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The Bucknell Poetry Path App Experiment: A Collaboration Across Campus

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Abstract

This paper details the experience of creating a smartphone app for Bucknell's Poetry Path through a collaboration between three groups on campus - a course, the IT group, and an on-campus arts center. The students in the class served as the "hub" of the collaboration, requiring them to communicate with each other and with other groups on campus on a project that was like no other in their experience. The result is an actively deployed smartphone app for walkers of the Path that complements the content of the Path and a learning experience for all that went far beyond a traditional course project.

Introduction

In the fall of 2014, the instructor of an electrical and computer engineering elective course was looking for multi-week, large-scale project for the course. In response to a campus-wide call for project ideas, the university's Library and Information Technology (L&IT) group responded and suggested the idea of creating a smartphone app for walkers of the campus' Poetry Path project. In the coming pages, we will explore this collaboration and the results of this work.

The Stadler Center for Poetry and the Poetry Path

Formally established in 1988, the Stadler Center for Poetry is Bucknell University's professional literary arts center. Its mission is to foster in a wide and varied audience an appreciation for the diversity and richness of contemporary American poetry, and to provide support for professional writers. The Stadler Center's programs include, among other offerings, an annual series of readings by visiting poets and writers, fellowships and residencies for emerging and established authors, and a nationally circulated literary journal. The Center also serves as the seat of the English Department's Creative Writing program. Like many such university-based arts centers, the Stadler Center serves both an on-campus and an off-campus constituency, bridging the divide between the university and the wider literary culture. Its reading series and related programming complement Bucknell's academic program and otherwise bring cultural enrichment to campus and the Lewisburg region. In the wider literary world, the Stadler Center serves the American literary community by providing time, space, and financial assistance for writers through its fellowships and residential programs. Major funding for the Center comes from the family of alumnus Jack Stadler '40, other alumni gifts, and an endowment established by Professor of English emerita Mildred Martin.

The brainchild of Stadler Center director Shara McCallum, the Poetry Path is the Stadler Center's public art project in the community. Inspired by New York City's "Poetry in Motion"

program,[1] which displays poetry in MTA subway cars, and similar projects, the Poetry Path seeks to put poetry in places where the larger public will encounter it, outside of the classroom or the covers of a book. The "path," which follows existing sidewalks and walkways, is a 1.4-mile walking tour of Bucknell's campus and the downtown area, beginning and ending at Bucknell Hall, home of the Stadler Center. Ten markers along the Path, like the one shown in Figure 1, feature poems chosen for their thematic resonance with culturally significant locales. The marker positioned near an Underground Railroad historic site, for instance, features a poem that explores African American culture. The marker located where churches face each other across an intersection features a poem about religious belief. The poems are changed on a biennial basis, so that the Path is consistently "made new again." The Path has been used by Bucknell classes, local public school classes, parents, alumni, and prospective students, and others.

Figure 1. Poetry Path marker.

The *Bucknell Paths* App

The primary goal of the app was to provide value to walkers of the Poetry Path. At the start of the project, no one really knew what that value would be in the end, but it was up to the students, in collaboration with the Path director, to explore ideas and come up with something. In the end, the students found multiple ways for the app to deliver additional value to a Path walker through logistical support and providing additional information.

The team delivered about 80% of the finished product of the project. This included a multi-platform app for iOS and Android devices and the supporting back-end that served content to the app. The major functions of the app are displaying poem and audio of the author reading the poem, line-by-line highlighting of the poem as the audio is played, walking navigation from one

path site to the next, and additional background information about the author and poem. Some screenshots from the Android version of the app are shown in Figure 2. The major functions of the back-end are serving the text and audio versions of the poem and a maintenance interface that allows updating of the Path content (adding and removing content as the Path changes over time). The delivered codebase was finalized by L&IT and is available on the Google Play Store and Apple's AppStore.

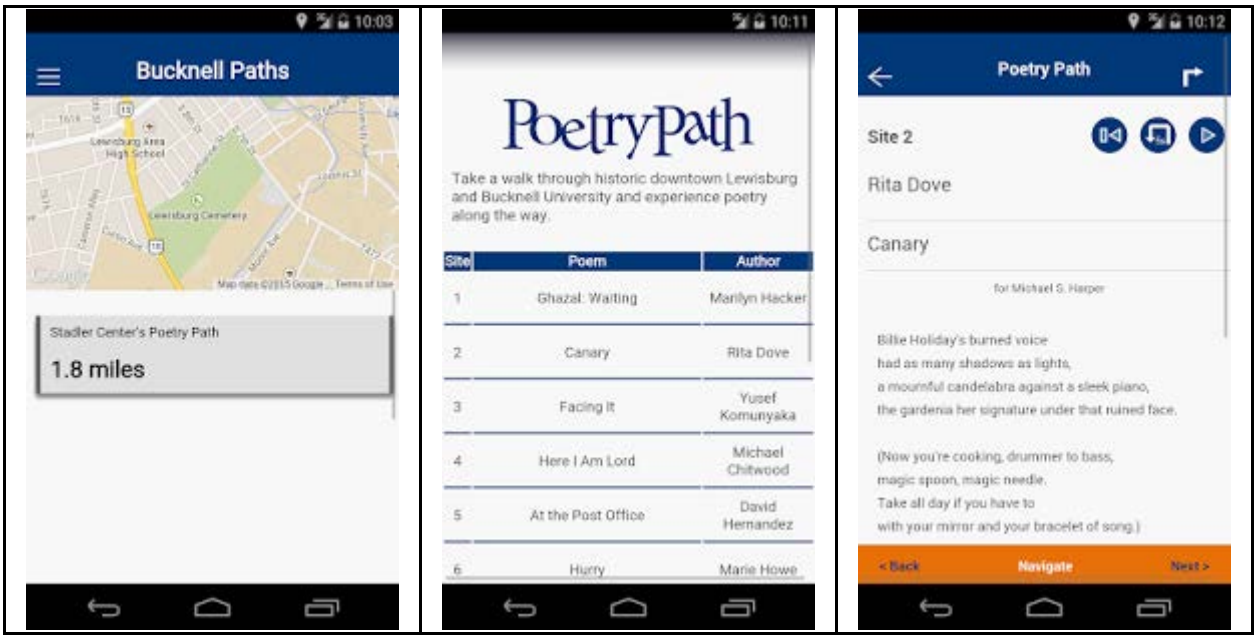

Figure 2. Bucknell Paths app screenshots

The Collaboration and Background

One of the aspects of this project that was quite unique was the diversity of the groups involved: an engineering elective course, the information technology group, and a university-based arts center. In our case, each group came into the project with a different set of interests and goals.

From the academic side, the course instructor was interested in an in-class project experience in an out-of-class context, hopefully a non-technical context. The project was expected to run for a majority of the semester, much longer than most if not all of the projects the students have worked on before, and solve a problem that was not generated by the students. The intention was to find a project that was between a *problem project* and a *discipline project* [2] where the rough goals and context of the project would be solely determined by the client of the project, the Poetry Center in this case. The instructor believed this approach most closely mirrors what most engineering students would encounter if they went to work in an engineering job because it is unlikely they would be give full autonomy in finding a project but it is likely that they would be given a great amount of flexibility in how they approach the project. Finally, the students would work in larger teams or a single team where the members each had individual responsibilities. At

least one student would be responsible for both managing the team and system-level coordination and planning. Again, many of these attributes differed from most projects the students completed before.

L&IT partners directly with faculty for research and teaching through their Instruction Technology team, however there are also many examples of other L&IT teams enhancing the academic experience through innovative collaboration. The genesis of these opportunities is usually organic and, with proper leadership support can produce some great cross-disciplinary results. This project harnessed a known, un-resourced, administrative challenge (How to introduce L&IT-supported mobile technology to the Bucknell Poetry Path), to a classroom-based learning opportunity (What real-life experience can offer our students as part of their senior seminar).

The collaboration was attractive to the Stadler Center for several reasons. As an independent arts center (which is to say, not formally attached to an academic department) and an important link in Bucknell's liberal arts infrastructure, the Stadler Center actively seeks cross-disciplinary projects in which poetry and the literary arts can enhance learning in other academic disciplines. As it happens, most of the Center's collaborations are with related disciplines within Bucknell's College of Arts & Sciences. This project presented a special opportunity to cross boundaries beyond the arts and humanities into an entirely unrelated and pedagogically very different area of inquiry, that of engineering. Also attractive, of course, was the opportunity to bring the Poetry Path up to date with current technologies, adding real value to the experience of touring the Path. The Center's on-going goal is to make the Poetry Path as convenient and accessible as possible, and this collaboration presented an excellent chance for improvement.

The Course, ELEC 403 Mobile Computing

ELEC 403, Mobile Computing, is a fairly new course at Bucknell that focuses on exposing students to concepts and technologies from the world of mobile computing. The course divides the "mobile computing" landscape into four areas: apps, devices, networking, and the "back end," computing and storage functionality. Each of these areas was introduced prior to the start of the project to ensure the students had some background in these areas so that they could do some high-level design of the system they were going to build.

This offering of ELEC 403 was designed to be a non-traditional course that was highly project-based. The learning objectives of the course were quite broad to focus more of the process of design and not the specific deliverables. This was done to allow the students freedom in their chosen solution. At the end of the course, it was expected that students be able to:

- effectively and efficiently operate on a large, multidisciplinary team,
- follow good design processes and effectively communicate design details, and

- identify and discuss the modern technologies and standards that were explored during the duration of the project.

As previously noted, the course was an upper-level elective open to juniors and seniors in the Electrical and Computer Engineering (ECE) and Computer Science (CS) departments. For the ECE students, the course counts as an in-department elective, and for the CS students it counts as a free elective; neither major requires the course. Ten students enrolled in the course; 7 senior computer engineers and 3 senior computer science engineers. Of the 10 students, 9 were domestic male students and one was an international male student. More work will be done in the future to attract a more diverse student body to the course. There are, however, limitations on this effort because of the small sizes of these two departments.

The mix of CS and ECE students creates a multidisciplinary team with limited breadth, but it is the addition of the L&IT staff and the Poetry Center director that increase this breadth. A project manager and programmer from L&IT worked closely with the team. In essence, we created a group that spanned not only multiple majors on campus, but multiple departments on campus, each of which came with different perspectives and interests. The L&IT staff were concerned with being able to finalize the student-created deliverables with minimal resources and how to ensure the app and supporting back-end would be well documented and simple to maintain. The Poetry Path director was concerned with ensuring the technology supplemented and supported the Path and did not detract from the experience.

The course met twice a week for two hours each time and was held in an ECE lab space that was equipped with computers. The first few weeks of the course followed a somewhat traditional lecture format that focused on introducing a number of topics in the area of mobile computing: smartphone hardware, networking protocols, sensor types, etc.

Once the project was introduced, the in-class time became mostly focused on giving the students time to meet, present, and work. The project lasted approximately 8 weeks. The entire class operated as one large team that was divided into sub-teams that tackled the various parts of the project. A single student was designated as the project manager (PM) at the start of the project. The PM was responsible for the logistics of the team, meeting with external entities (faculty, the Stadler Center, and L&IT), managing resources, and acting as the system-level engineer to ensure the various subsystems correctly connected together at the end of the day.

Deliverables and Milestones

The project was composed of the following set of deliverables which were designed to lead the students through the design and implementation of the project. We made an effort to merge the

design process followed by L&IT and the process followed in the ECE department's senior design course.

1. System-level project description: a prioritized list of functions, a list of actors and how they interact with the system, a system-level (level 0) diagram showing all inputs and outputs, a sub-system level (level 1) diagram showing all subsystems and how they interact, and a draft testing plan
2. Initial approach description: a rough list of ideas, directions, resource needs, and possible technologies; a division of tasks across the team; an initial project schedule with delivery dates for the future deliverables; what will specifically be shown at the next deliverable
3. Individual team member demos: each team member was expected to "own" some aspect of the system that they could develop and demonstrate. It was expected that there would be at least one set of individual demos.
4. Subsystem-level and system-level demos: it was expected that there would be more than one integrated demos of two or more subsystems.
5. Evaluation plan and measured results: a list of specific metrics, at least one test procedure for each metric, desired levels for each metric, and measured levels for each metric
6. Delivery and hand-off: a major point of this whole collaboration was to create a system that would be handed off to L&IT to be polished, deployed, and maintained over time. An official hand-off meeting with discussion and questions was a major milestone for the end of the project.
7. Reflection on the process and product

Each of the project milestones was evaluated by a rubric that included rankings of above expectations, meets expectations, below expectations, and unacceptable. The rubrics were distributed to the students prior to each milestone so they would know how they were being evaluated. The specific due dates for the first two milestones were set by the instructor. The PM, in consultation with the team, was expected to develop a list of due dates for the remaining milestones by the end of the second milestone.

Peer Evaluations

In addition to the above deliverables, students were asked to provide feedback on all teammates several times during the semester. Each student on the team was asked to list the specific contributions, the perceived level of effort, and the perceived level of productivity for every other member of the teams. It was assumed that not all students would have knowledge of all of the other teammates. This information was aggregated and used to identify major deficiencies and accomplishments. Students with multiple above average or below average ratings were informed of their status. Those falling below expectations were encouraged to improve. This only happened a couple of times and the students affected appreciated the feedback. When it

came time for final grades, the overall trajectory of each student's ratings was used to make minor adjustments both up and down.

While the feedback about peers was used in judging those students, the range of rankings provided by the evaluator was used to judge that student's effort and knowledge of his/her teammates. Given the large size of the group and variety of tasks, it was expected that there would be a wide range of effort and productivity rankings - this continued to prove true. Students providing "meets expectations" ratings across the board were informed that this was unlikely and asked to submit more useful feedback in the future.

Compared to Other Projects

One of the interesting aspects of this course and project were the ways in which it differed from the other courses offered by the department. Here are the major differences by design.

- Project length - this project lasted a majority of the semester so that the students could iterate on their ideas multiple times and the project scope could be rather large.
- Team size - the size of the team, 10 students, was much larger than anything in the department, including senior design. This allowed students to specialize within the group and by its nature, aggressively exposed many of the challenges of working in larger groups.
- Adoption by L&IT - assuming some level of success, the product of the course would be finalized, released, and maintained by L&IT. This is in stark contrast to other course projects that end with the course. This aspect was motivating to the students. Who doesn't want their effort to live on?
- Collaboration with multiple campus entities - it is unusual for three units on campus to work together on an in-class endeavor.
- Working with multiple perspectives - while the collaborators tried to align their interests and expectations as much as possible, some differences would exist and the students would have to figure out how to balance these ideas.
- A "real" client - the judge of value in this context was not the students. Both the Poetry Path and L&IT drove the direction and evolution of the project.

The Evolution of the Project

While this experiment resulted in a reasonable and valuable product that is currently in use, the process had a number of hiccups along the way. The project started out with the entire class and the L&IT collaborators walking the Poetry Path in the same manner than the average viewer would participate in the Path. Somewhat to everyone's surprise, none of the students had walked the path before. A question and answer session followed the walk with the students posing a number of questions about what their work could add to the Path.

The next step was for the students to begin brainstorming how they could enhance the experience they had been a part of. They came up with a variety of ideas and pitched them to the director who offered his thoughts of what would work best for the path. While the students listened, they often let their own interests cloud the director's comments. This "selective hearing" was remedied later in the project but resulted in the team putting a number of hours into secondary-interest functionality. The longer timeline of the project allowed the students to fail in minor ways, learn from the experience, and then iterate to find a more valuable approach.

Next, we discussed an overview of the technologies that can be used to develop a mobile app. Would they focus on developing an app exclusively for iOS or Android, or choose a common development platform that can deploy to both? What are the benefits and drawbacks of each approach? Should we store all necessary information on the mobile device, or interact with an API service? These and many other questions resulted in a great discussion of the design of the app.

As we discussed the pros and cons of each approach, the group decided on using a common development platform, PhoneGap,[3] to develop the app. Rather than creating native code for each mobile operating system, this solution allows developers to use familiar HTML, JavaScript, and CSS technologies to create the app interface. This has the advantage of producing one codebase that can be deployed to both iOS and Android platforms, but comes at the expense of not being able to take advantage of some of the more advanced hardware capabilities of each platform. For the needs of the project, and timeline, it was deemed to be worth the tradeoff.

We then turned our attention to the storing and retrieving the application's data, in this case author information, poem text, an audio track, and metadata that would allow the app to "read" along with the text on screen in time with the audio track. Since L&IT has thorough experience developing Oracle databases, we decided that would be the most logical approach as it would reduce the number of unknown technologies in the project. The data would be exposed through a .NET Web API, another known technology. We could have chosen to load all data natively on the device, but that would have the effect of greatly increasing the app's download size, and making it more cumbersome to update and add new poems in the future.

With the major technological portions decided, the students needed to decide how to break up the project into tasks. Logically, the project was broken up into a front-end team focusing on the app interface, and a back-end team targeting the database and API layer. The students chose who would join each team after considering personal interests and experience. In addition to these two groups, another smaller team would focus on project management and client interaction. During the course of the project, the team realized that personnel changes were needed and responded accordingly, shifting people around as needed to best support the

workload. The need and ability for people to move around as needed better reflected industrial team operation but was new to the students.

Now that there was a clear vision of how the app would be developed, the student teams met with L&IT for an orientation on developing within L&IT's existing development framework. Though most students had some programming experience, many were limited and all would need to learn new technologies for this project. Students were introduced to development and source control tools, including Visual Studio, Subversion, and Oracle SQL Developer, and given an overview of the suggested development workflow. They collaborated with L&IT staff to determine a recommended database structure, but ultimately were encouraged to learn on their own and figure out what works best for their team. Outside of a few hour long sessions, the students worked fairly autonomously.

Beyond these informative sessions, L&IT stepped back and let the students take the lead in the development of the app. L&IT staff played more of a systems administrator role, setting up a database and creating user accounts on both the database host and web application server with appropriate permissions for the students to develop with.

Within each team, tasks were divided among those on the team. This approach of allowing students to specialize and own different parts of the projects was also fairly new to the students. During the first demonstration milestone it was clear that they did not quite grasp how individual their work needed to be and how to clearly denote task boundaries. Their approach resulted in lots of duplicated effort. During the demonstrations, students realized the inefficiencies of their approach. The faculty and L&IT staff also pointed out how this could be improved and the students were sent back to adjust and demonstrate again later; essentially, all of the students failed that particular milestone. They did learn from the experience and consistently improved their task division as the project progressed.

The students met with the client throughout the project to get feedback on ideas and progress. These interactions increased as the project progressed and the students learned to better listen to the client's interests and let go of their own. As the project approached the end, the students really began feeling the pressure of the approaching deadline. They reached a point where they had to make some hard choices about what functionality would be included in the final version of the app. This required that they really focus in on the primary features which led them back to the path director. They did a much better job of listening this time and adjusted as needed. They also learned a lot about testing and the need for preliminary "live" tests and demonstrations.

The Results

In the end, the project resulted in success. The students created a product that provides value to the Poetry Path and is maintainable by L&IT. In the process, they learned about operating in a team, mobile computing technologies, design, and working with multiple constituents. The process was not without its challenges, but those helped support much of the learning along the way.

From L&IT's perspective, the project produced an application that is both useful to the campus and community, and maintainable by university staff, which was the primary goal. The project also furthered the university's mission by helping to provide students with a well-balanced and challenging education while teaching real world skills.

For the Stadler Center, the collaboration was successful in more than one regard. Facilitating the use of poetry in the pedagogical work of another discipline is squarely in line with the Center's mission and thus a success in itself, as was the chance to expose students to poetry who are not likely to encounter it in their coursework. (By the same token, one of the authors deeply appreciated the opportunity to experience firsthand the work of computer engineers). The more tangible outcome of the project is the successful addition of value to the Poetry Path. That value might be characterized as more efficient, convenient, and reliable delivery of product, in this case the Path's audio element.

While this project exposed the students to many aspects of design, teamwork, and mobile computing, the instructor set out only a small number of specific learning goals. It should be noted that from the start, the instructor wasn't exactly sure how this whole experience would go as the semester progressed.

Learning Objective 1 - Teamwork

The first learning goal was for students to be able to operate effectively and efficiently operate on a large, multidisciplinary team. This was evaluated in two ways that stem from work done by Cheville and Duvall. [4] The first method was to use peer evaluations. These were administered at three points during the semester - near the beginning, the middle, and the end. The first round of evaluations focused just on perceived team member effort as there had been little time to produce any results. Each member was asked to rate the perceived level of effort of his/her teammates using a scale of below expectations, meets expectations, above expectations, or unknown. An "unknown" option was included because of the team size and the assumption that some folks would not know about all of their teammates. Each person was asked to briefly note what tasks the other members had contributed to, as well.

The second and third administration of the evaluations asked each member to rate the perceived level of effort and productivity of all of the team members, including him/herself. This was rated using the same below/meets/above/unknown scale. Each person was also asked to list the specific contributions of each teammate. The specific list was included to help them better establish their rating by identifying specific items and for the instructor to evaluate the engagement of each evaluator - the assumption is that more engagement results in more details.

A weighted score was calculated for each metric, effort and productivity, for each evaluation round. For the calculation the number of responses for a given expectation value was weighted and all were summed. For weights, exceeds = 2, meets = 1, unknown = 0, and below = -1. For example, a student who received 1 exceeds, 2 meets, 1 below, and 5 unknown received a weighted score of 0.75 = (1(2) + 2(1) + 5(0) + 1(-1))/9. A general assumption that was articulated to the students throughout the course was that meeting expectations meant students were contributing positively to the team.

We analyzed this data in two ways and focused on trends. We looked at the values themselves and compared to previous scores. Specifically, we used the data to answer the following questions.

- How many students started off at “meets” or higher?
- How many students continually scored well (“meets” or higher)?
- How many students finished the project strongly and scored a “meets” or higher on the last evaluation?
- How many students showed significant improvement of a 0.2 increase or higher at any point during the project?
- How many students showed a significant drop of 0.2 or higher at any point during the project?

We considered a change of 0.2 a significant change because it means that two peers increased their rating of a student by one level or one peer increased their rating of a student by two levels.

Table 1 - Trends of perceived *effort* of peers (3 rounds of peer evaluations)

Student ->	1	2	3	4	5	6	7	8	9	Counts
Started at or above “meets”				x	x	x	x	x	x	6
Stayed at or above “meets”				x	x	x		x	x	5
Ended at or above “meets”	x		x	x	x	x		x	x	8
Improved 0.2 or more at any point	x	x	x				x	x		5
Fell 0.2 or more at any point					x		x	x		3

Table 2 - Trends of perceived *productivity* of peers (2 rounds of peer evaluations)

Student ->	1	2	3	4	5	6	7	8	9	Counts
Started at or above “meets”	x		x	x	x			x	x	6
Stayed at or above “meets”	x		x	x	x			x		5
Ended at or above “meets”	x		x	x	x		x	x		6
Improved 0.2 or more at any point					x			x		2
Fell 0.2 or more at any point									x	1

Table 3 - Summary responses to how the course changed the students’ approaches to teamwork

Student ->	1	2	3	4	5	6	7	8	9	Counts
Division of labor challenges	x									1
Division of labor promotes contributions		x					x			2
Be active about looking for reassignment			x							1
The need for task assignment flexibility				x						1
Task division = better results							x			1
Specialization = good						x				1
Efficiency of large vs. small team				x						1
Ups and downs of sub-grouping			x							1
Communication challenging in big groups		x	x							2
Communication is important!			x	x	x				x	4
Importance of coordinator in larger teams							x			1
Modular design = good; needed for large projects							x			1
Carefully consider team capacity WRT priorities								x		1

Tables 1 and 2 show the trends of scores for each student and the counts of those trends, Table 1 for the perceived level of effort and Table 2 for the perceived level of productivity. If we focus on just Table 1, we see that 1) six of the students started off meeting or exceeding expectations, 2) just over half of the students in the course continually had a weighted score of “meets” or above, and 3) almost all of the students ended the project with a weighted score of “meets” or above. This data suggests that there was improvement over the course of the project regarding student effort on the project.

The productivity data from Table 2 suggests a slightly different picture. First the number of students who start off strong (“meets” or above) is the same as the number of students who finished strong, but students 7 and 9 swapped. Additionally, there was fewer “significant” changes over the course of the project, compared to the effort data.

Finally, the data shows some difference between effort and productivity throughout the project. Peer effort was higher than productivity, based on the data available. Additionally, some students were perceived to be more productive than their effort suggested, specifically students 1 and 3, to some extent. Conversely, students 6 and 9 showed the opposite and were perceived to put in reasonable effort, but were perceived to have little to show for it. While these discrepancies were present, we do not have enough information to interpret the data beyond these general observations.

Overall, with regard to perceived student productivity and effort, the students met our expectations. Additionally, the artifact created reflects an acceptable level of effort and productivity.

The second method of evaluating students' teamwork abilities was conducted at the end of the semester. They were asked: *how did the project in the course change your approach to group work?* These responses are summarized in Table 3. An 'x' in a column denotes that the corresponding student mentioned that specific topic in his/her response. While the details of the responses varied, the major areas of comment focus on communication, personnel management, and coordination within a team. This is not surprising since these are all areas that typically are not encountered in the smaller group projects that the students have seen before. Since the students noted them, we assume that their understanding of the challenges of working on a team has changed, thus meeting the learning objective. There is an assumption that by recognizing the specific challenge that they will work to improve how they respond to it - recognition is a first step in the process.

In the end, we believe the course was successful in improving how the students work on a team. We saw a slight increase in perceived effort and productivity throughout the course and the students identified many of the challenges of operating on a team, especially a large multidisciplinary one.

Learning Objective 2 - Design and Documenting the Process

All of the students in the course were also enrolled in their respective department's senior design capstone course, as well. The course instructor wanted to include design in this project to give the students a chance to further exercise the design process skills that were being taught in senior design. Unfortunately, this area ended up being quite deficient as the semester progressed. This was more of time constraint issue than anything and instead of trying to pull time away from the project itself, the instructor conceded to reallocate the time to other aspects of the project knowing that the students would see design aspects in their respective senior design courses.

In the end, the team created enough documentation of the system operation that the L&IT group could move forward with the delivered product. Beyond that, little was documented.

Learning Objective 3 - Exposure to Mobile Computing

The last learning objective focused on the exposure of students to technology and standards in the area of mobile computing. This objective was assessed via a survey that was conducted at the end of the course. The following two questions were posed to the students.

1) What new technologies were you exposed to in this course?
2) What computing standards (new and already known) were you exposed to in the course? In one sentence, what does each provide / dictate?

In the past, we have noted that students who are exposed to computing standards do not necessarily identify them as standards or realize their importance. By asking them to self-identify the standards, we not only can tell if they were exposed to them but that they identify them as standards. Knowing this, the instructor made sure to emphasize the existence and importance of standards in this field. Table 4 shows the standards that were reported by the students and which students mentioned them.

Table 4 - Self-reported technologies and standards

	1	2	3	4	5	6	7	8	9	Counts
.NET family of technologies	x				x	x	x			4
Databases and SQL	x					x			x	3
HTML, CSS, Javascript	x	x	x				x	x	x	6
Industrial IDEs (XCode / Visual Studio)	x	x				x	x		x	5
Phonegap and other mobile dev frameworks		x	x	x				x	x	5
The network stack and sockets	x		x	x	x	x	x		x	7
Web APIs		x		x	x		x			4
Security concepts	x									1

The major takeaways from Table 4 are that all students identified being exposed to multiple standards and those played a major part in the implementation that they chose. We interpret this that they are correctly identifying what they interacted with. Another observation is that the exposure varies from one student to another. This was expected since each student specialized in a different part of the project. While every student did not enjoy the same experience, it is assumed that every student had more intimate knowledge of the aspects of the work that they owned. In the end, we believe that the course was successful in exposing the students to multiple mobile computing technologies and standards and the students interacted with these in a realistic context that helped them better understand what the technologies and standards provide.

Liberal Arts Immersion

While not an articulated learning objective of the course, but relevant given the fact that Bucknell is a liberal arts institution, we do believe that the students immersed themselves in the poetry side of the Poetry Path on numerous occasions. We have no data to support this, though. To fully understand how to provide value to the Poetry Path the students had to understand the "why" and "how" of the Path. They learned why different poems were used at specific stations and why the set of poems was chosen and how they complement each other. The students likely considered the poems themselves and ways in which technology could enhance a reader's experience of the text. In the end, we venture to say that the students were much more engaged in the Path than the typical Path walker. Maybe they even gained a better appreciation of poetry!

Reflection

All of those involved viewed this experiment as a resounding success. At the start, none of us were quite sure exactly what we would end up with. It is also important to note that an app for the Poetry Path would not exist without this effort since there were no other resources available to create it. Beyond that the group produced a viable software application in less than half of the staff time that would have otherwise been required.

Shifting the focus to the students and their learning, it is clear that they learned quite a bit about operating in a team environment including the demonstrated need for communication and clear division of labor. Additionally, everyone was exposed to multiple technologies and standards related to mobile computing. Beyond the specified learning goals of the course, the students learned quite a bit about the following topics.

- Requirements scoping - the students started off with a collection of rather grandiose ideas for the app that were quickly paired down at the end. Looking back they realized that starting small and simple might have been a better approach.
- Serving the client - it took the students a handful of weeks and multiple meetings to really begin to focus in on the interests of the Poetry Path. At first they were quite self-interested and did not realize that they did not really understand the project or the client. Towards the end, it became more clear that they should have spent more time getting to know the project before developing ideas.
- Scheduling - the team was tasked with developing its own schedule of deliverables. We watched the schedule get pushed multiple times throughout the project. While there were multiple iterations on the product, most of them happened towards the end of the course.

Looking back we believe a number of attributes worked well for all involved. The large team and long timeline allowed for a larger scope of the project and more iterations. There was excellent

exposure to project management concepts in practice, a role that entry-level graduates often don't get to play right away in the workforce. The hands-off approach by all involved allowed the students more flexibility to try different approaches, experience varying levels of failure, and adjust accordingly. Finally, this approach allowed the team to grow and change based on the team's own perception of what worked.

In the future, we would do more to help the students structure the timeline of deliverables. Related to the timeline, we would do more to help them divide the tasks within the project and work individually. One of the early deliverables in the course was an individual demo of some aspect of the project. It quickly became apparent that they did not quite grasp the idea of an individual demo as there were multiple instances of folks working in pairs on various pieces. This was quickly corrected and the students, in the end, understood why individual responsibility was important.

The second area that we would adjust in the future is how the students develop their initial ideas for the project and what they do to understand the client and project. The instructor was a little too hands off during the project which resulted in the students initially trying to implement a project that embodied more their ideas than their clients. This resolved itself in the end, but could have been remedied earlier.

While the size of the team seemed reasonable for the task, the distribution of responsibility was somewhat artificial. The instructor moved too quickly to assign roles within the team. In the end, there was a small tension between the initial roles and the organically derived roles on the team. It would have been better to allow the team to find these organic roles on their own without the structure imposed by the instructor.

The last area is the one that really fell short. Both L&IT and the instructor were disappointed with the documentation provided by the team. If done again, both would put more emphasis on the non-code deliverables of the project and spend time working with the team on these items. In order to do this, more efficient time use would be required earlier in the project, which would likely be possible if more structure was imposed at the start.

Future Directions

Based on the teaching rotation of the ECE, it is likely that this course will be taught in the next year or two and informal discussions have identified at least one possible project for the course. For the next offering of the course, we would like to involve someone who is more knowledgeable in engineering education to help design some better evaluation instruments for the course. Additionally, we would like to make sure we assess some of the technical deliverables of the course not just the teamwork aspects. We are interested in some of the ideas

presented by Cheville and Thompson in [5], especially the system-level aspects and the individual evaluation aspects.

Conclusions

All of those involved in the experiment were pleased in both the student experience and the product. Beyond the technical aspects of the work, it exposed engineering students to an aspect of the campus that they may not have interacted with before leaving the campus. In the future, we will look for ways further collaborate and encourage others to do the same.

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