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## **AC 2011-320: INTERDISCIPLINARY SUSTAINABILITY DESIGN AND DEVELOPMENT EDUCATION: RESEARCH, DEVELOPMENT AND DISCOVERY**

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**Interdisciplinary Sustainability Design and Development Education:  
Research, Development and Discovery**

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## Abstract.

The paper will describe our experience in solving pedagogical and curricular challenges in teaching design and development methods in producing a sustainable product to junior and senior level students within an interdisciplinary environment. Our experience has been that the critiquing process deters colleagues and classmates from creating and challenging each other to develop innovative ideas. To more fully appreciate the design process and its relationship to sustainability, incorporating an international travel experience was provided.

## Introduction.

Sustainability, also known as industrial ecology, is defined as “the means by which humanity can deliberately approach and maintain sustainability, given continuing economic, cultural, and technological evolution (Graedel and Allenby, 2010).”<sup>4</sup>

In response to growing concerns related to environmental sustainability, increased awareness in multi-use product life-cycles by corporate and industrial organizations have become evident. “Triple bottom line” decisions are now based on societal (people), economic (profit), and environmental (planet) performance, and not only profit. Societal responsibilities and environmental challenges are the new business opportunities. It is incumbent upon academia to educate future designers, engineers and other decision makers on sustainability topics. The University of Wisconsin – Stout has a unique mission in responding to sustainability and a strong relationship with industry to foster this response. Companies will need to hire technical and business professionals to manage the change and technology. The market will demand individuals with these skills, competencies, and personal convictions to create the changes necessary to achieve an environmentally sustainable future.

Industrial designers apply specific problem-solving processes to develop ideas. Classmates and colleagues inexperienced with design are unfamiliar with this style of development, such as sketching ideas, making mock-ups, producing engineering and illustrative graphics, creating models of a project, and problem solving methodologies applied. A specific area of difficulty experienced by many students in this environment is honest verbal and written critique of ideas for fear of criticism. The critique process is particularly challenging, as students from other disciplines are often afraid to receive and give criticism of their own and their peers' work.

This paper will introduce the challenges of creating a product within a multi-disciplinary group in the academic environment. Exposing classmates and colleagues to the industrial design problem solving process provided the opportunity for learners to collaborate with their peers outside their comfort zone. While challenges are always present in working within a multi-disciplinary environment, individuals focused toward a common goal can come together to create a viable sustainable product.

The consensus of students, faculty and administrators is that introducing a multi-disciplinary learning model provides learners with deeper and broader perspectives in meeting the needs of the project parameters. The application of this methodology has fostered increased problem

solving skills and respect for others' perspectives through collaboration between students of unique disciplines and skills. Program outcomes will be presented, based on learning experiences from experimentation and research of learning pedagogy, resulting in enhancements in course design and delivery causing increased learning outcomes.

This course addresses design methodology and provides the foundation for design skills, competencies, and personal convictions. Students in this course will add a serious credential that companies and communities will value as they strive to achieve a triple bottom line approach. Through the application of an interdisciplinary teaching approach, and a cross-disciplinary learning environment, students will gain an understanding of environmental, social, and economic concerns associated with creating a sustainable future.

Multi-disciplinary groups explored and compared cultures, business practices, technologies, design methods, and sustainable products of Scandinavia, creating a profound impact in their learning experience.

#### Background.

In November, 2007, Ronald Scozzari, from the Engineering and Technology department housed within the College of Science, Technology, Engineering and Mathematics and Jennifer Astwood, from the Art and Design department, housed within the College of Arts, Humanities, and Social Sciences had begun discussing collaborative teaching efforts to broaden the scope of student engagement and develop critical thinking and process skills for students. The focus which emerged from their disciplines was industrial ecology (global sustainability). Both had begun to realize the value that academic, civic and business organizations placed in supplementing existing academic knowledge with environmental and industrial ecology skills. This cooperative effort served to satisfy University of Wisconsin – Stout initiatives to develop new courses, or enhance existing ones, with interdisciplinary teaching and learning methodology.

The course would be designed at the 400/600 level in order to facilitate the experience necessary for the course requirements. The course would be available to students of any major on campus. The goal was to incorporate a multidisciplinary environment in which students would be placed in teams of dissimilar backgrounds. This model would seek to develop student respect for others' perspectives, necessitate effective communication of their own thoughts and ideas, and encourage them to adapt to multiple problems and solutions under varying circumstances.

The course represented a cross-disciplinary exploration of ecologically-friendly design, engineering, manufacturing and business models, infused with an international travel component with corporate, cultural, academic and civic leaders. Topics included cultural, economic and political influences; product design; manufacturing; sustainability; application of current eco-friendly product design models; various research topics; studio and laboratory experiences; project and presentation.

## Course Objectives.

Learners will understand the diverse nature and importance of sustainability concepts.

Learners will develop the ability to think critically.

Learners will analyze technical, technological, and design problems within social and environmental contexts.

Learners will make economically, environmentally, and socially sound decisions.

Learners will apply the technological knowledge, skills, attitudes, and flexibility needed to succeed in a sustainable economy.

Learners will demonstrate their knowledge through a project incorporating a sustainable design and development solution.

Learners will participate in a study abroad component, travelling to Sweden and Denmark.

Learners will apply new learning from international experience to projects upon return to U.S.

## Why Scandinavia Was Selected

Sustainability and long-term thinking were key concepts in Scandinavia long before sustainability became a buzz word for environmentalists and politicians around the world. Denmark is well known for its commitment to areas such as alternative energy, energy conservation, public transportation, urban planning, and ecologically and socially sustainable architectural design. Few can contest Scandinavia's place at the forefront of the corporate responsibility movement. Companies from Denmark, Sweden, Norway, Finland and Iceland consistently win corporate responsibility and sustainability awards, and their governments are often the first to pass progressive legislation.

## Challenges of Creating a Product within a Cross-Disciplinary Group.

Working in cross-disciplinary groups inevitably brings about a myriad of challenges. Quite often those involved struggle because of different motivations, conflicting perspectives and skill sets that are seemingly unrelated. This course was designed to expose students from varying majors to the process of working within a group of colleagues with different professional backgrounds to accomplish a common goal utilizing the product design process; in this case, a sustainable product. Not only does this experience expose the students to different ways of problem solving, it develops interpersonal skills that will be indispensable in the professional world.

## The Process.

The course is structured so that the class meets weekly for lecture and group activities and accompanied by a week-long research trip to Scandinavia. Students familiarize themselves with the subject matter by performing literature searches and observational research. Based on their findings, groups of students will brainstorm possible solutions to an array of design opportunities. An example of one group's challenge was to redesign the eating experience at a fast food restaurant. They chose to redesign the eating experience at McDonalds. The students would brainstorm on a wide range of ideas varying from products that would educate people on

what types of food they are putting into their bodies, the design of the interior space of the restaurant, packaging, to composting. The groups then explored 40 different ideas further and developed them into concepts. From there, they refined five of those ideas. This particular group's concepts focused on awareness, waste reduction, growing your own vegetables, adjusting health and lifestyle, and simplified composting and disposal. From the top five concepts, the students performed additional research by going to Scandinavia and observing a different approach to design and sustainability. After the students returned from Scandinavia, using their research data, they refined three of those concepts. They explored those concepts further visually, using mock-ups and renderings. The group focused their three ideas on waste disposal, packaging, and the eating space. After an additional critique, the group developed those three concepts further. At the final critique, area design professionals attended the critique to give the students feedback on their final solutions.

In the last two years, the students were exposed to industry practices, manufacturing processes, and sustainable outcomes. During the past two trips to Scandinavia, the students have participated in manufacturing tours at Volvo, met with design professionals at IKEA, participated in executive boardroom discussions of efficiency, technology and tradeoffs with the CTO of a major Solar Energy company in Norway, visited a Biofuels plant in Sweden, visited the Lego factory and a product consultancy in Denmark, met with an energy cooperative representative to discuss wind energy onsite at a windmill farm on the Copenhagen coast, and traveled to Hammarby Sjostad, a sustainable community in Stockholm, Sweden. In addition to students visiting companies and viewing sustainable communities, they were exposed to an alternative approach to transportation in Europe by traveling throughout Sweden, Norway, and Denmark using public transportation. In addition to site tours, the students visited museums.

Our goal with the students traveling to Europe is that they would gain new insights on how to better develop and refine their sustainable product in addition to gaining an international experience. After returning from their one week excursion, students then presented their research findings of their overseas travel experience. During the past two years, we have found that students return from overseas with fresh perspectives and new insights on how to better enhance their final products.

#### Discussing the Critique Process.

Each group's designs are assessed in the classroom by faculty critiques. Students in the art and design program have already been exposed to this manner of exhibiting work and receiving feedback. Initially, it is challenging for people to not separate themselves from their work. Students in engineering, psychology, and business may find this particularly uncomfortable. At times, students will take feedback on their work personally. However, with repetition and practice, this occurs less. It is a valuable skill in any profession to be able to take criticism with an open mind and use it to better their skillset.

To get the cross-disciplinary group experience started, the students are divided into groups and given a one day project. They are given a problem to brainstorm and solve. An example of the problem would be, "In groups of three, brainstorm 15 concepts in the next hour for water transport in third world countries." The benefit of doing this is that students get a sense of

working together under a timeline as well as brainstorming with people from different professional backgrounds. Because this is a quick one day project, the students feel more freedom to explore new and potentially risky ideas. This type of brainstorming involves coming up with quick ideas, and initially not worrying about the validity of the outcome. This teaches the students that they can indeed edit their ideas. Even if there is a seemingly outlandish idea, the students can take pieces of that proposal and apply it to make their design more innovative.

The instructors have noticed increased success in this method of quickly grouping the students together. They become united by a quick timeline and are forced to experience a critique at the end of the class period.

#### Differences in the Projects in the Past Two Years.

The course has been taught during spring semester 2009 and 2010. Although the course has been taught twice, it is still a work in progress. When the course was initially created, the students' only constraint was to design a sustainable product. They were put into groups and asked to define a direction they wanted to pursue. The students were divided into multi-disciplinary groups from the start to ensure varying perspectives.

The second time the course was taught, the students were again put into multi-disciplinary groups, but their constraint was to redesign a part of the fast food experience. Some students focused on packaging, one group focused on the ordering process, and one group focused on the interior space. The groups had a lot of freedom to take their designs in the direction they wanted but the final outcome had to be sustainable.

There are pros and cons to both methods. A pro of the first method is that it allowed the students to explore design opportunities that might otherwise have been overlooked. Students brought their own experiences to the table to determine which direction to follow. This helped to drive the progression of their work as well as the final sustainable product.

The second approach of constraining the students to a specific industry is that the students focused more on the final design versus doing a lot of initial research to help them pinpoint a design opportunity. Although the fast food experience may not have been their chosen topic, it helped to limit their choices and gave them a common task as a group.

Both methods have proven quite successful with the timeline of each project throughout the semester. Traveling to Scandinavia during the middle of the process has given students a different perspective when completing their design.

Another factor to take into account when designing the projects for this course is the enrollment numbers from each of the different majors prior to the course starting. Each year, different majors take on the course. In future courses, the class will be flexible to allow creation of different products and spaces, depending on the skillset of those participating in the course.

## Assessments

There currently is one assessment which will be incorporated into the research, reflecting student feedback of the course, provided by the Office of International Education. The synopsis provided is from students in the second year (2010). Assessments from the first year are in the process of being extracted, as the assessment software provider has changed, and system support is unavailable. Content areas are:

- a. Academic Quality (overall mean: 4.0 out of 5.0)
  1. Relevant content
  2. Engagement with host country culture and people
  3. Quality of instruction by non-(insert University name) faculty
  4. Value added of excursions
  5. Faculty/student ratio
  
- b. Group dynamics rating (overall mean: 4.44 out of 5.0)
  1. Overall Group Dynamics
  2. Maturity of students and cross cultural sensitivity
  3. Fit of student goals/interests with program goals
  
- c. General Assessment
  1. Enjoyed trip. Increase relationship with sustainability
  2. Great experience. Very aggressive schedule.
  3. Instructors unfamiliar with new geographic settings seemed disorganized at times.
  4. Found difficulty finding hotel upon arrival
  5. Would like more free time
  6. Cost of trip was too high compared to duration
  7. Sweden and Denmark were great cultural and learning experiences
  8. Instructors could provide more insight to culture
  
- d. New learning on trip compared to learning locally
  1. International perspectives of corporate culture
  2. The country culture. Learned to be more independent. On site factory tours
  3. Learning to implement sustainable design, influenced by other cultures
  4. First-hand experience. This experience cannot be taught.
  5. Comparisons of how different countries are being sustainable
  
- e. What did you wish you knew before going?
  1. What to do with unstructured time



2. Unanticipated costs for local travel
  3. More preparation about international travel
  4. I wish I had learned Swedish or Danish and be able to converse with locals
- f. Would you recommend this program to a friend?
1. 44 % yes
  2. 44% maybe
  3. 11% no
- (A reason why was not provided or defined by the survey)

A second assessment is in process, and consists of an electronic questionnaire designed by the authors. The survey will reflect questions in Likert Scale fashion pertaining to:

- a. Prioritizing reasons/motivations for selecting the course
- b. Extent to which interdisciplinary course model improved learning
- c. Extent to which other interdisciplinary courses improved learning
- d. Extent to which project direction changed after international experience
- e. Extent to which international travel enhanced perspective of project parameters
- f. Extent to which working within an multi-disciplinary team improved the project
- g. Extent to which an interdisciplinary learning format influences future course selections
- h. Semester of participation

Monetary Costs of an International Travel Experience Positioned within a Traditional, Campus Based Course.

Preparing for travel and lodging was expensive. Lodging accommodations were at well-known, large hotel establishments such as Scandic and Raddisson hotels located in city centers of Stockholm and Gothenburg, Sweden, and Copenhagen, Denmark. The budget was defined by anticipating 10 students enrolling in the course. The average cost to students for both first and second year offerings was \$5,000. This included tuition, associated campus fees, study abroad health insurance, airfare, local transportation (rail and bus), entrance fees (museums), lodging, application/contingency fees, travel expenses and overload wages for both instructors. Additional expenses to students included passports, meals (except breakfast, provided by hotel), and personal expenses. The instructors suggested budgeting \$100 per day for discretionary expenses, totaling \$700. Within the budget was an additional \$100 reserved per student to be used for unanticipated experiences, travel or meals.

Alternatives to the International Component to Benefit Learners include:

- Securing site visits to local manufacturing operations exhibiting sustainable practices.
- Engaging representatives from non-profit and civic organizations as guest speakers.
- Visiting a local food co-op or community garden.
- Attending city and / or county meetings which discuss sustainability topics.
- Visiting agricultural establishments applying sustainability concepts within the farms.
- Securing site visits to local utilities supporting and exhibiting alternate energy models.

We have also incorporated local visits and guest speakers into the course. Students find these methods engaging and broader perspectives are formed in their learning.

### Orientation of Students and Parents

The Office of International Education dedicates at least a four hour orientation session, whereby faculty, students and parents are invited. Sessions include psychological, social and environmental orientation, travel tips, and emergency procedures while abroad. Once the general orientation has been completed, each study abroad group is separated, and students, parents and faculty directors can discuss specific aspects of their trip, and answer all questions. Instructors also develop another orientation session for parents and students closer to the travel dates for final questions and follow-up information.

### Travel Planning Experiences

Planning activities and visits to organizations for overseas group travel is very enjoyable, yet challenging. During the first year, we were very ambitious in our timelines. Travel included three countries: Sweden, Norway, and Denmark. Lodging for the first year was located at city centers of Stockholm Sweden, Oslo, Norway, and Copenhagen, Denmark, with easy access to the central train stations. In addition to a travel plan that consisted of visitations with corporate organizations during each morning, and cultural experiences such as visits to museums each afternoon, the students were taken to three different countries in a one week time period. When planning each day's activities, one must consider the generosity of the host in the corporate setting to exceed the originally defined timeframe of the visit. These experiences were unexpected, yet fortunate occurrences. Planned timeframes of three hours dedicated to museums were limited due to morning corporate visits extending to the afternoon. Plus, incorporating three different countries within a one week time period proved to be exhausting.

During the second year, the travel plan was less aggressive, and allowed flexibility for unforeseen circumstances. Travel only incorporated two countries, Sweden and Denmark. Lodging remained at city centers with easy access to central train stations.

During the first two years, the instructors researched cultural venues and contacted corporate representatives. They also researched all travel components such as air and ground travel, lodging, acquired maps and developed the entire itinerary for all students. The university contracted a travel agency to book air, train and lodging.

#### Group 1 Dynamics – Classroom Learning Environment (Spring semester, 2009)

The first class was composed of 9 students, defined into three groups. Disciplines ranged from engineering, business, psychology, fashion technology, interior design, industrial design, and art education. The students exhibited sincere passion for industrial ecology, and, with minor personality and professional challenges, worked cohesively in their groups. This group was adaptive and flexible to learning new concepts and methodologies. Many were unfamiliar with the Industrial Design Product Development methodology, and were challenged in embracing and applying this method. There was only one student trained to become an industrial designer in the class.

One student possessing either an art education, industrial or interior design, or fashion technology background was placed into each of the three groups. This person was to act as the key person who somewhat understood the industrial design process. Not all individuals understood the industrial design process, skill levels and outputs required. Since not every group was able to have a person with an art and design background, the visual execution or communication of the final concept was lacking. Even with this shortcoming, project deliverables at each stage exhibited creativity, critical thinking, and included hard fought intellectual battles to ensure specific sustainability criteria were incorporated. Within this group, 3 students had experienced a professional work experience in the form of an internship or co-op experience. Final product quality could have reflected additional refinements. However, time constraints, lack of art and design skills, and over-analysis of criteria prevented this. Defending their products to industry professionals proved challenging, but successful, providing valuable, relevant experience in the critiquing process.

Informal inquiry of Group 1 indicated their passion for learning about industrial ecology and sustainability. Many were practitioners who incorporated walking, bicycling, reusing, recycling, composting, growing gardens and purchasing food from local growers.

#### Group 1 Dynamics – Travel (Spring semester, 2009)

The students in this first group were genuinely passionate about global sustainability, enjoyed the challenges of international travel, mass transportation, locating sites which reflected products correlating to their projects, and engaged with local cultures easily. For many, this was not their first international study abroad experience. Their maturity and adaptability to unforeseen

circumstances, expenses, and cultural differences was admirable. As a group traveling together, they forged strong personal bonds and cohesiveness unforeseen by the instructors.

#### Group 2 Dynamics – Classroom Learning Environment (Spring semester 2010)

The second class was composed of 13 students, defined into three groups. Disciplines ranged from manufacturing, packaging engineering, industrial design, interior design, construction, and psychology. With the exception of six industrial design students, the rest were unfamiliar with the Industrial Product Design and Development methodology. The composition of this class proved advantageous due to three additional interior design majors who were familiar with the design process. The groups were not as challenged by the design and development process as the group from the prior year. To make the process easier for non- art and design majors in the second year, the project was provided with a more defined set of variables (within the context of the fast food experience), enabling the students to focus acutely on the challenges provided. Only one student in this group experienced professional work experience in the form of an internship. Informal inquiry of Group 2 indicated they were less interested in sustainability and more interested in the travel opportunity. The minority practiced sustainability in their lives.

#### Group 2 Dynamics – Travel (Spring semester, 2010)

Most of the students enrolled during the second course required additional emotional support when travelling overseas, as compared with the students from the prior year. For many, this had been their first study abroad experience. Embracing unknown nuances of airline travel, mass transportation, scheduling, and unfamiliarity with surroundings, required most students additional time for adjustment. Several had formed common bonds with their classmates. A new dynamic introduced to this group was two sets of couples who were dating at the time as well. With assurances from instructors, and additional maps and directions provided, some students embraced the culture, a sense of place, and set forth to investigate many fast food settings to support their projects. Others were intimidated by the surroundings, and had difficulties in adjusting and planning their free time.

Upon return from Scandinavia, all students worked together well within their multi-disciplinary groups, and delivered final projects of higher caliber and refinement than those of the first class. Final product quality was above average to excellent due to a more refined student skillset from the art and design majors, and enhanced organization of the project parameters. Defending their products to industry professionals, again, provided real world, relevant experience in the critiquing process. Additional lessons learned include redefinition and greater control of project parameters, incorporating additional design process exercises, refining the delivery method with more actionable participation in addition to discussions, and a greater understanding of managing group dynamics.

## Conclusion

The course design was unique to the University of Wisconsin – Stout. At the time, courses were either semester length campus based sustainability courses or study abroad courses. This course incorporated several elements of complexity and instructional innovations unique to the University of Wisconsin – Stout. It incorporated both campus based and study abroad components in one semester. The course was designed to provide unique instructional and experience perspectives within an interdisciplinary co-teaching delivery. Students of all majors were invited to attend the course, providing a multi-disciplinary atmosphere. Collaborative learning significantly contributed to the depth of student experiences. Students learned to challenge, negotiate and critically think through problem solving challenges. These experiences provided the framework to design and develop successful, sustainable solutions.

We are excited to be delivering a third class during spring 2011. It is composed of seven students. Three are Interior Design majors, one from Construction/Facilities Planning, one Applied Science major, one Engineering Technology major, and one industrial design major. Elements of architectural design, construction, LEED standards and green construction methods will be the framework for projects. Travel will incorporate Denmark, Sweden and the Netherlands. This third year, a travel company was contracted. They researched and provided all information, made all arrangements, and will provide representatives on-site at all airports and train connections, upon arrival and departure from major travel points. Thus far, this collaboration has proven significantly more advantageous.

Presently, a longitudinal study is being conducted to track students' perceptions of their experiences. We encourage others to continue researching and applying interdisciplinary learning within a multidisciplinary student environment. We are confident new experiences will broaden and enrich this model, and seek to learn how to incorporate new learning into our own experiences.

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