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Landscape Online
open access peer reviewed

SHORT PAPER Page 1

Landscape Online | Volume 82 | 2020 | Pages 1-14 | DOI 10.3097/LO.202082

Submitted: 29 June 2020 | Accepted in revised version: 28 August 2020| Published: 25 September 2020

Integrating Multiple Perspectives in an Urban Ecology Course

Abstract

New approaches are needed to educate university students about urban sustainability challenges. In particular, students need opportunities to learn the importance of integrating not just biophysical issues (e.g. climate change, pollution, loss of biodiversity, etc.), but how these issues are related to societal issues (e.g. racism, poverty, access to health care, etc.). To this end, we created a course that uses a comparative, study abroad approach, focusing on the cities of Rochester, NY (USA) and Malmö, Sweden. Students are provided with numerous scaffolded opportunities to learn from each other, from local experts, and from faculty and students abroad. An assessment of learning outcomes in the course revealed that students who completed the study abroad portion of the course integrated more key topics into their final projects ($\bar{x}$ = 3.93 ± 0.22) than students who took the same course, but did not go abroad due to the global pandemic in 2020 ($\bar{x}$ =2.13 ± 0.40; p = 0.004). A survey of students also illustrated that the exposure to a new culture and ideas was key in changing how they thought about environmental problems.

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Keywords:
urban environmental education, urban ecology, urban landscape, higher education, study abroad, COVID-19

1 Introduction

1.1 Motivation

Solutions to environmental problems facing urban environments require integration of disciplines and multifunctional approaches. For example, multifunctional green infrastructure could address issues such as climate change, food insecurity and biodiversity preservation (Lovell and Taylor 2013). Support for these ecological and technological initiatives requires an educated citizenry that participates in the planning and implementation process (Ahern 2013, Lovell and Taylor 2013, Kremer et al. 2016). Fundamental to this support is the concept of ecosystem services, which is increasingly being utilized in urban sustainability public policy and planning (Hansen et al. 2015, McPhearson et al. 2015). One of the barriers to the integration of ecosystem services into urban public planning is the separation of fields into separate administrative offices that prohibits the integration and coordination needed (Ahern et al. 2014, Hansen et al. 2015). In addition to contributing to a citizenry that is educated about sustainability issues, higher education can contribute by developing future professionals who are knowledgeable about these issues and can effectively work across disciplines (Svanström et al. 2008, Seatter and Ceulemans 2017). Thus to address these environmental issues, what is needed is an educated workforce and citizenry that can 1) apply concepts of ecosystem services to an urban environment; and 2) integrate multiple disciplinary approaches to find a common solution.

To help students at Rochester Institute of Technology (RIT) realize the benefits and potential of integrating urban ecology practices, and ecosystem services in particular, into urban design and planning, we developed a course in Urban Ecology with a 2.5 week study abroad component in Malmö, Sweden. The study abroad component provides students with a firsthand experience living in an urban environment that embodies sustainability initiatives, within a society that values environmental sustainability (Malmö stad 2020). Because the course draws students from a variety of academic programs, the field activities emphasize how protecting the environment while making cities both livable and ecologically sound requires the integration of many disciplines, allowing students to focus their varied skill sets on final projects incorporating aspects of urban ecology that appeal to them. Our goal is to inspire students to understand and apply urban ecology principles in the future, as they participate in their communities, contributing through their disciplines. We also encourage them to become involved in the sustainable transformation of RIT and Rochester, NY as these locations strive to become US showcases of urban sustainability.

1.2 Goals of the study

The goals of the study were to address questions of:

- How do we go beyond traditional teaching methods in order to encourage learning urban landscape ecology from different perspectives?
- Does this interdisciplinary, study abroad approach lead the students to comprehend and integrate different disciplinary perspectives and approaches in order to better understand the sustainability challenges facing an urban landscape?

2 Background

The United Nations has identified 17 Sustainable Development Goals (SDGs), many of which include restoration of ecosystem services in order to achieve the identified goals (UN 2020). In order to achieve these goals, a citizenry who are educated about current global environmental issues (e.g. climate change, habitat loss, stormwater runoff and pollution, invasive species, soil erosion, biodiversity decline, resource over-exploitation, etc.) is needed. There is a need to educate both average citizens, whose everyday choices impact sustainability, as well as to train scientists, engineers, and social scientists who address these environmental problems directly through research, technological solutions and public policies (UN 2020). Additionally, these environmental problems need to be addressed within an urban context, as nearly 70% of the world's population is projected to live in cities by 2050 (World Bank). Thus, the field of urban ecology has become a needed discipline in higher education.

Urban ecology merges the traditional ecosystem-based approach of interacting components that have feedbacks and synergies with the more recently emerged field of landscape ecology. Forman's (1991, 1995) work on the land mosaic model laid the groundwork for landscape ecology, and also the framework for applying ecosystem ecology to urban settings while also incorporating designers, planners and decision makers (McDonnell 2014). Suddenly a myriad of disciplines, not just ecology, were relevant to addressing urban sustainability issues, including landscape architecture, public policy, urban planning, and public works management. The field of landscape ecology has been grappling with these interdisciplinary, integrative approaches in research for some time (Tress et al. 2005), and has more recently also focused on the need for an inquiry-based and field-oriented approach to teaching the discipline (Beck and Blumer 2012, Almeida-Gomes et al. 2016). Traditional classroom lecture-based approaches often fall short in addressing the complexity of multiple perspectives, leading to a need for the development of new approaches (Tytler 2012, Bader and Laberge 2014, Kinslow et al. 2018). This may be particularly true for urban settings, which need diverse perspectives to identify and solve complex scientific, social and technological problems (Lovell and Taylor 2013, Russ and Krasny 2015, Kremer et al. 2016).

Work by Lozano et al. (2017) summarizes existing approaches to teaching sustainability in higher education in Europe. While there is general consensus that pedagogical strategies are needed that employ active learning, critical thinking and reflection, the authors find that traditional lectures are still the norm, and alternative pedagogies have not been widely utilized (Lozano et al. 2017). Seatter and Ceulemans (2017) provide a review and analysis of pedagogies for transformative learning in higher education for sustainability, and they conclude that emphasizing the role of competing groups to define sustainability within a cultural context means that sustainability is an ongoing "discourse" rather than a fixed definition. The authors conclude that transformative learning occurs from pedagogies that include inquiry-based activities, case studies, active learning, participatory/active field trips and constructivist learning (Seatter and Ceulemans 2017).

Multiple pedagogical approaches have been suggested to integrate sustainability and multiple perspectives into higher education curricula. One approach is to integrate sustainability topics into existing courses (Pijawka et al. 2013). Another popular approach is to use campus-based sustainability efforts as a hands-on, case-study approach (Savanick et al. 2008). A comparative approach to the study of urban ecosystems has been put forward as a way to bridge disciplinary boundaries, particularly international comparisons (McDonnell et al. 2009, McDonnell 2011, Niemelä 2014). As a teaching approach, this might include case studies or study abroad experiences. Even short term study abroad experiences have been shown to impact students' language skills, creative thinking and cultural adaptability (Regan 1998, Ritz 2011, Lee et al. 2012, Mapp 2013). Global learning and study abroad are included in George Kuh's work on high impact practices, which are strategies universities can employ to improve student engagement and success in college (Kuh 2008), particularly when these experiences include experiential learning about other cultures.

3 Teaching Activities

3.1 Why Malmö and Rochester? Parallel landscapes and histories

The university partnership between Malmö University and Rochester Institute of Technology began due to a shared interest between the two institutions in technology, green infrastructure and urban sustainability, and particularly in how these topics intersect with the local landscape and public policy. The cities of Rochester, NY (USA) and Malmö, Sweden share many features, including a parallel industrial history that declined in the late 20th century and geographic proximity to ecologically sensitive international waters (Lake Ontario and the Öresund, respectively). The city government of Malmö intentionally made decisions about the city's future based on the desire to become a "knowledge-based city" and a "green city of tomorrow." Over the past 20 years, Malmö has transformed itself into a leading example of development incorporating urban ecology (Malmö

stad, Sustainable Malmö, 2020). Rochester aspires to such a transformation, but is basically in the planning phases, focusing on its Roc the River initiative (City of Rochester 2020). Rochester has completed several pilot projects, such as Turning Point Park, several green roofs on public buildings, and various porous pavement/raingarden/bioswale installations.

As part of this university partnership, we created an urban ecology course that compared the two cities (landscapes, histories, problems, and solutions) and culminates in a study abroad experience mixing faculty and students from Malmö University and Rochester Institute of Technology. Throughout the course, students were asked to make comparisons between the two cities and their approaches to urban issues.

The course focused on ecosystem services on a landscape level through nine main disciplinary perspectives:

- Green and blue spaces
- Green infrastructure
- Social justice and cohesion
- Urban planning & development
- Transportation
- Energy
- Storm water/water management
- Biodiversity
- Waste management & recycling

During the semester, the topics were covered in class through lecture, workshops, local field trips, hands-on activities, guest lectures, and panel discussions (Table 1). Then, in a 3-week study abroad trip, students experienced the topics first-hand in Malmö through a series of workshops and field trips (Table 2). Learning outcomes for the course were: [A] Examine and compare urban environments from an ecosystem services perspective; [B] Integrate science, technology, and social science viewpoints to address complex, contemporary issues in local, regional, and global context; and [C] Utilize effective team problem solving, project/time management, and interpersonal communication skills on multi-disciplinary teams.

The course has been taught three times (Springs 2017, 2018, & 2019) in this workshop format, blending lectures, in-class exercises, and study tours in both Rochester and Malmö to local problem areas and sustainable solutions. Pedagogical best practice demonstrates that active learning is most effective, and thus we use a "workshop" format where lectures are often integrated with classroom activities and field trips (Bader and Laberge 2014, Seatter and Ceulemans 2017, Kinslow et al. 2018). Principles from Bloom's Taxonomy (Bloom 1956, Anderson and Krathwahl 2001) were used such that skills at the bottom levels of Bloom's (e.g. knowledge and understanding) were delivered via lecture and discussion. Then more complex outcomes were taught via activities and fieldtrips (e.g. application, evaluation, or creation of knowledge) (Table 1). The course follows the best practice pedagogies set forward in Seatter and Ceulemans (2017) with a focus on case studies, active learning and authentic field trips. The study abroad experience allowed RIT students to work collaboratively with international students and faculty, providing opportunities for global understanding and cultural awareness. Students created projects that emphasized key urban ecology initiatives found in the host country and were presented/disseminated through the use of ESRI Story Maps.

The fourth time the course was taught (Spring 2020), the COVID-19 pandemic meant that the course was taught initially in person in a workshop format (8 weeks), then online with synchronous sessions (5 weeks), and without the study abroad component due to an international travel ban. Some of the missed activities/tours were handled via virtual tours, lectures or panel discussions. For example, the Scandinavian Green Roof Institute shared their materials and PowerPoint presentation, and we were able to deliver much of the content virtually. While the canceled trip was unfortunate, it provided the opportunity to examine the student performance on learning outcomes of the course in the absence of the study abroad component of the course.

3.2 Malmö field trips

The field trips in Malmö were designed to highlight the integration of various disciplinary perspectives and also illustrate the lessons that the Swedes learned from each successive development over time (Fig 1). For example, the first ecodistrict, Au-

Table 1. Lectures and activities for Urban Ecology while at RIT in Rochester (Spring semester). Some activities run multiple weeks. **Focal topics** (1-9) from throughout the course included: [1] Green and blue spaces; [2] Green infrastructure; [3] Social justice and community cohesion; [4] Urban planning and development; [5] Transportation; [6] Energy; [7] Storm water/water management; [8] Biodiversity; and [9] Waste management and recycling. Topics addressed are indicated, with the most relevant topic for each lecture or activity in bold.

Assessed **Learning outcomes** (A-C) for the course are: [A] Examine and compare urban environments from an ecosystem services perspective; [B] Integrate science, technology, and social science viewpoints to address complex, contemporary issues in local, regional, and global context; and [C] Utilize effective team problem solving, project/time management, and interpersonal communication skills on multi-disciplinary teams.

Activity	Description & Pedagogical Approach	Topics & Outcomes Addressed
Urban Case Study	• Class discussion, led by students • Case study example of US city, including analysis of history and discussion of urban sustainability	[1], **[4]**, [6], [7] [A], [B]
Examining Rochester	• Guest lecture/discussion by local lawyer/social justice activist/professor • Discussion of history of Rochester, focused on both social justice/race relations and sustainability issues	[1], **[3]**, [4] [A], [B]
Ecosystem Cafe	• Lecture/discussion on ecosystem services • "Jigsaw" activity where students are in groups to address issue of ecosystem services on RIT campus; students rotate through groups to address ways to improve ecosystem services on campus	**[1]**, [3], [4] [A], [B] [1], [4], [5], [6], [7], [8] [A], [B], [C]
Biodiversity and Bug hotels	• Lecture/discussion on biodiversity in urban areas • Design and build a "bug hotel" to enhance urban biodiversity and provide ecosystem services	[1], [2], [4], **[8]** [A], [B], [C]
Restoration Ecology	• Guest lecture from ornithologist about backyard ecology • Visit and propose redesign of a neglected/under-utilized space on campus in order to improve ecosystem services and human use	[1], [4], [7], **[8]** [A], [B], [C]
Urban atmosphere and Global Calculator	• Lecture/discussion on urban atmosphere • Use a global calculator model to examine impact of personal sustainability choices on global climate change and atmospheric composition	[2], [4], [5], **[6]**, [9] [A], [B]
Urban Soils and Hydrology	• Lecture/discussion on urban soils; software modelling demo • On-campus field trip with guest lecturer from Civil Engineering; focused on examining water management infrastructure	[1], [2], [4], [5], **[7]** [B]
Health, Society and the Refugee Crisis	• On-campus field trip to the studio of Interior Design professor • Examine design student projects designed to bring together various cultures in Malmö [focused primarily on Syrian and Swedish cultures]	[1], **[3]**, [4] [A]
Re-examining Rochester	• Field trips in Rochester to examine: green infrastructure, green and blue spaces, urban planning • Interactive panel discussion with sustainability officials to learn about alternative viewpoints and approaches to issues	[1], **[2]**, [3], [4], [5], [6], [7], [8], [9] [A], [B]

gustenborg, was developed in the 1950s and focused on social interactions, green space and managing storm water runoff. In 2001, Malmö hosted the Sustainable Housing Expo (Bo01), and the development of the Western Harbour as part of this expo was mindful of lessons learned from Augustenborg's successes and failures (Andersberg 2015). Subsequently, the lessons learned from these two areas have led to the more recent ecological and sustainable developments of Hyllie and Sorgenfri (Fig 1D), solidifying sustainability as a foundation to Malmö's new economic engines of service, technology, and research. The course has a strong temporal and storytelling component, so that students learned that

Table 2. Field trips and study tours from the study abroad portion of the trip in Malmö, Sweden and surrounding area. **Focal topics** (1-9) from throughout the course included: [1] Green and blue spaces; [2] Green infrastructure; [3] Social justice and community cohesion; [4] Urban planning and development; [5] Transportation; [6] Energy; [7] Stormwater/water management; [8] Biodiversity; and [9] Waste management and recycling. Topics addressed are indicated, with the most relevant topic for each trip in bold.

Assessed **Learning Outcomes** (A-C) for the course are: [A] Examine and compare urban environments from an ecosystem services perspective; [B] Integrate science, technology, and social science viewpoints to address complex, contemporary issues in local, regional, and global context; and [C] Utilize effective team problem solving, project/time management, and interpersonal communication skills on multi-disciplinary teams.

Activity	Description	Topics Addressed and Learning Outcomes
Green neighborhoods		
Augustenborg	• Malmö's first experiment in green infrastructure and planned community (1950s); still in use today with new innovations and retro-fits • Tour by staff at the Scandinavian Green Roof Institute	[1], [2], [3], **[4]**, [5], [7] [A], [B]
Western Harbour	• Reclaimed area after the collapse of the ship-building industry; reinvented as a sustainable neighbourhood as part of the European Housing Expo (Bo01) in 2001 • Tour by Malmö University faculty from Department of Urban Studies	[1], **[2]**, [3], [4], [5], [7] [A], [B]
Hyllie	• Community on the outskirts of Malmö established in the 2010s, easy commuting to Copenhagen; buildings and planning with lessons learned from previous experiments • Tour with the City of Malmö's Communications Officer	[2], [3], [4], **[5]** [A], [B]
Sorgenfri	• Repurposed (2010s) central neighbourhood; formerly industrial; focus on walkability and waste management • Tour with Ph.D. student from Malmö University in Department of Urban Studies and SYSAV personnel	[2], [3], [4], [5], **[9]** [A], [B]
Rethinking urban/suburban green spaces		
Falsterbo Bird Observatory and Research Station	Example of how preserved habitat and research can be integrated into a suburban landscape; golf course using green management practices integrated with native landscapes, a marine sanctuary, and ornithological research space	[1], [4], **[8]** [A], [B]
Limhamn Limestone Quarry	Abandoned quarry near Malmö, reverting back to natural state with minimal management (primarily pumping of groundwater); Tour with City Planning official	[1], **[4]**, [7], [8] [A], [B]
Scandinavian Green Roof Institute	All-day hands-on workshop learning how to plan, build and maintain a green roof; examples of various roof types and tours of surrounding community (Augustenborg)	[1], **[2]**, [3], [4], [6], [8] [A], [B], [C]
Fredriksdal	Outdoor "living landscape" museum in Helsingborg that illustrates Sweden's history of housing, farming, and land management over centuries; display about Linnaeus and native plant biodiversity	**[1]**, [3], [8] [A], [B]
Educational study tours		
SYSAV waste-to-energy plant	Tour of facility; discussion and comparison to other waste management options and history of waste management in Sweden	[5], **[6]**, [9] [A], [B]
Kretseum	Wastewater and recycling educational/activity centre aimed at secondary students	**[7]**, [9] [A], [B], [C]
SeaU (Naturum)	Tour of educational centre; collection and identification of biological samples from the Öresund	[1], **[8]** [A], [B], [C]
Final project		
Story Map	Students create a Story Map (ESRI 2020) to teach others about an aspect of urban ecology of their choice; Electronic and oral presentation of final version in Malmö	[topics determined by students] [A], [B], [C]

Figure 1: Clockwise from top left: A) Exploring the green spaces of Malmö in Kungsparken; B) Educational Tour of SYSAV, a waste-to-energy plant; C) Tour of Kretseum, a museum dedicated to educating secondary students about wastewater and recycling (note the UN SDGs in the background) ; D) Sorgenfri ecodistrict, with a waste management and composting demonstration center; E) Students planting in a green roof at the Scandinavian Green Roof Institute; F) Collecting samples of sea life in the Öresund at Sea U, a marine educational center.

often these social and sustainable community experiments do not work perfectly on the first try, and that lessons learned must be applied to the next development.

In addition to visits to the ecodistricts, the students also participated in study tours, workshops and field trips to facilities that helped them engage with local sustainability issues and experts. Many of these tours had a “meta” approach, where students were exposed not just to the location and problem, but also had discussions with local experts about how the Swedish public is engaged in the particular issue. For example, the students visited the Kretseum (Fig. 1C), an educational facility aimed at teaching local secondary students about wastewater and recycling in Malmö. Students not only learned about the wastewater and recycling issues themselves, but also discussed and learned more about why the museum uses certain kinds of interactive displays, what their goals are for their audience, and strategies they employ to achieve these goals. One of the goals of

the Kretseum is to educate primary school students from immigrant and refugee populations about wastewater and recycling practices, so that the children can then teach adults in the household about the importance of this sustainability issue. These cultural and social issues are woven throughout the course and field trips (see Table 1 and 2).

3.3 The students:

The students who took the course came from a variety of majors, and were sophomore to graduate students in level. For some students, the course fulfilled part of their general education requirements, and for others, the course counted towards electives within their major. Most universities in the United States require a "general education" component of a bachelor's degree, with significant coursework required in the humanities, social sciences, natural sciences and mathematics, generally outside of the student's major. These courses support broader learning outcomes and transferable capabilities for careers and global citizenship (Gaston 2015). RIT's general education framework includes required components in both global learning and scientific principles, and the Urban Ecology course can be used to fulfil either of these requirements. Alternatively, students in environmentally related majors (e.g. Environmental Science, Environmental Management, etc.) can use the course as a professional elective to support their program requirements. Many students were drawn to the course to participate in the trip to Europe that is included in the course. More than half the students came from environmentally related majors (Fig 2), with significant proportions also drawn from art & design, engineering and social science. This diverse array of students brought their own disciplinary perspectives to the course. One of our goals was to help the students see urban issues through the lenses of each other's disciplines. Because the course can be used for general education credit, the course has no prerequisites and no previous knowledge is assumed, other than that students bring their own disciplinary knowledge to the course. Additionally, four international (non-American) students have taken the course (from India and Bangladesh) and thus some years, there was also cultural diversity as well.

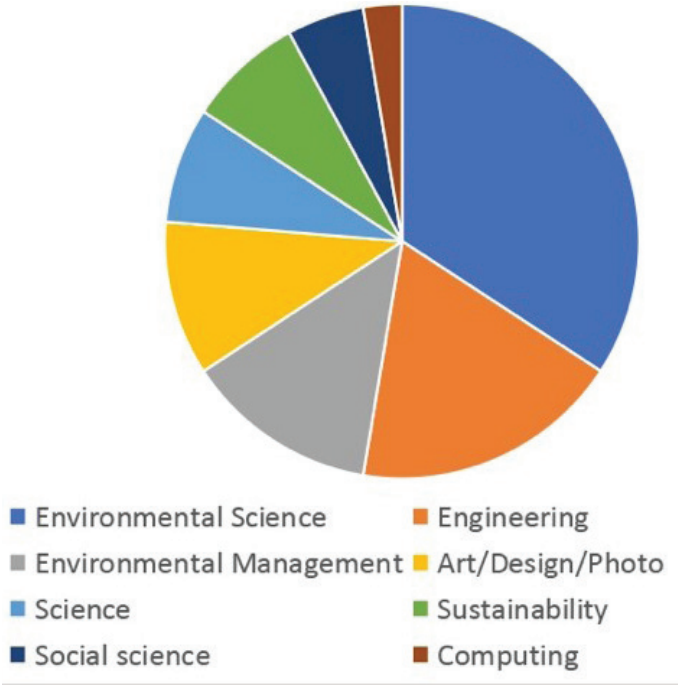

Figure 2: Proportion of urban ecology students (N=38) by focal area of study. Environmental related majors made up nearly half of the total number of students, with Engineering and Art/Design/Photo also contributing. In all, thirteen different majors were represented.

Students self-selected into the course based on their interest. RIT's Global Education staff screened the students through an application process to determine eligibility (minimum GPA, student conduct screening, passport/visa eligibility, etc.). Students were then accepted into the program based on academic seniority. Because the course was offered during the traditional spring semester, the fee for the travel portion could be covered by financial aid (e.g. scholarships, grants, loans, etc.). Additionally, students with demonstrated financial need were eligible for scholarships through RIT's Global Education program.

During the workshop sessions of the course, group work was emphasized and students were encouraged to share and integrate their knowledge of their chosen majors in order to address local urban problems. For example, one assignment asked students to reimagine an underused space on campus and propose ways to enhance its ecosystem services. Students worked alone initially, and then in groups to integrate their ideas. Students from diverse academic backgrounds brought different viewpoints and expertise to the assignment. For example, en-

gineering students might bring solutions that were technological or structural in nature (e.g. solar panels, hydrological improvements, etc.), while biology students emphasized living components of the systems (e.g. shrubs to enhance bird diversity or green walls). By working together, they found that they could integrate various solutions and address multiple problems at once (e.g. put solar panels onto a green roof with native vegetation, addressing both energy considerations and biodiversity concerns).

These exercises were intentionally scaffolded so that when the study abroad component of the course was reached, the students could work together to identify local "experts" within the group in certain subject areas and teach each other about what they had learned. For example, one art and design student was particularly interested in urban street art and graffiti, and led the other students on a walking tour through Malmö to examine and critique local examples.

3.4 Story Maps: The culminating project

Final projects for the course were completed while in Sweden, and were created using ESRI's Storymaps, interactive map documents that embed and spatially link text, photos, videos, and supporting documents for on-line presentations (ESRI 2020). The assignment required that students research a specific aspect of urban ecology of their choosing and then discuss how Malmö's initiatives could be adapted for and adopted by Rochester. Many times, students connected their major discipline to topics they have learned in Sweden, and then told a story that could be shared with others about their experiences. For example, a biology student explored avian biodiversity in urban settings, an engineer examined the transportation infrastructure (bikes in particular), and a design student looked at how parks and public spaces bring communities together. The students created a visual map with photos and text to tell their story about what they learned.

The key question we wanted to address was: does this interdisciplinary, study abroad approach lead the students to integrate different disciplinary perspectives and approaches in order to understand the urban landscape? Students in the course were asked to integrate ideas from various disciplines, and particularly the nine areas highlighted (see above, 3.1), both in the current context, but also historically. The study abroad trip approach to achieving this outcome was important, as we learned in the spring of 2020 when the global pandemic meant that the study abroad component was cancelled.

To assess the students' incorporation of ideas from multiple disciplines and examine the role of the study abroad component in student learning, we re-evaluated their final projects to look for this outcome specifically. Each assignment was scored as to whether it included each of the nine components. The expectation was not that all students would incorporate all components. Our hypothesis was that students who completed the study abroad component of the course would be more likely to incorporate multiple aspects into their projects because they were exposed to many more viewpoints than the traditional course approach.

In all, 35 projects were scored, with 27 of them coming from students who went on study abroad experience, and 8 who did not. Four additional projects were not scored because access to the assignment had expired due to the students graduating. All data were handled with approval from RIT's IRB for human subjects. We used JMP Pro 15 to perform statistical analyses.

3.5 Study abroad survey

Because the university-administered official course evaluations were administered during the normal semester (i.e. before we traveled abroad), the feedback that we have received in our official university teaching evaluations did not include the student's thoughts and evaluation of the study abroad portion of the course. To determine what the students valued from the experience, in May 2019, we sent an anonymous survey about the study abroad component of the course to students from the first three years. We did not subsequently send the survey to the 2020 cohort because they did not go abroad.

The survey had five questions:

- What was your best learning experience in Sweden?
- Please describe how you changed as a result of your study abroad experience (behavior, attitude,

mindset)?
- Please rank the field trips from best to worst (click and drag to order them):
- What would you change about the content/field trips of the study abroad experience?
- What aspect of what you saw in Sweden has the highest probability of being implemented in Rochester?

4 Results

4.1 Course learning outcomes

Results of the one-way ANOVA indicate that students from the 2020 cohort, who did not go abroad, had a significantly lower number of topics integrated in their final assignments (Figure 3; F = 6.6, p = 0.002). A typical final assignment in this cohort only included two topics ($\bar{x}$ = 2.13 ± 0.99), and did not consider wider perspectives or other disciplines outside their own.

One compounding factor was that students in 2020 experienced major disruptions to their learning experiences and their lives in general due to the COVID-19 pandemic, and consequently may not have put as much effort into the assignment. However, we did not evaluate the quality of the assignment, but instead focused on the number of perspectives presented as a less biased measure. We therefore speculated that the differences we observed were more likely to be due to the lack of exposure to the field trips and workshops abroad, and to the lack of interaction among RIT students and with Swedish students and faculty.

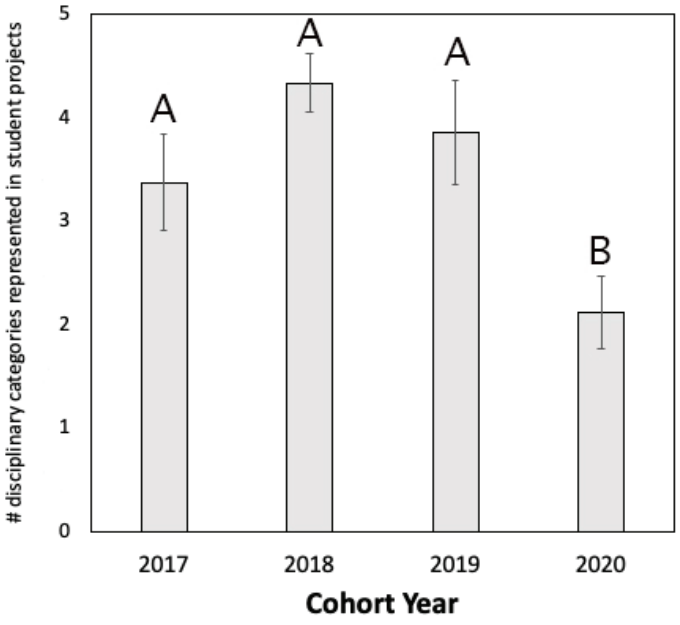

Figure 3: Average number of the nine components that students incorporated into their final project, by year. One-way ANOVA shows that students in the 2020 cohort (who did not go abroad) integrated fewer components into their projects.

4.2 Survey Results

The survey was sent to all the students from the first three years of the course (n=31), after the course was completed. We had a 42% response rate to the survey. In response to the question, "Please describe how you changed as a result of your study abroad experience (behavior, attitude, mindset…)?" more than half (55%) of the students mentioned the importance of learning to better value diverse cultures outside of their own, and 18% specifically mentioned becoming more open-minded. One student reported that, "*It broadened my horizons to the type of impact that I could make. Talking to a diverse group of individuals throughout the trip really highlighted the concept that it takes a village, and you can create an impact no matter what job title you have.*" Several students also reported that they felt more motivated to take what they learned and apply techniques at home to improve sustainability in their own cities, and to travel more to experience other cultures. When asked about their "best learning experiences," many students (31%) reported that they valued interacting with and learning from the Swedish faculty and students, illustrating that these personal interactions are an important component of the course. Additionally, two non-environmental students have gone on for advanced degrees in an environmental field, reporting they were strongly influenced by their experiences in this course.

5 Discussion

In order to continue to address the UN Sustainable Development Goals (UN 2020), new approaches are needed to teach urban ecology that integrates multiple disciplinary perspectives, and also allows

students to see the applicability of a landscape approach to their own fields. Based on these goals, we developed a course that takes a comparative approach and also includes experiential learning with local professionals in two cities.

The final projects illustrated the students' ability to integrate various perspectives while examining environmental issues facing urban settings. Students who participated in the study abroad portion of the course had significantly ($p = 0.004$) more topics integrated in their projects ($\bar{x} = 3.93 \pm 0.22$) than students who did not ($\bar{x} = 2.13 \pm 0.40$). The experiential learning components of the study abroad portion (field trips, workshops, study tours) exposed the students to professionals who provided examples of how various fields were integrated to solve issues facing the city. For example, a workshop at the Scandinavian Green Roof Institute included hands-on activities of both building and maintaining green roofs in the local community, and also included tours and discussions about the lessons (success and failures) in the surrounding eco-district of Augustenborg. Examples of innovations in storm water management and also societal context of what populations have lived in the community over the last 60+ years lead to awareness about interactions in technological innovations as well as societal shifts, such as age demographics or refugee populations.

A review of over 100 key articles on "urban environmental education" led to the emergence of 5 main themes: City as classroom; problem solving; environmental stewardship; youth and community development; and city as social-ecological system (Russ and Krasny 2015). Our course encompassed many of these themes. In particular, the authors suggest that the approach to problem solving should not just include biophysical environmental issues (e.g. climate change, biodiversity, pollution), but should also address associated social issues, including poverty, racism, and human health, and more recent publications continue to support this idea (Kinslow et al. 2018, Garrecht et al. 2020). These issues also tie into the theme of the city as a social-ecological system, in that social issues are tightly intertwined with environmental issues. For this reason, we include a guest lecture from a local professor/lawyer/community justice activist, who addresses the history of environmental and racial injustices in Rochester, as well as integrating discussions of the issues facing Malmö (e.g. housing, health care, access to education, etc.) as a result of the influx of refugees from Syria and other parts of world ravaged by war. As the class visits each successive eco-district in Malmö, the guide and class specifically address questions of access and social justice in those areas – who lives there, who has access to the area, and how are social services acquired? Evidence shows that the students incorporate these topics into their final projects, with 40% addressing social justice and cohesion as a theme, and 11% choosing that topic as their primary focus.

We continue to find ways for students to practice environmental stewardship when they return to Rochester or their home communities. After visiting Malmö, many students reported (28%) a desire to apply the lessons they learned in Malmö to their own communities. To address this, we have provided several opportunities for students to continue to be involved in environmental issues on campus: 1) Participate in the annual study abroad symposium to share their experiences and encourage other students to go abroad; 2) Become "global ambassadors" with RIT's Global Education office to promote global learning; 3) Participate in environmental projects on campus, such as the community garden; or 4) Teach others about environmental issues as part of the annual "Imagine RIT" creativity festival. For students who are still on campus, these avenues provide opportunities for them to apply their knowledge locally.

This comparative, study abroad approach could be used at other universities, and in other cities. While Malmö is a particularly good showcase of urban sustainability innovations, it is hardly the only one, and we often found that students benefited from identifying issues in many different urban contexts.

6 Conclusions

After four offerings of the Urban Ecology course, we can draw the following conclusions:

- A multiple perspective approach that integrates

natural and social sciences and includes cultural context is needed to examine sustainability issues within the urban landscape.
- Results of our assessment of learning outcomes and of our survey with students suggest that a study abroad comparative approach leads university students to recognize the importance of multiple perspectives in urban sustainability issues.
- The approach that this course uses could be adapted to other cities and other universities.

Acknowledgements

We would like to thank our Swedish colleagues at Malmö University – Drs. Ebba Lisberg Jensen, Göran Ewald, and Joseph Strahl for their contributions to the course over the years. The course would not have been possible without their hard work, insight, connections, and friendship. We would also like to thank RIT colleagues who contributed guest lectures to the course: Drs. Sue Pagano, Ann Howard and Mary Golden. RIT's Provost's office provided project funding in the form of two Provost Learning Initiation Grants (PLIG). RIT's College of Science and Office of Global Education also helped to fund the exploratory stages of this course, which made its development possible. The Office of Global Education also provided significant logistical and financial support to both faculty and students that made the study abroad portion of the course possible.

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