Teaching with head, heart, and hands: a continuing journey of becoming an inspiring teacher

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5. Reflections and Evidence

5.1 Graduate Teaching and Research Mentoring – Who am I as a Teacher?

I am originally from Korea. I got my undergraduate degree there, which may indicate "limit or weakness" or "different element or unique perspective/strength" to be imposed upon a type of teacher I can become here in an American institution of higher education. I know there are people like me professionally in this job of being a college professor although they are still quite a minority. It took years for me to turn my personal attributes into strengths and resilience to become the teacher and mentor as I am today. I hope that I can share at least a piece of that part of the story through this portfolio.

I so vividly remember the first time when I walked into the classroom to teach as a relatively young, assistant professor at GMU in August of 2003. I had just moved to Fairfax, Virginia from Illinois (U of Illinois at Urban-Champaign where I did my two-year long postdoctoral work) about a month before the school started. I had never lived or visited Virginia until then. I was very excited and quite nervous about my very first class. I worked really hard to prepare the syllabus, powerpoints, handouts, and other materials for class projects so ambitiously. At that time, I was still on my H-1 VISA (literally a "foreign worker"), which was scheduled to start being effective on September 1, 2003. Thus, I could not "legally" teach a class as the main instructor. My very short-lived faculty mentor, Dr. Don Kelso, had to accompany me to introduce me as a guest speaker in my own class for the first lecture. He considerately left the classroom soon after he introduced me to the students. It was a class of 16 graduate students (the maximum number for the course) on my very expertise, 'Wetland Ecology and Management' with lab/field for 4 credit hours. The class was full with high expectation that I could read from the faces of the late-night students. All eyes were on me. It was a bit scary in that very first couple of minutes as I was introducing myself. I had rehearsed the lecture a day before and gone over the things several times.

The class started at 7:20 pm and ended 10:15 pm, but often lasted with questions and discussion easily up until 11 pm. George Mason University was a quite different place back then compared to what it is now. So many students were professional graduate students, meaning the ones that are quite mature (age-wise) and have full-time day jobs in many federal and local agencies, and businesses, leading a hectic life style. It was very different environment from what I was used to. Up to this point, my only teaching experience had been as a teaching assistant for a few classes during my Ph.D work at the Ohio State University and as a thesis mentor for a Master's student at University of Illinois.

I had no clue back then how to be effective and efficient with my teaching, not to mention how to communicate with students. I just thought that if I worked harder and longer hours I would be able to do it all right. Contrary to my firm belief and the endless hours I devoted myself to the

preparation of the class, I was not getting any better over time in that semester. Most students only came to the campus once or twice a week due to their full-time jobs, so they waited almost after every class to talk to me with questions about assignment, class projects and class papers, on top of explaining their own personal situations that conflicted with the scheduled activities of the class. I came home in that semester with my brain so active that I had a hard time getting to sleep. I was too ambitious with the student class research projects, designing almost as many projects as the number of students, and mentored them individually throughout the semester as if I were advising a Master's thesis for each of the 16 graduate students. It seemed that a few students really appreciated my dedication to the class, but I did not get many positive responses from many students. Gradually complaints emerged during the middle of the semester regarding the wordload, the mid-term, and expectations for class projects. One student goaded the other students to participate in a collective, strike-like session one night. I honestly did not know how to handle that. I tried my best to have an open conversation about everything so that we could have a congenial discussion and move forward as a class.

I felt powerless that night. It was almost midnight as I was walking to the parking lot to get in my car to go home. I couldn't help bursting into tears like a fool. It wouldn't stop. I was sitting in the car for a while on a dark corner of the campus. It was quite tough to swallow that night. The first few years at GMU I didn't know much how to reach out or talk to other colleagues or the Center for help. I was so alone, yet still fighting to figure out how to be a college-level teacher. I felt that there were cultural and language barriers that I must overcome to better communicate. I was not emotionally connecting with students much. Growing up in Korea, the place of strong Confuscinistic foundation, I found it especially difficult to deal with students older than I was. I should have addressed their time commitment and abilities better to balance their work and the class more effectively and communicated my understanding and concerns clearly, but I failed to do that in that semester.

Still being heavy-hearted the next morning, I got an email from one of the students in the class as follow:

"Hi Dr. Ahn - I feel kind of bad about all the heat you took about the exam tonight. I hope that the class's comments didn't come off as overly negative, and apologize for my part, if they did. I didn't take in the discussion as negative, as much as people struggling to figure out how best to get the most from and excel in (or pass!) your course. I thought it was a pretty good, open discussion, one which many professors would not even have, which wasn't lost on me.
In any event, mostly I wanted to tell you, in case you're feeling a bit disappointed about all of this, is that I've really learned a tremendous amount in your class and appreciate your efforts and willingness to help and make yourself available. It's really great. I'm a bit of a perfectionist, so even though I did okay, I was/am pretty frustrated with myself for some of the careless errors, and get even more frustrated when my effort doesn't equate to performance.
Thanks for all the above, and I'll be in touch about my research project, once I finish the homeworks, if not before.
Cheers!
Pam Noyes"

The email solaced me. Another student also took the time to write me such a long email to help me with class plans and relationship with students, for which the student specifically asked for confidentiality, so I may not put it here. These two emails provided me with much need a cheer

for me and put me back where I should be in the following weeks to finish the very first semester as a professor. I called upon a one-on-one meeting with the student who habitually complained without much constructive points, leading a negative atmosphere for others' learning. We had a candid conversation as a mature adult one-on-one, and she stopped her unproductive complaints. Honestly, at that time someone told me that she wouldn't have behaved so disrespectfully like that if I had been a white, older faculty member, which made me feel even worse. But I came to know that there was just a long way to go from that point in my journey as a college professor, and that I could be successful only when I am fully who I am and always try my best to find and keep the inner strength. I also adjusted course activities for the rest of the semester so that the students could manage to achieve the level or amount of learning I hoped them to. The thing that you perceive as a weakness can be turned around to become a unique strength only you possess, and it is you than anyone else who can do that. The experience of the first semester was so strongly ingrained in my brain that I felt strongly about the need to become a better communicator. This may have played a role in my desire to design the *EcoScience + Art* initiative several years after that heavily focus on the theme of "communication" in education.

I have always held very high, professional standard for graduate student research and scholarship. During my first three years at GMU I was contracted to only develop and teach graduate classes, and I developed two graduate classes both for ESP and Biology – *Wetland Ecology and Management*, and *Ecosystem Modeling and Analysis*. Only after the first contract renewal the committee recommended that I should develop an undergraduate class. Last year, I developed another new course, *Urban Ecosystems and Processes*, which both undergraduate and graduate students can take. When I designed a graduate course I tried my best to make sure that the course had a strong research training, writing exercise, and analytical thinking. That was why I had designed a semester-long research project for each of the 16 students even in my first semester. So the course required a proposal writing, conducting a research project (intensive literature review for meta-analysis or for an integrated literature review paper), presentation (including format/style) that counts a great deal in a real world, and research publication exercise, all main components for a graduate student to master to be able to complete his/her thesis or dissertation. To facilitate this I also created 'publishing workshop' in every graduate course I teach and dedicated at least one full or half class to it. I always emphasize **4Ps** in a scholarly or academic work as a scholar: *Propose, Present, Publish, and Participate*. If you are in a graduate school you must have experience or training in all 4Ps with a clear understanding of the linkages among them. In addition, I engaged graduate students who took my classes, including my own advisees, in rewriting, editing, formatting/styling their class papers into manuscripts in an annual report format (e.g., Ahn Wetland Ecosystem Laboratory at GMU in supplemental material) to further train them after the semester in academic writing with an emphasis on writing one or two-page long piece of their science work to communicate with a general audience.

I remember that I was quite surprised in my first year (i.e., 2003) at the performance standard held for graduate degrees (I can only talk about this for my own department of course). Sometime I went to Ph.D. student defense back in those days and was so disappointed with the presentations and/or the level of the work presented for the degree. Many of them seemed barely deserving a Master's degree in its depth and breadth. It is a Ph.D.! I thought the change could start with me and my classes. Through the exercise focused on 4Ps in all my classes, many of my own graduate students came to work with me after taking my classes. And all of my graduate

students published the results on their research, on average 2-3 journal articles per student, which I am very proud of to this day. All of my graduate students also have presented their work in nationally and internationally recognized professional meetings and conferences. As any of the reviewers would know it requires a tremendous efforts of advising, both in-person and online for editing/proofreading, to train a new graduate student into becoming a published author. It took me to edit over 10 times for many of the manuscripts authored with students. It required countless meetings, many of them on Sunday afternoon in my office, especially graduate students who has full-time jobs and had difficulty meeting in person. Often we arranged to meet half-way between us during the weekend. I spent extensive hours of graduate advising for scholarship and I still do, which something I take very seriously in my time commitment.

I cannot help mentioning my very first graduate student, Kurt Moser, as well on retrospect. He was a history major for his undergraduate training, but slowly turned himself into a natural science major by taking a few science classes at NOVA before transitioning to GMU. One night, it was quite late when someone was knocking my office door when I met him for the first time. He was cautiously pushing his head into the office, asking if he could talk to me for a moment. He sat down and we talked for another two hours, and then he started working with me pursuing his Master's degree. We did a lot together. The lab space given to me when I arrived at GMU was a junk yard space literally, being a storage for old, unused equipment and supplies from senior faculty members. We cleaned and painted it up over the first many months and turned it into a working lab that is now the "Ahn Wetland Ecosystem Laboratory" (recently renamed as "…Lab/Studio" due to the art and communication components of my research recently expanded). Kurt learned all my core strength areas and published three high level journal articles throughout his Master's work with me. He still comes to see me at every *EcoScience + Art* lecture series I organize. The process of literally "raising" Kurt as a graduate student also greatly helped me build a sort of protocol/ structure for my graduate advising for the following years. About a little more than a year ago he wanted to talk to me about the next step in his life. After the graduation, he worked with environmental education task force many years in Alexandria, but with his father's recent passing he wanted to dedicate his energy and passion further into creating/building a more sustainable and resilience community where he lives. I felt quite grateful and touched that he still wanted my advice almost after over 10 years from his graduation on the next move in his life. Just past semester I could take my students in my new course *Urban Ecosystems and Processes* to one of the sites the Conservatory was doing tree planting for to learn more about the stream/wetland restoration work Kurt conducted with his residential community partners.

Over the years, all of my graduate students did an individual study with me many times through their graduate career on which I provided more in-depth and specific teaching and mentoring for their research projects. I provided most of them with research funding or helping with research proposals to obtain internal and external grants to be able to conduct their studies for the degrees.

The following is the list of publication with my graduate students

Rigley, D., Korol, A., Ahn, C. 2017. Using FeS probes to study soil redox-potential in created mesocosm wetlands as affected by planted macrophyte community, *Communications in Soil Science and Plant Analysis* (to be submitted).

Dee, S, Ahn, C. Korol, A., Lee, JA, Means A. 2017. Patterns of vegetation and soil properties in a

beaver created wetland located in the coastal plain of Virginia. , *Landscape and Ecological Engineering* (*in review*).

Noe GB, C. Hupp, E. Schenk, K. Krauss, S. McMillan, D. Kroes, S. Ensign, J. Gillespie, K. Wolf, and Ahn, C. 2017.Nutrient and sediment inputs change soil structure and biogeochemistry in floodplain ecosystems: a cross-study synthesis. Ecological Monograph (*in review*)

Means, M., Ahn, C, Noe G. 2017. Resilience of vegetation communities after a disturbance in constructed wetlands as affected by planting richness, *Science of the Total Environment* 579:1366-1378.

McAndrew, B, Ahn, C., Brooks, J. 2016. Effects of herbaceous plant diversity on water physicochemistry in created mesocosms wetlands. *Journal of Freshwater Ecology,* DOI: 10.1080/02705060.2016.1248504 (online published)

McAndrew B, Ahn C, Spooner J. 2016. Sediment and nitrogen capture performance of a floating treatment wetland for sustainable stormwater management in an urban environment – the case of the Rain Project. *Sustainability* 8 (10), 972; doi: 10.3390/su8100972

Korol, A., Ahn, C., and Noe G. 2016. Richness, biomass, and nutrient content of a wetland macrophyte community affect soil nitrogen cycling in a diversity-ecosystem functioning experiment. *Ecological Engineering* 95: 252-265.

Korol, A., Ahn, C., 2016. Dominance by an obligate annual affects the morphological characteristics and biomass production of a planted wetland macrophyte community, *Journal of Plant Ecology* 9:187-200: 1-14.

Means, M., Ahn, C., Korol, A, Williams, L. 2016. Carbon storage potential by four herbaceous wetland species as affected by plant functional diversity. *Journal of Environmental Management* 165: 133-139.

Williams, L., and Ahn, C. 2015. Plant community development as affected by initial planting richness in created mesocosm wetlands. *Ecological Engineering* 75: 33-40.

Lee, J., Chon, J., Ahn, C. 2014. Planning ecological infrastructure by cost-least path method for a small urban area based on ecosystem services. *Sustainability* 6: 7564-7584.

Petru, B, Cheschier, G, Ahn, C. 2014. Assessment of water budgets and hydrologic performance of a created mitigation wetland – a modeling approach. *Ecological Engineering* 71: 667-676.

Dee, S.M., and Ahn, C. 2014. Plant tissue nutrients as an indicator for functional development in created mitigation wetlands *Ecological Indicators* 45:68-74.

Ahn, C, and Jones, S. 2013. Assessing organic matter and organic carbon contents of soils of created mitigation wetlands in Virginia. *Environmental Engineering Research 18(3): 151-156.*

Peralta, R, Ahn, C., Voytek, M., Kirshtein, J. 2013. Bacterial community structure of *nirK*-bearing denitrifiers and the development of soil properties in created mitigation wetlands, *Applied Soil Ecology* 70: 70-77.

Wolf, K. L., Noe, G. B., and Ahn, C. 2013. Hydrologic connectivity to streams increases nitrogen and phosphorus inputs and cycling in soils of created and natural floodplain wetlands *Journal of Environmental Quality* 42: 1245-1255.

Petru, B, Ahn, C, Cheschier, G. 2013. Alteration of soil hydraulic properties in wetlands created to mitigate the loss of natural wetlands in the Virginia piedmont , *Ecological Engineering 51:140-150.*

Peralta, R.M., Ahn, C, Gillevet, PM. 2013. Characterization of soil bacterial community structure and physicochemical properties in created and natural wetlands, *Science of the Total Environment* 443: 725-732.

Ahn, C, Peralta, RM. 2012. Soil condition properties are useful in examining denitrification function development in created mitigation wetlands. *Ecological Engineering 49: 130-136.*

Dee, S.M., and Ahn, C. 2012. Soil properties predict plant community development of mitigation wetlands created in Virginia piedmont, USA. *Environmental Management 49: 1022-1036.*

Wolf, K. L., Ahn, C., and Noe, G. B. 2011. Development of soil properties and nitrogen cycling in created mitigation wetlands. *Wetlands* 31: 699-712.

Ahn, C. and Dee, S. M. 2011. Early development of plant community in a created mitigation wetland as affected by introduced design elements. *Ecological Engineering* 37:1324-1333.
Wolf, K. L., Ahn, C., and Noe, G. B. 2011. Microtopography enhances nitrogen cycling and removal in created mitigation wetlands. *Ecological Engineering* 27: 1398-1406.
Bender S., and Ahn C., 2011. A review of stream assessment methodologies and restoration: the case of Virginia, USA. *Environmental Engineering Research* 16 (2): 1-11.
Leonard, C. A., Ahn, C, Birch, D. L. 2010. Above and belowground vegetative responses to prescribed fire regimes in a tidal brackish marsh. *Journal of Ecology and Environment* 33(4), 351-361.
Moser, K. F., C. Ahn, G. B. Noe. 2009. The influence of microtopography on soil nutrients in created mitigation wetlands. *Restoration Ecology* 17: 641-651.
Ahn, C., P. M. Gillevet, M. Sikaroodi, and K. Wolf. 2009. An assessment of soil bacterial community structure and physicochemistry in hummocks and hollows of palustrine forested wetland. *Wetland Ecology and Management* 17:397-407.
Ahn, C., R. M. Peralta. 2009. Soil bacterial community structure and physicochemistry in mitigation wetlands created in the Piedmont region of Virginia, *Ecological Engineering* 35:1036- 1042.
Moser, K. F., C. Ahn, G. B. Noe. 2007. Characterization of microtopography and its influence on vegetation patterns in created wetlands. *Wetlands* 27: 1081-1097.

The list of professional presentations (national and international) with and by my graduate students are over 60, so not included here, but available upon request.

** The supplemental material for this section include graduate class syllabi, evidential emails from my very first semester that show that I worked with each student to develop and conduct a research project, publishing workshop I conducted for each class I teach, and the annual reports exercise I conducted to further train students beyond the semester.

5.2. Undergraduate Teaching with Research and Scholarship (RS) and Building an Outdoor Teaching/Research Infrastructure (Ahn Wetland Mesocosm Compound)

Last year, I became a full professor. It has been such an intensely busy 4-5 years. My promotion review was excellent. I worked harder in all sectors of professorship and improved more in the past seven to eight years out of the total of 14.5 years I have been at GMU. This is because my growth as a "teacher" and a "mentor" was really huge during the period while I was developing and teaching more undergraduate classes that focused on research and scholarship training, starting a campus-wide new interdisciplinary initiative called *EcoScience + Art*, and designing and executing *the Rain Project* as a pedagogical experiment. They were all carefully designed to be an integrated part of providing students with better experience of college education. The following is what the department chair who had been a chair for my tenure and full professor promotion over the period wrote in his summary of the review of my dossier in 2015;

"I have watched Dr. Ahn develop professionally and academically. He is a creative and diligent researcher and has developed into an inspiring teacher……Ahn remains excited and enthusiastic about his research and his teaching – especially bringing students into the wetland research environment. He continues to develop new ways to link these. The latest example was the floating wetland systems that he mentored with students from multiple schools at Mason and then deployed in the Mason Pond. The proposed benefits of this deployment are yet to be reported, but clearly the notoriety and the student involvement was tremendous. Dr. Ahn is a major asset to Mason"**…..**"

I only saw this this letter later after all the departmental reviews were submitted to the college-level P&T committee, but I was quite touched by his genuine comment. However, looking back, I was far from being complimented from the same person in my early years for my undergraduate teaching. I was often struggling to meet the enrollment requirement for the very first undergraduate class I designed. The first undergraduate course I developed was '*Ecological Engineering and Ecosystem Restoration*'. Not many students enrolled in the class. Maybe the word 'engineering' scared all those biology majors. When I tried to teach the course for the first time I could not do it due to an unexpected situation in the department. They needed someone to teach another class right before the semester began, so I willing accepted the challenge to teach '*Environmental Chemistry for Non-majors*' instead of the *Ecological Engineering* class I had prepared for. Although I felt quite disappointed at first I turned it around to make the Environmental Chemistry for Non-majors more interesting. I built a science communication component to it by helping students conduct a critical reading of science articles on hot environmental issues such as climate change and water pollution and communicate their understanding in more lay terms, which later became a seed for other undergraduate courses and the new initiative that I developed on the campus later on.

While I was still struggling with undergraduate teaching I designed an outdoor teaching & research infrastructure, now named as *Ahn Wetland Mesocosm Compound*, which is currently located on a 100-year floodplain behind the first soccer field within the Intramural Fields on the west campus. The completion of the compound itself has a long story to tell. I remember shoveling dirt for weeks and months with many students who volunteered to help over the years.

It took several years to become what it is as of today, and I have tried to give some background and reflection here.

I felt a strong need for an outdoor teaching facility. You cannot teach ecology and environmental science only in classrooms or in labs. I also strongly believe that landscapes are important and essential to the transfer of knowledge. I felt that universities should also take the responsibility of educating the next generation about sustainability and resilience. Working with nature outside the classrooms can provide not only environmental science students, but all with a long-lasting appreciation for nature, as well as teach values important for their lives. Students need to be trained in both observational and experimental studies to learn how the science, and especially of ecology, is done. I roamed around the campus many months to find a spot to build this infrastructure. It was not easy, but with the help of the ESP department I found a small piece of land where I could build the compound I designed.

It started with an architectural drawing with some help from a man at Facilities who I happened to meet during my many visits with them. He really saw my vision for this. I also talked with the CEO at Long Fence several times to explain the need and concept of the compound for its benefits for student learning. Many meetings and many correspondence followed. The company provided the fencing the area designated for the compound ($20k worth of fence material). I also worked with the university development office by submitting a few proposals to obtain external funding; however these were not successful. I met Peter Stearns, the former Provost, and using one-on-one ppt presentation, asked for help. When I started as an assistant professor I got quite a small start-up fund to build a lab ($20k or 25k). To make it worse, an unexpected situation happened not long after I started my first semester; the university had to freeze the spending of my small start-up fund for nine months or longer due to some budget issues in the State. Although I could quickly obtain some external funding to build my lab the pain was palpable. The Provost remembered the incident and tried to help me with building the outdoor compound I proposed by providing funds that covered the ground work fees for the facilities to bring water and electricity to the compound. Later on, thanks to a few small funds, including a fund from a local environmental consulting firm I got, I could establish the compound that now houses a set of 60 (200 gallon each) stock tanks (mesocosms) with two 500-gallon water tanks and a tool shed (outdoor lab/field prep space) that have been used for a variety of class teaching and research activities involving so many students.

Mesocosms have long been considered useful research tools for ecological studies of aquatic and terrestrial ecosystems. They have been used in commercial scale applications, such as in wastewater treatment and in ecological engineering and ecosystem restoration. Use of mesocosms, particularly in ecological science, has been common over the last three decades in studies of the fate and effect of pollutants, biogeochemical cycles and the effects of nutrients on ecosystem dynamics to name a few. Mesocosms provide a means of conducting ecosystem-level experiments under replicated, controlled, and repeatable conditions. They allow replicability and repeatability of hypotheses-driven experiments at a much lower cost than do large, field ecosystem studies, which is absolutely necessary to train students in research and scholarship.

We established a set of 20 mesocosms first inside the compound. Mesocosms were buried in the ground to insulate roots against freezing. Wetland plants rhizomes were planted into each mesocosms. Two water tanks (500 gallon each) store either rainwater or any source of water that will be used for a scientific experiment. Another set of 40 mesocosms were established later years and have been used for an externally-funded research project that involved four graduate students and several undergraduate student research experiences. It also provided a venue as a mentoring space for K-12 students, including a large group of high school seniors from all over the US through *Washington Youth Summit on the Environment* for years. The compound was also open to public regularly when students presented their research projects and learning outcomes to communicate science. The compound is still in development to some degree since I hope to have a weather station and a solar panel inside the compound someday to support many undergraduate research projects and learning experiences. The compound supported several K-12 summer science projects along with a research intensive undergraduate courses. I hope for a collaboration among many parties on the campus to continue to grow the compound since I have a few more new ideas to further improve its functionality as a teaching tool. The wetland mesocosms compound has been used for many courses over the years; EVPP 378/BIOL 379 (Ecological Sustainability), EVPP 355(Ecological Engineering and Ecosystem Restoration), EVPP 378/BIOL 379 (Ecological Sustainability), EVPP 442 (BIOL442)/EVPP542 Urban Ecosystems and Processes, EVPP 646/647 (Wetland Ecology and Management), and EVPP 650 (Ecosystem Modeling and Analysis) and a few other courses and student projects in ESP, Biology, Art, and Civil Engineering. Especially, the compound supported many undergraduate class and scholarly projects from *Student as Scholars.* The compound will continue to support and promote student teaching and research activities as an important asset to the University. The compound is also appropriate for part of the campus greening and sustainability work. The following is a list of articles and video clips published on the media about the compound and the use of it:

1. Getting down and dirty: professor builds wetland research area on campus', August 14, 2007, ***Gazette***, GMU (http://gazette.gmu.edu/articles/10623/).
2. Mesocosm Compound Provides Wetland 'Lab', ***Gazette***, **YouTube**, April 23, 2010. (**Video**) http://www.youtube.com/watch?v=8baKnW69ybk&feature=player_embedded
3. Ecological Engineer studies human-created wetlands, ***Gazette***, GMU, October 10, 2011 (http://news.gmu.edu/articles/7708).

4. Students Develop Model Wetlands, ***Broadside*** featured news, GMU, April 23, 2012 (http://broadsideonline.com/2012/04/23/students-develop-model-wetland-4792/)
5. Mason Wetland Laboratory Provides Resources for Important Watershed Research. GMU homepage headliner, May-June 2012 – Video (http://about.gmu.edu/mason-wetland-laboratory-provides-resources-for-important-watershed-research/)
6. Mason's Wetland Compound **video**, May 2012 (http://vimeo.com/43562094) –Please watch this to learn more about the outdoor compound and student learning

I could greatly improve my undergraduate teaching with the fully functioning outdoor compound by emphasizing experiential learning approach, focusing strongly on research and scholarship training in ecological and environmental science.

Research and scholarship in undergraduate science education has recently been emphasized in many colleges and universities. However, there has been little information that is specific and organized enough to guide instructors on how to teach undergraduates research effectively. A great deal of research were conducted on science teaching to improve science literacy among undergraduates, but there has not been numerous cases that clearly show what methodologies and/or how certain procedures work to materialize the role of 'research' on science teaching. Research and scholarship training is not just for those who plan to go to graduate schools or seek their career in research and academia.

There is a lack of courses that teaches ecological sustainability that mostly deals with issues relating to biodiversity and ecosystem services. Many ecology or environmental science majors will enter careers and occupations related to environmental consulting and other forms of ecological field research and activities. Ecology or environmental science is an interdisciplinary subject matter that would be in real need of their students being given the opportunity to actively participate in the process of research and scholarship. Therefore I developed a new undergraduate course to start in SP 2013 with a grant support from OSCAR to develop a research and scholarship intensive course, titled 'Ecological Sustainability (EVPP378/BIOL379)'. The course was designated as RS (Research and Scholarship) intensive, greenleaf, and capstone course.

One of my main philosophy about teaching is that teaching and research go hand in hand. They both feed each other to grow. One may argue, but I firmly believe especially in what I do teaching/learning may not improve without involving research, including research on new approaches and pedagogies. Research is an important part of teaching. Also training for the abilities to communicate that are lacking in almost every discipline of today's college education cannot be more emphasized in terms of the role of college education in general. Also, in natural science courses (especially in biology and environmental science), field-based, hands-on experience is almost mandatory approach through which students learn skills and methods to be able to get a better sense of how science get conducted, produces data that feeds policy making that determines many things so close to our lives. These types of activities are not quite common still in undergraduate courses. Undergraduate students often take a number of classes, yet are not being provided with opportunities to "use and integrate" the pieces of knowledge obtained in those classes. The ecological sustainability course was designed for that.

The course was designed with a timely and popular subject that would interest students to begin with. The theme in the course for the spring semester of 2013 was "*Wetland plant diversity and soil organic matter (SOM) accumulation-ecosystem's carbon sequestration*" as part of soil ecosystem's ability to sequester carbon to mitigate the impact of climate change. As an ecosystem ecologist I decided to use the best of my experience and expertise from fields and labs in teaching research processes and methodology to undergraduates often by incorporating one of my on-going research projects. I have always tried to link research and teaching in my performance as a professor throughout my academic career. When I designed my RS course I was at an early stage of one of my research projects that focused on studying the effects of planting diversity and time (i.e., age) on ecosystem functional development in wetlands created to mitigate the loss of natural wetlands. I transformed some aspects of the project into a resource for student class project materials. The course was built with several key activities that are pivotal to scholarly inquiries, including peer-reviewed journal article study (i.e., critical reading, summary, presentation, and discussion of the article), hypothesis forming exercise, field trips to local wetlands, participating in soil samples and laboratory analysis of the collected samples, data analysis and group discussion of the results, writing a paper in a journal article format and style, and communicating the results of the study with the public (e.g., K-12 students).

Each student is encouraged and directed to act as though he or she were an environmental or ecological researcher, and worked individually and often as a group (of 2-3 students), depending on the type of activity. For example, students individually studied literature that is original and relevant in both scope and subject matter for the research project. Hypothesis formation exercise was conducted by group, so the students were challenged to build hypotheses for their research project after reviewing relevant literature and visiting wetland sites. Each group came up with a hypothesis after intensive group discussion and presented in front of the entire class to get feedbacks and answer questions from the other group members. Field data collection and lab processing of samples were a group task as well. They would come up with a plan to divide the sampling job among the group members, and often devised a sampling scheme, collecting data and performed the analyses of those data to test their hypotheses together as a group. Writing a research paper was an individual task at the end of the semester.

Through this kind of scholarly inquiry and investigation approach that is common in natural sciences, students learned first-hand what it means to produce scholarship in the field of biology and environmental science. The students' task was to assess soil organic matter as a surrogate of soil organic carbon (e.g., approximately organic carbon is half of the organic matter in soils) in both local created wetlands of varying ages and mesocosm wetlands created with different planting diversity scheme. The steps in this course included the following activities:

Critical reading of peer reviewed journal articles

The goal of the lecture was to provide as much information as possible on each process involved in scientific research and specific knowledge on wetlands and plant diversity. I prepared weekly or biweekly reading materials most of which were peer-reviewed journal articles on the topic, carefully prepared starting with relatively an easy one to read as a non-researcher/scientist in the field. Students were asked to prepare a summary (2-3 pages with 800-1000 words limit) of the paper they read, followed by 2-3 questions. Students searched literature or online sources (e.g., I

taught how to use *Web of Science* for peer-reviewed journal articles with keywords) to look up to answer at least one of their own questions that they raised while summarizing the paper. I specifically chose 9 journal articles, including a couple of book chapters throughout the semester with specific key words such as created wetlands, plant diversity, and wetland soils. Students as a group took turns in presenting a paper summary through power point presentation each week, and tried to answer and discuss the questions raised by the other students, including their own. My involvement was heavy at the beginning of the semester with lectures on the content of the paper along with instructions on how to read graphs and tables correctly in science papers. In addition, I incorporated a couple of hour session on simple statistics along with my lectures on how to read and interpret the information conveyed in graphs and tables in science journal articles. Although the majority of the student previously had taken biostatistics courses they rarely applied the knowledge to their own scientific inquiries. Thus, the session worked really well to pull and refresh the pieces of knowledge they have earned from other classes and to challenge them to apply them to the research activities of this class. As time went by the students showed a visible progress in their reading, questioning, and discussing abilities on the given topic of a paper.

For the first half of the semester students learned scientific methodology, basics in wetland ecology and soil science, and any information and knowledge pertinent to being able to conduct their research projects with the topic chosen for the semester. In addition, I arranged a couple of guest lectures on the topic relevant to the research projects so that the students could meet and learn from working scientists/professionals in the field. The type of critical reading and discussion of scientific papers familiarized students with scientific literacy, units, focusing on how to correctly read and interpret graphs and tables that are often confusing, and scare non-experts.

Exercising hypotheses testing

Hypotheses are not guesses. They are only made after a student learns something about the system that they deal with. Students practice building their own research questions based on a broader scope of the research idea explained, from having read and studied journal articles and other complementary materials handed out on wetland plant diversity and soils. Each group presented their hypotheses or research questions after their internal group discussion and received questions and feedbacks from all the other students. And then students went through another round of hypotheses forming practice and presented their final, revised hypotheses of their research project to the entire class, aligned with their plans of how to test their hypotheses and what may involve in their methods and approaches for the testing.

Lab/field activities

There was a lab/field component, which was about 2.5 hours on Fridays, that involved field trip to local wetlands/parks/natural areas, field sample collection, and lab analysis of any samples collected (i.e., soils). The goal of the lab/field portion of the class was as follows. First, I wanted my students to see created wetlands commonly found in the northern Virginia with a few of field sites my research team have studied for several years. Second, I wanted the students to gain hands-on experience and master basic skills and field techniques used in soil samplings, water regime characterization, and plant identification. Last, I wanted them to experience some part of lab analysis of the collected samples, including soil sample drying, weighing, and applying loss-

on-ignition method to quantify organic matter content in each soil sample. The field experience would provide the students with an idea of what fieldworks in ecology are like and a real sense of the data that may no longer just "numbers" afterwards.

There were always small lectures provided a week before or one class before the scheduled field work to explain why and how we collect these samples and what information can be teased out from the analysis of those samples. Thus, students would understand the rationale of the experimental design and sampling protocol before conducting an actual field sampling. During the field training students demonstrated their improvements in their knowledge verbally on the research subject that cannot be quite conveyed in a classroom setting. Field-based learning in ecology and environmental science is a must and provides students with knowledge of an ecosystem that cannot be conveyed in a classroom setting – "the colors, sounds, smells, and textures experienced in a real wetland leave a lasting impression that makes the facts and figures all the more relevant.". The following picture shows student activities in lab/fields.


The research questions had two parts. One was about the SOM, all as affected by planting diversity in wetland mesocosms and the other was SOM comparison between three wetlands of varying ages created in the Virginia piedmont. The students collected the soil samples in both systems and followed a relatively simple lab procedure to analyze SOM with my assistance. The students found no difference of SOM between created mesocosm wetlands with four different planting diversity, fairly due to a young age of the wetlands (~1 yr) (Table 1), but found higher SOM content in the oldest created wetland compared to the other two younger wetlands in the fields. I helped each student group with data analysis, using EXCEL and a common statistical software (MINITAB) to help them understand the basic statistics as a common language of science. It is important to be able to read graphs and tables in science literature even as a non-major. I emphasized the fact that the students should not be afraid of looking at graphs or tables (although they often do, I find) that contain so much information that is not translated well into texts.

Writing a research paper and creating a poster for public presentation
All students were required to write a research paper theoretically being sent off to a journal. To facilitate the first, I designed one class session dedicated to a "writing workshop" where I instructed on how to write a manuscript for scientific journals, and also invited a guest speaker from the *Students as Scholars* program to do a lecture on how to make an effective poster for presentation. All of the above are all essential parts of scholarship training and experience.

The outcome of the research activities by undergraduates were presented in a few meetings, including *Students as Scholars* undergraduate research forum, College of Science undergraduate research colloquium, and *Innovative Teaching and Learning conference* at GMU (Probst, 2013). Another major, new component I designed for this RS intensive course was a public presentation of students' research. Research and Scholarship training and experience may not come in a full circle without "presentation" component. Before the semester began while I was designing the course activities I arranged a meeting with science teachers from two local K-12 schools to invite them to the Wetland Mesocosm Compound for our student presentation at the end of the semester (i.e., the first week of May for the spring semester of 2013). Involving K-12 students need time and often understanding of their schools' situations. Some schools I had contacted could not make it due to some financial issues to running a school bus to take the students to the compound. The two local schools, one being a middle school and the other a high school, were greeted and welcomed by all undergraduate students in the class who prepared their posters and hanged them on the fence of the compound, getting ready for their public presentation. First each group gave the students and teachers visiting a short orientation about the wetland compound and what type of research they did, trying to put things in the context of ecological sustainability. After that, students were divided into four groups to present each of their semester-long research project outcomes to the visitors. K-12 students were also divided into small groups and assigned to each presenting group.

K-12 students showed a great curiosity with excitement of seeing small critters, including tadpoles in the wetland mesocosms when they were given free time to look around before listening to the each group's presentation. I was carefully watching each group's presentation and communication with the K-12 students. My intention for this type of activity was particularly geared to train science communication skills in undergraduate students. When the undergraduate students started their presentation, using the jargons and terms commonly used in ecological sciences for the experiment they conducted all K-12 students stopped them and started asking questions, starting with very basic concepts about those. That inevitably and immediately challenged the undergraduate students to a great deal in my observation because they had to explain even a very basic concept like "What is a wetland?" in ecological and legal senses to help K-12 students understand the background and implication of the study. This kind of interaction continued throughout the presentation session that lasted 2-2.5 hours. The following picture shows the scenes of their presentation and communication sessions with the K-12 students at the wetland compound.

Undergraduate students presenting their research project at the end of semester to K-12 students invited as part of science communication exercise

After public presentation with K-12 students

I asked the undergraduates to respond to the following questions after their public presentation session: 1) describe your experience of presenting your class project work to K-12 students, and 2) evaluate and/or comment on the above experience in terms of science communication. The responses were extremely positive, especially comparing with their presentation to their own peers that they usually do in other classes. Also many of them expressed that they felt confident and proud of their presentation through gaining teaching experience from interacting with K-12 students. Many of them also mentioned that their interaction with K-12 students during their presentation was difficult, yet actually taught them a great deal in what it takes in communicating science that is an important aspect of research and scholarship. Speaking in scientific terms, then translating it to common terms for K-12 students seemed to really help undergraduate students consolidate and/or reinforce their learning experience they gained throughout the semester. Interacting with K-12 age groups may be a bit awkward to some of the undergraduates who never had previous experience getting kids engaged in any type of science communication, but all the students acknowledged the exercise was very helpful, which also seemed to get them to think about what may take to communicate science with general public and how critical it can be in enhancing ecological sustainability.

I presented and explained the case of this RS intensive course I taught in CUR (Councils of Undergraduate Research) Conference in 2014 in Washington, DC, emphasizing that K-12 participation was instrumental in enhancing research and scholarship experience in undergraduate science education. In the future I would like to continue to work with the university to develop a suite of measures to track and evaluate different approaches and methods that can be adopted to improve undergraduate research and scholarship experiences. Out of the two K-12 schools participated in the course the middle school science teacher came to the presentation with a short questionnaire prepared for her students to fill out, which basically questioned what the projects and outcomes were about along with questions about hypotheses and variables of the projects. I got to look at those later and thought if I could get to work with science teachers ahead of time on the questions and measures to be used to quantitatively assess the learning outcomes and impacts on both sides it would be greatly beneficial for STEM education in both K-12 and undergraduates, which necessitates further discussion.

I truly loved teaching this class. The part I liked the most was that the course let me emotionally connect with the students by working very closely with each one of them. Teaching the Ecological Sustainability course gave me an opportunity of exploring and designing more effective pedagogical approaches for undergraduate teaching. I could combine effectively my activities in both teaching and research in a more impactful way as a professor. I made a conscious efforts to get to know all the students who took the class, spending time to talk with each one of them about what courses they have taken before my RS course to gauge their backgrounds better earlier in the semester, and came up with a better grouping of students for class projects, which helped me connect with students better, thus leading a great experience of teaching and learning on both ends. Many students who took this course were interested in

applying or have applied for a graduate school in environmental science, biology, and other related fields (the class activity has been made into a story for GMU website; http://newsdesk.gmu.edu/2013/05/student-to-student-presentations-explore-wetlands-research/). There were many positive comments students left on course evaluations (see supplemental material under Tab 6)

The same approaches explained for the Ecological Sustainability course above has been applied to my other undergraduate courses since (i.e., Ecological Engineering and Ecosystem Restoration, and Urban Ecosystems and Processes). As I finished the spring semester of 2013 I felt strongly about starting something that would further help students to more actively participate in learning activities beyond classrooms across the disciplines. This leads me to talk about the "*EcoScience + Art*" initiative I started in Fall 2013 on the campus.

** The supplemental materials for this section include my undergraduate course syllabi, some documents that would show my efforts for the Mesocosm Compound development, media-published stories about my undergraduate teaching with research & scholarship training.

*5.3. A Campus-wide New Initiative, **EcoScience + Art**, and Student Leadership Group*

I strongly believe holistic approaches in education can reinforce students' learning experience and help them foster innovation, collaboration, and persistence. We need to make conscious efforts on creating and nurturing more interdisciplinary programs on the campus. Currently, there is a lack of an interdisciplinary student-faculty and student-student interactions outside the classroom. There is a great lack for undergraduate students in their early academic training of an opportunity to experience, learn, and actively participate in interdisciplinary works and novel ideas across the disciplinary boundaries. There are currently not enough resources that can be easily accessible and made available for student and faculty looking to reach out for collaboration across traditional academic boundaries, especially among science, art, and engineering. Many undergraduate students may not be aware of the vast number of environmental fields/projects that are interdisciplinary. There is a need to exposure students to diverse, collaborative areas of arts and science, informing them of career options outside of their own disciplines.

With that in mind, I started the *EcoScience + Art* initiative in Fall 2013 at GMU collaborating with faculty from School of Art. The main goal of the initiative is to provide students with an opportunity to experience, learn, and actively participate in creative interdisciplinary activities of education and scholarship that can come up with sustainable solutions for Mason. The fundamental idea is about collaborations between scientists and artists that can result in research projects, pedagogical innovation, and learning experiences on the campus. Furthermore, the *EcoScience + Art* intends to bring together individuals working across the boundaries of ecosystem science, ecological restoration, the arts and humanities, and engineering to provide not only Mason, but surrounding communities with the opportunity to share experience, knowledge, and understanding concerning the pressing environmental and cultural issues we face. I prioritized undergraduate student learning experience to be the core of a variety of activities of the initiative. A website for *EcoScience + Art* was created (http://ecoscienceplusart.wordpress.com/) and has served the community since by providing useful resources, promoting events, speaker bio, and recorded lecture videos, and providing a venue for conversation in the effort to design innovative interdisciplinary pedagogy and practice on the campus and beyond.

Through my own research as a scholar I had been following on many interdisciplinary calls and approaches by NSF (e.g., Ecological Reflection series) and other professional organizations for years. Due to the complexity of the issues our society faces these days we desperately need to find a better way to train the next generation who will be in charge of untangling the complexities of the problems and finding solutions for humanity. I made efforts to participate in their evening seminars by Cultural Programs of National Academy of Sciences that specifically focused on the integration and/collaboration between art and science. I also researched and studied new initiatives on similar topics on several major universities to learn how those programs work to grow the imitative. I see art as a catalyst for the changes we need to make to develop innovative education strategies. Incorporation of art in undergraduate curricula can benefit the pedagogy of various college disciplines. I hope to find 'how'.

There are mainly two components I designed for the *EcoScience + Art* initiative. One component of the initiative is a speaker series which introduce innovative, original, and pioneering figures of the boundary of arts and ecological sciences to students to motivate and inspire their creative collaboration. We all know how challenging it is often to create and conduct interdisciplinary projects. The attempts for interdisciplinary efforts often drain out without structural and systemic support and encouragement from the administration. To host a speaker series I put together a proposal and applied for University Life Programming Fund which promote faculty/staff/student interaction, and increase collaboration across units within the university (https://ulife.gmu.edu/university-life-programming-grant/). During that process I requested in person meetings with a number of university administrators to explain about the initiative and to discuss how we can work together. The fund from University Life covered honorarium and travel costs for speakers as well as a small miscellaneous cost for the event, including some foods for a reception. The speaker series is open to public. In designing the subject matter for speaker series, scientific methods and artistic design are considered in ecosystem restoration projects, including discussion on potential green infrastructure and environmentally-friendly developments on and off campus. During and after each seminar I had students and other participants fill out a questionnaire to figure out their backgrounds and opinions about the initiative and the lectures. The entire lecture part got also filmed and the media sources were uploaded onto our web blog, a place where students can express and exchange their opinions and ideas based on what they learn from each seminar. This encouraged further discussion on ideas and approaches that will become education resources to design more interdisciplinary courses and sustainable living on the campus. So many undergraduate students from all different backgrounds participated in the preparation, execution, and evaluation of the lecture series over the years, working very closely with me.

The inaugural event and seminar was during the fall semester for 2013, and successful with a pioneer eco-artist, Patricia Johanson with her talk titled *'Art, Ecology, and Infrastructure'*. The lecture was extremely well-attended with > 120 people from a number of different disciplines across the campus, including art, biology, environmental science, civil engineering, cultural studies, communication, film and media studies, women studies to a name a few. You can review more information on the website. The initiative has grown for the past three and a half years, providing useful resources and being the venue for further conversation and discussion of creative ways of teaching and scholarship. Once we start talking to one another across the academic boundaries, especially between sciences and arts it would be much easier to be creative in developing new educational agenda and pedagogical framework.

I made a great deal of efforts to invite speakers for this lecture series who can really empower and motivate students with their career path, life-long work, and the philosophies behind their work. I made several trips to DC and New York to talk to most of the speakers invited at least a semester before the lecture would be hosted to learn more about their work and to personally get to know them. Due to a small budget I could not provide the level of honorarium most speakers deserved, but they were so kind to come to GMU to give a talk when I met them in person and explained what their lectures would teach and share with our students. I myself learned a lot about giving and sharing when it comes to educating the next generation through them. Being personal with them also has helped me grow as a teacher throughout the process. Working with University Life and LEAD helped me organize the event by providing a room to meet students to

discuss way before the lecture event. My department staff members, Roslyn and Lisa in particular, were always with me searching for the room to secure to host the lecture every each semester. There are just so many things that are now coming to my mind when I am trying to reflect upon the trajectory of the EcoScience + Art. During this process I felt like (I still do since it is an on-going process for me) I was writing a new chapter in my career as a college professor. I was so fortunate to work with and mentor many students of disciplines other than natural sciences under the initiative over the years.

I have a story I can tell you about each one of the students who worked with me, but I still have a fond memory of this one student who worked with me first to put together a website for the EcoScience + Art. Daniel Lauchu was a junior film/media major. Daniel was at that time working as an office assistant for my department, but he got intrigued enough for the initiative, and worked countless hours back and forth with me to create and open up the website before the first event. One thing led to another I could grow the body of students participating in each event and its preparation. Many expressed their interests in participation in future events and regular meetings. So I started to build a student group called '*EcoScience + Art Student Leadership Group*' on the campus. You can find more information on the website (https://ecoscienceplusart.wordpress.com/people/). After three and a half years, the group of students (even though many graduated) succeeded to register themselves officially as Tier-2 Student Group on the GMU campus with me as a continuing faculty adviser as of Fall 2016. I was very happy about this accomplishment. I will continue to advise all of the members as a faculty adviser. Now it is up to them to continue to grow the initiative and to engage more students in the experience of learning together.

The other part of the *EcoScience + Art* is an interdisciplinary student project. As we entered the second year of the initiative I designed a project called "***The Rain Project***" to truly showcase what the initiative was about. I will explain in the next section of the portfolio about *the Rain Project* and how it helped student learn and myself as a teacher.

The following is the list of all the media and my presentations for the *EcoScience + Art* initiative

1. *EcoScience + Art*, George Mason University News article published, November 5, 2013.
a. *(http://newsdesk.gmu.edu/2013/11/ecoscience-art/)*
2. *EcoScience + Art* blossoms in Mason, University News article, website publication, March, 31, 2014, (http://newsdesk.gmu.edu/2014/03/ecoscience-art-blossoms-mason/)
3. *Mason Shines at National Conference on Undergraduate Research*, GMU News, August 15, 2014,*(http://newsdesk.gmu.edu/2014/08/mason-faculty-shapes-undergraduate-research/)*
4. *Mason presents EcoScience + Art*, 2014. *The Fourth Estate*, GMU's Student News Outlet (by Blanca Acevedo), (http://gmufourthestate.com/2014/11/08/mason-presents-ecoscience-art/)
5. Ahn, C. 2015. EcoScicence + Art to innovate college education, Invited speaker, TEDx talk
6. George Mason U, May 3, "Gathering STEAM, Harris Theater, George Mason University.
7. Ahn, C. 2015. EcoScience + Art Initiative: The New Paradigm for College Education, Scholarship, and Service. Multi-disciplinary Research Symposium 2015, Office of Provost, GMU, April 27.
8. Ahn, C. 2015. Art-Science Collaborations for Sustainable Stormwater Green Infrastructure at a College Campus, "Inspiring a Love of Science with S. T. E. A. M.", Mini-conference, Virginia Association of Science Teachers, Metz Junior High School, Manassas, VA.
9. Ahn, C. 2014. EcoScience + Arts – a new paradigm for college education and scholarship, The
10. Discipline Based Education Research (DBER), COS STEM Accelerator, GMU, November 11.

11. Ahn, C. 2014. Bridging ecological sciences with arts to creatively engage students in designing and building sustainable tomorrow, "Teaching Science with a T.E.A.M. Approach" (STEM + the Arts = S.T.E.A.M), Mini-conference, Osbourn High School, Manassas City Public Schools.

** The supplemental materials for this section include printouts of some content of the *EcoScience + Art* website, an example of student participation, an example of student review of the lecture attended, and media pieces published.

5.4. The Rain Project and beyond –Pedagogical Experiment and Innovation for Interdisciplinary Undergraduate Education

"We did it, we did it, Dr. Ahn!!" All the students screamed with such excitements watching the wetland floating on the Mason pond. Two of them hugged me by surprise. I could see big smiles on everyone's face. Yes "we" did it. The work accomplished was something beyond what a semester-long class may achieve. The amount of time and energy put into the whole process was really something. I felt relieved, knowing in that brief moment of screaming with joy, that everything went all right as I designed, planned and coordinated. Everyone and everything was safe and sound. It was more than just all right. It really rocked. All of us were having probably the most memorable moment of that semester together. I felt so connected with each one of the students who participated in the project. The sense of "we" was growing throughout the semester, yet that very moment the students and I really felt that we were "one".

The core part of the campus-wide, interdisciplinary, student project titled "The Rain Project" that I designed as a pedagogical experiment was successfully completed by putting out a floating wetland on Mason pond to improve its water quality and our environmental literacy on May 12, 2015. I couldn't sleep properly the night before with some degree of anxiety about the next day's scheduled launching of the wetland. An art major's senior project involved burning a wooden pagoda on the pond leaving a lot of wood debris and oily on its surface just a day before we planned to launch the wetland. This disrupted our original schedule and left us concerned about the launch. Safety documents had to be signed by students' parents, as mandated by the safety office and we waited a long time for the campus Land and Building committee's approval of the project. It was a long way for me to even get to that point with countless meetings with so many different parties and offices to make this happen. Those scenes quickly passed me by in front of my eyes in that moment.

All of a sudden I felt a little dizzy with an intense feeling of relief and also gratitude toward all the students who worked so hard and closely with me and with one another throughout the semester to bring this project to fruition. Many other student volunteers who came out to help us that day looked so excited and happy too. Thanks to the department (ESP)'s support I was able to offer all the students and participants sandwiches for lunch. The sun was so shining brightly down on us during the short break. We all made a "V" for Victory sign with our two hands for a photo moment by the University Creative Service to celebrate the achievement as shown in the

following picture.

Shortly after lunch, the students started a public presentation on the bank of the Mason Pond as scheduled for invited K-12 students and their science teachers from local high schools. This component was designed as part of training undergraduate students to improve their research and scholarship experience as well as to enhance their science, ecology in particular, communication skills. The day was long as we started quite early that morning to prepare and transport all the materials, including plants, mats, zip ties, buckets, trowels, and many other supplies in a loaded truck, to assemble the floating wetland already cut into a human kidney shape (~50 m^2) (as wetlands are often being called as nature's kidneys) before launching it on the water. Nonetheless, all the students actively participated in the class project presentation.

I came home late that day after making sure that everything was taken care of and the left-over materials and tri-pods borrowed from OSCAR returned to where they belong. I thought I would collapse. During that semester I was busier than ever. I started conceptualizing and designing the project one semester prior to the class with literature study, field testing, design workshops, and hosting lecture series relevant to the project; all of these activities consumed most of my mental and physical energy. However, when I came home that day I felt intensely alive. I was already thinking about the next step for the Rain Project. It was a great privilege and adventure to have worked with so many students and university administrators and staff members for the project. The teaching and mentoring experience that I had through this class and the project as a professor was tremendous. I intensely mentored more than 24 students from many different majors, including communication, art, science, engineering, humanities, business, and film/media. I recruited many of them through individual sessions/in-person meetings and still serve as an adviser for many of them. Thanks to their demands, I started a Facebook page around that time (May 2015). Many of the students hoped to stay in touch with me and one another so that they could keep up with the progress of the Rain Project. Throughout the summer of 2015, a couple of undergraduate research assistants who participated in the launching of the floating

wetland continued to work with me to monitor the wetland plants and water quality of the pond. The floating wetland attracted turtles, fishes, and birds while cleaning the water, especially removing excessive sediments and nitrogen.

Many of the participants of the Rain Project were seniors who graduated after the launching, but they loved catching up with how the floating wetland ecosystem evolved through the Facebook posts and my website (www.changwooahn.com). I strategically advised one graduate student from the beginning of the project to ensure good science practices were used to analyze and quantify the role of the floating wetland in providing a water quality ecosystem service. The student just defended his Master's successfully a few weeks before the deadline for this portfolio. He also published two journal articles on these results with me.

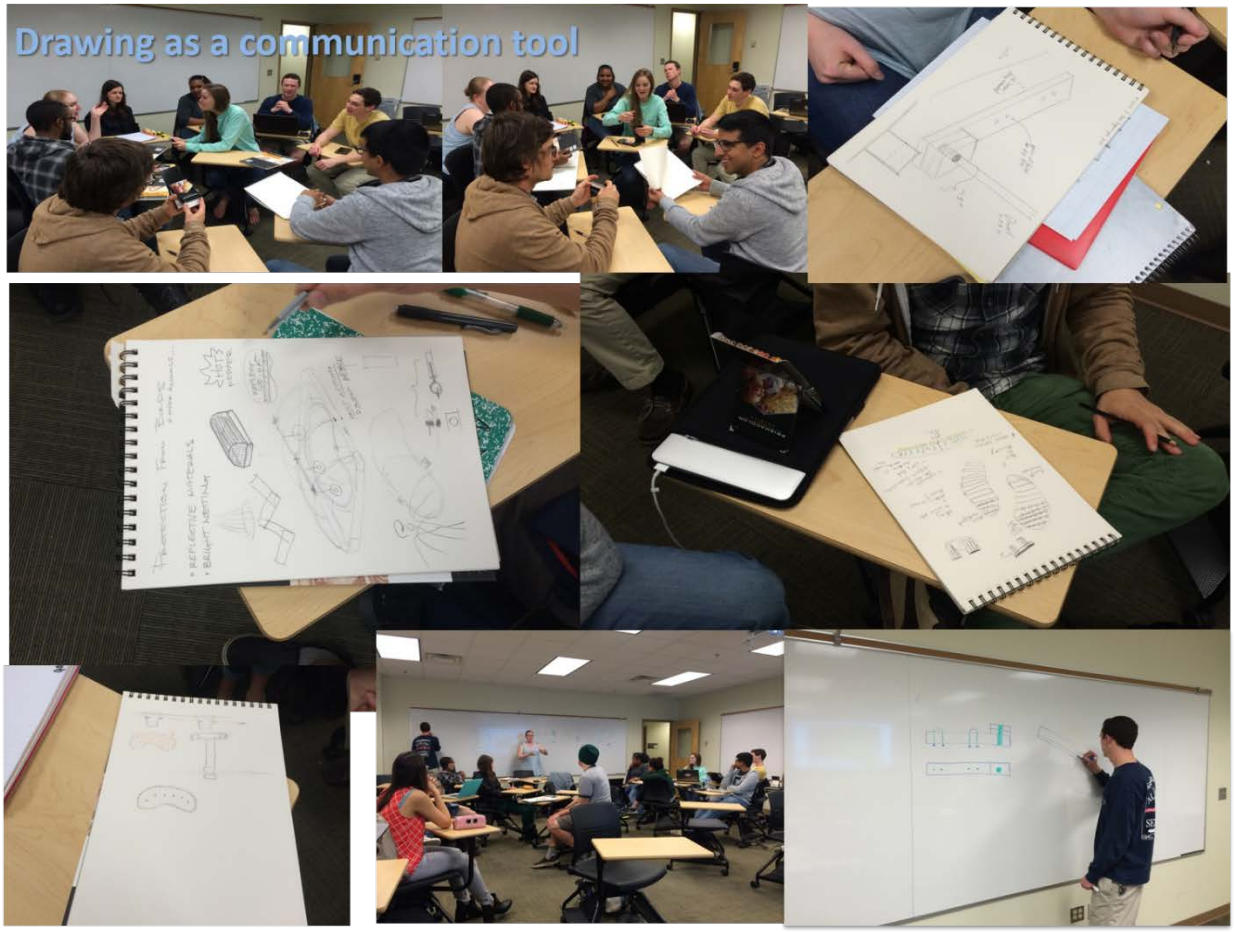
It was through the summer of 2014 when I designed "The Rain Project", a student participatory project with a project-based learning approach aiming to develop innovative interdisciplinary education and scholarship. The goal of the project was to raise awareness of stormwater issues, and to showcase an interdisciplinary, year-long (Fall 2014 through Fall 2015) collaboration activity for the campus community.

I designed this project to be carried out specifically by undergraduate students from a number of different disciplines (e.g., art, biology, environmental science, communication, engineering, and film/media) who worked as a team to design and implement green infrastructure for sustainable stormwater management on the campus. We live in an era of climate change, and climate change is a story of water, especially rainwater. Water is also a big part of sustainability. Many U.S. cities have recently turned to sustainable initiatives, looking out for new techniques and innovative sustainable infrastructure that mimics the way nature collects and cleans water. A campus-wide student leadership group was formed on the Rain Project through one-on-one interviews to engage undergraduate students of different disciplinary backgrounds in the project. The sustainable infrastructure for the project was a "floating wetland" that intended to improve water quality in a stormwater pond by removing nutrients (e.g., nitrogen and phosphorus). Too much of these nutrients often leads to algal blooms and degrades water quality in many waterways in the U.S. Removal of nutrients from the stormwater can be provided by the large surface area of hanging roots of wetland plants that trap and filter sediments and by bacterial communities living in the roots that facilitate a biogeochemical process.

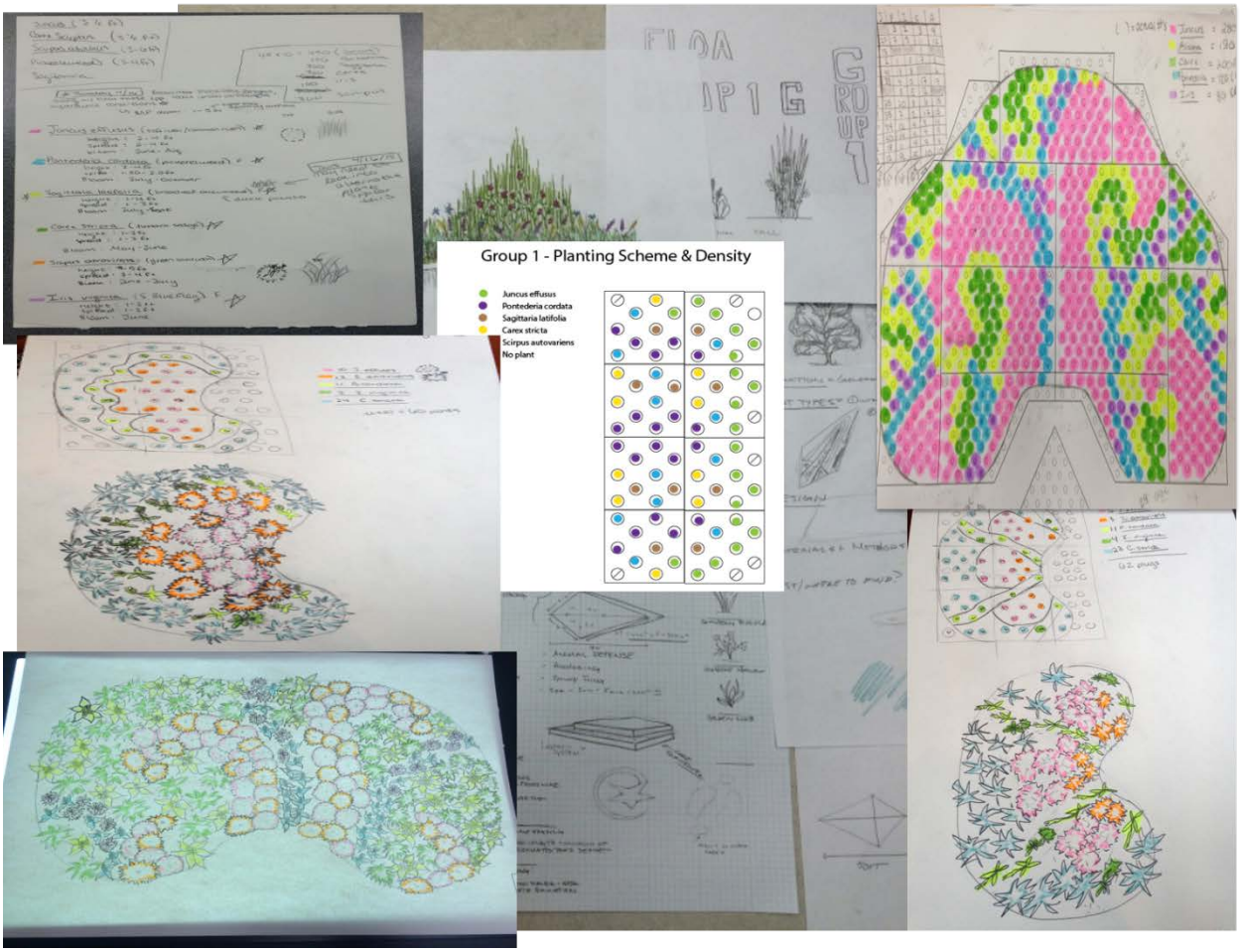
Designing and building of the floating wetland in this project were conducted as part my undergraduate research and scholarship-intensive class, *Ecological Sustainability* in Spring 2015, aiming to launch the wetland on Mason pond at the end of the semester. However, I was preparing for the activities for the Spring 2015 in my graduate class in Fall 2014, Ecosystem Modeling and Analysis, focusing on thorough reviews of relevant literature, case studies, and comparative analysis for feasibility of a variety of forms and materials to be used for a floating wetland to be designed. I also designed two guest lectures on floating wetlands, one from a local environmental consulting firm that had previously built floating wetlands of their own and the other from Virginia-Tech group that also created another prototype in the neighborhood stormwater pond. Those lectures were open to all undergraduate students as well who had expressed their interests in taking part in the Rain Project. Those guest lectures were all video-recorded and uploaded in my website so that other participants could watch and learn to better

prepare them for the actual building of the wetland. I also gave a powerpoint presentation of the Rain Project in other classes or venues around the campus many times to inform students of the opportunity to participate in this interdisciplinary project.

The design of a floating wetland started with a free-hand drawing during the Ecological Sustainability class in SP 2015. I incorporated freehand sketching by providing the students with color pens and sketchbooks.



Today, many universities, including engineering schools within universities, have abandoned such manual exercises entirely or focus only on computer-generated drawings. Many students were initially not comfortable with sketching or drawing. Comments included, “Oh, I can’t draw”, “I am not particularly good at it”, or “My brain doesn’t work that way”. Many students described themselves as strictly "right-brained" or "left-brained," with the left-brainers bragging about their math skills and the right-brainers touting their creativity. The left and the right brains might have different circuitry, but according to recent neuroscience research, the two hemispheres need to interact to develop a fully developed and functioning brain. I strongly believe that being able to quickly sketch can be a tremendously useful and powerful tool when used to communicate an idea.



The students went through the several steps that it takes to conduct a scientific research project, building hypotheses and/or specific questions, to discover what was going to work for each component of the floating wetland. The structure (rigidity and buoyancy) and function (water quality improvement) of the floating wetland required intense literature review and design considerations in hydrology (engineering-water flow, storm patterns, intensity and duration), botany and/or biology (how tall each species grows and how different plant mixtures can coexist to provide maximum power of water quality function), water chemistry of rain and ponds, living ecology (aquatic biota), and functional aesthetics. Along with these were many discussions of cultural and historical perspectives regarding stormwater management. These types of activities exposed both art and science students to intense research inquiry and hands-on experiential learning.

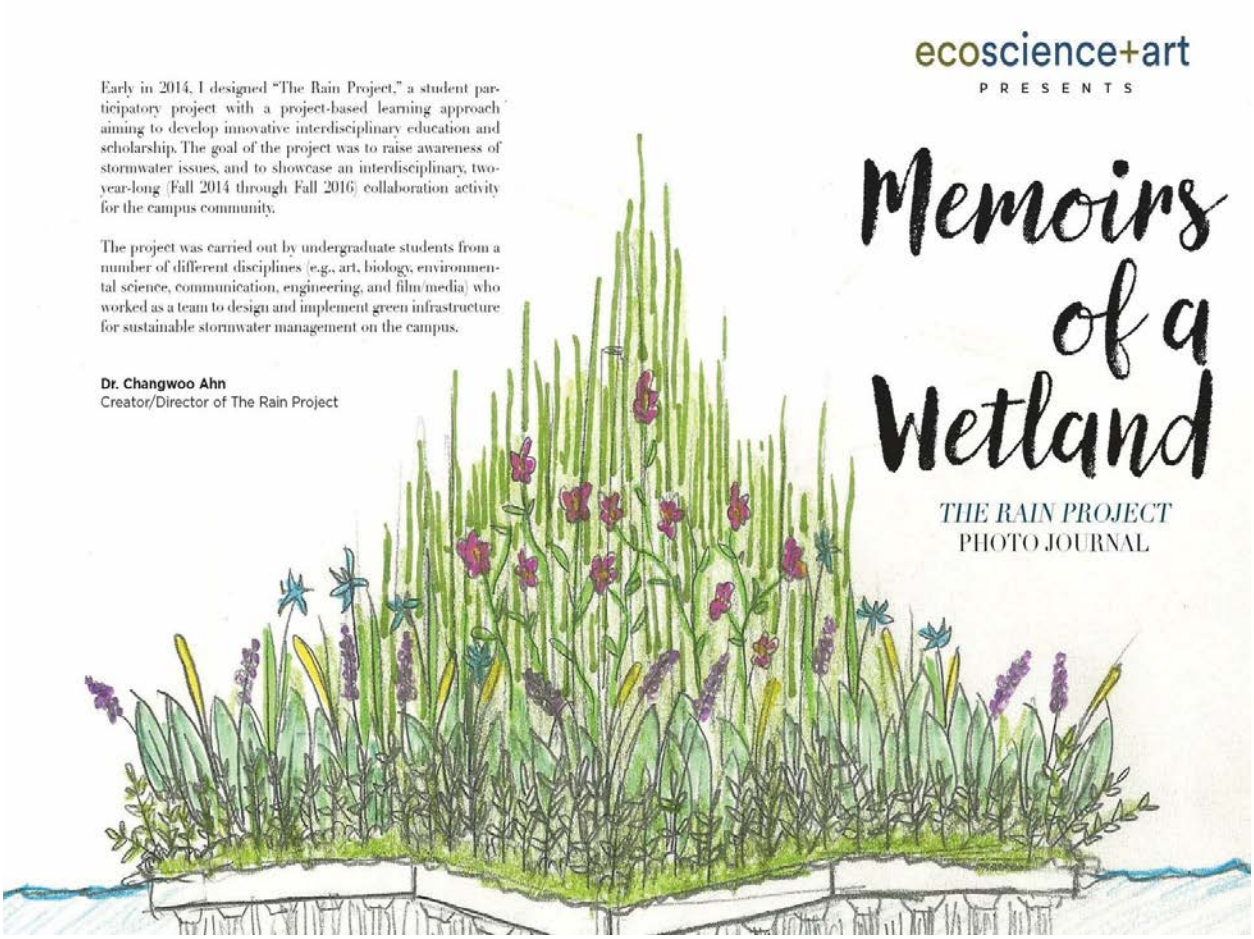
We chose a human kidney as a shape for our floating wetland, as wetlands have often been called "kidneys in the landscape" for their role in filtering contaminants and cleaning water passing through them. The students worked with me also to come up with details for planting of native wetland plants known for their abilities to take up nutrients. We did a small-scale simulation in early April with a small floating base (~ 6 m^2) as a proof of concept before we took on a full-scale installation (~ 54 m^2) for two kidneys. Through this experience, we better gauged the logistics and preparation needed for the full-scale construction and installation. We also surveyed

and monitored the target campus stormwater pond for its depth, water flow pattern, and physicochemistry regularly while developing a post-installation monitoring plan.

This kind of project involved students in strong collaborative training to work as a team to deliver the outcome, which I believe is an important element for college education. The opinions and voices of science students were not necessarily in agreement with those of art majors who focused more on the aesthetics and resulted in heated debates about the functionality of the floating wetland during several design sessions. Biology/ecology majors designed it for a biodiverse habitat to be while engineering majors demanded to plant just one species known to be the best in removing nutrients from water to cover the entire wetland, for example. After the project they told me that they learned how to communicate with one another to work together, and how to reach an agreement to move forward with the project to produce an outcome regardless of their differences in backgrounds, perspectives and opinions. We installed the full-scale floating wetland on May 12, 2015 (http://newsdesk.gmu.edu/2015/05/students-launch-floating-wetlands-on-mason-pond/). The story of *the Rain Project* was delivered to the Washington DC metropolitan area on May 22, 2015 via local news (NBC4 Washington) coverage. I also gave an on-campus TEDx talk about 10 days before the wetland launching to explain the background and the rationale of the project to a larger campus and local communities and invited the audience members to the student presentation. The following figure shows several scenes of student activities on that day.

Each step of the activities of the project was carefully recorded and/or documented during the project to share the experience and information to be learned, starting in fall 2014. I used my personal camcorder often to film the classroom activities, lectures, and field work. In addition, I mentored a film/media sophomore student to have him film some of the activities during the course of the project and mostly on the launching day. After the successful launching of the floating wetland on Mason pond at the end of the spring semester (SP 2015) we monitored the wetland and the water quality of the pond during the summer. We harvested all the plants and the floating wetland and quantified scientifically carbon and nitrogen content of sediments and plant tissues to assess the performance of the floating wetland in improving the water quality of the pond.

Through the summer and fall 2015 and the spring 2016 I continued to mentor the film student to work on a short documentary titled "The Making of the Rain Project", which I had student present at the *Celebration of Student Scholars* at the end of spring 2016. I did another last part of the Rain Project with an undergraduate student to design and put together a photobook about the project. It took us the summer and the entire fall semester of 2016 to finish the book. We could print out some copies of the book titled "*Memoirs of a Wetland*" at the end of December 2016. The photobook is a 84-page long compilation of the messages and the pictures of the Rain Project. The following is the cover of the book (e-book available at https://ecoscienceplusart.wordpress.com/special-projects/the-rain-project/).



The reviewers of the portfolio can view both electronically in the following web link (https://ecoscienceplusart.wordpress.com/special-projects/the-rain-project/).

The project outcome showcased a new model curriculum incorporating arts, environmental science, and infrastructure engineering as research and scholarship intensive, greenleaf course for undergraduate capstone experiences. Based upon the experience and lessons learned from it I've established a model for an interdisciplinary, environmental science course with a strong research and communication training. I am currently designing a course that will incorporate all the learning outcomes from the Rain Project that can be taught in the near future. This kind of teaching may challenge us by making it necessary to collaborate among a number of sectors/units involved on a college campus, but I believe that we should work together to find a better way to enhance academic performance and learning experience among students.

The outcomes of the project may also show how to tie activities of education and scholarship to service for campus community as well, addressing a timely issue of sustainable stormwater management in this case. In addition, establishing future collaboration among several departments along with the campus sustainability office, and *Students as Scholars* initiative at

GMU supports creative efforts to administer academic performance in the university. Not only scientific and technical learning outcomes, but also pedagogical and educational lessons learned from the project will be later reviewed and assessed, which is a critical step for research and scholarship experience for undergraduates. The Rain Project appears to cultivate "ecological literacy" among the participating students. Students will be able to better understand our relationship to "the larger context of life" with stronger communication skills through the collaboration experiences they had in this project. I hope that the approaches taken in the project can be adopted in other courses with adaptation and modification.

The students also commented on the benefits of collaborating between their different majors (e.g., science and art) on this project (see supplemental material). I am still giving many presentations about the project and its outcome to share with on-campus and off-campus communities.

The following is the list of my presentations and communication for *the Rain Project*:

Ahn, C. 2017. Invited speaker, D.C. Interdisciplinary Collaboration among Ecological Engineering, EcoScience, and Eco-Art for Sustainability and College Education -the case of the Rain Project, Art Science Evening Rendezvous (DASER), Feb. 9, Cultural Programs of the National Academy of Sciences (and co-organized by Leonardo), The National Academies of Sciences, Engineering, Medicine, Washington, DC.

Ahn, C. 2017. Invited speaker, Creating Sustainable Development: The Power of Collaborations between Environmental Science and Contemporary Art, School of Forestry and Environmental Studies, Yale University. January 26.

Ahn, C. 2016. Invited speaker, "Interdisciplinary communication and collaboration for higher Education". November 8, Biology/STEAL Accelerator Seminar, Biology, George Mason University

Ahn, C. 2016. Fostering an Ecology of Practice – Interaction of Art and Science. Creative Time Summit DC 2016. Breakout Session. October 16, Corcoran Gallery of Art, Washington, DC.

Ahn, C. 2016. Communicating ecological science by designing urban wetlands to foster a culture of sustainability, Invited speaker for the symposium titled "Using wetland infrastructure to design more sustainable cities: A China-US comparison", The 10th INTECOL, International Wetlands Conference, Hotspots of Biodiversity and Ecosystem Services under Global Changes, Changshu, China, September 19-24.

Ahn, C. 2016. Invited speaker for Climate Change and Art by Honoring the Future, Hylton Performing Art Center, Manassas, VA, September 8 with Fran Dubrowski, the director of Honoring the Future.

Ahn, C. 2016. Invited speaker, "Interdisciplinary communication and collaboration for higher education", Washington Youth Summit on the Environment (WYSE), June 29, Arlington, George Mason University

Ahn, C. 2015. Ecological Sustainability for a college campus, October 7, Merten Hall 3300, Office of Sustainability, GMU (contact: Caroline Kittle)

Ahn, C. 2015. Sustainable stormwater management using green infrastructure – a campus community

approach, October 22. Army National Guard (ARNG G4), Environmental Division Front Office (ARNG-ILE), Training and Outreach, Arlington, VA

Ahn, C. 2015. The Rain Project- Ecological Engineering Interdisciplinary project, September 30, GMU Engineers for International Development (EfID), http://www.gmu-efid.org/

Ahn, C. 2015. Invited speaker and session leader, "Reflection on the career as a wetland scientist and college professor -", Washington Youth Summit on the Environment (WYSE), July1, Arlington, George Mason University.

Ahn, C. 2015. The Rain Project- the floating wetland project, Mason Water Symposium by Water Forum, Highlighting Inter-disciplinary Water Research and Conservation, April 30.

The following is the list of media for the Rain Project:

1. In the moment: George Mason University Gets Steamed. January 29, 2015 (*The rain project* mentioned) (http://dcmetrotheaterarts.com/2015/01/29/moment-george-mason-university-gets-steamed/), DC Metro Theater Arts.
2. GMU goes full 'STEAM' ahead. Feb.3, 2015, Fairfax Times (Fairfax County News Online) (*EcoScience + Art* mentioned), (http://www.fairfaxtimes.com/article/20150203/ENTERTAINMENT/150209860/1267/gmu-goes-full-x2018-steam-x2019-ahead&template=fairfaxTimes.
3. Lecture and film event with internationally acclaimed eco-artist Lillian Ball April 9. Arts Council of Fairfax County, Feb.27, 2015. (*http://artsfairfax.org/news/entry/lecture-and-film-event-with-internationally-acclaimed-eco-artist-lillian-ball-april-9*).
4. *The Rain Project* –Interview with Changwoo Ahn (http://us9.campaign-archive1.com/?u=afa14f10cdc6080249d4d2ae8&id=5207b8b81f), STEAM (Science, Technology, Engineering, Arts, and Mathematics) Table Newsletter, Issue 4, March 2015.
5. *Let it rain* –featured story in Mason 4VA Collaborative by Linda Sheridan, April 8, 2015 (http://4va.gmu.edu/let-it-rain/).
6. **TEDx**Mason to "Gather STEAM" during Fourth Campus Talk, GMU Newsdesk, May 1, 2015 (http://newsdesk.gmu.edu/2015/05/tedxmason-to-gather-steam-during-fourth-campus-talk/).
7. **TEDx**Mason Speaker Profile, Changwoo Ahn *https://www.youtube.com/watch?v=BfLv7aOFpB0&feature=youtu.be*
8. Students Launch Floating Wetlands on Mason Pond, May 13, 2015, GMU Newdesk, (http://newsdesk.gmu.edu/2015/05/students-launch-floating-wetlands-on-mason-pond/).
9. Students Say Pond Class at GMU Really Floats Their Boats, **TV news** (**NBC4 Washington**) 3 minutes 11 sec., May 22, 2015 (http://www.nbcwashington.com/news/local/Students-Say-Pond-Class-at-GMU-Really-Floats-Their-Boats_Washington-DC-304771321.html).
10. Students construct wetland ecosystem, IV Fourth Estate, Vol 2 (24), August 31, 2015 (http://gmufourthestate.com/2015/08/31/students-construct-wetlands-ecosystem/)
11. Students Brave the Drink in the Name of Research (The Rain Project), Fall 2015, Inquiring minds, **Mason Spirit**- A Magazine for George Mason University Community, Office of University Development and Alumni Affairs in conjunction with the Office of University Relations.
12. The Rain Project, Grant Spotlight and Updates, GMU **Annual Report, 4VA**, 2014-2015
13. EcoScience + Art: The Rain Project, ***Periodic Elements***, Vol 13., College of Science, GMU, SP 2016.
14. **TEDx@GMU**, Interdisciplinary thinking and collaboration for higher education (https://www.youtube.com/watch?v=TXbx9Cm4O6g)

15. SER Press Release, 2016. *A* creative collaboration between the science of ecosystem restoration and art in an urban college campus published in International Journal, ***Restore (June 15)***.
16. **GMU** Creative Service Video compilation on the Rain Project- The Launching Day (in editing), May, 2016
17. "Nothing beats sincere and continuous encouragement", **Undergraduate Mentoring Blog** by Rebecca Jones, STEM Accelorator, May 19, 2016.

** I may not include all the supplemental materials for this section due to the 1' binder limit, however, I included the students' written response to the interdisciplinary pedagogical approach taken in the Rain Project along with a couple of class materials. I think that the reviewers will be able to get a better idea of my teaching activities and impacts through the '*The Making of the Rain Project'* video and '*Memoirs of a Wetland*' photobook, both available on the following website:
https://ecoscienceplusart.wordpress.com/special-projects/the-rain-project/