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Piloting transdisciplinarity among faculty and students concerned with flood management on the South Texas Gulf Coast: A four-stage model for initial collaboration

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Abstract

The economic, social, environmental, and scientific interrelatedness of our ecological survival depend on shifts in how we educate the next generation of educators, engineers, scientists, and social activists. Education, both formal and informal, as well as social activism, have to find ways to cross borders, collaborating to find solutions to the pressing problems of our time. On the South Texas Gulf Coast, one of these pressing issues is stormwater management and policy, but it has been challenging to effectively engage local leaders, water professionals, researchers, and community stakeholders in the solution-seeking process. To overcome this challenge, the research team adopted a transdisciplinary methodology to pilot a four-stage model for initial collaboration activities in applied, convergent research. This paper reports on this pilot simulation to (1) test the effectiveness and (2) demonstrate the means on how to facilitate a transdisciplinary approach in engineering problem solving and education, targeting the case study of local flood management. This collaborative model for the identification, planning, and facilitation of convergent solution seeking processes is adaptable and scalable widely in addressing the five grand challenges identified by the National Academies of Sciences, Engineering, and Medicine (NASEM).

Introduction

Environmental problems, such as the five grand challenges identified by the National Academies of Sciences, Engineering, and Medicine (NASEM) relating to food, water, energy, climate change, pollution, and waste are very complex. Addressing these grand challenges is a daunting endeavor, but is of increasing existential importance for the current generation and generations to come. The interrelatedness of these challenges with a broad range of social, economic, and scientific aspects demands shifts in how we educate the next generation of educators, engineers, scientists, and social activists. Education, both formal and informal, as well as social activism, has to find ways to cross borders, collaborating to find solutions to the pressing problems of our time.

Stormwater management and policy represent one of the grand regional challenges in the South Texas Gulf Coast area (Figure 1), since the area has experienced both an increase in frequency and magnitude of flooding in recent years (e.g., hurricane Harvey in 2017). To address stormwater management issues and reduce flooding impacts, strategies such as issuing Stormwater Master Plans, implementing stormwater impact fees, as well as encouraging more low impact development including green infrastructure and onsite rainwater capture have been locally considered. However, finding effective means to engage local leaders, water professionals, researchers, and community stakeholders in changing the conversation on stormwater management and implementation of these strategies has been a challenging task.

Figure 1. Map of South Texas Gulf Coast region showing major cities and counties

To address the regional stormwater management challenges, it is critical to integrate knowledge, methods, data, languages, and expertise from different disciplines to pursue common research challenges across multiple communities. One way to achieve this convergence is through a transdisciplinary framework. Transdisciplinarity, an approach to human communication, meaning-making and collaborative decisions, supports the co-construction and soft assembly of complex models and paradigms that value the input and design of structures across disciplines from the very beginning. The current ascendancy of transdisciplinarity in research is highlighted by an exponential growth of publications, a widening array of contexts, and increased interest across academic, public and private sectors [1].

Transdisciplinary research refers to research efforts conducted by investigators from different disciplines working jointly to create new conceptual, theoretical, methodological, and translational innovations that integrate and move beyond discipline-specific approaches to address a common problem. It entails the sharing of frameworks and assumptions in simultaneous dialogue in order to weave together a new approach to complex issues, which is historically viewed as the pinnacle of evolutionary integration across disciplines. Although transdisciplinary engineering is not widely found in the literature yet, a transdisciplinary approach is relevant to many engineering problems. Transdisciplinary research addresses three major kinds of research questions: (a) questions about the genesis and possible development of a problem field, and about interpretations of the problems in the life-world; (b) questions related to determining and explaining practice-oriented goals; and (c) questions that concern the development of pragmatic means as well as the possibility of transforming existing conditions [2].

This paper reports on a pilot simulation to (1) test the effectiveness and (2) demonstrate the means on how to facilitate a transdisciplinary approach in engineering problem solving and education, targeting the case study of local flood management in the South Texas Gulf Coast. The collaborators included seven professors and six graduate/undergraduate students from the disciplines of Environmental Engineering, Industrial Engineering, Anthropology, Bilingual Education, and Business Administration. We detail here the overall process of transdisciplinary solution seeking, outlining a four-stage model for collaboration. In Stage 1, the transdisciplinary team collectively identified focal themes based on email communication outreach from a local water planner tasked with stormwater strategic planning efforts. In Stage 2, we sorted these focal themes into categories for human and natural systems. Sorting quickly resulted in a complex and dynamic understanding of the interrelated nature of these systems. The overlapping positioning of human and natural systems became key to a transdisciplinary focus, positing a third space system that is emergent and self-organizing before, during, and after flood planning. In Stage 3, the sorted themes and original email were iteratively reviewed and a list of nearly one hundred research questions was produced. In Stage 4, we sorted the resultant questions and began developing strategies to address priority questions.

This collaborative model for the identification, planning, and facilitation of convergent solution seeking processes is adaptable and scalable widely. By outlining this four-stage approach to initial collaboration, this paper contributes to the implementation of transdisciplinarity to effectively address the five grand challenges that environmental engineering is facing in the 21st century. We conclude with reflections on the process and an outline of our next steps. As a pilot project, we focused on generating key questions with higher priority from a transdisciplinary approach (four-stage approach) in this paper. It is important to get the right questions first before seeking solutions to the problem. The next step after the proposed four-stage approach is to get answers to the key questions, which is part of the future research and is not within the scope of work of this paper.

Method: Four-Stage Approach

The project initiated with an interdisciplinary team of faculty who have intersecting community and environmental interests, and who were interested in developing an effective system by which to harness each member's individual expertise into a convergent approach to problem-solving issues of regional importance. It was determined to create a framework and process for transdisciplinary collaboration, which could serve as a model for future applications. The seven project-faculty included four engineers, one marketing, management and information systems analyst, one social anthropologist, and one bilingual educator. To expand the disciplinary breadth and experience of the project team, the seven project-faculty invited a total of two undergraduate students, three master's students, and one doctoral student to participate.

The decision to include students in the project team was a deliberative act to provide transdisciplinary training and experience in undergraduate and graduate education. A recent report by the Council of Graduate Schools (CGS) [3] states that in the ideal STEM graduate education, graduate students should develop their own project-based learning opportunities that are part of a team project effort. The CGS describes two major core competencies that STEM graduate education should address, including the development of (1) scientific/technological literacy and original research, and (2) leadership, interpersonal communication, professional competencies including teamwork with experts in other disciplines and diverse cultural background, project management and pedagogical skills needed to plan and implement research projects that will meet 21st century development demands. The four-stage model of transdisciplinary education detailed here provides an important co-curricular learning and professional development opportunity in higher education.

An email received from a water planner in a South Texas urban center became the case study and core document used by the team to simulate how a four-stage model might be deployed to initiate transdisciplinary solutions to grand challenges. The project team discussed and agreed that this particular socio-environmental issue would serve as a timely and relevant focus, given growing local and global concerns over projections that continued global warming has been shown to "further intensify the global water cycle, including its variability, global monsoon precipitation and the severity of wet and dry events" [4]. Based on the case study of stormwater management, the project leaders developed four objectives for transdisciplinary solution-seeking. Those objectives were to (1) identify natural systems relevant to flood planning; (2) identify human systems relevant to flood planning; (3) generate questions to guide scientific simulation and modeling using our lists of natural systems; and, (4) generate questions to guide scientific simulation and modeling using our list of human systems.

The transdisciplinary model development consisted of four stages. Each stage was undertaken collectively and in-real time through online synchronous collaboration. All meetings were held via Zoom with video on. The facilitator was a professor of bilingual education, one of the seven team members. Short biographical blurbs of the team members were elicited and shared before the first meeting, as were the project objectives and the core document. At each stage of the collaborations, independent and interdependent social-psychological knowledge informed the style shifts on the agenda. In this way, participants who preferred to work alone were given time to do so and those who preferred working in dyads did so as collaborations, generating analytic and synthetic new knowledge through transdisciplinarity. We documented this approach ethnographically. Data sources from Zoom video recordings and documents illuminate the core of our collaborations, and analytical reflections upon these outcomes are incorporated within our ensuing description of the four stages of transdisciplinary collaboration. We explain the protocols of each stage in detail, to enable translatability and replicability of the model.

Stage One Detailed Description

Stages One and Two were accomplished in one virtual meeting that lasted approximately one hour and thirty-five minutes. This meeting took place on October 15, 2021. Six professors and six students participated in the entire meeting. The professor specializing in marketing was absent. The Bilingual Education faculty member facilitating the meeting introduced the group as "a core group of creative thinkers" and reiterated the objectives while indicating that they do not have to be all accomplished in one meeting, stating that "the goal isn't to race through anything" but rather "to think outside the box." The objectives of the meetings were reiterated, as they had appeared in an earlier email, as follows:

1. Identify natural systems relevant to flood planning;
2. Identify human systems relevant to flood planning;
3. Generate questions to guide scientific simulation and modeling using our list of natural systems; and
4. Generate questions to guide scientific simulation and modeling using our list of human systems;

The introduction to the first session and re-presentation of the objectives with a small bit of elaboration took about six minutes. It was followed by an icebreaker, in which everyone was given two minutes to write down something they knew about themselves that others did not know. Short narratives were shared with one another and comprised a diverse array of topics, including, adventurous activity, music, schooling, sports, food, film, politics, and immigration. The objective of the icebreaker was to create a sense of knowing one another beyond the tasks identified in the formal objectives of the meeting. To some degree this sort of informal knowledge is shared with the goal of humanizing relationships and setting participants on a friendly footing with one another.

After participants shared their short narratives, the facilitator moved the group forward to the main task of Stage One. He shared his desktop to illustrate how to code topics in a content analysis by highlighting either lexemes or phrases or some combination of both. The facilitator shared a text unrelated to the topic (Figure 2) that would be the focus for the group. This was done purposefully, so as not to start highlighting the focal text by way of example and thereby biasing the thinking of the participants.

INSTRUCTIONS FOR TASK ONE

On your own, highlight vocabulary items and phrases that carry content in the document the facilitator shares with all members of the RSMT. You can't highlight every word.

Example:

"Race is a concept defined by society, not by genes. It's true that people around the world differ genetically due to their *ancestry*, and that people's racial identity may be statistically correlated with their ancestry, albeit unreliably. But "race" does not mean "ancestry," and it's a loaded term for scientific outreach: Biological races are not a current scientific concept and often reinforce historical biases" (Holmes, *Atlantic Monthly*, April 25, 2018).

https://www.theatlantic.com/science/archive/2018/04/reich-genetics-racism/558818/

Figure 2: Illustration of coding for lexical or phrasal topics

The facilitator asked if there were questions; there were none, so he assigned ten minutes for participants to work on their own to code content by highlighting words, phrases, or a combination of both, on the focal text, which was the email communication received from the local water planner. After ten minutes, the facilitator checked in with the group who had been working with screens off so as not to feel watched. No one indicated they required more time.

Stage Two Detailed Description

Stage Two took about 25 minutes of the first meeting, but some groups used additional time to finish Stage Two on their own time outside of the Zoom meeting. Participants were randomly grouped with partners. Groups were of two or three participants because the facilitator did not enter a small group and there were only eleven participants. The purpose of the last part of Stage Two was to share the list of coded words and phrases and to then sort the words and phrases into categories. The categories were taken from the agreed upon objectives: Natural systems, Human systems, or Both. Participants shared their impressions of the last stage. These impressions included comments on the different number of highlighted chunks of content and different approaches to sorting. For some, more of the information was part of a Human System, for others it was part of both Human and Natural.

A few days later, the facilitator consolidated the results he received in email attachments and shared them with the participants via email. Table 1 shows the number of key terms identified by each team, while Figure 3 shows the word cloud of all the key terms.

Table 1: The number of identified terms under each category

Teams	**Human System**	**Natural System**	**Both Systems**
#1-Two Environmental Eng. Faculty	19	2	9
#2-One Environmental Eng. Faculty and one Social Work/Anthropology undergraduate student	18	11	13
#3-One Industrial Eng. Faculty, one Anthropology faculty, and one Industrial Eng. graduate student	11	6	4
#4-Two Environmental Eng. Graduate students and one Environmental Eng. Undergraduate student	10	4	7

#5-One Bilingual Education graduate student	5	4	5

Figure 3: Word Cloud of All the key terms identified in stage two.

All the teams identified more key terms in Human Systems. However, it is interesting that teams with at least one non-engineering student or faculty identified more key terms in Natural Systems than teams with only engineering students or faculty. Figure 4 shows the word clouds of key terms in Human Systems identified by team #1 (all environmental engineering faculty) and team #3 (all environmental engineering students), which clearly indicates the different perspectives from faculty and students.

(a) (b)

Figure 4: Word Clouds of Key Terms in Human Systems Identified by: (a) Team #1 and (b) Team #3.

Stage Three Detailed Description

For Stage 3, we scheduled two meetings to address scheduling conflicts. In one meeting there were six participants (three students and three faculty members) (October 29, 2021); and in the second meeting, the remaining three students and three faculty members participated (November

5, 2021). Participants from both groups were instructed to use the original email text and/or the sorted words and phrases from Stage 2 to develop questions for simulation and modeling research around challenges to people and the environment before, during, and after a flood. Participants were instructed to work on their own for 20-30 minutes because this gave participants opportunities to individually select whether to work from the original email, the listed and sorted words and phrases from that email, or from both documents. The facilitator suggested that some participants may have a tendency to tackle the problem from the whole to the parts (i.e., via the original whole text of the email) and other participants from the parts to the whole (i.e. via the table of sorted words and phrases). Working with both, of course, would indicate that the individual may prefer to balance each approach, which was also an option. Were participants to work in small groups at first, which was not the case, there more likely might be a tendency for everyone to work from either whole to part or part to whole and thereby not adequately address diverse styles of problem solving. During the next part of Stage Three, the facilitator organized dyads composed of one student and one faculty member each, and placed each dyad into a breakout room for an additional half hour to discuss each other's questions and generate one list of questions per dyad. All questions were consolidated into one word document and shared with the group prior to Stage Four.

Stage Four Detailed Description

Stage Four afforded students opportunities to work with each other in one group, and faculty to work in the second group. Both groups prioritized the research questions generated in Stage 3. The meeting took place on November 12, 2021. One half hour was assigned for this task. More time was used outside of the meeting for students to complete their discussions on prioritizing the questions. The faculty groups generated 5 initial questions under Natural Systems and more than 50 initial questions under Human Systems and Both Systems, while the student group generated 31 initial questions in Human Systems, 8 initial questions in Natural Systems, and 29 questions in Both Systems. Both groups narrowed their initial questions down to a list of top 5 questions in each category as shown in Table 2.

At the beginning of this pilot study, the entire group consists of faculty and students from different disciplines. From the results in Stage Two, there were different perspectives and opinions from the entire group. At the end of Stage Four, it is surprising but also expected that these different perspectives and opinions converged into similar questions. By comparing the top 5 questions under each category, it can be noted that each category has one same or similar question from both students and faculty as marked in bold and italic in Table 2, including needs of communities (Human), flooding frequency (Nature), and data (both).

Table 2: List of Top 5 questions under each category

Systems	**Students**	**Faculty**

Human	· Does the public know what stormwater is, do they care about it, and do they financially support their role in management? · How can water professionals, stakeholders and the public in general work together to address flooding issues? · ***What are the needs of different communities to make scientifically informed decisions to minimize flood impacts?*** · What community sectors are least integrated into stormwater management and what outreach efforts could be most impactful, including existing platforms and new innovations? · What do multiple, diverse and inclusive scenarios of community collaborations and outreach look like in simulations of before, during and after a flood?	· How do K-12 schools respond before, during and after flooding? · How do we disseminate flood impact awareness effectively to the most vulnerable communities? · ***What are the immediate needs of individuals who were in harm's way after a flood, and how best do we address them?*** · What will be the negative consequences if the stormwater impact fee is added? · What would the development of a community resilience literacies program look like countywide?

Nature	· Are there any exposure maps? Are they up to date? · ***How have 100-year flooding events changed over the last 2-3 decades? Is it getting worse?*** · What are the environmental impacts of flooding (air quality, soil, groundwater)? · How much $$$ spent on recovery for each 100 Year Flooding? · What is the contribution of storm surge versus precipitation/extreme event on local and regional flooding?	· Are there any existing onsite rainwater capture devices? How many? Cost and Benefits analysis? · How does the flooding frequency/events in the Coastal Bend area compare to other coastal zones? · ***How have 100-year flooding events changed over the last 2-3 decades? Is it getting worse?*** · What are the relevant datasets that need to be collected/procured to estimate effects of flooding (at local and regional scales)? (other version: How can we use current data to prepare for a future natural disaster?) · How are flood frequency and magnitude changing over time (at local and regional scales)?

Both	· How can we create a model to simulate the damage of flooding in different regions? · Could Insurance companies provide the exact amount of money that is spent on flood recovery over the last 5 years? · The impact of storm water on air quality, water quality, soil with people? · What are the series of steps for conducting this research project including getting it approved, getting it funded, collecting data? · ***What kind of data are available? What else are needed?***	· Are there any correlations between economically disadvantaged people, education, minority groups, age groups or other factors and flooding? · How can we calculate a reasonable stormwater impact fee? · ***What kind of data should be included in crisis response proposals to local leaders?*** · What do different relationships between flood control in the midst of a flood and stormwater master planning look like via multiple computer simulations? · With three 100-year flooding events in the past 5-years in the city, what might be anticipated there and elsewhere in the Tejas Borderlands in the next 100 years?

Conclusion

Stormwater management represents one of the challenges all municipalities are facing. Excess stormwater, if not managed properly, will cause flooding. Flooding has caused the most devastating and costly natural disasters in the world. Throughout human history, the impacts of floods such as family and community disruptions, dislocation, and permanent injuries have gone far beyond the cost and fatalities. In the United States, floods can be considered as one of the most important homeland security issues because they pose the greatest threat among all natural hazards to the safety and economic well-being of local communities. For example, in October 2012 superstorm Sandy wreaked havoc in New York and New Jersey, causing roughly US$60 billion damage [5]. In Texas, localized heavy rain and flooding events happen fairly often when all moisture in the atmosphere is converted to rainfall in a small area. Studies have shown the odds of very intense rainfall in Texas have gone up substantially over the last century [6]. Thus, properly managing stormwater and reducing flood risk is important from both a societal and economic perspective in order to reduce damages and losses and to minimize or avoid human suffering.

This study explored a different approach, which relies on inputs from people/experts of diverse disciplines and with different backgrounds. It is intended that this four-stage process can serve as a model which can be adopted to engage a transdisciplinary framework on similar environmental issues and in different regions around the world. A good understanding and practice of transdisciplinarity can address the growing environmental sustainability needs of the region, nation, and the world.

Through the process described here, this four-stage model of collaboration seeks creative approaches to complex social and environmental problems, encourages broader coalitions of scholars and practitioners from different disciplines and backgrounds, and positions researchers to understand and manage issues that cut across sectors. With transdisciplinary research, we move from sharing different analyses or creating new applications to creating a space for shared dialogue, leading to a joint analysis using new approaches that could not have existed without the crisscrossing of ideas to knit a new web of knowledge and form novel frameworks to catalyze scientific discovery and innovation.

The present paper described a promising approach, although the study/simulation is limited by its number and types of participants. To apply the approach to real-world stormwater management, various stakeholders will need to be included in the discussion. Thus, future study needs to be planned to include stakeholder groups such as local government officials, water resources managers, policy makers, engineering practice professionals, etc. These stakeholders can be engaged utilizing the same four-stage collaborative model, the results of which will engender new transdisciplinary insights and convergent solutions. It is expected that interesting interactions among these stakeholder groups will provide refinements on the effectiveness and potential improvement of the approach described here.

References

[1] J. T. Klein, “Discourses of transdisciplinarity: Looking back to the future,” *Futures*, vol. 65, January 2015, Pages 10-16.

[2] C. Pohl and G. H. Hadorn. *Principles for Designing Transdisciplinary Research*. Munich: oekom, 2007.

[3] Council of Graduate Schools, “Professional Development: Shaping Effective Programs for STEM Graduate Students,” Council of Graduate Schools, 2017.

[4] V. Masson-Delmotte et al., “Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change,” Cambridge, UK: Cambridge University Press, 2021.

[5] J. C. J. H. Aerts, N. Lin, W. J. Wouter Botzen, K. Emanuel, and H. de Moel, “Low-Probability Flood Risk Modeling for New York City,” *Risk Analysis*, DOI: 10.1111/risa.12008, 2013.

[6] W. J. Nielson-Gammon, J. W., “Changing Climate of Texas,” Impact of Global Warming on Texas, 39–68.