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Curiosity, Connection, Creating Value: Improving Service Learning by Applying the Entrepreneurial Mindset

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Introduction

Providing students with meaningful learning experiences can be challenging. One approach is to use authentic learning, where knowledge is applied in real world contexts. Through content analysis of relevant journal articles from different disciplines, Rule outlined four characteristics of authentic learning.[1] First, the problem at hand is rooted in the real world, and the solution to the problem has the potential to make a measurable impact on people outside the course. Second, learning is achieved through the application of higher-level inquiry and thinking skills. Third, authentic learning occurs through working within a community of learners. Fourth, students must be empowered in some way, which can be achieved by providing an open-ended assignment.

One successful approach towards implementing meaningful learning experiences involves engaging students in service learning activities, which Bringle and Hatcher described as a pedagogical method of bringing more authentic experiences into the classroom.[2] The portrayals of students engaged in service learning are typically those of a group of students either 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 offered the following six elements to describe service learning:[3]

- the student provides meaningful service,
- the service that students provide meets a need or goal of some kind,
- members of a community define the need,
- the service provided by the students flows from course objectives,
- service is integrated into the course by means of one or more assignments that requires some form of reflection on the service in light of course objectives, and
- assignments rooted in the service must be assessed and evaluated accordingly.

Prior Work

The first-year programming course sequence at Ohio Northern University, consisting of the courses Programming 1 and Programming 2, has used the theme of developing K-12 educational software as the subject of its culminating term project for many years. These applications were written in Java and utilized both an appropriate event driven programming paradigm and a graphical user interface. However, the applications were developed without the benefit of a client. Consequently, the instructor could only provide feedback on the technical aspects of the implementation; additionally, most of the feedback was summative. With the recent establishment of an engineering education program within the college, the opportunity arose for providing the first-year programming students (whom will now be referred to as "programmers" to help differentiate between the various student types referenced within this paper) with a meaningful client-driven design experience. In the 2013-2014 academic year, the authors tested the hypothesis that teams of first-year programmers can gain a subset of the benefits associated with service learning by establishing a client relationship with a group directly involved with a service learning project.[4-6] The purpose of the project was to develop an interactive software application that would complement a lesson plan written by engineering education majors participating with a campus organization that annually performed STEM teacher workshops in the Dominican Republic. The engineering education majors developed lesson plans as part of a fall semester course that were afterwards supplemented by software applications written by teams of first-year programmers in the spring semester.

A mixture of validated quantitative and qualitative methods taken from the community service literature (to be described in detail later in the Assessment section) was used to perform the assessment and validate the hypothesis. While the results were generally positive,[6] the investigators uncovered several shortcomings, which included insufficient client-team interaction, unrealistic expectations regarding project scope, and an inability to develop an appropriate level of understanding of either client or customer needs. To address these issues, a critical re-evaluation of the term project's target and structure was performed for the 2014-2015 academic year.

Revising the Term Project: Modifications

The course where the engineering education majors learn to develop lesson plans for STEM outreach activities was normally offered in the fall semester; consequently, the lesson plans used by the programmers to create their applications were completed before the programming project was assigned. In a sense, the completed lesson plans implicitly presented themselves as "dead documents" meant to be followed, not as an invitation for suggestions. As a result, the qualitative portion of the post-activity surveys conducted by the 2013-2014 introductory programming cohort reported a communications gap existing between their team and the engineering education majors, as most of these majors were then occupied with current course work and thus had little to no motivation for revising completed lesson plans to complement the programmers' ideas. To address this shortcoming, an elective special topics course in lesson plan design was run in parallel with the second-semester first-year programming course for the 2014-2015 academic year, thereby allowing the software applications and lesson plans to be integrally developed as part of a true collaborative effort. To create a greater sense of connectedness, and with hopes of collecting constructive end user feedback, the target audience was changed from teachers in the Dominican Republic to local fourth-, fifth-, and sixth-grade students participating in STEM Academy workshops conducted annually by the college's ASEE Student Chapter. Having once been students at that level, this allows for both the programmers and the engineering education majors to better relate to the target audience. Additionally, as this was now a local outreach effort, more of the college students could readily participate in the activity as the costs of travelling to a foreign country were eliminated.

Realigning the Term Project: Curiosity, Connection, and Creating Value

It was not enough to simply modify the term project assignment along traditional lines; it was determined through careful consideration and considerable reflection that a different mindset was needed for approaching the project. As the development of deliverables to a client constitutes an entrepreneurial activity, the investigators opted to use the entrepreneurial mindset as a framework for improving the learning environment. As posited by the Kern Entrepreneurial

Engineering Network (KEEN), an entrepreneurial mindset consists of curiosity, connections, and creating value.[7] Curiosity is important in a world of "accelerating change," as solutions quickly become obsolete. Accordingly, students need to be empowered with an "insatiable curiosity" for investigating opportunities for new discoveries. However, making new discoveries is not enough, according to KEEN: students must be taught to "habitually pursue knowledge" and then combine it with their own discoveries to reveal innovative solutions, as information needs to be interconnected in order to yield insight. Such innovative solutions are most meaningful when they result in creating "extraordinary value" for others. Thus, KEEN encourages educators to train students to "persistently anticipate and meet the needs of a changing world." When combined with an engineering skillset focused on opportunity, design, and impact, one arrives at the set of KEEN Educational Outcomes:[7] an entrepreneurial mindset coupled with engineering thought and action, expressed through collaboration and communication, and founded on character.

To assist in illustrating the relationships therein, KEEN provides the following set of example behaviors associated with their outcomes. Curiosity is demonstrated through such means as demonstrating a constant curiosity about our changing world and by exploring a contrarian view of accepted solutions. Connections involve integrating information from many sources to gain insight and by both assessing and managing risk. Creating value occurs by identifying unexpected opportunities to create extraordinary value and from both persisting through and learning from failure. Engineering thought and action allows one to apply creative thinking to ambiguous problems, and systems thinking to complex ones. Additionally, technical feasibility and economic drivers can be evaluated, and societal and individual needs can be examined. The ability to collaborate allows one to form and work in teams, as well as to understand the motivations and perspectives of others. Communication allows one to convey engineering solutions in economic terms, and to substantiate claims with data and facts. Finally, character is displayed through such behaviors as fulfilling commitments in a timely manner, discerning and pursuing ethical practices, and contributing to society as an active citizen. It was noted that service learning, as applied through engineering, embraces many of these example behaviors. Accordingly, a new hypothesis was posed for the 2014-2015 offering of the first-year programming sequence: that by embracing the entrepreneurial mindset as stated by KEEN – curiosity, connection, and creating value – as well as developing various aspects of the underlying engineering skillset, the benefits from the client-programming team relationship would be noticeably enhanced.

The Clients' Experience

Curiosity

The clients consisted of engineering education majors interested in taking an elective course on lesson plan development featuring a software application. The clients were allowed to embrace curiosity by defining their own lesson plans within the constraint of implementing a STEM outreach activity for delivery to a targeted set of customers: fourth, fifth, or sixth grade students. Not having any programming experience of their own, the engineering education majors were curious as to how a collaborative relationship with teams of programmers would work. Having first-year programmers craft software applications for use in support of STEM outreach activities, with the potential for classroom adoption, is definitely a contrarian way of acquiring such software.

Connections

One of the tasks presented to the engineering education majors was to make a strong connection between the application and the grade school students who would be using the application. This required the insight that K-12 educators must consider the manner in which a particular lesson plan addresses relevant educational standards like Common Core.[8] Accordingly, the engineering education majors had to research the appropriate standards associated with the target audience, and also communicate the importance of adhering to these standards to their programming teams using language appropriate for those who are not educators. Additional connections were promoted through periodic meetings between the clients and their assigned programming teams, which allowed the clients to discover the strengths and, more importantly, the limitations of working with first-year programmers, thereby providing opportunities to rein in the scope of their design to fit the first-year programmers' limited design capabilities.

Creating Value

At first glance, the value to be created from this collaboration was obvious: a group of elementary school students obtaining an educational learning experience as a result of the delivered software applications – but that was an expected opportunity. When looking at the need for assessing various aspects of the programming teams' performance, the lead investigator fortuitously happened upon the description of the single point rubric when reading a K-12 oriented education blog.[9] While similar to an analytic rubric, the key distinguishing characteristic of the single point rubric is that, for each criterion, only the expected level of performance is provided with a qualitative definition or precise quantitative measure. The remaining performance levels are deliberately left unspecified. The single point rubric thereby presents a single set of criteria, or "one point", for students to consider.[10] This "single point" approach involves developing criteria where only the traits associated with proficiency are stated; the cells for the remaining performance criteria levels are then used to document those traits that are found to be either above or below expectations. Consequently, the clients were active participants in developing a total of five rubrics using the single point format:[11]

- "Client: Proposal Evaluation Rubric" – used to evaluate the initial proposals and to provide constructive feedback before full-fledged development begins.
- "Client: Program Evaluation Rubric" – used to both evaluate the programs developed by the student teams and the perceived level of interaction by the programming team with the client.
- "Judges: Software Application Evaluation Rubric" – used to evaluate the software applications from an educational and non-technical standpoint.
- "Written Report Evaluation Rubric" – used to evaluate both the content and the mechanics of the final report submitted by each team.
- "Peer Evaluation: Teamwork and Effective Collaboration Rubric" – used to evaluate each student's participation on the project in terms of the effort they put into team tasks, their manner of interacting with others on the team, and both the quantity and quality of the contributions they make when collaborating in team discussions.

An example of a criterion from the “Client: Proposal Evaluation Rubric” using the single point rubric format is shown in Figure 1.

Mastery *Evidence of Exceeding Standards*	**Proficiency** *Performance Standards*	**Developing** *Areas that Need Work*	**Lacking** *Areas that are Weak or Missing*
	Context: The proposal describes an application that is fundamental to the lesson plan either as an extension or as in-class material.		

FIGURE 1. EXAMPLE OF A SINGLE POINT RUBRIC CRITERION.

The single point rubric is not a passive document where one merely looks for a box to circle – it solicits responses. Leaving the non-proficiency cells of the performance level areas blank invites conversation; if performance under a particular criterion is found to be either above or below the stated standards, then the blank space in the appropriate cell is used to provide either typed or handwritten feedback specific to what has been observed. Additionally, the single point rubric helps to underline the concept that meeting the expected performance is not equal to a grade of ‘A’; instead, a 5-4-3-0 weighting factor is employed, thereby placing a display of consistent proficiency at the cusp of the ‘B’-‘C’ boundary of 80%, a value empirically derived from the typical scores observed to be assigned to the average term project.

With respect to creating value through the example behavior of persisting through and learning from failure, the clients reviewed the post-activity qualitative survey data generated by the programmers and then submitted a reflective piece outlining what was done well and what should be changed for 2016. The list of suggested improvements is as follows:

- Do a better job of explaining to the programmers the contents of the provided lesson plans.
- Implement a Critical Design Review (via the use of external judges) to provide greater, more targeted feedback near the end of the project timeline.
- Allow more time for the programming teams to work on the project.
- Incorporate into the “Client: Program Evaluation Rubric” a criterion for evaluating grammatical use within the text of the software application.
- Better train judges in the use of the Judging rubric.
- Adopt a file nomenclature system so that clients working with multiple programming teams can readily see such materials readily organized by project.
- Insist on proper written communication skills when teams send email to the client, such as appropriately worded subject lines and copying messages to all members of the team.

It is worth noting that all of the engineering education majors who participated in this research during the 2014-2015 academic year signed up to continue with this research in the 2015-2016 academic year.

The Programming Teams' Experience

Curiosity

Having first-year programmers craft software applications for use in support of STEM outreach activities is highly contrary to the "accepted" solutions of either having computing professionals perform the development or using service learning as part of a capstone design course to complete the project.[12-13] Having a real-world end user in the form of elementary school children changed the perspectives of the programmers; for example, these are some of the remarks made in the post-activity survey:

> "This program was geared towards kids from fourth to sixth grade so we had to keep that in mind. It wasn't just a game that we were trying to do, the overall outcome of the application was for the kids to learn from it."
>
> "[The program was] a real program to be used by real people, and not being shoved into some archive where it will never see the light of day."
>
> "We had to think differently because we were making a program for sixth graders instead of programming professors."
>
> "It provides a solid incentive to do good work, as someone can actually use what we're doing."

Connections

The greatest challenge faced by those participating in this project was that of the programmers having to integrate different forms of information from a variety of sources to complete their team-based, client-oriented term project. As beginning programmers, they had to "connect" with the subject material in the Programming 2 course and apply their knowledge towards a problem for which they had to define the solution space before continuing with developing the application itself. For defining the solution space, the programmers needed to connect with the education field to learn about the concepts of educational standards, interpreting lesson plans, and the constraints associated with the cognitive capabilities of elementary-level students. This required them to consult with their clients – engineering education majors – in order to gain the insight necessary for developing their application. To help prepare for this collaborative effort, the programmers were introduced to the Agile Manifesto,[14] which includes customer collaboration as one of its primary precepts. Of the accompanying 12 Principles of Agile Software, particular emphasis was placed on the following elements:

- Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.
- The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.
- Simplicity – the art of maximizing the amount of work not done – is essential.

The programmers were then introduced to their clients as part of a laboratory session where each engineering education major provided a brief presentation on their lesson plan. Each programming team had to evaluate and rank the lesson plans in a bidding-type process. These bids were reviewed by the instructor and teams were then assigned to specific lesson plans. The first half of the next laboratory session was dedicated for the teams to interact with their assigned client in order to discuss the specifics of the lesson plan and to discern the client's needs for a software application that would support at least some aspect of the lesson plan's stated outcomes.

The teams' first deliverable was to generate a proposal detailing what they planned to implement as an application and how that application supported one or more of their lesson plan outcomes. The aforementioned "Client: Proposal Evaluation Rubric" was used to evaluate the initial proposals and to provide an additional connection via constructive, formative feedback before coding on the project began. Time was provided in both laboratory and lecture for the teams to work on application development; clients were available for consultation for the first half of each of these laboratory sessions.

As for the example behaviors of assessing and managing risk, the application had to be designed and implemented in a relatively short and fixed amount of time, but in a way that would provide for a successful outcome. This, of necessity, served to encourage the programmers to plan appropriate limits to the scope of their design and to take into consideration the needs of the elementary student using their application. In the post-activity survey, one of the qualitative questions asked about the challenges faced; the following are some of the more pertinent responses:

> "The challenge was trying to make the application fun and interactive for the kids."

> "Conforming to a lesson plan. We wanted to make sure we did it right by the educational standpoint."

> "We were faced with problems in knowing how to present the material for kids to learn since we are not educators, but we worked closely with our client to achieve the best understanding for kids."

> "The biggest problem in this experience was trying to keep all the information simple enough for students to understand and working within the curriculum. We overcame these problems by using a different mindset to accomplish similar goals we wanted to achieve."

The final laboratory session of the Programming 2 course was used to demonstrate the applications to a group of external judges consisting of two members from the Ohio Northern University Education Department, a representative of the College of Engineering's STEM outreach program, and the two lab assistants assigned to the course. The presentations were held in a science fair type format, where each team was stationed at an assigned set of computers and each judge would then individually and interactively review the materials displayed by the team, as shown in Figure 2. This format provided the teams with connections to different stakeholder audiences, thereby allowing for feedback from multiple viewpoints. The clients and instructor observed, but did not directly participate in, this activity. The teams were allowed to use the oral feedback obtained from the judges to tweak their applications prior to their final submission. Moreover, the scores from the "Judges: Software Application Evaluation Rubric" was used to determine a "best app" award, where each member of the winning team received $100.

Following this activity, teams had one day to make any necessary changes, after which the applications were delivered to the clients.

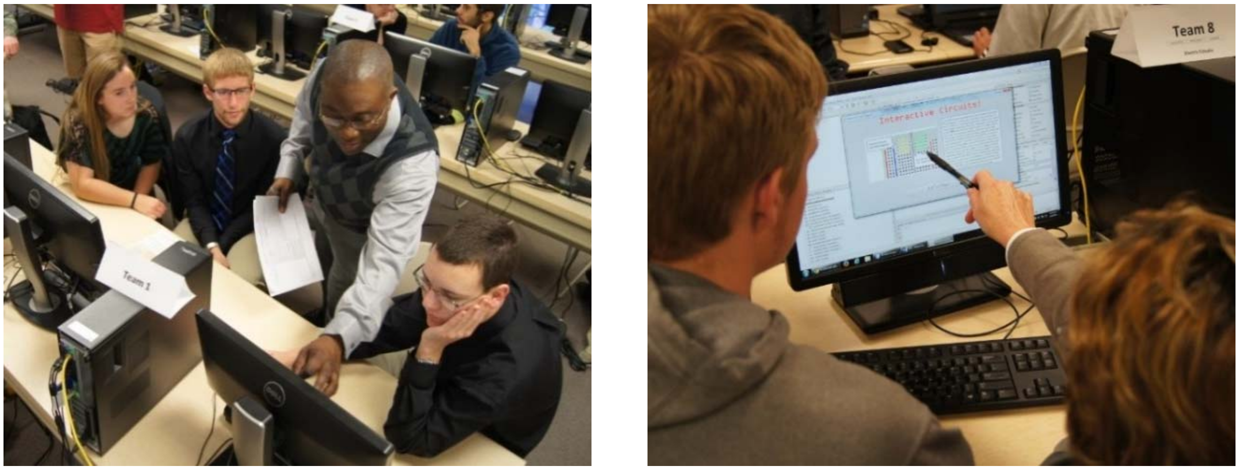

FIGURE 2. JUDGES INTERACTING WITH THE PROGRAMMING TEAMS.

Creating Value

It can be easily said that this project was an unexpected opportunity for creating extraordinary value: how often do first-year college students, let alone first-year programmers, get to design and develop software that will be used by others? Many of these programmers consequently put forth considerable time and effort in developing their application as they were motivated to do so because of this value proposition. This is not to say that they did not encounter struggles along the way. To ensure that the investigators could learn from these struggles, and identify areas of “failure” that could be improved upon for the next offering of the course, an in-class post-activity debriefing session was held. The best practices and the constructive criticisms of other strategies were written on the whiteboard to ensure all of the comments would be easily captured via smartphone photography at the end of the session. In this way, the programmers created value for the investigators through observations such as the following:

- Use the judges to perform a Critical Design Review in week 14 (*i.e.*, one week earlier), and then provide a week for fixes and/or improvements before delivering the application to the client.
- Dedicated class time with clients was appreciated as it was beneficial to be able to ask questions directly instead of relying on back and forth correspondence via email.
- Separate rubrics were a useful idea, as it allowed programmers to focus on a specific aspect of the project instead of dealing with one massive rubric containing everything.
- Take steps to ensure that programmers actually look at the rubrics before things are due, perhaps through review activities or in-class application exercises.
- Having multiple judges helped, as different audiences provided different perspectives.
- Using the science fair format with individual judges was very effective; after going through the judging process the first time, the programmers generally knew what to expect in subsequent visits, allowing them to hone the description of their work via repetition.

A survey sent to the judges after the science fair activity was conducted also yielded value. Among the points raised were a need to focus more on effective and appropriate ways to communicate to the targeted age groups and adding course material on gamification techniques and concepts to improve the effectiveness of the applications.

Assessment: Quantitative Results

The Community Service Attitude Scale (CSAS) survey, developed to measure college students' attitudes toward community service,[15] was selected as the primary assessment instrument to measure the overall effectiveness of applying the entrepreneurial mindset to this project. This instrument has been validated for reliability[15-17] and has also been used in engineering education contexts,[17, 18] including having been used to assess the performance of the previous introductory programming cohort. 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 the 10 aspects of student attitudes[19] toward community service that are presented in Table 1. For purposes of this research, both a pre-activity and post-activity survey using the CSAS instrument was conducted in order to better measure the impact that the activity had on the students in the Programming 2 course.

TABLE 1. ASPECTS OF COLLEGE STUDENTS ATTITUDES TOWARD COMMUNITY SERVICE.

CSAS 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
One's *helping* via engagement in community service

Table 2 provides a summary of reported student attitudes from four papers found from a review of the relevant literature. These data sets are shown in comparison to the pre-activity and post-activity summaries from the 2014 and 2015 term projects. The first column of the table includes numbers presented within parentheses; these values denote the questions from the survey that are then aggregated to form the summary response for that particular attitudes. To provide a sense of scale, the number of participants is reported for each study.

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

7-point Likert Scale 7 = "strongly agree"	**Shiarella**[15]	**Bauer**[16]	**Bielefeldt**[18]	**Downey**[19]	**2014 Pre-Activity**	**2014 Post-Activity**	**2015 Pre-Activity**	**2015 Post-Activity**
n =	332	78	17	77	22	22	23	23
Phase 1: Perceptions								
Awareness (1-4)	6.21	5.68	6.27	6.23	6.02	5.80	6.07	6.17
Actions (5-9)*	5.61	5.30	6.07	5.66	5.82	5.81	5.86	6.16
Ability (10-12)	5.42	5.27	5.95	5.26	5.63	5.59	5.70	5.67
Connectedness (13-18)	5.02	4.70	5.57	5.10	5.29	5.11	5.14	5.42
Phase 2: Moral Obligation								
Norms (19-23)	6.03	5.71	6.17	5.92	5.77	5.71	6.03	5.93
Empathy (24-26)	5.61	5.00	5.75	5.59	5.62	5.67	5.32	5.61
Phase 3: Reassessment								
Costs (35-40)	4.46	2.78	4.67	4.84	4.97	5.38	4.98	5.43
Benefits (41-46)	5.67	5.24	6.05	5.81	5.65	5.57	5.22	5.55
Seriousness (27-31)	4.82	4.47	5.15	4.79	5.01	5.19	4.96	5.17
Phase 4: Helping								
Helping (32-34)	4.95	4.61	5.50	4.99	4.88	5.09	4.97	5.28

*questions 5 and 6 not used in the 2014 pre- and post-activity surveys

Overall, this data indicates that there is general agreement with college students having favorable attitudes regarding community service. The data from the literature also serve to validate the 2014 and 2015 pre-activity data. A detailed analysis of the 2014 data has been previously published;[6] among the observations was that there were mixed results as to the effectiveness of the approach used, as 6 out of the 10 attitudes actually had lower aggregate scores reported in the post-activity survey than in the pre-activity survey.

So how did the adoption of the entrepreneurial mindset affect the 2015 results? Table 3 presents a comparison between the 2014 and 2015 cohorts. The Δ column reflects the differences recorded for the means of the ten CSAS attitudes (in terms of post-activity values minus pre-activity values) while the ***p*** column presents the p-value results of applying a paired *t*-test to the attitudinal pre- and post-activity data recorded for each programmer. Those results satisfying a significance level of $\alpha=0.10$ (to detect any possible differences) are indicated with the light green shading of the appropriate cell entries; results satisfying a significance level of $\alpha=0.05$ (a typical standard for statistical significance) are indicated with green shading.

TABLE 3. PRE- AND POST-ACTIVITY CSAS STUDENT ATTITUDES DIFFERENCES AND PAIRED *T*-TEST RESULTS.

	2014 Cohort Data		2015 Cohort Data	
7-point Likert Scale; 7 = "strongly agree"	Δ	*p*	Δ	*p*
Phase 1: Perceptions				
Awareness	-0.22	0.279	+0.10	0.180
Actions	-0.01	0.242	+0.30	***0.045***
Ability	-0.04	0.476	-0.03	0.444
Connectedness	-0.18	0.361	+0.28	***0.093***
Phase 2: Moral Obligation				
Norms	-0.06	***0.000***	-0.10	0.247
Empathy	+0.05	0.261	+0.29	***0.098***
Phase 3: Reassessment				
Costs	+0.41	***0.008***	+0.45	***0.035***
Benefits	-0.08	0.364	+0.33	***0.023***
Seriousness	+0.18	0.231	+0.21	0.160
Phase 4: Helping				
Helping	+0.21	***0.018***	+0.31	***0.086***

Light green shading indicates possible statistical significance.
Green shading indicates statistical significance.

Before entering into a detailed discussion, two figures are provided to help with the visualization of these results. Figure 3 provides a comparison of the measured differences in all 10 attitudes between the mean pre-activity and post-activity results for both the 2014 and 2015 term projects.

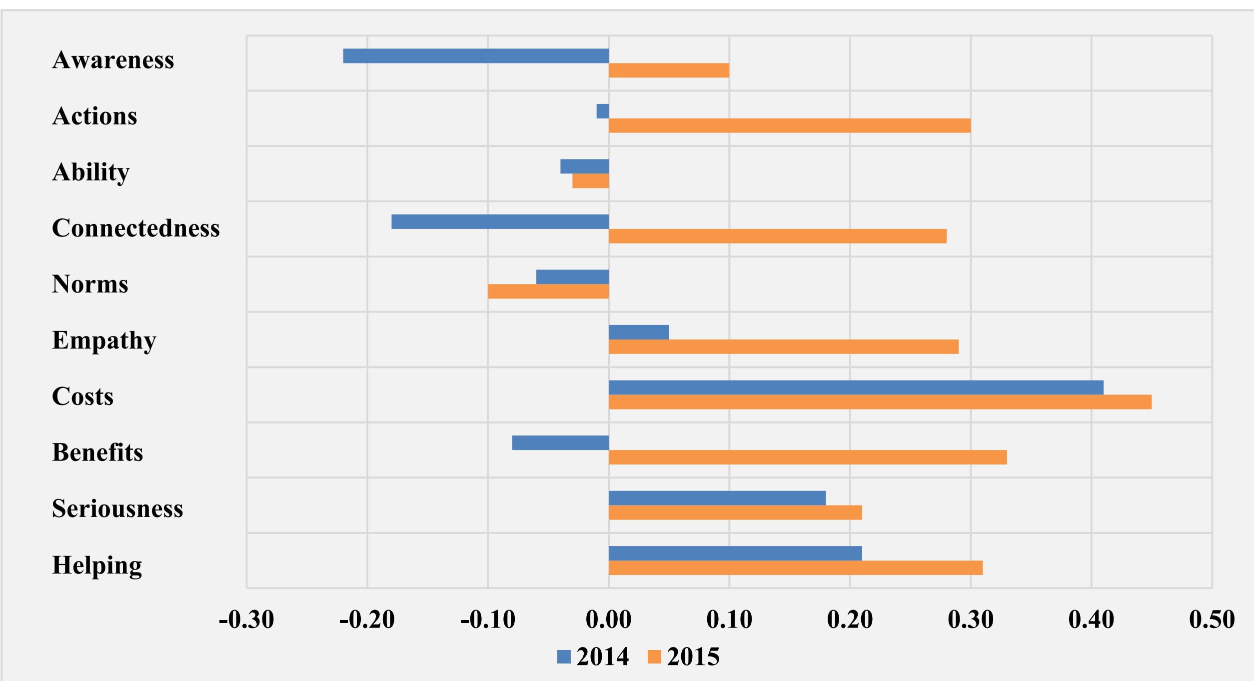

FIGURE 3. COMPARISON OF CHANGES BETWEEN 2014 & 2015 SURVEYS IN CSAS STUDENT ATTITUDES.
DATA INDICATES DIFFERENCE BETWEEN PRE-ACTIVITY AND POST-ACTIVITY MEASUREMENTS.

The modifications clearly had a positive effect, as the 2015 data indicates a pre-to-post increase in 8 out of the 10 attitudes, compared to only 4 in 2014.

As illustrated in Figure 4, student attitudes improved, when compared to the previous year, in 9 out of the 10 attitude classification areas – only the "Norms" attitude exhibited a decrease.

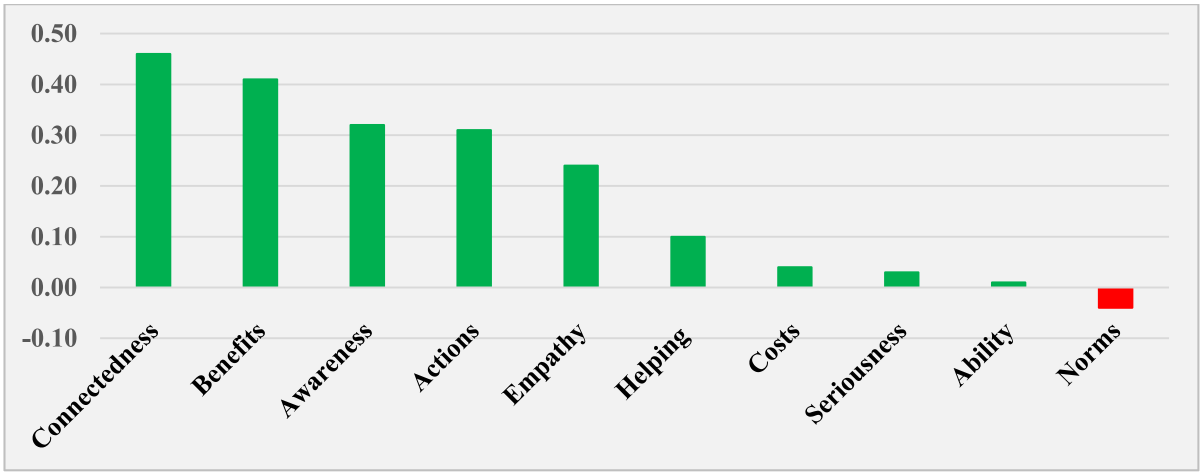

FIGURE 4. DIFFERENCE IN MEAN CSAS STUDENT ATTITUDE CHANGES FROM 2014 TO 2015.

When examined in terms of the KEEN educational outcomes of an "entrepreneurial mindset coupled with engineering thought and action, expressed through collaboration and communication, and founded on character",[7] the data from the CSAS surveys appear to support the hypothesis of this paper. First, the paired *t*-test results indicated that the changes made for 2015 resulted in some level of statistically significant change in student attitudes in six out of the 10 CSAS categories. Additionally, as illustrated in Figure 4, five out of the 10 attitudes exhibited noticeable positive changes in the delta (that is, how the post-activity survey data changed with respect to the pre-activity survey data) measured in the 2015 cohort relative to the 2014 cohort. The following paragraphs discuss these noticeable swings observed in the data in descending order of attitudinal change.

The "Connectedness" CSAS attitude directly relates to KEEN's "Connections" entrepreneurial mindset attribute. In 2014, the delta was -0.18; in 2015, this delta was +0.28 – an attitudinal swing of +0.46 on a 7-point scale. With a paired *t*-test result in 2015 of p=0.098, versus p=0.361 in 2014, this attitude was deemed to have been potentially affected from a statistical perspective by the assignment redesign. The primary factor in play regarding this change is that the programmers actively interacted with their clients, the engineering education majors, in a cooperative effort in developing applications in support of lesson plans that were still undergoing development and refinement. Accordingly, both parties had a vested interest in this collaboration.

"Benefits" involves a self-assessment of the benefits to oneself for providing the service. In terms of KEEN, looking at one's costs and benefits is an act of assessing and managing risk, which is an example behavior associated with the "Connections" entrepreneurial mindset attribute. This metric was judged to be statistically significant, having a 2015 paired *t*-test result of p=0.023, versus p=0.364 with the 2014 cohort. The 2014 version of the assignment had a delta of -0.08 while the 2015 version yielded a delta of +0.33. This sizeable increase was probably due to either the increased collaboration or the rewards for performing well, both intrinsic and extrinsic.

Proximity to the end user appears to have influenced the programmers' perception of their ability to provide aid. In the “Awareness” dimension of the CSAS, the original assignment in 2014 yielded a delta of -0.22 while the revised assignment in 2015 produced a smaller, but positive, delta of +0.10. However, as the 2015 paired *t*-test result for this attitude is p=0.180, this change cannot be statistically validated as being due to the hypothesis. The CSAS defines “Awareness” in terms of the student’s awareness of the community’s needs, while the KEEN equivalent is found within the “Engineering Thought and Action” educational outcome in the example behavior of examining societal and individual needs. In 2014, the programmers most likely completed the survey using either their immediate community or what they believed to be issues in other countries as a frame of reference. After the project, programmers may have felt less aware of their real problems faced by disadvantaged communities, thereby contributing to that difference. By using a local and well-defined activity, the 2015 cohort was better enabled to understand how their applications could be used to meet the needs of elementary school students, both individually and as a distinct community.

The 0.30 delta increase in “Actions” for 2015 versus the small decrease in 2014 can also be explained by the change in the end user. “Actions” describes the programmers’ attitudes toward the perception of actions that can meet the need. Such actions are similar to the KEEN example behavior of identifying unexpected opportunities to create extraordinary value, which is part of the “Creating Value” attribute of the entrepreneurial mindset. Since the programmers were creating applications for children, as opposed to teachers in a foreign country, it is plausible that the programmers felt more empowered to use their skill set to make a difference. It is notable that, while in 2014 the paired *t*-test result was p=0.242, in 2015 this improved to p=0.045, a statistically significant level.

“Empathy” also experienced a large delta increase of +0.29 with the 2015 offering while the 2014 project yielded a delta of only +0.05. The paired *t*-test results also improved, from p=0.261 in 2014 to a potentially significant level in 2015 of p=0.098. The “Empathy” attitude involves the programmers’ ability to understand the emotions and motivations of those in need. KEEN has a nearly identical example behavior listed under the “Collaboration” educational outcome which involves understanding the motivations and perspectives of others. Proximity to the end user certainly makes sense in this dimension, considering it is difficult to feel empathy for a teacher one has never met in another country thousands of miles away. The STEM outreach activity performed by the ASEE Student Chapter is typically widely publicized within the college, so the immediacy of the event may have increased empathy, especially upon seeing one of the pictures (Figure 5) from a recent STEM outreach activity. This image was used to illustrate a typical interaction with the target audience in the handout announcing the 2015 term project.

FIGURE 5. STEM OUTREACH ACTIVITY CONDUCTED BY ONU'S ASEE STUDENT CHAPTER.

The next four CSAS attitudes experienced a relatively small delta increase between the 2014 and 2015 cohorts. “Helping” is categorized herein, although it did have a much greater gain than the other three attitudes, as it is noticeably less than the first five attitudes discussed. The *t*-test results for this metric lessened somewhat, although with a 2015 p-value of 0.086, the results still possess some degree of statistical significance. In this case, the choice to reconsider the end user seems to have yielded a positive result, as helping through community service is a way to contribute to society as an active citizen – a KEEN example behavior associated with the “Character” educational outcome.

The remaining three attitudes in this set, “Costs”, “Seriousness”, and “Ability,” exhibited only minor increases in their delta values; however, “Costs” did demonstrate consistency in terms of being statistically significant, with p-values in 2014 and 2015 of 0.008 and 0.035, respectively. The “Costs” attitude is concerned with the sacrifices made by the student to perform the service. In relation to KEEN, this would be an aspect, along with the “Benefits” attitude, of the entrepreneurial mindset’s “Connections” attribute’s example behavior of assessing and managing the risks to oneself. Similar to 2014, the 2015 programming cohort underestimated the work load and time commitment associated with the project.

The “Seriousness” attitude examines the degree to which particular needs are significant, which from a KEEN perspective is a contextual examination of societal and individual needs as part of “Engineering Thought and Action”. The low increase here may be due to the nature of the project itself and the context; with a 2015 paired *t*-test value of p=0.160, whatever effects occurred through the assignment redesign are not statistically significant. While the programmers have an authentic client and their applications have the opportunity to be used, the programmers are still within the confines of the classroom and the application is still, at its core, an assignment. Moreover, the service is not to benefit the disadvantaged; rather, the service was meant to provide the STEM outreach volunteers and teachers with programs to supplement their educational activities. Finally, “Ability” concerns the programmers’ perceptions of their capability to meet the need; KEEN extends this attitude by answering how via the listed example behaviors of applying forms of thinking to complex and ambiguous problems under the “Engineering Thought and Action” educational outcome. While there was still a decrease between the 2015 pre- and post-activity results as evidenced in Figure 3, it was less than that exhibited in 2014. It is possible that this slight improvement between cohorts can be attributed to the increased support through active collaboration; however, in both 2014 and 2015 this attitude displayed the least amount of statistical significance amongst the 10 CSAS attitudes measured, with p-values of 0.476 and 0.444, respectively.

Only one attitude delta decreased between the 2014 and 2015 offering: the "Norms" dimension. "Norms" examines the programmers' personal beliefs and their sense of whether those beliefs obligate them to help. For KEEN, the "Norms" attitude can be related to discerning and pursing ethical practices – an example behavior associated with "Character". It is possible that this decrease can be attributed to the fact that the service was not voluntary but a required assignment in a classroom setting, thereby causing the programmers to believe their personal norms did not factor into the development of the applications. In 2015, this was not found to be statistically significant, as the paired *t*-test resulted in $p=0.247$.

Assessment: Qualitative Results

Responses from a set of qualitative questions provided further evidence in support of the hypothesis. Eight questions composed the written section of the post-activity survey:

- How was this assignment similar to and different from your other programming assignments?
- What were the benefits of participating in this service-learning activity?
- What were the challenges you faced in your service-learning experience? Did you overcome them or were they left unresolved?
- What impact, if any, do you believe your service-learning activity had on the engineering education majors that you worked with?
- Do you believe that this assignment is relevant for your future? How so?
- Are you inclined to continue the sort of service you performed for this assignment, or some other volunteer activity, in the future?
- What was your outlook about service-learning before you started this assignment and what is it now?
- How do you view your own ability to make a difference in your community and the world?

The programmers were quick to point out fundamental differences between the assignment presented in this paper and the previous four programming-related projects within the course. For instance, the programmers needed to work collaboratively in groups *and* with an external client rather than individually. One student summarized this key difference: "It was different because we had to actually communicate with our peers and with the customer on what they wanted or what they did not want." Due to the introduction of an external client, the programmers needed to consider a new audience as they "were making a program for sixth graders instead of programming professors." The client also provided a sense of freedom with design, as "normally, [the programmers would] have to make certain logic and make the correct output. However, this [assignment] was set up where [they] would be able to decide the outputs while consulting with a client on their needs and likes." The newfound flexibility excited a handful of programmers who claimed they "liked the freedom [they] achieved," but others felt that having the "power to design [their] own application was terrifying."

When identifying the benefits of participating in the service learning activity, several of the first-year programmers provided further comments on the differences between the other projects – with a few additional insights. More obvious benefits were frequently reported, such as "how to work with a client," "how to participate with a group of students," and how to "[work] with other majors to achieve a common goal." Others chose to describe their feeling regarding performing community service; the programmers claimed "[they] had the opportunity to program for the needs of others" and "gain[ed] awareness that community service is extremely beneficial to society" as a result. The client-based project also provided a motivational construct to encourage performance as programmers reported that "[the client / end-user] provide[d] a solid incentive to do good work, as someone can actually use what [the programmer was] doing." Programmers also took more practical applications of the knowledge they gained through the project like "making animations," "problem solving," "idea generating" techniques, and "target[ing] a product for a more specific audience." Finally, one programmer highlighted the overarching goal of incorporating service learning into the course with the response, "[the project] helps the [programmers] in the class learn about real life programs while also helping the community members."

With respect to the challenges faced and whether the difficulties were overcome, the programmers reported a wide array of issues. One programmer experienced issues with the division of labor; in the response, the programmer claimed "I did almost all of the work." Other responses included time management difficulties like "finding meeting times" and various "time conflicts" where only a subset of the group could meet. Programmers struggled to "make the application fun and interactive for the kids," especially working within the time constraint as "[the] project [was] probably the most important one from the year, but [the programmers] were only given two weeks for it." The inevitable "small unexpected bugs" were also included as difficulties. All programmers reported overcoming whatever difficulties the group faced, if any manifested at all.

The programmers reported upon the impact that they thought that the service learning activity had had upon the engineering education majors. From the programmers' perspective, the largest impact was that the engineering education majors obtained a set of software applications to use with their lesson plans and could "use [the] programs to aid in their demonstration to the students." However, some commented that the engineering education majors learned simple lessons like how a programmer would "design and put together a product." The engineering education majors also learned about the "value of finding someone who is an expert in an area and using [the expert's] resources to accomplish their goals." Two programmers reported they were "unsure" or "[they] did not believe that [the clients'] service learning exercise had much, if any, impact" upon the engineering education majors.

The first-year programmers were able to identify areas in which the lessons learned from this term project will benefit them in the future. As with the other questions, some programmers mentioned the new programming skills they obtained like "GUI in NetBeans," (translated, being able to use a specific software development system to create an application with a graphical user interface) but others highlighted the client aspect of the project. The project was perceived to be useful since it “required working in a team to accomplish a monumental task” and involved “creating products for real world use.” Other programmers commented on having a simulated work environment of sorts as it “gave [them] a real feel of how a work environment would be like.” Examples given included the manner in which “a customer will request a program” and “listening to a client and doing what they want.” Programmers occasionally focused solely on the application at hand, such as claiming the term project would only be relevant if “[they] end up working with engineering educators.” Others were able to detach the specific nature of the application and generalize by claiming “it is just not developing an app, but also writing reports and making it available to others.”

When the programmers were asked if they would continue the sort of service provided in the project or some other volunteer activity, 13 responded with yes while the remaining reported they might. One programmer commented that the project was a “very particular service opportunity,” so it would be hard to make a definite decision. Another student claimed “[the service in the project] is something I enjoy doing, and I enjoy helping others, especially with their learning.” Another programmer reported that “service learning is a cool concept” and that “I didn't really understand what [service learning] was, but now I see how it really allows you to connect with the material you're experiencing first hand, and using to make a real difference.” Finally, one programmer commented that “I never thought of [the project] as a service-learning project since [the programmers] were forced to do it. Now, I know that [service learning] can actually be used to teach grade school students.” This particular programmer’s comment is understandable; can a project truly be one of service learning if the students involved are required to perform the service? Weigert’s qualities of service learning help dispel this question as the “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.”[3]

The final question asked the programmers how they viewed their own abilities to make a difference in their community and the world. From the responses to this question, it appears as though the programmers feel as though they can “make a difference in the community and potentially the world eventually” while others at least claimed they could make a “small difference.” In fact, one programmer wrote a lengthy summary of how he or she could serve the community:

> “One person can make a huge difference. If I am one of the people that make a huge difference in a community or the world, good for me. If I only make a difference in a community, good for me too. It is important to help, but I do not need the satisfaction of seeing change or being recognized for the time I dedicated to helping. I believe I can help people, and I will try my hardest to help those people.”

Conclusions and Future Work

Regarding future work, research continues into finding new ways to incorporate additional value into this service learning experience. Such plans include collaborating with students enrolled in the Mathematics or Science concentration areas of the Middle Childhood Education degree program offered by Ohio Northern University's Education Department and by establishing partnerships with local K-12 educators. The single point rubrics developed as a part of this research was definitely an unexpected opportunity for creating potentially extraordinary value, and is being investigated further in the context of developing useful tools for fostering formative assessment.[11]

This paper has presented the reimagining, through application of the KEEN Entrepreneurial Mindset, of the culminating term project for a first-year programming sequence. The results from using the Community Service Attitude Scale (CSAS) survey to measure the change in attitudes by the current and previous programming cohorts exhibited nine out of 10 attitudes being positively affected by the implemented changes, with five showing a strongly positive response. Only one attitude was negatively affected, and that only slightly. Paired *t*-test results provided additional positive feedback, with six of the 10 attitudes displaying some degree of statistical significance. The qualitative responses were also positive in their content. Overall, the authors find this collection of data sufficiently supporting the stated hypothesis that the client-programming team relationship would benefit through adoption of the KEEN Entrepreneurial Mindset as an organizational framework. The natural blend of the entrepreneurial mindset with service learning led to a meaningful and authentic real-world experience for the first-year programming students.

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