What a Smell! Lessons Learned from a Collaborative Compost Capstone

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Abstract

Faculty members, nineteen cadets (students), and employees from the physical plant at the Virginia Military Institute undertook an extensive collaborative capstone experience during the 2014/2015 academic year. The primary goal was to investigate the feasibility of and design a cost effective method for on-site composting of food waste generated in the dining hall. A secondary goal was to kick-start a new trend of living laboratory experiences that would allow cadets to work with physical plant employees in solving real world problems at the Institute while meeting requirements for a capstone experience (required for all cadets). The project culminated with a recommendation not to continue to pursue on-site composting at this time. Overall, it was a rewarding and beneficial experience for all of the faculty members and physical plant employees involved, and for most, but not all, of the cadets. This paper shares lessons learned by the faculty members and the cadets.

Keywords

Capstone, workload, brainstorming, living laboratory.

Project Overview

The core curriculum at the Virginia Military Institute (VMI) requires all students to complete two integrative experiences, a writing-intensive experience and a capstone experience.[1] The VMI Academic Regulations does not stipulate the credit hours required for either experience. However, most departments have incorporated the requirements of the capstone experience into a traditional three-credit course with departmentally specific capstone requirements. Nearly all cadets (students at VMI) take the capstone course during the final semester of their senior year.

Early in the fall semester of 2014 the sustainability coordinator, who was also a physical plant employee, proposed an interdisciplinary project to investigate the feasibility of on-site composting of all of VMI's food waste. Faculty members from four academic departments, Biology, Economics and Business, Civil & Environmental Engineering, and Mechanical Engineering, expressed interest in collaborating on the project. All agreed to use the project to help some of their senior cadets fulfill capstone requirements. Cadets were told to sign up for the project in the spring semester. The Biology department enlisted ten cadets and created a more traditional three-credit seminar course that had a single three-hour meeting time once a week. Four Civil Engineering cadets signed up for a three-credit independent research course that did

not have a specific meeting time. Four Mechanical Engineering cadets signed up for a three-hour course that met twice a week. One cadet in the Economics and Business department signed up for a three-credit independent research course that had no specific meeting time. All of the courses were used to satisfy the capstone experience.

The first challenge was finding a time that all of the cadets could meet together. Most could meet for the first hour of the scheduled Biology course, so that became the default meeting time. The project started the first week of classes in January with a field trip to the kitchen in the dining facility to see how food waste was generated. The cadets then toured potential off-Post (the campus is called Post at VMI) sites available for the composting bins and storage. The tours were followed by an introductory Composting 101 presentation that gave an overview of what is needed to properly compost food waste. The first week of the course ended with the respective faculty members giving expectations to their cadets. It became apparent that expectations varied considerable from department to department. Some departments had specific capstone requirements while others took more of an independent research approach to the capstone experience.

Cadets were then encouraged to set their own timeline and begin formulating a plan to meet their departmental expectations. The Mechanical Department took the approach that the sustainability coordinator was the client and that all questions would go to the client first. Also, the final product would be submitted to the client for approval. The clients input would have a significant impact on the final grade. The Biology Department took a more prescriptive approach, breaking the ten cadets into three groups, and assigning tasks to each group. The Civil Engineering and the Econ/Business Departments assigned goals and tasked their cadets to find ways to reach these goals.

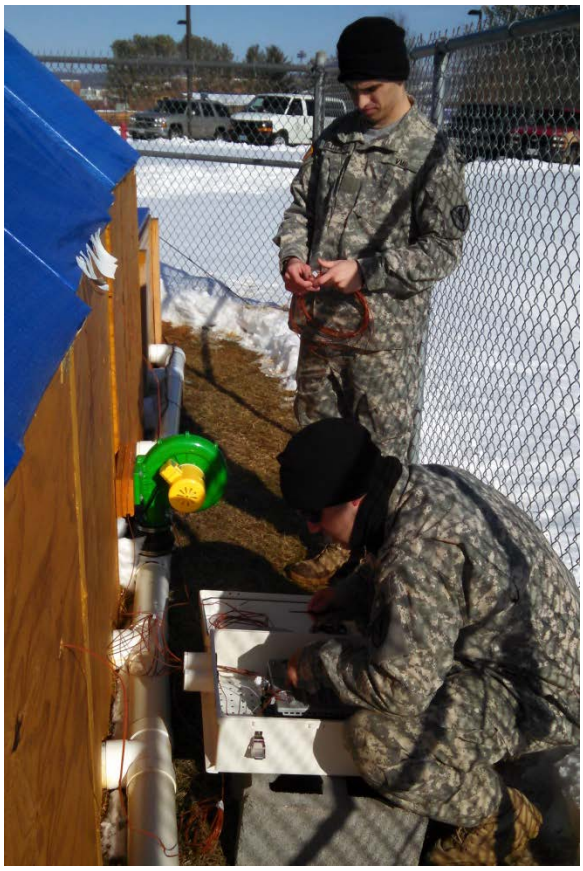
A controlled brainstorming session using the techniques outlined in Alex Osborn's Applied Imagination[2] was held during the second week of the course. The brain storming techniques used were new to many of the cadets (and some of the faculty) and allowed quite a few out-of-the-box ideas to be generated. The technique included a designated time to simply give ideas with the stipulation that no one could comment on them either positively or negatively. This one technique allowed some of the more reserved cadets to give ideas without the fear of being ridiculed. Following the meeting, the cadets worked more or less on their departmental expectations for a few weeks. A plan was formulated to compost approximately five days' worth of food waste in bins previously constructed by local high school students. In order to allow adequate time for the static phase, when the composting material is not agitated, it was determined that the bins would have to be loaded near the middle of February so that they could be unloaded just before spring break. All groups worked towards this middle of February deadline.

Pure food waste is typically not composted by itself. Instead, a bulking agent such as mulch or leaves is added to aid in the process. The Biology cadets developed ways to sample the food waste during the static phase in an effort to investigate which bulking agent helped with the composting the best. It was critical that the temperature reach a minimum level to ensure that all the coliform bacteria and other hazardous microorganisms were killed and that the compost would be safe to handle and use. The Civil Engineering cadets setup a data acquisition system to monitor the temperatures inside the compost during the active phase. Since it was decided to not

mix or rotate the compost during the static phase, it was important that air was introduced to the compost mixture. Some costs are saved by not manually mixing the material, but other costs are incurred by having to introduce air into the bins. The Mechanical Engineering cadets worked on a way to ensure air could be pumped into the compost from the bottom economically. If composting proved to be economically unviable, the idea would be scuttled. The Econ/Business cadet worked to generate realistic cost estimates of the process. The sustainability coordinator provided the food waste and the cadets loaded the recycling bins on a cold afternoon in February. Even with the cold weather, the food waste was "extremely smelly." All cadets involved in the project started to load the bins, but not all of them made it to the end of the day. Figures 1 and 2 show cadets mixing the food waste with the bulking agent and loading the bins.

Figures 1 and 2. Cadets mix the food waste with mulch (the bulking agent) and fill the three test bins in layers. The fourth bin on the left was used for a later study.

The Biology cadets came up with an innovative way to reach down into bins to take samples without disturbing the compost. Figure 3 shows the tubes that were used to reach down into the compost and the repurposed laundry bags that were used to hold and weigh the samples. The Civil Engineering cadets placed thermocouples at different levels in the compost and programmed a Campbell CR5000 data acquisition system to record temperatures both inside the compost at different levels and just outside the bins. Figure 4 shows the thermocouples being installed and Figure 5 shows the temperatures throughout the duration of the project. The bottom two records (yellow and green) show temperatures on the outside of the bins. The rest of the records show temperatures inside the compost at different levels. Note how the temperature rose around the fifth day and reached what are considered adequate levels in spite of the extremely cold weather. Sterilization of different bacteria occurs during different phases during static compositing, so there is not one temperature that has to be reached to necessarily ensure proper composting. However, a temperature of about 55 degrees Celsius (131 degrees Fahrenheit) is generally considered a minimum temperature required for effective sterilization.[3]



Figures 3 and 4. Samples stored in laundry bags and access tube to take samples. CE cadets attach thermocouples to the data acquisition system.

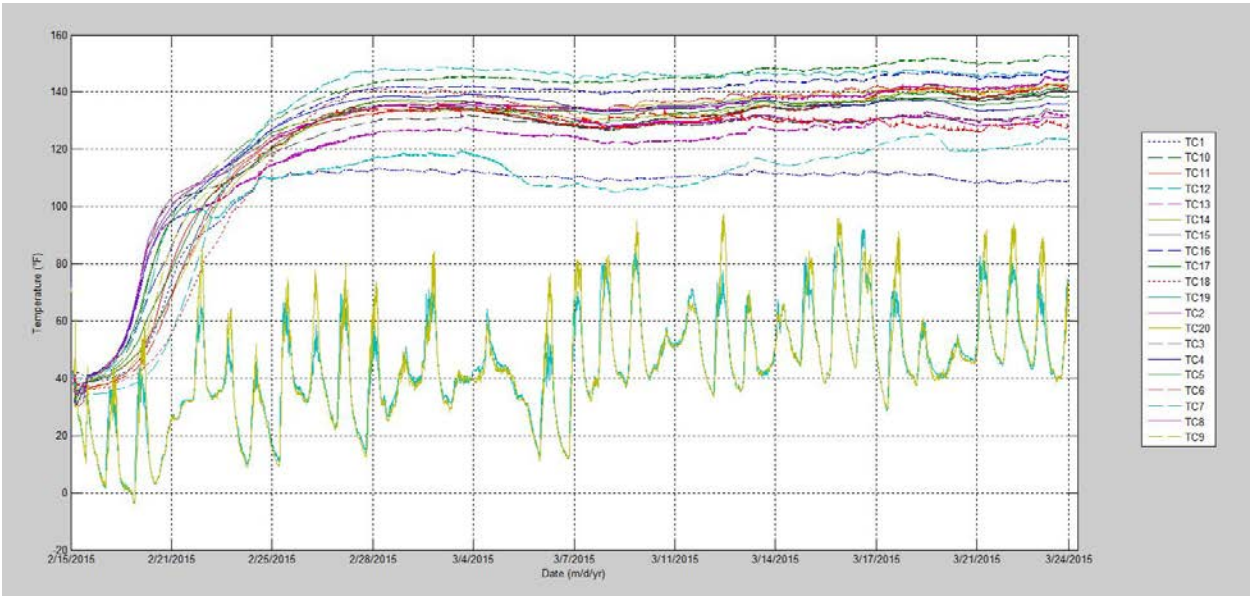


Figure 5. Temperatures in the compost and just outside the bins during the static phase.

Following the approximately five weeks of static composting in the bins, the material was removed and piled up to continue the process. Cadets in all departments continued to work on their reports and to formulate recommendations. Each department had different report requirements. Although the requirements differed, each addressed issues that each department felt were most important. Final reports were submitted to the faculty members and one final meeting of all cadets took place so that each department could present their final recommendations. End of semester evaluations were also completed. Following this meeting, the faculty members and the sustainability coordinator met with additional members of the physical plant to present the results and recommendations.

Project Benefits

Performing the collaborative project had many benefits to VMI as an institute, to the cadets, and to the faculty members. The project allowed cadets to work with cadets in different majors and to perform academic work that was outside of their normal departmental topics. The project also allowed the cadets to meet with physical plant employees and get introduced on what it required to operate the Institute. When the project was completed, one simple question was able to be answered with good certainty. Should VMI pursue on-site composting at this time? The clear answer was "No," this was not the time to pursue on-site composting. Without the information obtained and the work done by the cadets during the project the physical plant employees would not have had enough information to make that decision at that time.

The faculty wondered if the cadets felt that they had a better experience than their fellow cadets that were taking more traditional capstone courses. In order to measure this, Jones' MUSIC Model of Academic Motivation (eMpowerment, Usefulness, Success, Interest, and Caring) survey was used to gage cadet perception in the five areas noted at the end of the project.[4] The results of the survey indicated that cadets did reach high levels (4.1 and 4.6 respectively out of 6) in the areas of success and caring by the end of the project. VMI cadets are trained to be critical, and often express more criticism than positive comments when filling out surveys. Any rating that is above 50% can often be considered positive. The areas measured results to the following questions:

Success

- I was confident that I could succeed in the coursework.
- I felt that I could be successful in meeting the academic challenges in this course.
- I was capable of getting a high grade in this course.
- Throughout the course, I felt that I could be successful on the coursework.

Caring

- The instructor was available to answer my questions about the coursework.
- The instructor was willing to assist me if I needed help in the course.
- The instructor cared about how well I did in this course.
- The instructor was respectful of me.
- The instructor was friendly.
- I believe that the instructor cared about my feelings.

The interdisciplinary aspects of the project required cadets to think beyond their major. The capstone experience is one of VMI's two required integrative experiences. Clearly, cadets were not only encouraged but were required to make connections with cadets from other departments in order to get the project completed on time. This did cause some friction among the cadets at times. Working through the friction was equally valuable.

Although the project was only one semester and the timeframe was rushed, each department was able to focus on one or two pertinent research questions and ultimately be a part of high-level undergraduate research performed by the cadets. One example was the temperature measurements made by the Civil Engineering cadets as shown in Figure 5. The field work was done during one of the coldest months that Southwest Virginia has experienced in many years. The outside temperatures dropped below zero Fahrenheit a couple of nights during the static composting phase. Still, even though the bins were relatively small and not fully insulated, the internal temperatures took off and reached the minimum required temperatures. These temperature results obtained during such a cold time of year will be useful for the composting industry. Other significant undergraduate research results were also obtained. The project did provide an avenue for cadets to perform undergraduate research at an appropriate level. It also provided an opportunity for faculty members to work with cadets performing undergraduate research.

The faculty enjoyed learning from the other faculty (and from cadets in other departments). The non-engineering majors were surprised that the engineering majors required more a client driven approach to the capstone process. Both of the engineering departments required their cadets to produce reports targeted to a client, in this case, the physical plant. The engineering departments learned how the other departments used a more classroom driven approach to the capstone process, requiring cadets to meet more like a traditional class. It was useful for the faculty to share how their departments handled capstone projects. Although there is one Institute wide requirement to perform a capstone experience, it became evident that each department handled this requirement differently. The faculty members were able to take what they learned from each other and improve their own capstone courses. The faculty members also cared about the outcome of the project more compared to a capstone course that uses a fictitious project.

Project Challenges

The timeframe was the biggest challenge for the cadets. Attempting to start from scratch and complete an entire project during one semester was difficult. It took time for the cadets to figure out exactly what they needed to do. Then, they were required to make decisions about the testing phase. In hindsight, some of the decisions made were not the best decisions. However, there was not sufficient time to change the course of action. It was beneficial for the cadets to have to learn to live with their decisions, both good and bad. This does pose a problem. If someone is relying on the cadets to truly solve a real life problem, one semester often does not afford enough time to ensure that the right decisions are made. Whoever the client is has to keep this fact in mind. Ideally, such a project should take two semesters, or possibly more time. It was discussed whether or not the three credits over one semester could be broken into two 1.5 credit courses over two semesters. Although not impossible, this makes scheduling difficult at VMI where cadets are required to take physical education and ROTC courses nearly every

semester. For many cadets, there is simply not enough room in the daily schedule to take extra courses, or to schedule two courses to replace one course.

The interdisciplinary aspect of the project caused some cadets to question and challenge the amount of work expected from them when compared to the amount of work expected from cadets in other departments. Cadets started to express some aggravation and jealousy as they started to perceive that they were required to do more work than others. Faculty members handled these complaints in different ways. One approach was to try to convince the cadets that yes, you are being asked to do more than cadets in other departments. Your departmental expectations require that you do more work. This approach did not work. The cadets remained aggravated and jealous throughout the project. The better approach was to remind the cadets that yes, you may feel like you are doing more work. But, remember, there is much more work required behind the scenes to produce any product. The other cadets may be doing more work than you know about. Also, you will get out of the project what you put into it. If someone elects to be a "leaner" instead of a "lifter," that is their prerogative. Let the final grade reflect their work but don't worry about them – worry about yourself. This approach seemed to quell much of the aggravation and jealousy.

The faculty members were somewhat unequally yoked. Two of the faculty members were able to count the course towards their full teaching loads. However, some of the other faculty members were required to add the course on top of an already full teaching load for either no compensation in time, no additional pay or only a small stipend. Although the experience was rewarding in many ways, the incentive to take on a significant amount of extra work waned as the semester progressed. Why would any faculty member take on so much extra work for no or very little compensation? One reason would be to help with promotion and tenure requirements.

The living laboratory concept of incorporating day to day needs at the Institute into problems to be solved during a course was successfully accomplished. The cadets were able to both fulfill their capstone requirement and help to solve a problem by providing information to make a decision – should VMI undertake on-site composting of all of its food waste. However, a significant amount of effort was required outside of the normal classroom setting in order for the project to have been successful. First, the sustainability coordinator worked during the Fall semester preparing for the project to take place the Spring semester. The project could not have been successful without this preparation. Half of the faculty members were required to overload in order to participate in the project. An occasional overload situation is not too bad, but if the idea of requiring a living laboratory concept were to be extended to the entire student body, most faculty members would be required to overload, or additional faculty positions would have to be added. Last, some cadets did excellent work, work on par with what would be provided by an outside consultant. But, some did below average work. Can the results obtained by a cadet that is doing just the minimum to get by be utilized to make real life decisions? This is a tough question. When safety is involved the answer is clearly no. Care has to be taken using results from projects using the living laboratory approach if projects were to be offered to all cadets.

Project Conclusions

Overall the project was deemed a success. Not every cadet received a passing grade for the capstone course, but all that put in adequate effort did pass. The client (the physical plant) felt

that adequate work was performed to justify a decision. Each department had different capstone requirements but was able to meet these requirements during the semester. In all departments, the written reports may have been slightly shorter than those produced in a capstone course using a fictitious capstone project. Real problems simply take longer to address. In regards to the primary goal of determining the feasibility and design a cost effective method for on-site composting, the cadets determined that on-site composting could be achieved despite extreme weather conditions. However, a cost effective design was determined to not be feasible at this time based on comparing the proposed life cycle (capital) costs and the operation and maintenance (O&M) costs with the current costs of food waste disposal. In addition, cadets also determined that on-site composting would not be feasible based on the current Virginia Department of Environmental Quality's Solid Waste Compost Facility Permit requirements. The project was performed with a temporary permit. Applying for and receiving a full permit was found to be cost, time, and space prohibitive.

In regards to the secondary goal to start a new trend of living laboratory experiences that would allow cadets to solve real problems, the living laboratory concept was successfully used to help the physical plant employees decide whether or not to purse on-site compositing of food waste at VMI. Cadets were able to satisfy their capstone requirements by performing undergraduate research on an actual project at the Institute. However, challenges were noted that need to be addressed in order for similar projects to take place in the future. Faculty felt that the project would have been better to have taken two semesters instead of one. The sustainability coordinator was required to do a significant amount of preparatory work the semester before the project took place. Also, the faculty workload issues need to be addressed.

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