

## Greening the campus through research-to-practice: A case study in experiential education

**Pamela-Jean N. Driza**

University of Florida

**Maruja Torres-Antonini**

University of Florida

**Abstract:** In order to state their commitment to sustainability, colleges and universities across the United States are signing environmental charters which emphasize the importance of incorporating environmental issues into education, research, operations, and outreach. As a signatory of several charters, the University of Florida (UF) has taken a particular interest in greening their student housing and has made considerable progress in retrofitting a housing stock over 100 years old. However, despite the implementation of sustainable practices throughout their residence buildings the university has continued to identify areas needing further improvement. As participants in the U.S. Green Building Council's (USGBC) Research to Practice (R2P2) program, which aims to engage the educational community in a variety of on-campus research, a team of UF students and faculty utilized the opportunity to investigate obstacles faced in enhancing student housing performance. This case study reports on the pedagogy used by this team to assess the efficacy of applicable sustainable strategies and the environmentally significant behaviors of residents within three residence halls. This pedagogy aimed to first, involve students in project-based learning (PBL); and second, to provide a service to the university by contributing to its efforts to green the campus. Findings of this study illustrated a number of methods for improving building performance. Additionally, as pedagogy, PBL was found in this study to set the stage for acquisition of *Gestaltungskompetenz*—the organizational, participatory, collaborative, interdisciplinary, and reflection competencies necessary for sustainable development. However, while these findings offer great promise for improving sustainable practices and education, more focused research is needed to explore the challenges and opportunities of their application. Therefore, this study is an invitation to further our exploratory research and continue the discovery of applications for the PBL model in sustainability education.

**Keywords:** Sustainability education; project-based learning; *Gestaltungskompetenz*; building performance; student housing

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*Pamela-Jean N. Driza is a licensed interior designer, LEED AP BD+C, and Ph.D. candidate at the University of Florida. Her dissertation research centers on environmentally significant behavior within buildings and enhancing predictions of resource consumption in LEED-certified buildings.*

*Maruja Torres-Antonini, PhD, LEED AP is associate professor of Interior Design and affiliate faculty in the Sustainability in the Built Environment program at the University of Florida. Her research, publications and outreach focus on sustainable design and construction, and education for sustainable development.*

## EFFORTS TO SUSTAINABLY CONSTRUCT CAMPUS BUILDINGS

In order to state their commitment to sustainability, colleges and universities across the United States are signing environmental charters such as the Talloires Declaration, the first official statement made by academic administrators to incorporate environmental issues into their teaching, research, operations, and outreach. Over 280 institutions have additionally signed the American College and University Presidents' Climate Commitment (ACUPCC), which recognizes the need to reduce 80% of global greenhouse gas production by the mid-century. To reach this goal, its signatories commit to model ways to minimize global warming emissions, provide the research needed to achieve climate neutrality, and to make that knowledge widely available [1].

The University of Florida (UF) is a signatory of both environmental charters. Its Department of Housing and Residence Education (DHRE) in particular has made considerable progress in imbedding sustainable features into their residence halls. The DHRE represents 2,832,599 square feet of constructed building space or approximately 3% of UF's 2,000-acre campus. Its efforts to sustainably construct campus residence buildings over the last ten years have led to the registration of buildings with the US Green Building Council's (USGBC) LEED 2.0 and successive rating systems as well as the greening of a housing stock over 100 years old. To date the UF campus features 21 LEED ranked buildings including 1 Platinum, 17 Gold, 3 Silver, and 10 Certified, as well as 22 other buildings pending certification. Additionally, UF is one of 40 national companies and institutions piloting the LEED Portfolio Program through which it aims to certify 32 facilities under the Existing Buildings Operations and Maintenance System [1]. Retrofit measures in campus residences have included widespread conversion to compact fluorescent lamps; installation of low-flow water fixtures; upgrade of central heating, ventilation and air-conditioning systems (HVAC), and planting of drought tolerant Bahia grass [1]. Additionally, educational programming offered by the housing administration, such as the annual week-long energy and water reduction "EcoChallenge", complement these upgrades [1]. However, the university still continues to identify areas needing further improvement.

Supporting these and similar "greening of the campus" initiatives across the nation, in the fall of 2011 the USGBC's Center for Green Schools issued a call to participate in their emerging Research to Practice (R2P2) program, which aims to engage the higher education community in detailed research on a variety of on-campus green building topics [1]. Student teams were challenged to transfer project-based knowledge to practice by developing replicable research and educational tools that could be shared world-wide through the USGBC's website. UF was one of thirty-eight international collegiate teams that piloted the program, utilizing the opportunity to establish a multi-disciplinary team to investigate obstacles the DHRE faced in optimizing the overall performance of their student housing. Out of the 24 undergraduate residence halls on UF's campus, the study focused on the three collectively referred to as the Yulee Residence Area—Mallory, Reid, and Yulee Halls—which represented the extent of the DHRE's sustainable efforts.

The purpose of this case study is to report on the pedagogy used by this team to assess the efficacy of applicable sustainable strategies and the environmentally significant behaviors of residents within each hall. This pedagogy aimed to first, involve students in project-based, experiential learning; and second, to provide a service to the University of Florida DHRE by contributing to its efforts to green the campus.

## A CASE STUDY IN EXPERIENTIAL EDUCATION

The multidisciplinary team presented in this case study consisted of 25 students, two instructors, and three administrative departments. Undergraduate and graduate students majoring in five different subject areas—Architecture, Art History, Landscape Architecture, Liberal Arts and Sciences, and Sustainability in the Built Environment (SBE)—integrated for this project. The large majority of these students were enrolled in the DCP 3210 Sustainable Solutions in the Built Environment course, which overviews a sampling of issues in the planning, design, construction, and operation of the built environment. An Interior Design Ph.D. student contributed instruction and assumed the role of project leader.

The pedagogical method was anchored on a project-based learning (PBL) framework. PBL is an instructional approach built upon authentic learning activities that engage student interest and provoke students to encounter and struggle with the central concepts and principles of a discipline [2]. PBL is generally conducted by groups of students who work together toward a common goal. Performance is assessed on an individual basis and considers the quality of the final product, the depth of content understanding demonstrated, and the student's contribution toward the project's realization [2].

In addition to fostering learning of work skills increasingly valued in the 21<sup>st</sup> century, such as communication and time management, PBL pedagogy facilitates development of additional work competencies in research and inquiry, group participation and leadership, and self-assessment and reflection.

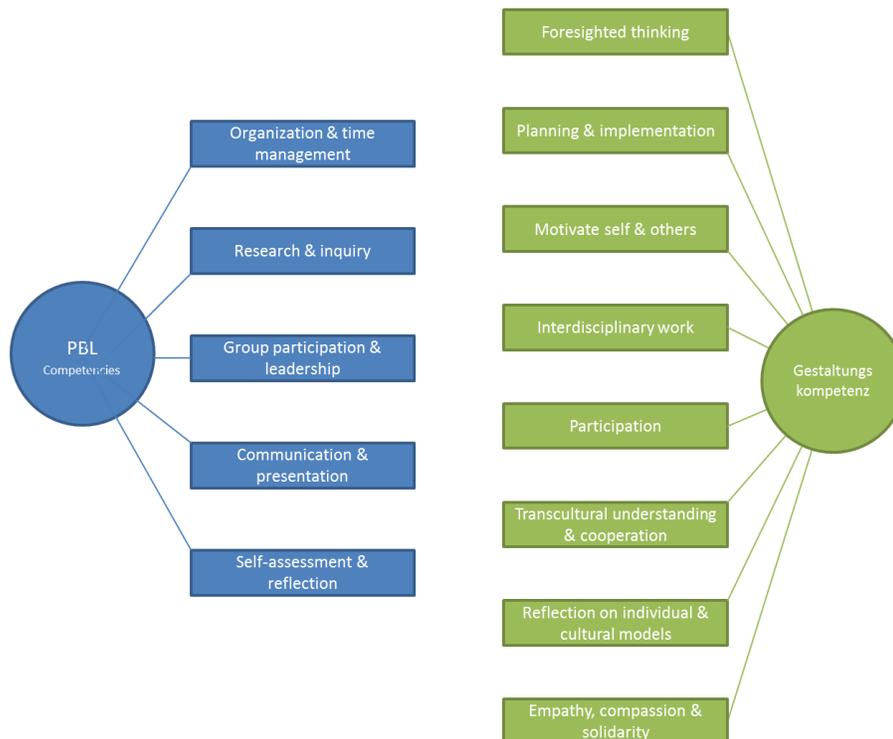


Figure 1. Competencies associated to the Project-Based Learning model and the *Gestaltungskompetenz* concept. Adapted from Buck Institute for Education, 2012; Barth, Godemann, Rieckmann & Stoltenberg, 2007.

As illustrated in Figure 1, these competencies closely align with those entailed by the

*Gestaltungskompetenz* concept [3] established in German schools under a federal program for sustainability education. The notion encompasses a set of key proficiencies expected to enable active participation of the citizenry in sustainable development: abilities for foresighted thinking; interdisciplinary work; transcultural understanding and cooperation; participatory skills; planning and implementation skills; capacity for empathy, compassion and solidarity; ability to motivate self and others; and ability to reflect on individual and cultural models. Alignment between the two models stems from the identification of organizational, participatory, collaborative, interdisciplinary, and reflection competencies as being facilitated through PBL and acknowledged in the *Gestaltungskompetenz* as essential to preparation for sustainable development. A number of studies have described the positive changes in student motivation, attitude toward learning, and critical thinking skills that result from participating in PBL [4, 5, 6]. Additionally, such real-world learning opportunities are seen as increasing student's understanding of sustainability issues and application of related problem-solving approaches [7]. This supports the frequent mention of PBL as a key strategy for sustainability education.

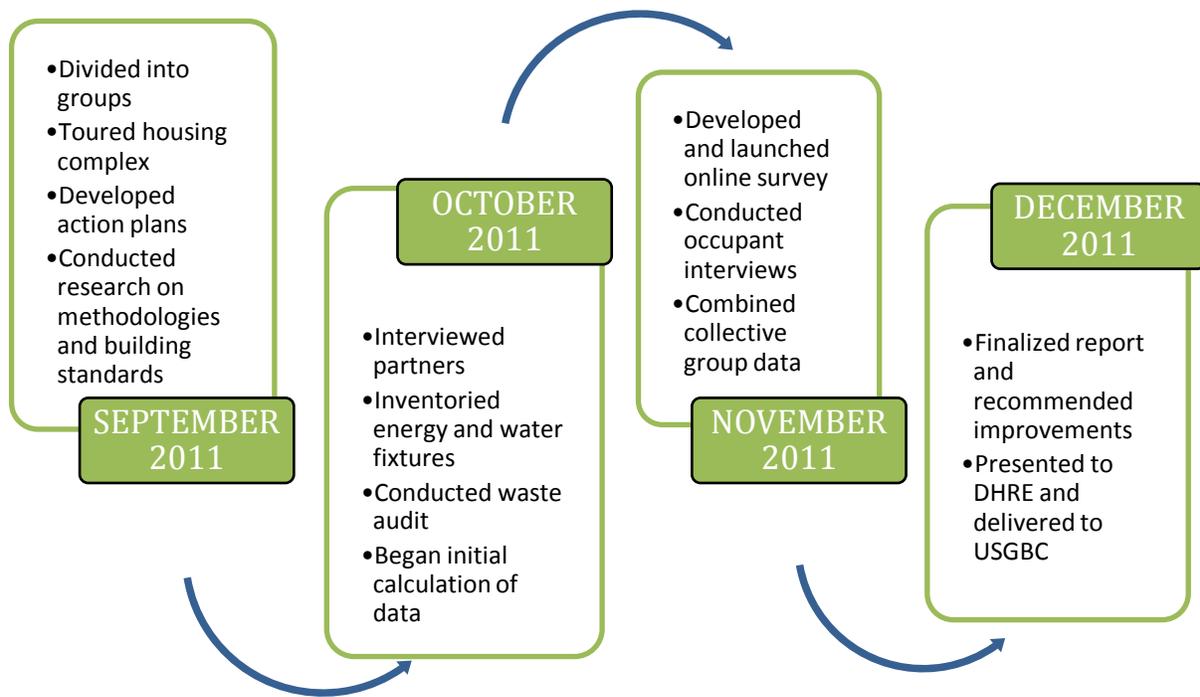


Figure 2. Integrated Approach Timeline

## THE STUDY

Students were divided into groups and tasked to evaluate the energy use, water consumption, waste generation, and related resident behaviors within the Yulee Residential Area. In order to successfully assess each residence hall's sustainable attributes and occupant behaviors, students were expected to establish partnerships with the DHRE as well as with the UF Office of Sustainability and Division of Facilities Planning and Construction. Each group needed to develop an action plan appropriate for their assigned topic area and manage their time to meet weekly project deliverables. Additionally, students leveraged their study of industry standards to develop a methodology for assessing the performance of each residence hall and use

their understanding of environmental behavior theories to assess occupant behaviors within the halls. Finally, groups collaborated to prepare a cohesive document that recorded the overall research process and findings. This final document was formally presented to DHRE and later delivered to the USGBC for dissemination as a resource on their website. Figure 2 illustrates the steps taken by the DCP 3210 course.

**Setting.** The Yulee Residence Area is located on the east side of the UF campus. The buildings are each within a half mile of a popular campus dining facility and just a few blocks from the Downtown district [1]. The location is served by several public bus routes, which connect to key destinations throughout the city. Although these buildings were originally constructed in the 1950's, each has recently undergone extensive renovations to introduce energy-saving HVAC systems, insulated windows, recycled content countertops, and automatic light sensors. The Yulee Residence Area houses approximately 518 students of whom 64% are first-year undergraduates and the remaining 36% are upperclassmen. Of the 271 rooms in the complex, 59% are double occupancy rooms, 14% are single occupancy, and the remainder is triple occupancy rooms. Unique to this area is the Global Living Learning Community, a residence-based co-curricular program which facilitates residents' exploration of a sustainable and environmentally conscious lifestyle. [1].

**Method.** This study was conducted in two phases. Throughout Phase I groups worked with each other and their institutional contacts to complete their assigned tasks. Groups utilized mixed methods to collect data relative to their respective topic areas and then compared their findings to industry standards and the goals established by UF administration. For example, the Energy group conducted an equipment inventory, collected four years of consumption data, and used Energy Star Portfolio, an interactive energy tracking tool, to assess the performance of newly installed energy saving features within the Yulee Residential Area. Similarly, the Water group assessed the water performance for each building by conducting an equipment inventory, collecting four years of consumption data, and estimating water use with the USGBC's LEED water calculator. Finally, to understand the inputs, uses, and waste outputs of the Yulee Residence Area, the Waste group audited samples of the residents' refuse.

During Phase II the study focused on the environmentally significant behavior of residents within the Yulee Area as they related to energy, water and waste. Data collected in phase I was used to guide the creation of an online survey, which gauged the residents' consumption of resources, generation of waste, perception of obstacles to behaving sustainably, and knowledge of sustainable features and practices. The survey was distributed to all 518 residents in the Yulee Residence Area and completed by 100 students for an approximate 20 percent response rate. Finally, the student groups worked together to triangulate findings from both phases and highlight challenges and opportunities offered by the Yulee Area building features, environmental education programming, and implemented sustainable strategies.

**Findings.** Upon the completion of data collection, the student groups were required to consolidate, compare and interpret their collected findings. The triangulation of information from the DCP 3210 class verified that many of the innovations, incentives, and practices implemented in the Yulee Residential Area positively contributed towards overall sustainability goals. However, as illustrated in Table 1, the analysis also revealed a number of trends that currently impact overall building performance and could be further improved to reduce the energy use, water consumption, and waste generation within each hall. Among others these included the expansion of existing environmental cues, continued installation of low-flow water fixtures, and reducing obstacles for recycling.

Research to Practice Findings	
<i>Student findings and related recommendations [1]</i>	
<i>Energy Consumption and Related Occupant Behaviors</i>	<p>On average, 83% of the residents indicated that they turned off the lights when they left an unoccupied room. This suggested that the DHRE's education and environmental cues contributed towards energy conservation efforts. However, an average 45% of residents responded that they left electronics plugged in when not in use. Therefore, it is recommended that similar cues be posted in order to educate residents about the negative impacts of "phantom loads".</p> <p>Despite being 1,000 square feet smaller, having fewer rooms, and having less air- conditioned/ heated spaces per floor than the other two halls, Reid Hall has consumed the most energy since 2007. This may suggest a number of issues, including the need for further updates to the building construction, student education, or continued incentives for resident participation. Further research would be required in order to determine the most effective path of action.</p> <p>An average 46% of students indicated that they did not conserve energy more regularly because they were not habituated to doing so. In order to reach these remaining occupants the DHRE may assign community leaders for each residence floor. "As suggested by social scientists, users are most likely to change their behavior in response to direct appeals from others". Therefore, these leaders could help monitor resident behaviors and provide an example for those who are unfamiliar with energy conserving practices.</p>
<i>Water Consumption and Related Occupant Behaviors</i>	<p>The DHRE's impact on the resident consumption of water was evident by the 77% response rate of students who consciously turned off the water while brushing their teeth. However, while acknowledging this success, it was noted that the Yulee area did not utilize low-flow water technologies or a gray water system. By student estimates these strategies could save approximately 3.37 million gallons of water within the Yulee Area on an annual basis.</p> <p>Despite the DHRE's installation of 5-minute shower timers an average 41% of residents indicated that they took 6-10 minute showers. This is twice as long as recommended by the EPA and suggests that additional efforts would be required to reduce the consumption of water in this particular area.</p> <p>An average 42% of residents indicated that they did not conserve water more regularly because they were not habituated to doing so. In order to reach these remaining students a legacy project, or a project that is handed down from one semester to another, may be initiated and maintained in the Yulee Area. This project will give all of the residents a chance to make a positive change to the Yulee Area and be a continuous reminder of water conservation.</p>
<i>Waste Generation and Related Occupant Behaviors</i>	<p>On average 42% of residents indicated that they made an effort to divert waste from landfills by either recycling or reusing consumer products. However, findings of the waste audit indicated that 62% of the items in landfill-bound garbage cans were either recyclable (29%) or compostable (33%). Thus, in order to combat the suggested confusion with recyclables, it is recommended that clear and consistent instructions be provided near landfill-bound receptacles. Additionally, a comprehensive and accessible composting program may also be a method to mitigate waste generation.</p> <p>On average 55% of residents did not recycle more regularly because the bins were inconveniently located. For example, it was noted that trashcans were located in every dorm room, however, recycling bins were only located in the common kitchen areas. To reach these occupants it may be beneficial to locate larger recycling bins within their dorm rooms.</p> <p>An average 25% of residents indicated that they did not recycle more regularly because they were not habituated to doing so. Thus, it may be beneficial to obtaining and displaying written commitments indicating that each resident will do their part to recycle their waste.</p>

Table 1. Research to Practice study findings

## THE EDUCATIONAL EXPERIENCE

As expected, the PBL approach delivered a rich and powerful experience for all participants. A student qualified this experience by stating, “each person educated through this process (whether student, resident, analyst, maintenance or installation staff) takes with them the [ability] to apply sustainable practices for the rest of their lives” [8]. Throughout this process students gained firsthand experience in collecting data, building collegiate partnerships, and had to think critically about their interpretation and communication of findings. Student groups had to face the realities of collecting institutional data and thus became resourceful in extracting information that is not usually made available to the public. The strength of the learning experience stemmed from its being based in reality and thus presenting the challenges students can expect to confront in the work environment. Ultimately, by utilizing the PBL framework students were able to reflect upon their own ideas and opinions, exercise voice and choice, and make decisions that affected the project outcomes as described below.

**Developing competencies.** Throughout the progression of the R2P2 project, observations, institutional partner statements, and final reflections provided by student groups revealed their acquisition of key competencies (see Table 2). For example, organizational skills were evidenced by the student groups (Organization and Time Management and Planning and Implementation competencies). Soon after the introduction to this project student groups created action plans, which described the anticipated steps for investigating each of their assigned topic areas. The Energy group successfully outlined a process for touring the buildings in the Yulee Residence Area, cataloging existing energy conserving features, and interviewing residence personnel about their use by occupants. Similarly, the Waste group prepared a detailed plan for understanding city and campus waste collection practices and then executing a residence hall waste audit within the allotted timeframe of the project. Throughout the R2P2 project, students were systematic in their intended process and purposeful in making timely decisions.

All along this real-world learning opportunity students needed to negotiate, apply, and critically reflect on concepts and methods for assessing sustainable strategies. Although some instructor guidance was initially necessary to ensure the overall development of the project, the individuals in each group were self-motivated and ultimately responsible for driving their respective research efforts (Motivate Self and Others competencies). Thus, as each component of the project began to unfold, the class as a whole was challenged to analyze and solve unexpected obstacles, tapping on the Foresighted Thinking as well as Research and Inquiry competencies. For instance, as the project developed the Water group’s planned strategy for assessing water consumption was refined as a result of their continued investigation of building performance literature. From then on the Water group began to leverage newfound knowledge to anticipate and circumvent future difficulties in their study methodologies. As another example, prior to selecting a method for assessing the sustainable strategies in each building, students referred to industry standards and identified successful instruments, such as the Energy Star Portfolio. Also, after visiting the local waste management center, the Waste group gained thorough understanding of the local requirements for the processing of recyclables. This information enabled them to successfully audit the waste outputs of each residence hall and distinguish items that had been improperly recycled or else misidentified as landfill-bound waste.

The success of their R2P2 project largely rested on the students’ ability to collaborate with an interdisciplinary group of peers and collegiate partners. Student groups were assigned at the onset of the study and individuals embraced these partnerships through to the completion of the program (Participation competencies). During the research process, team leaders began to

emerge within topic groups and were observed organizing activities that exploited the strengths of each team member (Participation and Leadership competencies). Just as important was the relationship that students built with the numerous stakeholders of the project. Although the collaboration between student groups and institutional administrators was at times hampered by conflicting schedules, all of the student groups recognized the importance of nurturing and maintaining these contacts throughout the research project (Interdisciplinary Work competencies).

Finally, it was essential that students learned to critically analyze and consider each of the steps they included in their action plans. Each group’s continuous assessment of the methods used to accomplish their assignment, and their apparent efficacy, enabled them to refine their process throughout the completion of the project (Self-Assessment as well as Reflection competencies). This level of consideration allowed each team to make significant progress and discoveries within their assigned topic areas. As illustrated in Table 1, this included resident’s impacts on energy consumption by way of phantom loads or impacts on recycling rates due to unfamiliarity with local recycling guidelines. When making decisions about final recommendations for the DHRE, students compared and integrated quantitative and qualitative data related to building consumption rates, observations and occupant survey responses. As a result, student teams were able to suggest solutions that specifically responded to the social norms within the Yulee Area (Reflection on Individual and Cultural Models competencies). For example, utilizing a social marketing technique by assigning community leaders for each residence floor. These leaders would help monitor resident behaviors and act as a constant example for those who are unfamiliar with conservation practices [8].

Student reflection on the learning outcomes of the experience		
PBL [2]	Gestalt. [3]	Reflections on student learning outcomes [8]
Comm. and Present.		“The Research to Development project served as an educational tool to those who participated in creating the report in that it required communication and critical thinking skills in order to acquire and make sense of data.” – female, undergraduate, SBE major, Energy group
Organization and Time Management	Planning and Implementation	<p>“[To analyze energy consumption] our group took a building tour, an inventory of fixtures (such as sensor-activated lights and double-paned windows) was conducted, and observations regarding available day lighting opportunities were made. [Additionally,] questions were also posed to the RA regarding lighting, HVAC, resident behavior, appliances, and other accessories to electrical consumption in the building”. – female, undergraduate, SBE major, Energy</p> <p>“To understand the sustainable behaviors of a population it [was] necessary to look at inputs, usages, and waste. While planning the waste audit, we began to understand what a huge undertaking it would be to account for 100% of the waste generated by the residents. To [manage our] time we decided to look specifically at the waste from the common areas of each floor.” – female, undergraduate, SBE major, Waste group</p>
Research and Inquiry	Foresighted Thinking; Motivate self and Others	<p>“[We] worked to learn the process of building water analysis as the semester unfolded. Initially [we] visited the halls and pictorially documented relevant fixtures and behaviors. We later discovered a more accurate approach whereby each building would be systematically inventoried and cataloged according to flush or flow rates.” – female, undergraduate, SBE major, Water group</p> <p>“We also visited the Leveda Brown Environmental Park and Transfer Station just north of Gainesville Regional Airport. Our tour at the transfer station taught us about exactly what was able to be recycled and why certain seemingly arbitrary oversights could make waste rejected from the process” – female, undergraduate, SBE major, Waste group</p>

Group Participation and Leadership	Interdisciplinary Work; Participation	<p>“This [process] was made easier due to our team’s many different background experiences” – male, undergraduate, SBE major, Waste group Team Leader</p> <p>“This has been a great learning experience not only for our R2P2 team, but also for the multitude of stakeholders in this project” – female, undergraduate, SBE major, Waste group</p>
Self-Assessment and Reflection	Reflection on Individual and Cultural Models	<p>“Being able to collectively track and understand the connection between behavior and outcomes from energy consumption allows the researcher to reflect on how to elicit more desirable behavior.” – female, undergraduate, SBE major, Energy group Team Leader</p> <p>A quote from one collegiate contact suggests that student findings inspired the continued learning of these key competencies: “The ideal outcome of the program is for the residents to be able to “identify three ‘green behaviors’ in which they participate in every day.” – Coordinator of Academic Residential Programs, DHRE</p>
	Transcultural Understanding and Cooperation	<p>“We learned through our research that civic engagement creates a way to make permanent, long-term change in the attitudes of the students. Technology can only solve so much, without the consent and real understanding of people” – female, undergraduate, Landscape Architecture major, Water group Team Leader</p> <p>“Once this information is shared, students living in the residence halls will get a good idea of how their actions and choices really make a difference in the performance of this building and result in more thoughtful, sustainability-aware intellectuals.” – male, undergraduate, SBE major, Waste group Team Leader</p>
	Empathy, Compassion and Solidarity	<p>This competency was not applicable to this project.</p>

Table 2. Student reflections on the learning outcomes of their R2P2 project and their alignment with competencies fostered by PBL or defined by the *Gestaltungskompetenz* model.

## EDUCATING FOR SUSTAINABILITY

Findings of this study illustrate that PBL experiences can set the stage for the acquisition of organizational, participatory, collaborative, interdisciplinary, and reflection competencies, and so uphold endorsement of PBL by sustainability educators as a key pedagogy for sustainability education. PBL anchors on the notion that issues of sustainable development are multidimensional and contextual, and as such cannot be approached from any single field or subject [9]—their solving requires being skilled in working with others and profiting from this exchange. Working on the microcosm that is the college campus, as proposed by the USGBC R2P2 initiative, gives students the opportunity to learn within the context of a rich environment with which they are already familiar. It also allows them to serve their institution and its members through their learning, and in doing so, to embrace the ethics of sustainability. Upon its completion, the final R2P2 report was presented to the DHRE and helped to highlight the many successes of their existing greening efforts. Following their past history of embracing student research findings toward the enhancement of their operations, the DHRE is considering the recommendations included in the R2P2 report to implement future sustainable strategies in the Yulee Residential Area. Finally, by featuring this and other R2P2 project reports in the USGBC’s Center for Green Schools website the methods used, and conclusions derived from, this study are offered as a model for similar efforts at other campuses [10]. However, application of the PBL pedagogy is not without limitations.

**Learning from the real world.** Though diversity of team member background and expertise was an asset for bringing in a richness of knowledge and perspectives to the project, it also added an additional layer of complexity to the study process. Early on in the research process it was clear that the Energy, Water and Waste groups worked at a different pace; some groups were initially more proficient at making institutional partnerships or communicating their findings than others. As a result, more time and effort was required of the instructors to maintain the uniform progression of the class. On the other hand, working with institutional partners whose agenda and timeline did not always align with the deliverables of a student project posed its own problems. Despite interest and commitment to assist students in carrying out this research, it was not always easy to access institutional documentation such as resource consumption documents, construction drawings, and occupancy data. Though such obstacles are indicative of real world experiences and added to the learning objectives of the study, they occasionally encumbered the project's progress.

Implementation of PBL pedagogy can thus be challenging, which may account for the fact that PBL has still to become mainstreamed into all disciplines. A large majority of the DCP 3210 students appeared to be unfamiliar with this learning approach. The format appeared to be less prescriptive than most pedagogy to which students were accustomed; thus generally it seemed to require strong individual motivation to engage with the project. Students who lacked this drive appeared uncomfortable contributing to team decisions, less likely to seek solutions to encountered obstacles, and often relied more heavily on the strengths of other team members. PBL offers great promise for sustainability education, yet more focused research is needed to explore the challenges and opportunities of its application in a range of curricular contexts. This study is an invitation to further our exploratory research and continue the discovery of applications where the PBL format will support educating our society for sustainable development.

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Pamela-Jean N. Driza



Maruja Torres-Antonini



University of Florida's Yulee Residence Area

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