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GRASP: Testing an Integrated Approach to Sustainability Education

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Abstract: The current paper introduces and presents a preliminary pilot study of the Guided Research Applied Sustainability Project (GRASP) model for sustainability education. GRASP integrates curriculum, research, operations and engagement at the university level to create specialized projects that both engage students with real world issues and provide usable outputs for campus and/or community partners. Drawn from theory and practice in Education for Sustainable Development (ESD) as well as experiential education, the GRASP model includes five primary elements, which are the project topic (substantive issue being studied), groups (students working together), mentors (conduit between the instructional staff and enrolled students), assignment (pedagogical deliverable students submit for grade), and procedure (process of topic selection and project completion). GRASP was designed to enable implementation in both small and large courses at the undergraduate and/or graduate level and was tested in a large (200+ student) undergraduate Sustainability course. Projects included a campus sustainability audit and mixed methods analysis of documentary film campaigns. Survey data collected from students and mentors determined that the GRASP model is effective in providing students with a positive and engaging learning experience. Outcomes identified relate to attitudes and values as well as knowledge and skill attainment (e.g. teamwork, applied sustainability research). Suggestions include additional instruction on research methodology and greater clarification of project guidelines and mentor roles. The results of our pilot study reaffirm the potential impact of an experiential approach to sustainability education that incorporates multiple stakeholders from within the university campus and is scalable to large classes. GRASP is recommended as a model with which to meet these goals.

Keywords: Sustainability; Experiential Education; Project-Based Learning; Curriculum

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Sustainability is interdisciplinary and applied in nature, making experiential education approaches ideal. However, obstacles related to feasibility and implementation have prevented wide-scale adoption, especially for large courses and at public universities. In this paper, we introduce and present a preliminary case study of the Guided Research Applied Sustainability Project (GRASP) model for sustainability education, which was designed to integrate campus research, engagement, and operations into curriculum in a way that can be carried out in a large public university setting. In designing GRASP, we drew from past theory and practice in Education for Sustainable Development (ESD) as well as the experiential education literature, including service-learning, participatory action research, transformational learning, and project-based learning. We then assessed the feasibility and effectiveness of GRASP in a large (200+ student) undergraduate Sustainability course and collected data from students and mentors to evaluate its effectiveness and make suggestions for improvement. As such, the following sections will:

1 Discuss research on ESD and experiential education, focusing on key unresolved issues;
2 Introduce the GRASP model and discuss implementation in a large undergraduate course;
3 Present qualitative and quantitative data on student learning outcomes and experiences;
4 Draw conclusions from the pilot, highlighting key aspects of GRASP for future practice.

1. Education for Sustainable Development

1.1. Sustainability and the University

Colleges and universities across the United States and world have devoted increased attention to Education for Sustainable Development (ESD) over the past decade (Cortese & Cook, 2010; McKeown, 2002; UNESCO, 2005). The goal of ESD is to develop citizens who have "the knowledge, skills, attitudes and values necessary to shape a sustainable future" (UNESCO, 2013, para. 1). More than simply adding discussion of environmental issues into current coursework, an ESD approach "requires far-reaching changes in the way education is often practiced today" (UNESCO, 2013, para. 3).

Cortese and McDonough (2001) identify four primary "domains" in which the university integrates sustainability: research, curriculum, operations, and engagement (see Figure 1). Research refers to empirical analysis of sustainability issues, generally conducted by professors and graduate students, leading to new insights and solutions to sustainability problems. Curriculum refers to academic courses that teach about sustainability concepts and issues, preparing the next generation of sustainability leaders (Barth and Timm, 2011; Cortese & Cook, 2010). Operations typically refer to campus greening, either via informal student campaigns (Beringer and Adombent, 2008), or formal policy shifts in 'how institutions operate, buy, invest and build' (Orr, 2006, p. 9), with the goal of reducing carbon emissions and setting an example for other institutions. Engagement refers to active participation by university students, faculty, or staff with the local, regional and global community, connecting and allowing for mutually beneficial relationships (Cortese & McDonough, 2001).

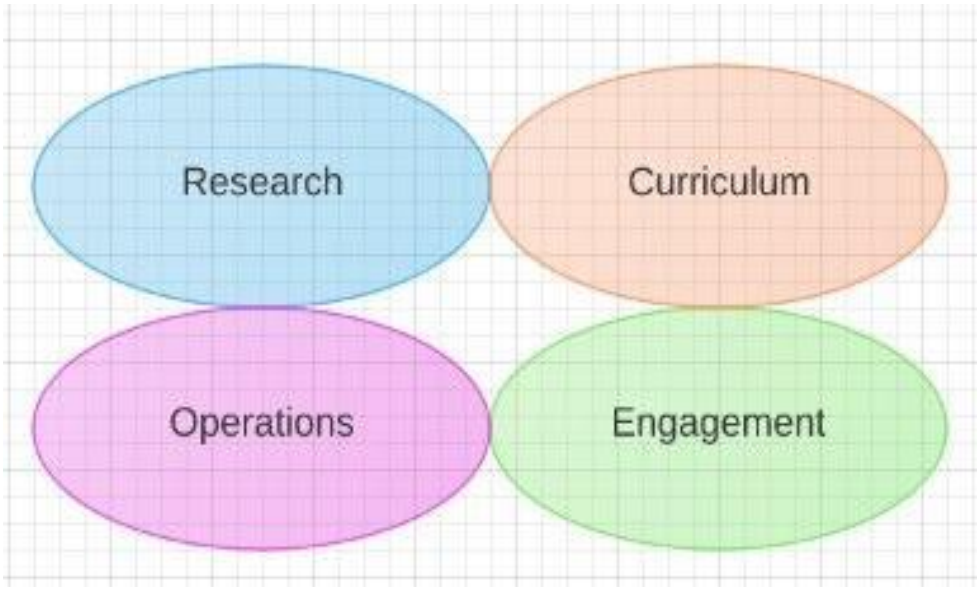

Figure 1. Four domains of campus sustainability

Universities are unique in their ability to incorporate all four of these domains into sustainability, as the university already contains the infrastructure needed to support them. Universities have access to a variety of sources of capital in the drive towards sustainability - engaged students with the desire to both learn and serve, faculty experts with existing research lines, external partnerships in the local and global community, and an entire campus system (e.g. water, energy, food, buildings, grounds) available for educational and research experimentation (Cantor, 1995). While other types of organizations - business, government, K-12 schools - may possess two or even three of these domains (e.g. curriculum, engagement, and operations in a K-12 school or research, engagement, and operations in a local city government), universities sit in a unique position in their ability to integrate all four, enabling a multi-faceted approach to sustainability that trains leaders, solves problems, and engages communities.

Many university ESD models have capitalized on this opportunity and worked to integrate these domains in innovative programming (see Figure 2). Service-learning models, for example, integrate the engagement and curriculum domains (AASHE, 2010; Barth & Tim, 2011), the model of the 'campus as living laboratory' integrates research and operations (Orr, 2011; Seif Hattan, Feder, Naik. et al., 2010), independent study models integrate the research and curriculum domains (Buckholz, 2013) and campus greening initiatives integrate operations and engagement (Beringer and Adombent, 2008). However, few have attempted to link all four together and approaches at most universities are still typically quite independent (Cortese & McDonough, 2001; Beringer & Adombent, 2008; Seif et al., 2009).

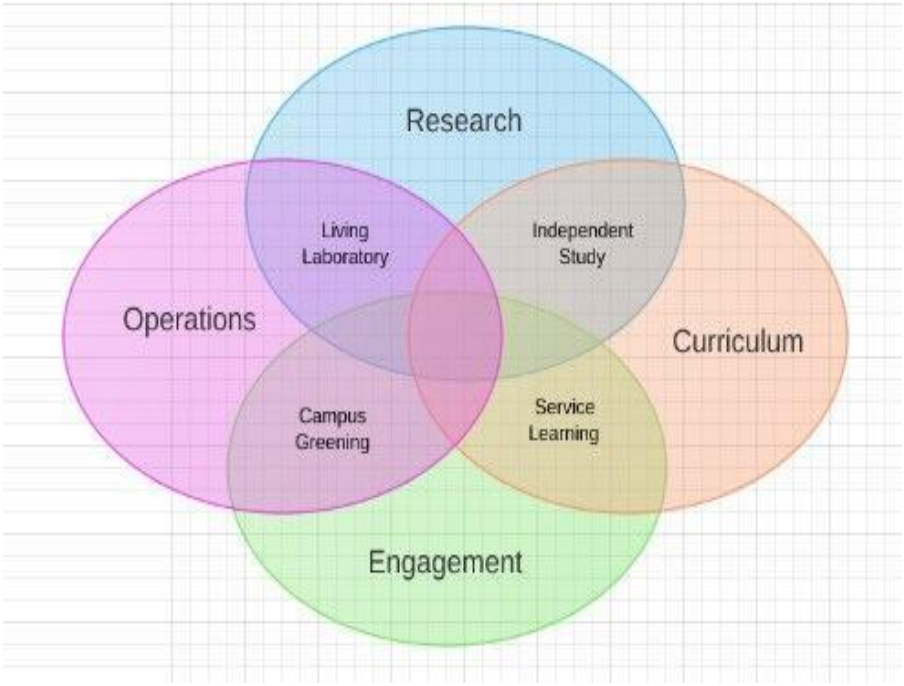

Figure 2. Integrating Domains of Campus Sustainability

1.2. Sustainability Curriculum

Within the domain of sustainability curriculum, campus initiatives have focused on increasing the number and types of environmentally focused courses (Cortese & Cook, 2010; Rode & Michelson, 2008). Most of these have been traditional (e.g., lecture, seminar) courses with sustainability included as a theme (AASHE, 2010). While traditional lecture-style teaching and assessments approaches are often considered to be the both time-efficient and cost effective (Karayan & Gathercoal, 2005), this type of teaching only partially addresses what ESD literature suggests as best practices or general goals (Cotton, Bailey, Warren, & Bissell, 2009; Domask, 2007). In reviewing the literature, we identified five primary pedagogical goals for ESD:

1 Learning about complex issues via relational, integrative thinking and/or systems theory (Barth & Tim, 2011; Cusick, 2008; Dale & Newman, 2005; Tilbury & Wortman, 2004).
2 Gaining tangible skills in natural and social science research and practice methodologies (Barth & Tim, 2011; Dale & Newman, 2005; Lundegard and Wickman, 2007).
3 Addressing real world issues using problem solving and/or action research (Armstrong, 2011, Dale & Newman, 2005; Domask, 2007; Svanstrom et al., 2008).
4 Engaging in meaningful social or team collaboration with peers and/or society members (Armstrong, 2011, Blumenfeld et al., 1996; Dale & Newman, 2005; Domask, 2007).
5 Affecting attitudes, values, and lifestyles within students and the larger university culture (Dale & Newman, 2005; Murray & Murray, 2007; Shepherd, 2008).

As these goals suggest, sustainability issues must be addressed with new and different ways of thinking and teaching (Cortese and McDonough, 2001; Orr, 2010). Simply adding course content alone will not be sufficient to convey the complexities of sustainability issues; newer teaching strategies are required (Armstrong, 2011; Barth & Timm, 2011; Orr, 2006; 2010). ESD requires

"participatory teaching and learning methods" (UNESCO, 2013, para. 2). Interactive learning is a pedagogical method that focuses on asking questions and engaging students in interacting with one another (Mazur, 1997). Research has show that interactive learning significantly increases knowledge gain, knowledge retention, decreases gender gaps in performance, and increases the retention of students in STEM (science, technology, engineering, mathematics) disciplines (Lambert, 2012).

Experiential education takes interactive learning one step further by engaging students in "learning by doing" (Domask, 2007, p. 55), or "engag(ing) the learner directly in the phenomena being studied" (Cantor, 1995, p. 1). Experiential education can include a variety of activities, such as engaging students in research or in service with external organizations (Domask, 2007; Harris, 2004). Service learning, for example, matches local community needs with student learning to achieve mutual benefit (Hayes & King, 2006). Participatory action research involves students and faculty in research with communities (Moore, 2005). Transformational learning focuses on developing deeper understandings and new perspectives on nature-human and human-human relations and the skills needed to cope with uncertainty and/or poorly defined situations (Kevany, 2007; Moore, 2005; Svanstrom et al., 2008). And project-based learning engages students in hands-on inquiry around a central question that leads to the production of meaningful products for an external audience (Barab & Leuhmann, 2003; Blumenfeld, Fishman, Krajcik, Marx, & Soloway, 2000). Typically, project based learning is comprised of four components: 1) an authentic (often scientific) question driving the research project; 2) the creation of meaningful and relevant products for an external audience, 3) collaborative group work (e.g. other peers, mentors, professionals) to negotiate tasks, practices, goals and meanings, and 4) a structured support system (Barab & Leuhmann, 2003; Blumenfeld, Marx, Soloway & Krajckik, 1996).

Despite some differences, all of these approaches share the features of social interaction, problem solving, and integration of multiple perspectives (Armstrong, 2011; Dale & Newman, 2005). They aim to teach conceptual understanding (not just factual knowledge) and are thought to enhance cognitive processes such as higher ordering thinking and perspective taking (Warburton, 2003). Students who participate in experiential learning gain practical skills and key competencies that help them understand how sustainability issues affect the planet and what intervention points exist (Blumenfield et al., 2000; Brundiers & Wiek, 2010; Cortese and McDonough, 2001; Ellis & Weekes, 2008; Hegarty, Thomas, Kriewaldt, Holdsworth & Bekessy, 2011). Here, the teacher becomes a facilitator or guide rather than a primary factual resource (Barab & Leuhmann, 2003). Finally, these pedagogies are thought to achieve transformations of attitudes, beliefs, and behaviors, citing the personal connection between the student and the problems being studied (Domask, 2007; Hegarty et al., 2011). This may be due to course objectives including value-laden knowledge rather than purely knowledge that is "immunized from the human condition and devoid of story, attachment and meaning" (Sipos, Battisti, and Grimm, 2008, p. 70).

1.3. Barriers to Implementation

Despite the promise of experiential education, its integration into sustainability curriculum has been slow, especially in higher education (Armstrong, 2011; Rode & Michelsen, 2008). While scholars have focused on the need for new approaches and outlined desired learning outcomes, little research has focused on actual implementation and measurement of outcomes for such programs (Armstrong, 2011; Barth & Timm, 2011; Rode & Michelsen, 2008; Svanstrom et al., 2008). Identified barriers including traditional curriculum frameworks and

technical limitations needed to implement such programs have prevented wide-scale adoption of experiential learning (Barab & Leuhmann, 2003; Brunetti et al., 2003; Davis, 2009; Domask, 2007; Orr, 2006).

Traditionally, discipline specific material tends to dominate pedagogy (Moore, 2005), such as the tendency to focus solely on ecological content, rather than integrate social justice issues (Barth and Timm, 2011; Dale & Newman, 2005). Traditional assessments also tend to focus on individual rather than collective grades for team performance (Barab & Leuhmann, 2003; Cotton et al., 2009; Dale & Newman, 2005). An additional challenge is how to develop curriculum that exhibits the gravity of the issues in ways that enable empowerment and capacity building, rather than a sense of hopelessness (Domask, 2007).

Additionally, technical concerns such as large class sizes, short quarters, and limited resources in terms of the staffing and time make implementation difficult. Researchers note that scaling projects into large courses is almost never accomplished (Barab & Leuhmann, 2003); or, when it is, educators note that, "a one-year timeframe for the study [would be] optimal and preferable, [but] logistically, the project had to fit within the three-month school term" (Brunetti et al., 2003, p. 212). To overcome these challenges, some researchers recommend, "[developing] flexible support structures that facilitate local adaptation and ownership of each curriculum" (Barab & Leuhmann, 2003, p. 456).

1.3. Measuring Outcomes

In reviewing the literature on experiential education in ESD, there is a noticeable lack of empirical evaluation to examine the success or impact of such projects (Barth & Timm, 2011; Domask, 2007; Ellis & Weekes, 2008; Rode & Michelson, 2008). Much of the current work relies on descriptive case study methodology, with little qualitative or quantitative data on student experiences and outcomes (Barth & Tim, 2011; Dale & Newman, 2005; Rode & Michelson, 2008). While frameworks for measurement have been proposed by some (Brunetti et al., 2003; Brundiers et al., 2010; Domask, 2007; Kevany, 2007), few have been tested (Barth & Tim, 2011; Ellis & Weekes, 2008; Murray & Murray, 2007).

Outcome frameworks tend to be characterized in terms of knowledge and skills, as well as attitudes and values (Barab & Leuhmann, 2003; Barth & Tim, 2011; Brunetti et al., 2003; Domask, 2007; Kevany, 2007; Svanstrom, 2008). Those who have tested such outcomes have found that students who participated in real-world team research projects gained both knowledge of the complex and interdisciplinary nature of sustainable development and skills in research, problem solving and teamwork (Barth & Tim, 2011; Ellis & Weekes, 2008; Murray & Murray, 2007). In terms of values and attitudes, students have reported feeling a greater connection to sustainability issues (Murray & Murray, 2007) and feeling a strong sense of achievement after completing applied research projects (Ellis & Weekes, 2008).

Although limited, student input on the process of experiential education projects is also informative for future practice. Students reported appreciating mid-way assignment deadlines, having advisors (Ellis & Weekes, 2008), and smaller groups sizes (Barth & Tim, 2011), though expressed concerns about assignment clarity (Murray & Murray, 2007). While a handful of studies have investigated and measured student experiences, this appears to be the exception rather than the rule.

Overall, this review of the literature suggests that there a need for an sustainability curriculum model that: (1) integrates the four aspects of sustainability available on campuses (curriculum, research, operations and engagement), (2) incorporates principles of experiential

education to meet ESD goals, (3) addresses issues related to implementation at scale, and (4) is tested with student data to evaluate outcomes and inform development.

2. GRASP Model for Project-Based Learning

2.1. What is GRASP?

In response to these needs, we created the Guided Research Applied Sustainability Project (GRASP) model. As the model is designed to assist students in *grasping* sustainability concepts as well as research and leadership skills, we felt the name was appropriately suited for our aims. The basic premise of GRASP is simple: identify current sustainability-related research, engagement, and operations projects on campus and integrate them into guided, group projects in Sustainability courses. In doing so, the GRASP model engages students to integrate the principles and concepts they are learning in class with a class assignment in which they can gain practical skills, demonstrate understanding, and substantially impact their local community or the larger world. Reflecting the general goals of ESD curriculum, the pedagogical outcomes of GRASP are to: (1) increase understanding of real-world sustainability issues, (2) improve research (e.g., interviewing, data analysis) and professional (e.g., teamwork, communication) skills, (3) strengthen connections to the university and/or global community, and (4) enhance self-efficacy and desire to contribute to sustainability issues in the future. We see these four outcomes as invaluable in preparing young leaders to work towards solutions of our most pressing sustainability issues in both the academic and professional world.

2.2. GRASP Elements

The GRASP model has five primary elements, which are the project topic, groups, mentors, assignment and procedure. Topic refers to the substantive issue and specific research topic for each project. GRASP topics should aim to include all three aspects of sustainability (e.g., economic, environmental, and social) and be designed in conjunction with current, active campus engagement, research, and operations projects, when possible. Such integration enables students to work actively within the course on real-world sustainability issues, rather than engage in projects designed simply to meet course requirements. The numbers of sustainability issues that can be explored with GRASP are limited only by the imagination of those choosing to implement it.

Groups refer to the characteristics and features of the project groups. Group projects are preferable to individual projects for three primary reasons. Groups generally conduct actual sustainability research and practice, thus group projects enable students to gain practical skills that are needed in the workplace. In addition, group work promotes skill development in leadership, teamwork, and communication and enables students with different backgrounds and skills to each work to their strengths while benefiting from the strengths of others. Finally, group projects enable project-based learning to operate at scale in larger classes in which individual projects would not be technically feasible. Group size should, however, be limited to no more than five students.

Mentors refer to the group of course leaders who serve as a conduit between the instructional staff and enrolled students, providing additional leadership and guidance on the research process and assignment. Mentors can be course teaching assistants, undergraduates who have taken the course in prior years, or the campus researchers or practitioners who are responsible for the projects. However, they should be conversant and experienced in the project

topic, the methods used, and the research process, in order to assist students. Mentors are especially important for large classes, allowing for a nested project supervision structure to assist in implementation (e.g. student groups, mentors and teaching staff). Depending on course enrollment and project needs, mentors can work with just one or multiple groups, but more than five groups per mentor are not advisable.

Assignment refers to the pedagogical deliverable that students are to submit for their final project grade. Although projects may vary significantly, it is ideal for the assignment to remain as consistent as possible among them. Options for the assignment are a research report, poster, in-class presentation, portfolio, or even a short film. It is also important that specific details of the assignment requirements (e.g., formatting style, word or page counts, grading rubric) are included. Such specifics alleviate confusion and stress for students, allowing them to focus on the substantive aspects of the project.

Procedure refers to the actual process of students selecting topics and any other resources or time provided throughout the course to assist in completion. Depending on the class size, selection procedure can be difficult, but the use of online resources such as Google forms or university software can be of great assistance. Key elements in selection include the following: (1) introductions of all projects on the first day of class, (2) a setting (either in-class or online) for students to find one another and form groups, and (3) a deadline early in the course for students to find groups and inform the instructional staff. Additional procedural elements that are helpful include periodic in-class time for group meetings and instruction on research methodology (during class or discussion sections, by group mentors, or provided written resources).

GRASP takes into consideration several problems identified in previous literature such as the integration of all four domains of campus sustainability, the need for a support structure in implementation, and the critical importance of skill development. In addition, GRASP has the ability to provide campus and community partners with a usable output (e.g. a research report, film, presentation). Finally, this model incorporates elements from different pedagogies within experiential education, including project-based learning (assigning projects with real impact), service learning (working with community partners), participatory action research (students as researchers), action research/active learning (recommending and/or implementing real change), and transformational learning (development of new perspectives) (Kevany, 2007; Moore, 2005; Svanstrom et al., 2008).

2.3. Pilot Implementation of GRASP

GRASP was piloted in a large, lecture-style, upper-division undergraduate Introduction to Sustainability course at the University of California, Irvine in Winter 2012. The course is taught each Winter quarter and is cross-listed in the Schools of Physical Science (Earth System and Science), Social Science (Political Science), and Social Ecology (Planning Policy and Design). From the course syllabus: "The purpose of the course to provide a multifaceted introduction to the concept of sustainability. We will consider sustainability from a variety of different points of view and endeavor to establish its relevance to the beliefs, values, institutions and practices that together form the complex world we inhabit." (Matthew, 2012). Over the years, the course has substantially increased its enrollment, from 70 students in 2009 to 237 students in 2012.

The course presents students with foundational concepts and multiple disciplinary perspectives on sustainability; students are tested on this material via traditional multiple-choice tests of reading and lecture material during the quarter as well as completion of a quarter-long course project. The project has evolved over the years from an individual report to a research

poster, group project, and finally into the GRASP model. Each project element, as defined above, will be discussed in the following sections.

Topics. Project topics were designed to "address an applied sustainability research question in the areas of campus sustainability or global injustice [and] cover all three aspects of sustainability – environmental, social and economic" (Matthew, 2012). They were also designed to incorporate both local and global sustainability issues as well to leverage resources and partnerships within the domains of university research, operations, and engagement. In order to select appropriate topics, the course instructional team reached out to sustainability researchers on campus as well as university operations and engagement staff to inquire for interest. Positive responses were received from the four domains of campus sustainability: campus operations department (operations), one research lab (research), the campus field study director, the University's Environment Institute (engagement) and the course professor and teaching assistants (curriculum). Positive responses were received from the campus operations department, one research lab, the campus field study director, and the University's Environment Institute. After meeting with all interested parties to determine interest and ability to provide guidance, projects were designed within two broad topics: Campus Sustainability and Global Activism Through Film.

UCI Campus Sustainability. 32 campus sustainability projects were identified to form a comprehensive campus greening audit. The description of the general topic area read:

> "UCI has worked on a number of sustainability projects over the years and has both goals unique to our campus (Long Range Campus Plan, 2007) as well as goals and requirements as part of the larger University of California System. UCI's sustainability goals cover all three areas of sustainability - social, environmental and economic. The UCI administration is interested in students pursuing a variety of campus sustainability projects to assist them in their sustainability decisions and goals" (Matthew, 2012).

Specific topics were designed in collaboration with the Vice Chancellor for Administrative and Business Services, overseeing the Director, Environmental Planning & Sustainability on campus. This audit extended and updated work conducted in the form of a preliminary campus audit Masters Thesis (Carr, 2008). These projects were grouped into the following seven categories: transportation, hospitals, food, purchasing, landscaping, education, and energy use.

Global Activism Through Film. 18 film-based activism programs were designed in conjunction with the Transformational Media Lab, part of the Center for Unconventional Security Affairs. The description of the general topic area read:

> "Film has been used as a tool for promoting social change throughout its history. However, the recent upsurge in popularity of documentary, combined with technological advances in new media, have opened up a new set of opportunities for film to serve as an agent for social change. One organization that has successfully utilized film as tool for social change is Invisible Children (IC). Founded in 2005, IC is a media organization as well as an economic development NGO with the goal of raising awareness and meeting the needs those suffering as a result of the

> ongoing war in central Africa. They have contacted UCI to request a program evaluation of the impacts their films and programs, not just on those they serve in Africa, but on those who become involved here in the United States. Sustainability issues related to civic engagement, political participation, and global awareness will be explored through analysis of survey data and case studies of IC and related films." (Matthew, 2012)

Specific projects were designed to analyze survey data collected by University researchers in conjunction with Invisible Children in 2011 as well as to compare Invisible Children's programs to other sustainability-related documentary films (An Inconvenient Truth and No Impact Man). The projects were grouped into the following four categories: IC participation, IC knowledge, IC outcomes, and film case studies.

Groups. Students were asked to form groups of 4 for each project. These numbers were strictly enforced to ensure consistency. Students were encouraged to find teammates from various majors, though this was not enforced or monitored. Groups were asked to work together both in and outside of class and a private "message board" on the university's instructional server was provided to each group for communication.

Mentors. Each team was assigned a project mentor. Project mentors varied from advanced undergraduates with prior research experience, to TAs for the current course, to campus research staff with an interest in the outcomes of the projects. From the course syllabus: "Every project will be assigned a mentor. The mentor is a person who is not a member of your group, but will serve as a research guide and resource. You are expected to respond to and arrange times when necessary to meet with them throughout the quarter as your projects progress. Mentors will also be reviewing your final papers and working with the course assistants to assess your work" (Matthew, 2012). Mentors varied in how they communicated with their groups - some had additional deadlines for their groups and/or scheduled office hours or meetings with their groups.

Assignment. The GRASP assignment was worth 40% of the students' final grade and consisted of a research report of findings from the group's investigation. Research methods for specific projects varied, ranging from interviews and internet research on campus purchasing decisions to content analysis and coding of open-ended survey data, but the format of the final paper was consistent across topics. The report assigned required sections for abstract, introduction, literature review, method, results, discussion, and references.

Procedure. Students were introduced to the projects during the first class and asked to sign up for projects via the university's educational electronic environment (eee) system by the second week of the quarter. After groups were formed, students were given two in-class times to meet with each other and their project mentors. Groups turned in their introduction and methods sections during the first meeting and preliminary results sections during the second meeting.

3. Evaluation of the GRASP Pilot Project

3.1. Methodology

At the end of the quarter, all students and mentors were emailed to complete a survey evaluating the projects after all assignments were submitted. A total of 131 students (65%) and 7 mentors (63%) completed the survey. The student survey included questions assessing both the project experience and perceived outcomes of participation. It included both closed- and open-ended questions; closed-ended questions enabled comparative measurement of responses between students and open-ended questions provided them the opportunity to share specific thoughts that could not be captured quantitatively. Questions addressing project experience included 12 likert-scale items rating the overall effectiveness of the project (1 question) as well as the project assignment (2 questions), procedure (2 questions) groups (4 questions), and mentors (3 questions). Two open-ended questions were also included, which asked students about the most enjoyable elements and main challenges of completing the project. To assess perceived outcomes, students were asked two likert-scale questions and one open-ended question about how much they think they learned from the project. Finally, students were asked at the end to share any specific suggestions for future years. A modified version of the same survey was given to the mentors with primarily the same questions as above. All survey items, along with descriptive statistics for the closed-ended responses, are presented in Table 1.

The open-ended responses were coded and analyzed iteratively, using constant comparison and multi-phase coding (Corbin & Strauss, 2007; Creswell, 2009). An initial set of codes was developed based on previous literature as well as the GRASP model components; additional codes were added, as needed through open coding, and then grouped into categories through axial coding. Finally, themes were constructed from analysis of the codes and categories in conjunction with a review of the literature. Findings are discussed in the following sections.

Table 1: Means and Standard Deviations for Survey Questions

Questions	Students (n = 117)	Mentors (n = 7)
Project Experience[a]		
How positive was your experience?	3.92 (0.96)	3.43 (.53)
What were the most enjoyable elements of the project?[b]		
What were the most challenging elements of the project?[b]		
Assignment[c]		
Assignment guidelines	3.89 (0.85)	3.86 (.69)
Deadlines assigned	3.9 (0.91)	3.43 (.69)
Procedure		
Direction from teaching assistant overseeing project	3.88 (0.88)	4.43 (.78)
Meeting time in class	3.67 (1.00)	4.29 (.95)
Groups		
Number of students per group	3.7 (1.08)	4.00 (1.15)
Communication with team (over email)	3.67 (1.06)	4.14 (.37)
Communication with team (in person)	3.61 (1.02)	4.71 (.48)
Meeting time outside of class	3.55 (0.99)	4.00 (1.15)
Mentors		

Mentor deadlines for your team	3.79 (0.98)	3.43 (.97)
How helpful was it having a mentor guide you?	3.52 (1.43)	na
Getting/Giving feedback/notes on project drafts	3.82	4.29 (.75)
Perceived Outcomes		
How much did you learn about applied research?[d]	3.72 (.88)	na
Understanding how to write a research report?[c]	3.71 (.75)	na
Teaching methodology to students[a]	na	3.21 (0.72)
What improvements would you recommend for the future?[b]		

[a] Scale ranged from 1=very negative to 5 = very positive
[b] Open-ended question
[c] Scale ranged from 1-very ineffective to 5 = very effective
[d] Scale ranged from 1=learned very little to 4 = learned a lot
na = not asked

3.2. Project Experience

Overall, students reported positive experiences with the projects (e.g. *"I learned a lot! I am very happy to take this class"*); over three-fourths (78%) reported having a 'somewhat' to 'very positive' project experience. Among project elements, students rated the assignment highest (71% rated as 'somewhat' to 'very effective'), followed by the mentors (62%), and groups (61%). Students' open-ended responses revealed more detail and depth into their experiences.

Students reported a variety of positive experiences with the project topic; they enjoyed learning about topics that were "*relevant to the class and also relevant in terms of things that were happening in the world outside of class."* They also noted appreciating the "*clear directions*" and "*being able to do real effective research."* Several mentioned that "*time set aside for us to meet during class and deadlines made things much easier*" and appreciated how midway deadlines prevented procrastination. And the mentor experience received high remarks from students. "*I think having a mentor allowed us to express our ideas more, but also created a more one-on-one contact rather than about 400 students per one professor*."

Students did have several suggestions for improvement. They requested more detailed project instructions, specifically related to the research paper (e.g. "*a clear overview on what needs to be included and where it needs to be included*") and making the projects worth a smaller percentage of the overall course grade. Several felt that it would be beneficial for students "*to find out more about our research subjects before... choosing*" or to offer individual project options. They also suggested incorporating the projects into course lecture content in terms of methodological instruction (e.g. contacting sources, coding) and reserving class time for "e*xplaining how to do certain parts*" or informing students "*where we should be at each week.*" To address issues of procrastination and group communication, they recommended, "*more deadlines for points*" and "*mandatory weekly meetings*."

3.3. Perceived Outcomes

In addition to these predominantly positive project experiences, students also reported several positive outcomes from their participation in GRASP. 85% reported learned a 'fair amount' to 'a lot' about applied research, and 60% reported that they effectively learned how to

write a research report. Open-ended responses from revealed outcomes related to *knowledge and skills* as well as *attitudes and values* from their participation in the projects.

Knowledge and Skills. Students reported gains in general knowledge about their research topic as well as skill-based knowledge about both conducting applied research as well as working in a team environment. Open-ended responses indicated that they learned a great deal about their topics (e.g., "*how the City of Irvine and UCI implement various environmental programs*") from both the literature review as well as the research process itself. Students also mentioned learning about the difficulties involved in conducting sustainability on campus; e.g., **"***sustainability is more complex than just saving some trees and combating climate change.*" They also reported increased knowledge and skills in conducting applied research. Responses mentioned all parts of the research process, from "*what goes into the numbers and figures that are reported in results*" to "*[writing] the various parts of a research project*". Finally, students reported gaining teamwork and leadership skills. They noted learning how to "w*ork with someone that has radically different views than mine*" and to appreciate how "*differing perspectives are necessary.*" Several students specifically mentioned gaining communication skills as well as skills associated with "*how to organize a group and set deadlines*".

Attitudes and Values. Students reported several changes in attitudes and values, specifically in terms of perceived efficacy and new understandings. Perceived efficacy refers to experiencing for the first time or anew, the ability to accomplish a certain task or produce a desired result. The development of new understandings refers to when students report gaining a newly acquired perspective on an issue, whether it be specific to the project content, or, personal. Students reported increased feelings of efficacy and noted feeling, "*how much of a difference a single person can make,*" or how "*we as students can actually have an impact on campus.*" They also reported an increased desire to work on sustainability issues. One student noted that "*understanding the global issues…[made me] 'want' to change and help*" and another reported that, "*I learned that sustainability is more important and calls for attention more immediately than I thought.*"

3.4. Mentor Responses.

The mentors also reported a general positive experience with the projects, while noting many similar issues to the students. Among the positives noted were in-person interaction with the student groups (including the provision of in-class meeting time), watching and helping the student learn, and their own development of leadership and communication skills. One mentor noted that, "*When I got to meet a group outside of class, we ended up talking about more than just the project - we talked about IC as a whole, sustainability, other interesting classes, other social issues, future plans, etc.*" and another shared his most enjoyable experience as "*hearing them call the president of companies to find out information. Also the fact they appreciated the greener alternatives and could see why they're a better option.*" The development of leadership experience and skills were noted most by the undergraduate mentors as well as "*experiencing the classroom from the TA's point of view.*"

The most frequent challenges cited were related to organizational constraints (e.g. "*I think it requires a lot of organization and skills to help keep other students stay on track*") and lack of consistent communication with their groups, including "*working with students who were either too busy for their group or who procrastinating/didn't care*" and "*waiting till the last minute to bombard me with questions and problems.*" Mentors suggested that students had

widely varying research experience and strongly suggested the addition of "*a manual on the elements of the research project*" and/or "*a lecture directly addressing sustainability issues regarding (the projects).*" Additional suggestions were for smaller groups and allowing students to choose from a wider variety of projects, both of which echo student suggestions. Recommendations for the mentor role include connecting the mentor more to the course (e.g. course email blasts), clarifying authority, increasing points for student participation/responsiveness and preparing/informing students of this authority.

4. Discussion

4.1. Review of Findings

Results of survey data collected from students as well as instructor observations indicate significant promise for the GRASP model, along with suggestions for future refinement. Students reported having learned a fair amount in their quantitative responses and specifically mentioned feeling inspired, liking teamwork and hands-on experiences. Their appreciation for mid-way assignment deadlines and having mentors/advisors echoes previous ESD curricular research (Ellis & Weekes, 2008). Overcoming commonly noted barriers, students reported gaining knowledge of both environmental and social sustainability issues (Dale & Newman, 2005), as well as gaining skills in conducting research (e.g., data collection and analysis) and report writing- both a goal of ESD and outcome associated with project-based learning, participatory and action research (Barth & Tim, 2011; Dale & Newman, 2005; Lundegard and Wickman, 2007; Moore, 2005b). Additional GRASP outcomes reported by students included increased self-efficacy and a sense of increased awareness and/or new perspectives on current issues, consistent with ESD goals and transformative learning outcomes (Dale & Newman, 2005; Kevany, 2007; Murray & Murray, 2007; Moore, 2005; Svanstrom et al., 2008; Shephard, 2008). Mentors also reported positive experiences, noting that they also enjoyed learning more about research and sustainability and that they gained valuable leadership skills (especially among the undergraduate and graduate student mentors). Overall, survey results suggest that GRASP is successful in meeting several ESD learning goals, including addressing a real world issue, gains in sustainability knowledge and teamwork skills, and practice in research methodologies (e.g., Armstrong, 2011; Barth & Tim, 2011; Blumenfeld et al., 1996; Dale & Newman, 2005; Ellis & Weekes, 2008; Murray & Murray, 2007.

The most challenging aspects for both mentors and students appeared to be issues with teamwork (trusting and ensuring equal participation, communication/responsiveness) as well as conducting research (compiling data, writing a research report) (Armstrong, 2011, Blumenfeld et al., 1996; Dale & Newman, 2005; Domask, 2007; Kevany, 2007; Mezirow, 1985; Moore, 2005a). Students recommended smaller group sizes, clarifying assignment goals (Barth & Tim, 2011), as well as clarifying the mentor role (authority, deadlines participation points) and providing a lecture or manual on 'how to' do research and write a research report. To address communication issues, mentors recommend connecting them with the course more closely, keeping in class meetings during the quarter, making participation points higher and mentor deadlines into real deadlines (e.g. matching course deadlines in syllabus for all projects). To address problems with research, the teaching team should only identify and vet projects with easy and early access to data and a relatively straightforward methodology, as well as provide an

overview of how to do research and a final research report in class or online to students and mentors.

4.2 Impact on Domains of Sustainability

As discussed, the GRASP model, as implemented in the pilot, successfully incorporated all four domains of sustainability in several ways. It integrated with the research domain by partnering with faculty to integrate student projects into their work; students collected and analyzed data for active research studies on energy efficiency and global activism. Several projects were also designed in conjunction with campus operations, including those that investigated the environmental impact of drought tolerant groundcover and that assessed university furniture purchasing policy. And campus engagement was integrated through projects that identified prospective internships sites and conducted work for partner NGO organizations. Some projects also integrated more than two domains, such as a research project with partner organization Invisible Children or an operations project designed to create a interpretive tour of a LEED certified campus building. Each of these four domains contributes uniquely to the role of the university in education for sustainability (ESD) and all are equally important. The integration of these domains with one another through the GRASP model takes advantage of the opportunities afforded by the university context to organize and address these needs holistically and reciprocally.

4.3 Relationship to Past Literature

The GRASP model both reflects and extends previous literature on experiential learning, pulling from elements of existing pedagogies and integrating them into a replicable and scalable model for experiential course projects in sustainability courses. GRASP is not meant to be a replacement of alternative pedagogies of experiential education; rather, it provides a unique contribution as a practical and replicable *project* model, particularly in its integration of the four elements of campus sustainability and its scalability for large classes due largely in part to the use and application of guidance via project mentorship.

Within the context of experiential learning broadly, the GRASP model clearly engages, "the learner directly in the phenomena being studied" (Cantor, 1995, p. 1). Students were actively engaged in reading campus purchasing policies, interviewing department managers, and analyzing survey data from international political movement volunteers. In addition, GRASP instructional staff (e.g., professor and course TAs) work with campus researchers, staff, and partners to design appropriate real world projects –reflecting the shared learning outcomes of project-based learning and participatory and action research (Moore, 2005).

In terms of real world knowledge and skill development, GRASP presents students with projects that reflect the complex nature of sustainability – a learning outcome identified by project-based learning (Barab et al., 2008; Blumenfeld et al., 1996). As seen in the responses, students reported gains in professional development, or 'employability' skills and research by participating in social science research methodologies - learning outcomes identified by project-based learning and participatory and action research (Barab et al., 2008; Blumenfeld et al., 1996; Moore, 2005). GRASP also enhances students' ability to work meaningfully on a team– a learning outcome of project-based learning and transformative learning (Kevany, 2007; Mezirow, 1985; Moore, 2005).

Finally, GRASP integrates pedagogies of service learning, action research and project based learning in its recognition of the importance of reciprocity. The development of reciprocally beneficial relationships between students, co-educators and community members is core to service learning (Hayes, 2006, p. 2); similarly, project based learning and action pedagogies research require students to either produce relevant end products for external audiences (Barab et al., 2008; Blumenfeld et al., 1996), or implement actual changes (e.g. writing a publication, or changing university policy). Students not only gained knowledge, research and professional skills (e.g. writing professional emails), but forged relationships with various community members in the process (faculty, administrators and staff) - truly benefiting from the real-world nature of the model. However, these community members received great benefit from student projects (e.g., increase in sustainability-related field study placements, data analysis that contributed to published manuscripts). Reciprocal value, however, was not limited to community members; project mentors also reported increases in knowledge, professional networks and critical leadership skills.

4.4. Key Factors for Future Implementation

Our development and pilot implementation of GRASP reveals several key factors of experiential learning that are vital to student success. We discuss these factors in terms of the model itself, sharing insights related to guidance, research, application, sustainability, and projects.

Guidance. As emphasized by the first word of the GRASP model, "G," ensuring that all team members from the students to the teaching team have a mentor for guidance and accountability is critical; sustainability projects without such a support structure may leave students with a sense of helplessness rather than empowerment (Domask, 2007). While providing students with uncertain situations is an aspect of transformational learning, the GRASP model believes carefully draws a fine line between encouraging student independence while providing them with a support structure that allows the whole team to learn from one another and/or their respective mentor.

Research. To overcome the barrier of traditional curricular frameworks in higher education, it is critical that undergraduate education communicate more than fact based sustainability knowledge to students (Warburton, 2003). GRASP aims to additionally expose students to process based knowledge by *involving* them in the research process (e.g. participatory action research). In the current competitive job market, providing students with applied research skills and critical knowledge on the complexities of even a singular sustainability issue is invaluable.

Application. One of the strengths of the GRASP model is that students feel meaningfully engaged in real-world projects with tangible outcomes, suggesting that this is the type of learning that creates long-term sustainability leaders. In addition, GRASP allows students to engage with real-world projects, providing valuable research output to campus and community partners. Engaging multiple student groups means that GRASP allows for the tackling of large tasks and data sets that would otherwise be prohibitive for the campus departments and partner NGOs to whom they provide their results.

Sustainability. In alignment with ESD goals, GRASP projects should incorporate all three aspects of sustainability (social, economic and environmental) (Robinson, 1993); in our pilot implementation, projects ranged from campus economic investments to child soldiers in Africa. Research indicates that students predominantly associate ecological issues most readily with sustainability education (Barth and Timm, 2011); expanding GRASP projects to include issues of social and economic sustainability and linking them back to environmental issues provides a larger and more meaningful context with which to study sustainability.

Projects. While traditional curricular frameworks emphasize individual over collective assessments, the GRASP model challenges educators and implementers alike to look beyond the idea of a one-time essay, test or individual research project. As the nature of sustainability in the educational, academic and professional world is predominantly interdisciplinary and team-oriented, GRASP acknowledges the value of the leadership (even when difficult) and communication skills students gain through participatory teamwork.

4.5. Conclusion

Overall, the model and pilot implementation presented shows proof of concept for GRASP as a viable tool for sustainability curriculum at the university level. Addressing issues of scale and training students in practical research and leadership skills enables GRASP to address the needs of 21st century campuses to meet 21st century issues through a classroom curricular project. Integration of multiple domains of campus sustainability (see Figure 3) enables GRASP to leverage the resources of the university for maximum student and partner benefit. Project topics in the pilot study included assessing sustainable operations on campus as well as academic research and community engagement partners in evaluation.

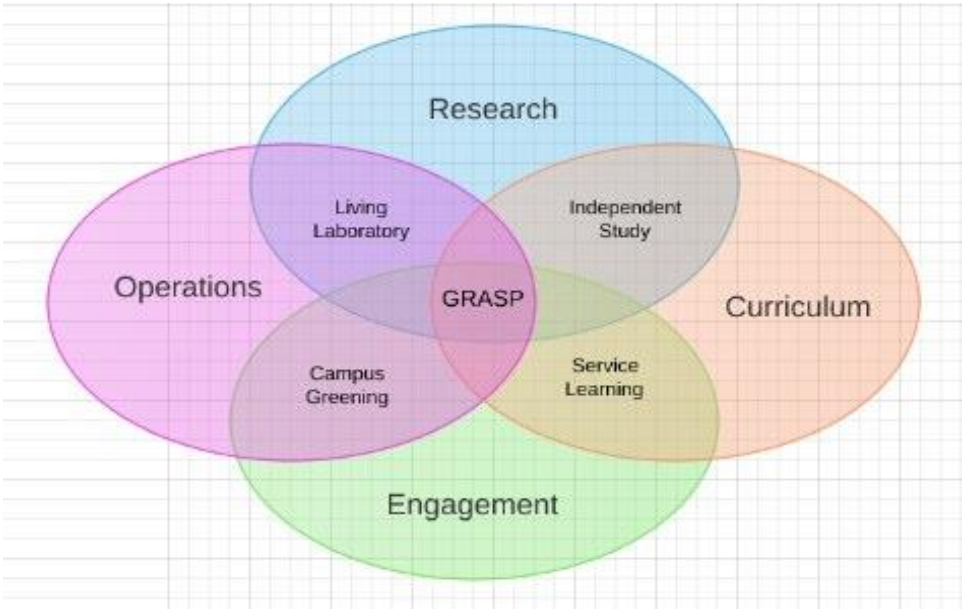

Figure 3. GRASP Model integrates all four domains of campus sustainability

Educators wishing to implement GRASP in their classes should be sure to identify real-world projects with engaged campus or community partners, invite campus leaders to serve as project mentors, and provide detailed instruction and resources to enable students to successfully

complete their assigned projects. We look forward to continued exploration and refinement of this model in the years to come.

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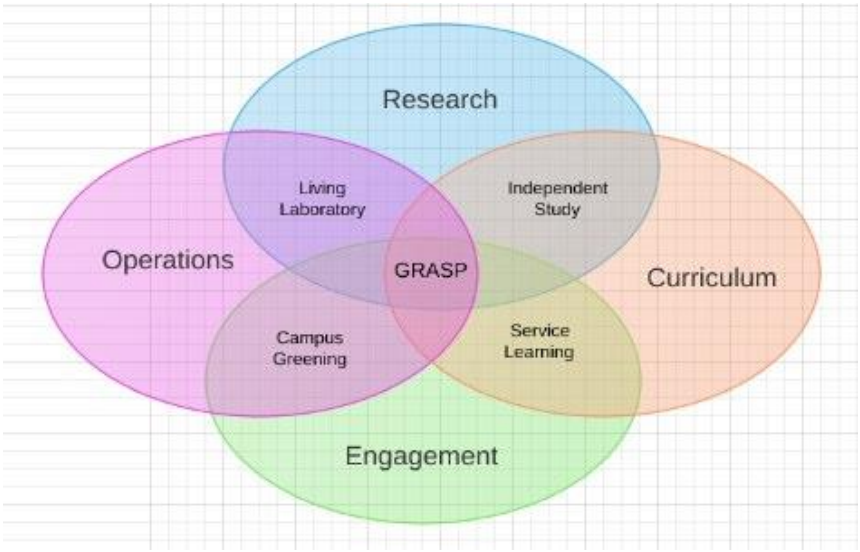

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