Board 113: Green Roof Rehabilitation: Creating Community in the School of Engineering

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Abstract

Green roofs are often used on buildings to manage stormwater and create green spaces. A neglected green roof on the Shiley School of Engineering building was used as a service learning opportunity and to build community. This student-led green roof rehabilitation effort over the last 2 years has included plant selection, weeding, and planting on the roof. Plants were evaluated each year for growth and drought tolerance, and a survey was given to student volunteers to evaluate the experience. During Year 1, three plots were planted with thyme, stone crop, and a sedum mix to determine which plants did best. All of the thyme died, and the sedum mix partially died off in the center. The stone crop survived and grew. Based on the results from Year 1, the thyme plot was replanted with stone crop at the beginning of Year 2. Additional stone crop and sedum mix was also planted in a different area of the green roof to evaluate location on survival and growth rates. During Year 2, several weed species covered the plots in the first location. Die off was also observed. The stone crop and sedum mix both grew and experienced less die off in the new location. Students thought working on the green roof was enjoyable, it was rewarding to make the green roof look better, they enjoyed working with all grade levels and majors, and it increased their sense of community in the Shiley School of Engineering. Most students also indicated they just wanted to help and were not working on the green roof just for extra credit or service credits. This neglected, often missed green roof was used as a learning opportunity, with the added benefit of building community and a sense of service for the students.

Introduction

Green roofs are an increasingly common green infrastructure method for decreasing runoff volume from buildings and treating runoff[1,2]. In addition to stormwater management, green roofs provide multiple ecosystem services such as reducing temperatures in urban areas, providing a wildlife corridor for birds and bees, and insulating buildings[2,34,5,6]. Green roofs can also provide green spaces for urban dwellers. These spaces provide a place to relax and socialize, and users report a greater sense of social well-being and place-attachment similar to the social benefits of conventional green spaces[7,8]. Green roofs can provide a visual relief from the urban landscape and increase the aesthetic value of the building[9]. Green roofs can be a social benefit, particularly in high-stress environments such as academic settings.

There are two types of green roofs: intensive and extensive. Intensive roofs have 15 cm (6 inches) or more of soil media and typically are planted with trees, bushes, and other plants[10]. Extensive roofs have 8-15 cm (3-6 inches) of soil media and are planted with drought-tolerant plants[10]. Both types of roofs include a waterproof barrier, a layer of soil media, and plants[10]. Sedums are most commonly used on extensive roofs due to their drought tolerance. Many green roofs, particularly in academic settings, are not regularly maintained[11,12]. Silva et al. (2015) observed a large variation in frequency and type of maintenance for green roofs, and the largest problem with green roofs was death of vegetation and establishment of weeds. Weeds typically take over green roofs that are not regularly maintained within a few years[12,13]. Although the main function of green roofs still occurs even with weeds[14], it is no longer aesthetically pleasing, and a

place people want to look at or spend time in. The condition of the green roof influences perception as a result of lack of maintenance, particularly when weedy species colonize the roof and drought/extreme temperatures lead to gaps in vegetation[8,12,15]. Green roofs on academic buildings can provide an opportunity for students to learn more about green roofs, particularly the importance of maintenance. Most traditional environmental engineering classes do not cover green infrastructure or cover it minimally, including green roofs. Typically, the focus in these classes is on conventional water and wastewater treatment. Students need to be exposed to green infrastructure, including design features, limitations, and benefits before embarking on their careers.

Green roofs also have the potential to build community within the Shiley School of Engineering, as well as promote service learning. Many universities have implemented service learning in courses, particularly in first-year introductory courses and senior capstone design courses[16,17,18]. One university has implemented a multi-year service learning program where students work on a community service project for course credit[19,20]. Service learning can also be implemented on a volunteer basis through student organizations[21], which relies on students' innate desire to help improve communities[22] instead of as a requirement for a course. Studies have shown that service learning benefits retention, community service after graduation, and civic responsibility[23], has a positive impact on tolerance, personal development, and college connections[24], attracts underrepresented groups through community-based projects[18,25], and can help create leaders in engineering[26]. Service learning can also create a deeper understanding of the subject matter[24]. Helping maintain the green roof can provide benefits to students that may not occur in a typical classroom setting.

This paper presents the green roof rehabilitation efforts over the last 2 years, and how it has created community in the Shiley School of Engineering at University of Portland. Although not a formal service learning project tied to a class or student organization, this student-led project had similar outcomes to more formal service-learning projects. Students were involved in plant selection, weeding, and planting on the roof. Plants were evaluated each year for growth and drought tolerance, and a survey was given to student volunteers to provide feedback on their experience.

Green Roof at the Shiley School of Engineering Building

The 256 m^2 Shiley Hall green roof was installed in 2009 as part of a building renovation project. Funded by a grant from the City of Portland, the green roof is an extensive roof with an average soil thickness of 8.0 cm[14]. The green roof was installed in vegetated mats with a substrate of nylon mesh to hold the growing media and several types of sedum. Many of the sedums died and several weed species have become established. The remaining sedum types are *Sedum Album* (White Stonecrop) and *Sedum Reflexum* (Blue Stonecrop), and are mostly on the edges of the green roof (Figure 1). Additional details on the green roof can be found in Okita et al. (2018) and are summarized in Table 1.

Figure 1. Shiley Hall Green Roof

Table 1. Shiley School of Engineering Building Green Roof Characteristics

Location	Year Installed	Area (m^2)	Average Soil Thickness (cm)	Soil Type	Plant Type
Shiley Hall, University of Portland	2009	255.5	8.0	Loamy Sand	*Sedum Album, Sedum Reflexum*

The green roof is accessed through an Electrical Engineering laboratory, and is only viewable through windows in the staircase between the 2nd and 3rd floors of the building. Access is limited to faculty and staff, as well as students who have special permission. Students typically only have access to the roof if they are doing research related to the green roof, have a capstone project on the green roof, or are on a tour led by faculty.

Rehabilitation Plan

During the first year, three 3m x 3m square plots with different types of plants were planted. Students chose an area of the green roof next to the windows, which is the most viewable part of the green roof from inside the building. The sun can be very intense in this area during the summer months, particularly with the reflection from the windows. Three different types of

plants/plant mixtures were planted to determine which plants thrived in this area: stone crop, a sedum mix, and thyme. Stone crop is the common term for sedums and was used in this study to differentiate from the sedum mix. The different types of plants included in the stone crop and sedum mix plots are listed in Table 2. Doone Valley thyme (*Thymus doerfleri*) was selected for the thyme plot. Both the stone crop and thyme were in 8.9-cm (3.5-inch) pots, and the sedum mix came in 25.4-cm (10-inch) square pots. Students selected the thyme because it is drought tolerant, and the stone crop because these plants are commonly used on green roofs. The sedum mix was a mix of plants selected by the nursery specifically for green roofs. Figure 2 shows the planting during Year 1. Stone crop is on the left, sedum mix in the middle, and thyme on the right.

Table 2. Stone Crop and Sedum Mix Plant Types

Stone Crop Plants	Sedum Mix Plants
Sedum reflexum	*Sedum reflexum*
Sedum album	*Sedum album*
Sedum ochroleucum	*Sedum divergens*
Sedum pluricaule	*Sedum lineare*
Sedum hybrida	*Sedum sexangular*
Sedum makinoi	*Sedum kamschaticum*
	Sedum rupestre
	Sedum spurium
	Sedum confusum
	Sedum acre
	Sedum lineare
	Sdum floriferum

Figure 2. Planting on Green Roof during Year 1 (stone crop on the left, sedum mix in the middle, thyme on the right)

During year 2, we planted 2 3m x 3m square plots on the opposite side of the green roof, which is shaded during the hottest part of the day, and replaced the 3m x 3m plot of thyme (which all died) in the original planting location with stone crop (Figure 3). The new location currently has some sedum plants along the edge of the green roof, but there are still large gaps in vegetation. One 3m x 3m plot was planted with the sedum mix and the other 3m x 3m plot was planted with stone crop in the new location (Figure 4). Instead of planting in a grid similar to year 1, students attempted to plant a pattern in the new location, which will become more apparent when the plants fill in.

Figure 3. Replacement of Thyme with Stone Crop (Year 2)

Figure 4. New Planting on Green Roof during Year 2 (sedum mix on the left, stone crop on the right)

New plants were irrigated at least once per week during summer 2022 and 2023. Plants were evaluated and measured each year to help plan for the following year and determine the optimal plant mix. We plan to continue replanting the roof and removing weeds until the entire green roof is rehabilitated.

Community Efforts

As part of the Introduction to Environmental Engineering class, civil engineering students tour the green roof and discuss maintenance issues with the green roof. Discussions of possibly creating a group to work on the green roof has occurred during these tours. These discussions continued beyond the tour with students in other disciplines, which increased interest within the Shiley School of Engineering. However, it wasn't until a mechanical engineering student approached a faculty member about cleaning up the green roof that plans for gardening work parties were developed and implemented.

The green roof rehabilitation was a grass roots effort led by students to remove weeds and plant new plants. Students leading the effort advertised the green roof gardening work parties in engineering classes, put up signs, recruited classmates, and created an online signup sheet. To encourage participation, first-year students were given credit for service as part of the requirements of the introductory engineering course and extra credit (5 pts) was offered in the environmental engineering class.

In 2022 and 2023, there was a weeding party and a planting party one month apart. During the weeding party, students selected a planting area and cleared this area of weeds. Students worked with a faculty member to select and purchase plants from a local nursery, which were planted in the cleared area during the planting party. Additional weeds were cleared during the planting

party. During both weeding and planting parties, the faculty member taught students about the function of the green roof and the issues caused by lack of maintenance. Planting techniques were also taught during the planting party.

Community Building Assessment. To assess whether these activities helped build community, students were asked the reason for coming during both years. A survey was given during year 2, which included the following declarative statements:

1. Working on the Green Roof was enjoyable
2. It was rewarding to make the Green Roof look better
3. I only helped with the Green Roof to get service credits/extra credit for a class
4. I appreciated interacting with all majors at all grade levels
5. Working on the Green Roof increased my sense of community in the School of Engineering

Students were given varying degrees of agreement or disagreement on a Likert scale, and asked to select which best represented their opinion:

5	Strongly Agree
4	Somewhat Agree
3	Neutral
2	Somewhat Disagree
1	Strongly Disagree

Results and Discussion

Rehabilitation. The students' efforts have had mixed results on the green roof. During Year 1, the thyme grew 14-100% before dying in October during an unseasonably hot period (Figure 5). Several weed species have replaced the thyme in this plot. The sedum mix grew 30-110%, but there was die off in the center of the plants (Figure 5). Die off ranged from 60-90% of the plant. Although some weed species reestablished in this plot, the plantings are still visible. All stone crop plants stayed alive and grew 71-243% (Figure 6). As can be seen in the photo, several weed species have been reestablished in the area, but the stone crop had significant growth and none of the plants died. There was a small amount of die off (10-50%), but many of the plants were fully alive and thriving.

Figure 5. Thyme Planting (left) and Sedum Mix Planting (right) after 1 year.

Figure 6. Stone Crop Planting after 1 Year.

Based on the results from Year 1, students decided to re-plant the thyme plot with stone crop. They also chose a different location on the roof to evaluate whether location on the roof impacts plant growth and survival rates. This new area was planted with the sedum mix and stone crop.

During Year 2, the stone crop that replaced the thyme was choked with weeds. The one plant that was identifiable in this plot grew 186% (Figure 7). The plot with sedum mix grew an additional 14-108% (Figure 8). Several weed species were present and die off increased 15% between Years 1 and 2. However, it appears that some of the sedum is spreading beyond this plot, indicating the plant is propagating. The plot with the stone crop grew 12-133%, although there was some die off and several weeds (Figure 8). This indicates more effort into maintenance, including clearing weeds and additional irrigation, is needed in this location.

Figure 7. Stone Crop Planting that Replaced the Thyme after 1 year.

Figure 8. Sedum Mix Planting (left) and Stone Crop Planting (right) after 2 years.

For the second planting location, the sedum mix grew 50-80% (Figure 9). Although this is not as much growth compared to the first location, there was significantly less die off. There was 0-30% die off in this plot. The stone crop grew 43-157% (Figure 9). Two plants died and 2 plants experienced 30% die off, but the rest of the plants were fully alive. It appears the plants are less stressed during the dry, warm months in the new location compared to the original location.

Figure 9. Sedum Mix Planting (left) and Stone Crop Planting (right) in New Location after 1 year.

As a result of the green roof rehabilitation, students learned planting techniques, how green roofs worked, and the importance of plant selection and maintenance. They also were able to observe how location can impact plant growth and survival rates. This hands-on activity provided an opportunity for students to understand design features, limitations, and benefits of green roofs, a common green infrastructure method for rainwater management.

Community. The green roof work party appeared to help build community and create comradery with students. During year 1, 19 students participated in the weeding party, and 15 students participated in the planting party. During year 2, 9 students participated in the weeding party and 13 students participated in the planting party. The lower participation in the weeding party during year 2 could be due to the weather; it was cold and rainy that day. Only 3 students participated for service credit during Year 1 and 1 student participated for extra credit during Year 2. The main reasons for participating was for fun and because they liked gardening. Students from civil engineering, mechanical engineering, electrical engineering, and non-engineering majors participated both years.

The survey was given to students during the Year 2 planting party. Eight of the 13 participants completed the survey. The volunteers who completed the survey during the Year 2 planting party all agreed that the work parties gave them a sense of community and belonging, and that it was enjoyable (Figure 10). They all appreciated interacting with all engineering majors at all grade levels.

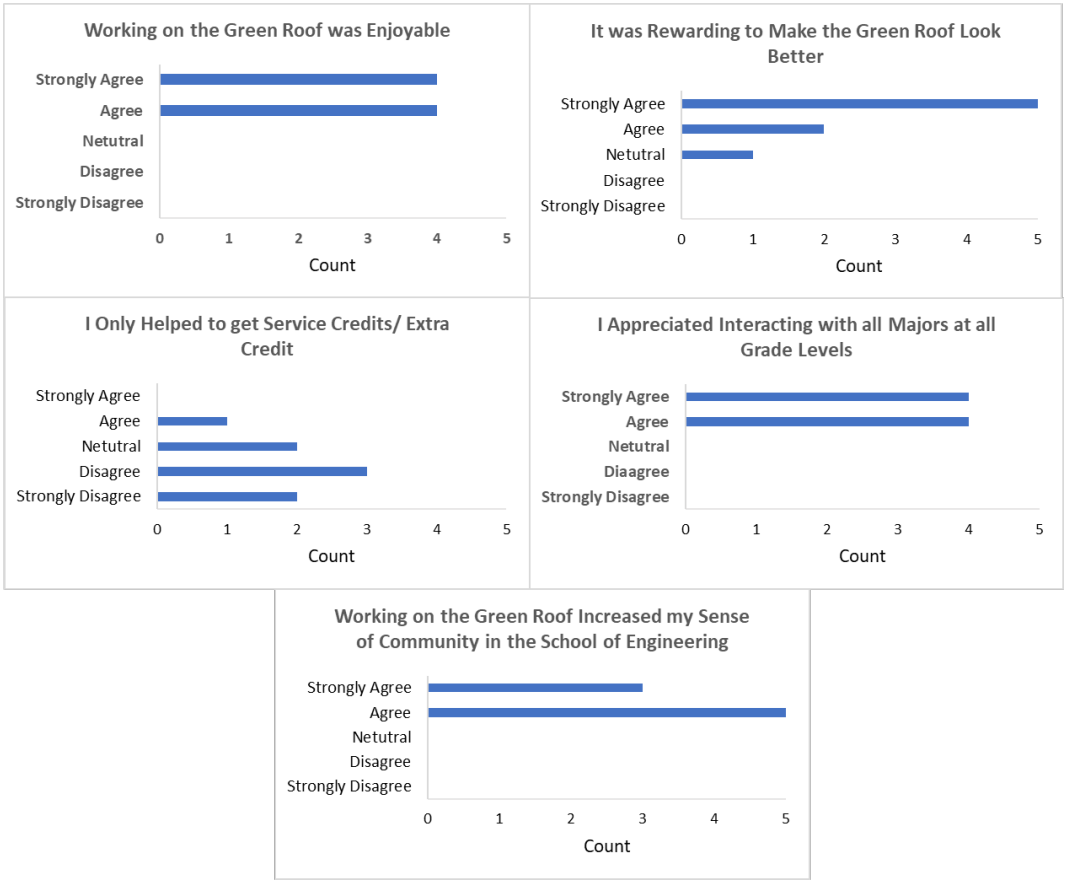

Figure 10. Student Responses to Survey.

Table 3 shows the average answer based on the Likert scale. Average responses were 4.5 for questions 1, 2, and 4 and 4.4 for question 5, indicating students agreed with these statements. The general sense from the faculty member helping the students was that students really enjoyed helping, and that it gave them a better sense of community. Many students that would not normally interact due to different grade levels or majors were talking and working together. For instance, a group of first-year students worked with a group of juniors during the planting party while discussing upper level engineering courses, and a group of non-engineering majors introduced themselves to a group of civil engineering majors and worked side by side. This was a great opportunity to help students feel more connected to the Shiley School of Engineering. Average responses for question 3, regarding helping only for service credits or extra credit, was 2.2. Only one student agreed with the statement that they only helped for credit. The remaining students were neutral, disagreed, or strongly disagreed with the statement, which indicates most students were voluntarily helping. Discussions with the faculty member during the work parties indicated students were helping because they liked gardening, enjoyed doing activities outside, or just enjoyed being on the green roof.

Table 3. Average Student Responses to Survey.

Questions	Average Answer
1. Working on the Green Roof was enjoyable	4.5
2. It was rewarding to make the Green Roof look better	4.5
3. I only helped with the Green Roof to get service credits/extra credit for a class	2.2
4. I appreciated interacting with all majors at all grade levels	4.5
5. Working on the Green Roof increased my sense of community in the School of Engineering	4.4

The Shiley School of Engineering plans to continue the weeding and planting parties until the entire green roof is reestablished and the majority of the weeds are removed. To improve upon the community-building and learning opportunities with the green roof, next steps include making the green roof accessible to all students. Currently, only faculty members and research/capstone students with special permission can access the green roof. If the green roof were more accessible, students could regularly pull weeds and ensure the recent plantings had sufficient water. Students could also enjoy the social emotional benefits of spending time on the green roof.

Conclusions

The green roof rehabilitation efforts over the last 2 years has helped create community as well as allowed students to learn about green infrastructure in a hands-on way. This is particularly important considering the maintenance issues of green roofs, which would not typically be taught in a classroom setting. Students learned about optimum plant selection and how green roofs worked. There was a clear appreciation of working on the green roof and making it look better. Increased access can enable students to pull weeds more than once per year which would be an improvement from the current annual maintenance. This neglected, often missed green roof was used as a learning opportunity, with the added benefit of building community and a sense of service for the students.

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