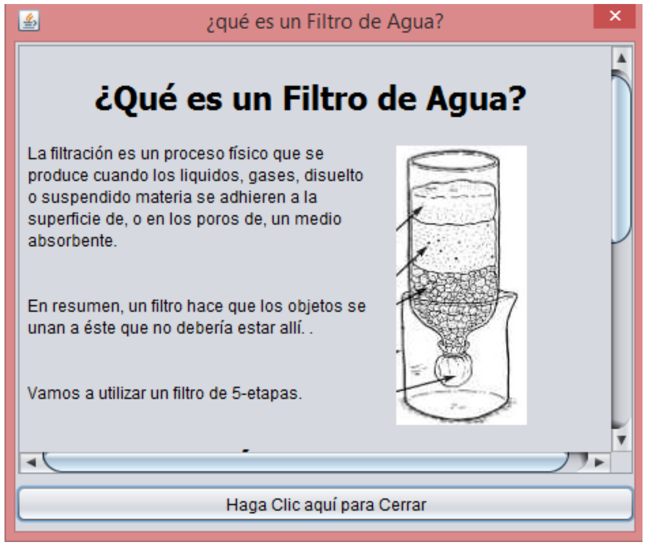

FIGURE 4. HELP DIALOG FROM WATER FILTRATION APPLICATION.

As part of the project deliverables, an oral presentation that included a demonstration of the application was given to members of both the Programming 2 and EPICS courses. During the question and answer session that followed, a concern was raised over the accuracy of the filter rating algorithm. The group was advised to consult with a member of the Civil Engineering Department to ensure that their water filter simulation accurately conveyed the properties and interactions of the filtration materials. The resultant input was incorporated into the final version of the application, which is available for download via that project's web site, as shown in Figure 5.[33] After reviewing the final version of the application, the application was approved by the EPICS students for use with the water filtration lesson plan in the Dominican Republic.

FIGURE 5. WATER FILTRATION APPLICATION WEB SITE.

Once all six applications and supporting web sites were submitted, one of the participating students from the EPICS course created a single point of contact web page for the distribution of the applications, which is shown in Figure 6. The URL for this page[34] was subsequently provided to the participants in the teacher workshops conducted by members of the Northern Engineers Without Boundaries group in the Dominican Republic in May 2014.

FIGURE 6. APPLICATION DISTRIBUTION WEB PAGE.

Assessment

The hypothesis for this research asserts that first-year programming students can gain some of the benefits associated with service learning by using an external group directly involved with a service learning project as a client. To test this hypothesis, the Community Service Attitude Scale (CSAS) survey, developed to measure college students' attitudes toward community service,[35] was selected as the primary assessment instrument. This instrument has been validated for reliability[35, 36, 37] and has also been used in engineering education contexts.[37, 38] The CSAS survey consists of 46 questions utilizing a 7-point Likert scale, where 1 represents "strongly disagree" or "extremely unlikely" and 7 represents "strongly agree" or "extremely likely." The survey assesses 10 aspects of student attitudes:

- *awareness* of community needs,
- perception of *actions* that can meet the need,
- perceiving one's own *ability* to help,
- one's sense of *connectedness* to one's own community that motivates helping,
- one's sense that personal or situational *norms* obligate one to help,
- one's sense of *empathy* for those in need,
- both the *costs* and the *benefits* to oneself of helping,
- beliefs about the *seriousness* of the consequences of not helping others, and
- one's *intentions* to engage in community service.[39]

For purposes of this research, the CSAS survey was administered twice to the Programming 2 students as a pre- and post-activity instrument. Some minor modifications were made to the instrument for its use with this assignment. First, as concerns were expressed regarding "survey burnout" in the first year curricula, the instrument was shortened by deleting two of the action-oriented questions regarding volunteer work at community agencies (CSAS survey questions 5 and 6). Also, the Programming 2 students were not yet aware of the nature of their term project when the pre-activity survey was administered, so CSAS question 32 was rephrased slightly from "I want to do this (service-learning) activity" to "I want to do a service-learning activity." An additional modification involved providing a broader definition of the word "community" in order for the CSAS survey instrument to better fit within the context of an international service project. Accordingly, the following paragraph was inserted as a preface to the survey questions:

> "For these questions, assume "community" and "community groups" may refer to populations outside of your local area or even outside of the United States, and "community projects" can refer to projects that can be done here but are intended to help outside of the local area or country, like development of classroom / curriculum materials."

The CSAS survey, with the modifications for this research annotated, is provided in Appendix B.

A third party electronically administered the survey to the 22 students who were actively enrolled in the Programming 2 course in order to provide anonymity to the students; hashed student ID numbers were used to pair the pre- and post-activity survey data. A paired *t*-test was applied to each question at a significance level of $\alpha = 0.05$. Unfortunately, due to some students not properly entering their ID number in either the pre-activity or the post-activity survey, only 16 pairings were available. The post-activity survey instrument also included seven qualitative questions related to the activity; these questions, based on a survey available from Towson University, [40] are provided in the next section.

Data Analysis

A review of the literature provided only one instance where paired *t*-tests were used with the CSAS survey prior to this research. In 2013, Downey reported on a study that was conducted in an introductory psychology course regarding student learning and personal outcomes via one of two projects, with both projects being used to teach the same basic research concepts.[39] Roughly one half of the students performed naturalistic observation on the behavior of community members, while the other half incorporated features of service learning through conducting a 60-minute interview with local veterans regarding a psychological concept. In her results, Downey reported that, regarding attitudes regarding community service, for both of the projects none of the paired *t*-tests of each of the 46 CSAS scales were statistically significant.

Table 2 presents a summary of reported student attitudes found in the literature, along with both the pre-activity and post-activity summaries from this research. In the first column, the numbers presented within parentheses indicate the specific questions aggregated, as presented in Appendix B, to form the summary of that particular attitude. For each study, the number of participants is reported. Due to space limitations, only the name of the first author is used to label each column. For Bielefeldt's paper, the numerical data was presented solely through a bar graph; the bars for first-year students were measured and then interpreted to within $1/40^{th}$ of a unit.

TABLE 2
PRE- AND POST-ACTIVITY CSAS STUDENT ATTITUDES PAIRED WITH THOSE REPORTED IN THE LITERATURE.

7-point Likert Scale 7 = "strongly agree"	Shiarella[35]	Bauer[36]	Bielefeldt[38]	Downey[39]	Pre-Activity	Post-Activity
***n* =**	332	78	17	77	22	22
Phase 1: Perceptions						
Awareness (1-4)	6.21	5.68	6.27	6.23	6.02	5.80
Actions (5-9)*	5.61	5.30	6.07	5.66	5.82	5.81
Ability (10-12)	5.42	5.27	5.95	5.26	5.63	5.59
Connectedness (13-18)	5.02	4.70	5.57	5.10	5.29	5.11
Phase 2: Moral Obligation						
Norms (19-23)	6.03	5.71	6.17	5.92	5.77	5.71
Empathy (24-26)	5.61	5.00	5.75	5.59	5.62	5.67
Phase 3: Reassessment						
Costs (35-40)	4.46	2.78	4.67	4.84	4.97	5.38
Benefits (41-46)	5.67	5.24	6.05	5.81	5.65	5.57
Seriousness (27-31)	4.82	4.47	5.15	4.79	5.01	5.19
Phase 4: Helping (32-34)	4.95	4.61	5.50	4.99	4.88	5.09

*Questions 5 and 6 were not used in the pre- and post-activity surveys

Overall, both the pre-activity and post-activity survey data compares favorably with that reported in the literature: there are no instances where this data is the lowest amongst those being reported, only one instance (with the Costs attitude) where both the pre- and post-activity data are higher, and only one instance (with the Seriousness attitude) where the post-activity datum is the highest. The most dramatic change is with the Costs attitude, showing a delta increase of 0.41. Most of this difference can be ascribed to a higher than anticipated course workload due to external influences causing the timeframe of the previous programming assignment to overlap with the first week of this assignment, which caused some stress for the Programming 2 students. There were two noticeable delta decreases, of 0.22 and 0.18 respectively, in the Perceptions phase attitude categories of Awareness and Connectedness. An examination of the individual paired data responses showed that, in cases involving differences, students were still indicating agreement with the various questions involved, but with less conviction. Of particular note is that there was a delta increase of 0.21 in the Helping attitude, which indicates that students overall were positively influenced by this assignment towards at least consideration of a greater involvement in community service.

Quantitative

From the 44 questions utilized from the CSAS survey, the results of the conducted paired *t*-tests provided five questions where the changes in student attitude were observed to be significant (at the $\alpha = 0.05$ level) and two additional questions where the changes were observed to be highly significant (at the $\alpha = 0.01$ level). Table 3 contains the data from all seven questions that exhibited a significant or highly significant statistical difference for the paired *t*-tests conducted with the pre- and post-activity survey instruments. To place these questions and *t*-test results into context, the actual questions, each followed with its analysis, appear following the table.

TABLE 3
NOTABLE RESULTS FROM PAIRED T-TESTS BY QUESTION.

		Confidence Interval				
Q #	T	**Upper 95%**	**Lower 95%**	**Prob**$(T \geq \|t\|)$	**Prob**$(T > t)$	**Prob**$(T < t)$
8	-3.149	-0.222	-1.153	0.007**	0.997	0.003**
24	-2.406	-0.050	-0.825	0.03*	0.9953	0.015*
27	-1.772	0.165	-1.790	0.097	0.952	0.048*
33	-2.179	-0.014	-1.236	0.045*	0.9771	0.022*
34	-2.111	0.006	-1.361	0.051	0.974	0.026*
36	-3.093	-0.350	-1.900	0.007**	0.996	0.004**
37	-2.144	-0.005	-1.620	0.049*	0.976	0.024*
Note: $N = 16$, df = 15				*$p \leq 0.05$ **$p \leq 0.01$		

Question 8: "Volunteering in community projects can greatly enhance the community's resources."

This question was one of the two questions where the differences between the pre-activity and post-activity responses were found to be highly significant. Examining the data, there was a noticeable post-activity shift toward strongly agree whereas the pre-activity survey collected responses that were either neutral or disagree. This change is encouraging, considering one of the objectives of this project was to introduce the concept of programming as a service to the community at large.

Question 24: "When I meet people who are having a difficult time, I wonder how I would feel if I were in their shoes."

This question had a shift from mixed responses in the pre-activity survey toward agree in the post-activity survey. This could be due to the students being exposed to a client-based project where the team's work does not only have to satisfy the requirements of the instructor but also a client's needs. With this focus, students had to be more attentive to comments from the reviewers for the team's project in order to be competitive. Furthermore, while students needed to address the concerns of the EPICS students, the end users also needed to be considered. Therefore, it is also possible that, through performing this assignment, the Programming 2 students were able to better imagine themselves in the situation of the community of people that their project was intended to assist.

Question 27: "Lack of participation in community service will cause severe damage to our society."

Similar to the previous question, there was another shift toward agree from the original mixed results. After the development of the educational applications, students could have realized the potential impact of their projects on their end user. Since students were not aware of the nature of the project at the time that the pre-activity survey was administered, it is likely that "severe damage to our society" was perceived to be too strong of a statement. In terms of educational outreach, an implicit notion of education being a counterbalance to poverty may have caused students to agree more with this statement.

Question 33: "I will participate in a community service project in the next year."

Examination of the data revealed that there was a shift toward agree from mixed results. The increased interest with involvement in community service is likely due to more students realizing that they can apply their programming skills for the greater good; this notion of programming for a cause is supported qualitatively as well.

Question 34: "I plan to seek out an opportunity to do community service in the next year."
Upon examining the responses, there was a slight increase toward agree. The interpretation of the results from this question is similar to question 33.

Question 36: "I would have forgone the opportunity to make money in a paid position."
This was the second question where the differences found between the pre- and post-activity responses were highly significant. While the pre-activity survey results were slightly negative, the post-activity survey responses were far more positive, with qualitative data supporting the shift. This shift can be explained through the comments made by multiple students that they believe it is more beneficial to them to be paid for their professional services rather than to offer such services free to the community.

Question 37: "I would have less energy."
Likely attributable to the time constraints associated with how this collaboration was run, students reported that they believed that they would have less energy in their post-activity survey responses than in the pre-activity survey. With the narrow window to develop the software application and coordinate meeting times, it is understandable why students would believe that they would have less energy to accomplish other activities.

<u>Qualitative</u>

As part of the post-activity survey instrument, seven open-ended questions were presented; the 22 students who completed this survey had the option of either answering or ignoring each question. The quotes presented within this section are taken from the student responses.

1. *How was this assignment similar to and different from your other programming assignments?*
   Students generally recognized that more was now at stake, in that "it wasn't just a grade" as the assignment "simulated the real world more than the other programming assignments."

2. *What were the challenges you faced in your service-learning experience? Did you overcome them or were they left unresolved?*
   The challenge most referred to was having to deal with a foreign language. Along these lines, one student insightfully commented that "the main challenge was making the app as intuitive as possible, and avoid relying upon text-based explanations." Additional challenges involved dealing with limited time constraints and working within a group environment for developing the application. Finally, a couple of students felt challenged as they have never traveled to the assigned country. In almost all cases, students indicated that the challenges they cited were overcome.

3. *What impact, if any, do you believe your service-learning activity had on the engineering education students you worked with?*

The students were split on this question, in that some believed that there was little to no impact whereas others stated that there was a positive impact, “but it's unclear how much.” The expectations of the client was brought up as an issue, as one student mentioned that the result for the clients was “coming to the realization that the time given to develop these applications and what they expected were not quite on par with each other.”

4. *Do you believe that this assignment is relevant for your future? How so?*
   Student responses were uniformly positive, albeit for different reasons. Some focused on the fact that this assignment was their first group programming experience. Other students related that in the future they would “be making applications that are for customers,” so they were appreciative of having a client-based assignment.

5. *Are you inclined to continue the sort of service you performed for this assignment, or some volunteer activity, in the future?*
   Nine respondents clearly indicated a positive response, and seven more indicated that they were possibly inclined to continue. On the other hand, five students indicated that they were disinclined.

6. *What was your outlook about service-learning before you started the assignment and what is it now?*
   Some students were either unaware or indifferent beforehand, but developed a positive outlook via the assignment as “now, it makes sense and seems pretty beneficial for those involved.” For those who indicated that their outlook had not changed, it was generally the case that they “always thought it was something very beneficial.” Others, while indicating they were personally not interested in participating firsthand in a service learning experience, saw value in being exposed to the concept through this assignment.

7. *How do you view your own ability to make a difference in your community and the world?*
   Students were generally positive in their responses, providing comments such as “I think that everyone has the potential to make a difference in their communities and in the world” whereas others stated that, while their individual contribution might not have much of an impact, “if enough people help it actually can make a difference.”

Future Directions

For the Spring 2015 offering of Programming 2, some changes are planned based on two observed shortcomings. First, while there was both an external client and a target audience, there was insufficient client-team interaction, partially due to schedule conflicts and partially due to the lesson plans having already been developed and finalized during the previous semester. Consequently, the participating students from the EPICS course operated with a set of unrealistic expectations concerning what could be accomplished via a software application written by first-year programming students while the Programming 2 students did not develop an appropriate level of understanding of either client or customer needs. To address this issue, the lesson plans will now be developed in a special topics course for engineering education majors that is designed to be offered concurrently with Programming 2 and scheduled to allow for direct communication between the two groups of students; this should allow for greater client-team interaction and also provide a feedback loop for the betterment of the client's lesson plan development. An additional benefit is that the special topics course will readily allow for the evaluation of the scalability of this approach; if successful, the goal is to incorporate this project into one of the required courses offered in the spring term of the junior year in the engineering education curriculum. To further assist with promoting a better understanding of needs, the Programming 2 course is being updated with introductory material derived from User Experience (UX) design concepts that focuses on discerning and meeting the needs of a project's stakeholders. Regarding the second shortcoming, this was the first group programming assignment given in the first-year programming curriculum; while the students did manage to combine their efforts, it was without the benefit of using modern collaborative version control software applications, which caused the students some difficulties. To address this issue, the Programming 2 students will be given team-based assignments and be provided with experiences using version control software prior to working with the engineering education students.

Conclusions and Takeaways

Through this research, first-year programming students were assigned a term project that presented an opportunity to serve others through the client-driven development and dissemination of a real world software application. This project provided the Programming 2 students with an authentic learning experience in support of the client's service learning activities in the Dominican Republic, from which there were several positive takeaways. The results from the paired *t*-tests of the pre- and post-activity CSAS surveys, as well as from the post-activity qualitative survey, indicated that the Programming 2 students benefited from this experience. In their written responses, students also viewed the assignment as beneficial with respect to both programming in a team environment and in working for an external client. An unexpected takeaway was the students' realization that communication with clients is an important factor in design. The lack of direct interaction with several of the lesson plan authors made it difficult for the team to fully understand what was expected of them, and the stakeholders involved either with the EPICS course or with Northern Engineers Without Boundaries had inflated expectations for the applications due to their insufficient interaction with their respective teams.

This research has also shown the value of the CSAS survey instrument as an assessment tool for measuring attitudinal changes associated with service learning experiences. To the best of the authors' knowledge, this is the first time that such results are being reported in the literature.

As an aside from the focus of this particular paper, which is how this research affected the first-year programming students, the evaluation of the effectiveness of the distributed software applications in the Dominican Republic has proven difficult. Surveys have been attempted with previous associated research efforts, but cultural differences rendered those results as fundamentally unusable for the purposes of receiving critical feedback.[26] The distributed software applications do serve the purpose for which they were designed and were warmly received when presented at the May 2014 educational workshops in the Dominican Republic by students from the EPICS course. However, conclusive evidence of success with the teachers cannot be provided due to the cultural constraints in play.

While this paper has referred to partnering with clients involved with service learning experiences in the Dominican Republic, such overseas opportunities are not required for interested educators to take away lessons from this research that can be applied to their own first-year curriculum. The concepts presented in this paper that can be applied to recreate this approach to authentic experiential learning can be distilled into the following four points:

1. *<u>Select Meaningful Projects</u>*

   Students are very astute at sniffing out busywork-type assignments, and treat such assignments with lessened respect. In contrast, students, especially those in the first year of their college education, appreciate having opportunities that help to reinforce their choice of major as being "the right one." By establishing thematic arcs within the context of a course or curriculum that illustrate how graduates of the program can make a difference through their professional work, instructors can readily provide such opportunities. Accordingly, selecting term projects that incorporate authentic experiential learning with real clients can serve as a culminating experience that further reinforces the student's viewpoint, which can consequently lead to higher student retention.

2. *<u>Utilize Available Resources</u>*

   When asked why he wanted to climb Mount Everest, George Mallory replied, "Because it's there."[41] This quip was not meant by Mallory to be flippant, nor is it now as mentioned in this context. Rather, it is meant to succinctly illustrate the following point: the simplest approach to authentic experiential learning is to utilize those activity-based resources that are readily available. Specifically, utilizing existing resources at one's institution is often the most sensible and straightforward method in order to bring multidisciplinary projects to fruition. It was for this reason that a partnership was created with the EPICS course to develop supplementary materials for use by the members of Northern Engineers Without Boundaries in the Dominican Republic. Essentially, all that is required is to find someone having one or more addressable needs that can be feasibly met through forming a partnership. In many cases, this can lead to a "win-win" situation for both parties, as some of their needs may contain components for which first-year students possess a sufficient skill set to develop an acceptable solution.

3. *<u>Find External Clients</u>*

   Try as one might, an instructor cannot independently construct a self-contained authentic experiential learning experience that will be accepted by the students; there needs to be an external, outside influence. Note that the definition of "external" is not with respect to the institution, but with respect to the course. For example, designing a graphical user interface for researchers in an attached medical college that uses gamification to improve the effectiveness of computer-based pulmonary testing (such as blowing through a tube at a steady rate to keep a rendered hot air balloon at a certain height, for the duration that it takes for the balloon to horizontally travel across the screen) would be perceived by the students as an external client, even if those researchers and the instructor are all being paid by the same institution.

4. *Employ Spiral Learning Structures*

Simply put, modifying the previous assignment such that it spiraled through multiple iterations of the Kolb Experiential Learning Cycle made a critical difference in both the successfulness and the quality of the submitted term projects. The four steps involved in the cycle – to experience, to reflect, to conceptualize, and to experiment – lead students to both form and reform their thoughts and ideas. By structuring assignments such that there are multiple iterations that build upon prior results, pertinent concepts are reinforced and the resultant deliverables are improved as a result.

In closing, the authors would like to present one final student comment from the qualitative portion of the post-activity survey instrument:

> "This project has made me think more about what kind of software I could make to better benefit the community and children. I have always wanted to make a difference with my programs and this has further confirmed that."

Through their client-oriented work on this project, the Programming 2 students attained clearly tangible benefits from their indirect participation in the associated service learning activity, thereby supporting the hypothesis for this research. Those interested in replicating this assignment at their institution are welcome to contact the authors for any assistance that can be rendered.

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Appendix A. Example of Dominican Modules Lesson Plan

Dominican Modules Lesson Plan

Topic: Water Filters and Water Purification

Subject: Engineering / Environmental Science

Duration: 30 minutes

Learning Objectives:

1) Teachers are informed of the risks of unpurified water (bacteria).
2) Teachers understand the workings of a water filter.
3) Participants comprehend the difference of materials and order of filtration's effect on water purity. (Amount of bacteria before versus amount of bacteria after)
4) Able to apply the engineering design process to build a model water filter.

Main Idea:

This module will introduce the teacher to the basics of water filtration. The lesson will provide an example of engineering applied in an environmental science / biology setting through the modeling of a water filter.

Content:

- What do we define to be clean water?
  - Even though the water may look clean, it doesn't necessarily mean that it is safe to drink.
- How do we get clean, or at least safer, water?
  - Water treatment! While commercialized water has gone through multiple stages of water treatment, a simple system can be built to remove a significant amount of impurities--a water filter.
- What is Filtration?
  - "Filtration is a physical process that occurs when liquids, gases, dissolved or suspended matter adhere to the surface of, or in the pores of, an absorbent medium" (CDC).
- How effective is it?
  - Filtration of contaminants depends on:
    - the amount of contaminant
    - size of the contaminant particle
    - the charge of the contaminant particles (CDC)
- Layered Water Filters
  - Having multiple staged water filers provides an method of removing debris and some pathogens from dirty water.
  - Start with a layer to catch the big objects, then scale down farther and farther to catch smaller objects and particles.
- What is the best design? Are there other materials that work?
- What will the outside of the water filter be? Plastic bottle? Tin can?

Interactivity:

- Teachers will be given different materials virtually and be asked to place them in a specific order to ensure the best filtration possible.
- Therefore, the teachers will be experimenting with different combinations.
- A few given materials could be cloth, fine and coarse gravel, sand, cotton, charcoal, cheesecloth, etc.
- Specify the size of the "pores" for each material.
  - The idea is to order the materials from large pores => small pores
- Supplemental videos are encouraged.

Assessment Method:

Guiding Questions:

- How effective are water filters? Can we go one step farther?
  - Boiling?
  - Chlorine treatment?
- How can the process of building a water filter be applied to your subject?
  - Filtering out bad ideas and reaching clarity, solution?
  - Writing process and editing?
  - Brainstorming?

Resources:

- Center for Disease Control on Water Purification Technologies
  - http://www.cdc.gov/healthywater/drinking/travel/household_water_treatment.html
- LifeStraw - water filtration on the go! How does it work?
  - http://science.howstuffworks.com/environmental/green-tech/remediation/lifestraw1.htm

Appendix B. Modified Community Service Attitude Scale (CSAS) Survey

Please indicate how much you agree with each statement with 1 being that you strongly disagree and 7 being that you strongly agree with the statement. Range: 1 = strongly disagree, 7 = strongly agree

1. Community groups need our help.
2. There are people in the community who need help.
3. There are needs in the community.
4. There are people who have needs which are not being met.
5. **[Deleted]** *Volunteer work at community agencies helps solve social problems.*
6. **[Deleted]** *Volunteers in community agencies make a difference, if only a small difference.*
7. College student volunteers can help improve the local community.
8. Volunteering in community projects can greatly enhance the community's resources.
9. The more people who help, the better things will get.
10. Contributing my skills will make the community a better place.
11. My contribution to the community will make a real difference.
12. I can make a difference in the community.
13. I am responsible for doing something about improving the community.
14. It is my responsibility to take some real measures to help others in need.
15. It is important to me to have a sense of contribution and helpfulness through participating in community service.
16. It is important to me to gain an increased sense of responsibility from participating in community service.
17. I feel an obligation to contribute to the community.
18. Other people deserve my help.
19. It is important to help people in general.
20. Improving communities is important to maintaining a quality society.
21. Our community needs good volunteers.
22. All communities need good volunteers.
23. It is important to provide a useful service to the community through community service.
24. When I meet people who are having a difficult time, I wonder how I would feel if I were in their shoes.
25. I feel bad that some community members are suffering from a lack of resources.
26. I feel bad about the disparity among community members.
27. Lack of participation in community service will cause severe damage to our society.
28. Without community service, today's disadvantaged citizens have no hope.
29. Community service is necessary to making our communities better.
30. It is critical that citizens become involved in helping their communities.
31. Community service is a crucial component of the solution to community problems.
32. **[Modified]** I want to do a service-learning activity.
33. I will participate in a community service project in the next year.
34. Would you seek out an opportunity to do community service in the next year.

Please indicate how participating in service-learning is likely to impact you with 1 being extremely unlikely and 7 being extremely likely to impact you. Range: 1 = extremely unlikely, 7 = extremely likely

35. I would have less time for my schoolwork.
36. I would have forgone the opportunity to make money in a paid position.
37. I would have less energy.
38. I would have less time to work.
39. I would have less free time.
40. I would have less time to spend with my family.
41. I would be contributing to the betterment of the community.
42. I would experience personal satisfaction knowing that I am helping others.
43. I would be meeting other people who enjoy community service.
44. I would be developing new skills.
45. I would make valuable contacts for my professional career.
46. I would gain valuable experience for my resume.