

# **Development of a graduate-level capstone course for interdisciplinary researchers: design approaches and lessons learned**

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## **Development of a graduate-level capstone course for interdisciplinary researchers: design approaches and lessons learned**

### **Abstract**

Compared to undergraduate capstone courses, there are limited discussions about interdisciplinary capstone requirements, structures, challenges, and experiences for graduate students. This paper will detail the interdisciplinary NSF Research Traineeship (NRT) Capstone course structure that can be beneficial to the implementation of an interdisciplinary capstone course at the graduate level. The NRT capstone is a two-credit course, and part of the NRT program at our university. The NRT prepares master's and doctoral students from engineering and social sciences to solve the grand challenges of creating resilient food, energy, and water (FEW) systems in rural communities. Resilience/sustainability problems are complex and often require professionals with different expertise and backgrounds to work as a team to generate an emergent solution; thus, an interdisciplinary curriculum provides students with the skills needed to work in an interdisciplinary environment.

The NRT Capstone Course is a project-based, cross-listed course that has been developed and co-taught by faculty from the Colleges of Engineering, Agriculture, and Arts and Sciences at our university. The NRT Capstone curriculum builds on knowledge students gained from a prerequisite interdisciplinary course about system thinking, called Integrated FEW Systems. In the capstone, students work on an interdisciplinary team based on their research interests. Teams are formed with students from at least two disciplines. In spring 2021, we had three teams, and each team was comprised of five or six M.S. and/or Ph.D. students.

The course format, team teaching strategies, and grading structures encouraged an interdisciplinary approach to investigating their research question(s). Students attended faculty-guided lectures designed to provide training in communication, team collaboration, research, and final research product preparation. Course grades were project-based and included individual assignments and team assignments. Student teams were charged with writing an interdisciplinary conference or journal article. Teams developed an outline, and received written and verbal feedback from faculty after submission, identified an appropriate target journal, and wrote a draft research paper. At least two faculty members served as mentors to each team. To complement the teamwork, students individually wrote a literature review relevant to the interdisciplinary research topic. Teams incorporated the individual literature reviews into the team research paper. Student teams also met for 50-minute workdays every other week where they collaborated with their team members on the final research product. Teams presented their final research products during the course's final exam block; presentations were in person, masked and distanced, with some faculty attending virtually.

The products of the first NRT Capstone class, taught in spring 2021, included one team's interdisciplinary journal paper, recently published in a *Frontiers* journal. Following the course, another team is working on finalizing their paper to be submitted to a different *Frontiers* journal. The third team is restructuring its research findings to present their outcomes and is a work in progress. Feedback through an end-of-course survey highlighted that what students valued most

about their Capstone Course experience was real, hands-on interdisciplinary teamwork. Their feedback also provided ideas for fine-tuning future course activities.

## **Introduction**

The need for interdisciplinary research and skills has grown, thereby increasing the importance of interdisciplinary training for graduate students. Interdisciplinary applications expand knowledge in research communities beyond disciplinary boundaries and are U.S. policy priority [1]- [2]. The report by the National Academies of Sciences, Engineering, and Medicine on Graduate STEM Education for the 21st century [3] noted that current and future global challenges; such as creating a resilient and sustainable environment, developing renewable energy, improving health, and mitigating climate change present scientific, technological, and societal challenges that require teams of researchers from different disciplines to solve these challenges as they present uncertainty, complexity, and interdependence [3]. In addition, employers from industry, government, and Non-Governmental Organizations have mentioned that there is a need for graduates who have a comprehensive knowledge base across the STEM and humanities fields so they can advance convergent research that is needed to solve current and future world challenges [3]. Thus, interdisciplinary research and education training are vital for future competitiveness, and college graduates should be prepared with skills to solve complex societal problems using interdisciplinary perspectives.

Disciplinary or interdisciplinary capstone courses at the undergraduate level are prevalent, but interdisciplinary capstone courses are more limited at the graduate level [4]. Since the mid-1990s, the engineering community has been advancing the development of interdisciplinary skills based on the shift to the outcomes-based accreditation criteria, Accreditation Board for Engineering and Technology (ABET) [5]. To satisfy ABET requirements, many engineering departments in four-year institutions across the United States require a senior capstone design course in their curriculum [6], in which students combine their knowledge and skills learned in previous courses to solve real-world problems in a disciplinary or interdisciplinary setting [7]- [8]. Capstones are more limited at the graduate level. Some master's programs in sustainability, environmental sciences, and natural resources do offer different forms of a capstone experience, however, most of them are applied capstones [7], [9].

Interdisciplinary capstone courses at the graduate level are not common. Some graduate engineering programs required a capstone course. These capstones vary in format and credit hours [10]. Some assigned individual projects, and some offer collaborative team work [10]. Of more interest in this paper is interdisciplinary capstones at the graduate level. Some programs do offer interdisciplinary capstone at the graduate level in particular graduate sustainability programs, environmental studies and sciences [7], [9], [10]. Jiji et al. [7] introduced the Capstone Interdisciplinary Team Project for Master of Science in Sustainability at the City College of New York. They developed a six-credit, year-long capstone for students from different disciplines working on interdisciplinary projects. Instructors from different departments developed sustainability-focused capstone projects and served as mentors. Phillips and Doyle [9] introduced an interdisciplinary capstone experience for joint master's students in environment and resources degree at Stanford University. Their capstone requirement includes an associated three-credit

seminar that is co-taught by the Interdisciplinary Program in Environment and Resources faculty director and the joint MS program manager. The capstone seminar runs as a facilitated independent study course over one quarter. Students select their own projects and work either individually or in a group of up to three students, and students give a final presentation of their work at the semester's end during a capstone project symposium. Rodriguez et al. [11] developed the transdisciplinary challenge as part of the INFEWS-ER virtual resource center at the University of Illinois Urbana-Champaign. They offer graduate students, undergrad students, and postdocs an opportunity to work in transdisciplinary teams to solve grand food, energy, water systems challenges by developing research questions, finding the relevant data to answer their research questions, conduct analyses, and producing final projects with tangible results. Each student group works on their challenge under the guidance of at least one mentor, who helps define the scope of the challenge and provide basic resources for starting the work. This can be taken as a three-credit hour special topics course. It seems that there is no uniformity among interdisciplinary capstone requirement, however, interdisciplinary graduate capstones focus on real world projects, and students can work either individually or in a group under the guidance of at least one mentor [7], [9], [11]. In some graduate programs in sustainability, students can fulfill their capstone by an internship or a client-based project [7]. As the NRT capstone is a two-credit hour course, we determined the NRT capstone requirements based on the time and resources faculty and students were able to dedicate to the NRT capstone project.

The United States National Science Foundation Research Traineeship program was established to provide graduate students in STEM interdisciplinary training and prepare them for the national workforce. This program provides funding for new models of graduate training that encourages collaborative research [12]. The NRT at Kansas State University prepares graduate students in STEM, master's and doctoral students, to solve the grand challenges of creating resilient Food, Energy and Water (FEW) Systems in rural communities. Problems at the nexus of FEWS are complex and solutions to these problems must integrate engineering, natural sciences, and social sciences. The NRT capstone requirement for the NSF Research Traineeship (NRT) in FEW systems at Kansas State University was developed as part of the NRT requirements in the 2020-2021 academic year to enhance graduate students' interdisciplinary research skills.

This paper aims to describe the experience gained from the NRT capstone, which may be beneficial in the implementation of an interdisciplinary capstone course at the graduate level in other four-year institutions. The paper presents the NRT Capstone course structure, the capstone learning experience, products, assessment, and lessons learned.

The author team is an interdisciplinary team and includes faculty, administration, and staff from the Colleges of Engineering, Agriculture, and Arts and Sciences. The author team includes five people who identified as women. Two of these women are engineers, one is an educator, and two are social scientists. The author team also includes five people who identified as men. Three of these men are engineers, and two of these men are social scientists. Several author team members have experience in undergraduate capstone in engineering and social science as well as experience doing interdisciplinary research and working in interdisciplinary teams. These experiences allow us to develop an interdisciplinary capstone curriculum at the graduate level.

## **Course Structure**

The NRT capstone provides students an opportunity to gain interdisciplinary research experience by synthesizing the science, engineering, technical, and professional skills they have gained throughout their NRT traineeship and their graduate degree study. Students select the NRT capstone products, and work in a group of up to six master's and/or doctoral students from at least two disciplines. It was anticipated that students would finish their research products in a semester. Seven Master's and nine Ph.D. students from the College of Engineering, the College of Agriculture, and the College of Arts and Sciences participated in the NRT capstone in spring 2021 semester. All teams produced a research paper but only one out of three groups had their paper close to ready for journal submission. The NRT capstone is a two-credit hour project-based required course to NRT trainees that meets twice a week for 50-minute classes. The NRT capstone is offered in the spring semester every other year, and it is co-taught by engineering and social science faculty. The NRT capstone is built upon the system level thinking framework taught in the Integrated Systems course, which is an introduction to systems thinking, with specific application to the FEWS nexus, in which students explore natural-environmental systems, human-social systems, and interactions within these systems. NRT capstone course material integrates engineering, social sciences, and professional skills needed to work in interdisciplinary groups, with focus on practicing interdisciplinary research. The NRT capstone runs as a mix of lectures co-taught by faculty, and work days in which teams work on their final capstone product. It also includes group and/or individual assignments, and final presentations of groups' work at the end of the semester.

The main learning goals for the capstone are to practice interdisciplinary research by integrating their science and engineering coursework with the systems thinking framework, and to build professional skills such as collaboration and communication into a final research product that addresses FEWS problems. In addition, each student gains scientific research skills by producing a literature review of their research product.

The NRT capstone course format, content team teaching strategies, and grading structures encouraged an interdisciplinary approach to investigating FEWS problems. Students attended faculty guided lectures designed to provide training in communication, team collaboration, research, and final research product preparation. Topics that were discussed in NRT Capstone lectures were: skills for working in interdisciplinary teams (team collaboration and communication), how to write a literature review in the social sciences and engineering, how to write a research publication, how to select a peer reviewed journal, where to look for funds for their research, how to write a research proposal, and science communication. For more see course schedule in Table 1.

Table 1: NRT capstone schedule spring 2021

Week	Day	Topic	Lead
1	M	Welcome- interdisciplinary teams formed	Engineering faculty
	W	Working in interdisciplinary teams- team goals	Education faculty
2	M	Working in interdisciplinary teams- communication	Engineering faculty
	W	Team work day	
3	M	Refining team topic	Engineering faculty
	W	Writing literature reviews- social science	Social science faculty
4	M	Writing literature reviews- engineering	Engineering faculty
	W	Team work day	
5	M	Research papers- determining target journal or conference	Social science and engineering faculty
	W	Research papers- Forming a hypothesis	Social science faculty
6	M	Research papers	
	W	Team work day	
7	M	Well being day- <b>no class</b>	
	W	Research proposals- finding funding agencies	Engineering faculty
8	M	Research proposals- finding funding agencies	Engineering faculty
	W	Team work day	
9	M	Research proposals RFPs and FOAs	Engineering faculty
	W	Research proposals RFP example	Engineering faculty
10	M	Flex day	
	W	Team work day	
11	M	Extension reports	Engineering faculty
	W	Policy reports	Social science faculty
12	M	Faculty interdisciplinary research presentation	Social science faculty
	W	Team work day	
13	M	Grant management	Engineering faculty
	W	Editing	Engineering faculty

14	M	Evaluating team members	Education faculty
	W	Group presentations	Education faculty
15	M	Team work day	
	W	Team work day	

Following the university COVID guidelines, the first two weeks of the semester were taught online. The rest of the semester was taught in-person distanced and masked, with an option to attend virtually if needed. Course grades were project-based and included individual assignments and team assignments. Student teams had to pick a research product from the final product choice board: research paper (conference or journal), research and extension report, NSF or USDA-style research proposal, or a community project. After carefully considering all of the research product options, all team picked a research paper for their final product, and as such, they were charged with writing an interdisciplinary journal article or conference paper.

### Course Assignments and Grading

Course assignments were balanced between individual and group assignments, as shown in Table 2. The first major assignment, due in Week 6, was the Project outline, in which teams identified an appropriate target journal or conference, defined research questions and hypotheses, provided rationale for their final product, included a detailed outline for the final product, and listed potential benefits beyond the class project. Two different faculty members mentored each of the three teams; faculty were able to provide detailed feedback at this early stage of research conceptualization. To complement the teamwork research project, students individually wrote a literature review relevant to the interdisciplinary research topic, which was due in Week 10. Faculty of the same discipline as the graduate student graded it. For some research projects, the literature review could be integrated into the final product; for one of the projects, which was itself a literature review, this was more difficult.

Table 2: NRT capstone course evaluation

Literature survey (individual)	20%
Project outline (group)	10%
Final product (group)	35%
Final presentation (group)	10%
Peer evaluation (individual)	10%

On Weeks 2, 4, 6, 8, 10, 12, and 15, students attended team workdays to develop the final product. It should be noted that, due to Covid-19, there was no university-wide spring break for the spring 2021 term. Teams were asked to submit goals for the workday and following the meeting, a member of the team submitted team accomplishments, and any questions for their faculty advisors; these assignments were on Canvas. Faculty attended some but not all of the student workdays. Teams were given flexibility to hold workdays in the classroom, another on-campus location, or virtually on Zoom.



The final product (i.e., interdisciplinary research paper) was due in Week 15 and graded by the team's two faculty mentors. During finals week (Week 16), teams presented their final research products during the course's final exam block; presentations were 20 minutes with five minutes of questions and answers. The final 15 minutes of the period was for a class evaluation survey conducted by the NRT evaluator. Presentations were in person, masked and distanced, with some faculty attending virtually. All faculty graded the team final research product presentations based on a rubric, shown in Table 3. The team's final research product followed the formatting and citations requirements for the selected conference or journal, and drew on the interdisciplinary expertise of the entire team. The faculty advisors of the team graded the final research product based on a rubric that assessed overall quality and interdisciplinary expertise graded it. The rubric's achievement level was similar to NSF rankings, where faculty can select two levels (e.g. Very Good/Excellent).

Table 3: NRT capstone final product rubric (Modified to use by creative commons license [13])

Achievement Level [Similar to NSF rankings, can select two categories (e.g., Very Good/Excellent)]					
Criteria	Poor	Fair	Good	Very Good	Excellent
<b>Framing the research (abstract, intro/lit review)</b>	<ul style="list-style-type: none"> <li>Minimal abstract</li> <li>No context for the research</li> </ul>	<ul style="list-style-type: none"> <li>Abstract lacks details</li> <li>Minimal context for the research</li> </ul>	<ul style="list-style-type: none"> <li>Abstract summarizes research but is lacking key information</li> <li>Literature review summarizes appropriate papers</li> </ul>	<ul style="list-style-type: none"> <li>Abstract appropriately summarizes the research</li> <li>Literature review covers appropriate topics and synergizes some papers</li> </ul>	<ul style="list-style-type: none"> <li>Abstract meets target journal's requirements &amp; appropriately summarizes the research</li> <li>Intro/Lit review strongly motivate the research</li> <li>Lit review synergizes literature from multiple disciplines</li> </ul>
<b>Research question</b>	<ul style="list-style-type: none"> <li>No research question</li> <li>Major works omitted</li> </ul>	<ul style="list-style-type: none"> <li>Research question(s) were not formed but could be formed through the Paper</li> </ul>	<ul style="list-style-type: none"> <li>Research question(s) are formed through the Paper</li> </ul>	<ul style="list-style-type: none"> <li>Research question(s) are formed through the Paper and somewhat stated</li> </ul>	<ul style="list-style-type: none"> <li>Research question(s) are formed through the Paper and clearly stated</li> </ul>
<b>Research content</b>	<ul style="list-style-type: none"> <li>Minimal research content</li> <li>No graphics</li> </ul>	<ul style="list-style-type: none"> <li>Some research content but it does not present any new knowledge or insights</li> </ul>	<ul style="list-style-type: none"> <li>Present some new knowledge/insights with minimal explanations</li> <li>Provide at least 2 graphics</li> </ul>	<ul style="list-style-type: none"> <li>Present new knowledge/insights and explain "what"</li> <li>Provide at least 2 graphics</li> </ul>	<ul style="list-style-type: none"> <li>Present new knowledge/insights and explain "why"</li> <li>Provide at least 2 graphics</li> </ul>

		<ul style="list-style-type: none"> <li>• Provide 1 graphic</li> </ul>			
<b>Science communication</b>	<ul style="list-style-type: none"> <li>• No clear organization</li> <li>• No citations</li> <li>• Not appropriate for the target audience</li> </ul>	<ul style="list-style-type: none"> <li>• Organization is not logical</li> <li>• Does not use in-text citations</li> <li>• Uses most jargon not appropriate for the target audience, doesn't define acronyms</li> </ul>	<ul style="list-style-type: none"> <li>• Paper has basic flow of ideas but not all subtopics follow a logical order</li> <li>• Most sources are documented, but many are not in the desired format</li> <li>• Uses some jargon not appropriate for the target audience, doesn't define acronyms</li> </ul>	<ul style="list-style-type: none"> <li>• Paper has a clear direction and subtopics are connected</li> <li>• All sources are documented, but a few are not in the desired format</li> <li>• Appropriate for the target audience</li> </ul>	<ul style="list-style-type: none"> <li>• Paper has a very clear direction and subtopics are connected</li> <li>• All sources are accurately documented in the proper format</li> <li>• Very appropriate for the target audience</li> </ul>
<b>Overall score</b>	<b>Poor (5)</b>	<b>Fair (7)</b>	<b>Good (8)</b>	<b>Very Good (9)</b>	<b>Excellent (10)</b>

Students also completed peer review along with their final product, as shown in Table 4. In the peer review, we asked students to assess the work of themselves and their colleagues in their groups by evaluating and providing feedback and suggestions on each other's teamwork. The rubric's achievement level for the peer review was from 1 (weak effort) to 5 (excellent work). A feedback of 1 required a written explanation. We also provided space in the peer review rubric for general feedback.

Table 4: NRT capstone peer review rubric (Modified from Northwestern Course MSED 467 [14])

Achievement Level					
Criteria	1 (Little or weak effort; detrimental to group)	2 (Insufficient effort; met minimal standards)	3 (Sufficient effort; contributed adequately)	4 (Very strong work; contributed significantly)	5 (Excellent work; was crucial component to success)
Participation in developing ideas and planning product/project					
Contributions to outline and lit review of the final product					
Contributions to the results, and discussion of the final product					
Willingness to discuss the ideas of others					

Writing and editing the final product					
				Total Score	

### Final Course Products

As part of the NRT capstone, all teams selected a research paper (conference or journal paper). One team published an interdisciplinary journal paper in 2021 in a *Frontiers* journal. Following the course, another team worked in the summer and fall on a revised manuscript to be submitted to a *Frontiers* journal, with an expected submission in summer 2022. The third team modified the target publication from a peer-reviewed journal to a magazine article in the National or regional pork association based on the feedback from the faculty and students in the course, with a targeted publication in summer 2022.

### Students' Experiences

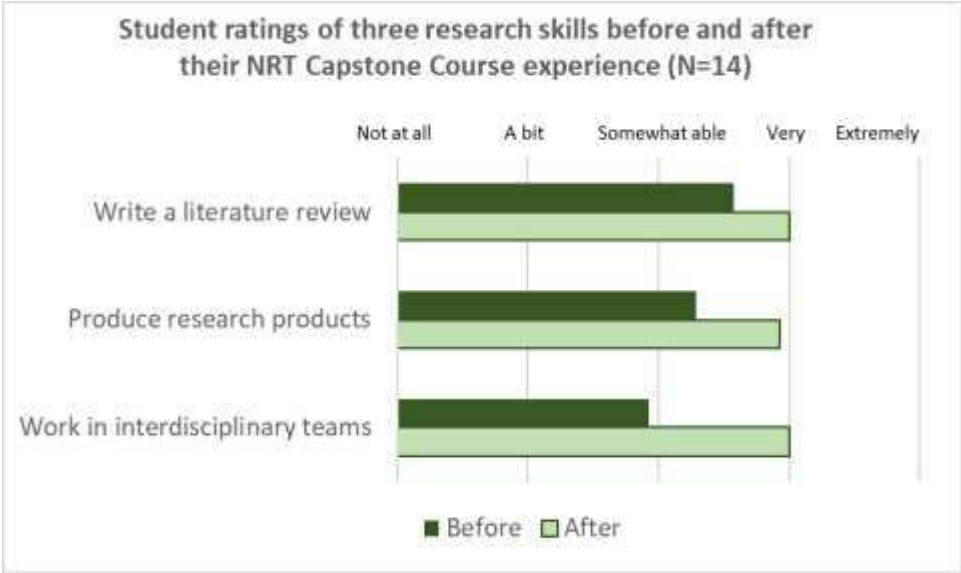
To better understand NRT students' experiences during the capstone course, and elicit ideas for course improvement, the team asked students to complete an end-of-course survey. Development of the NRT Capstone Course survey occurred in late April and early May 2021. The NRT program external evaluator drafted survey items based on the NRT team priorities for the course and worked with several team members to review and test the survey.

The NRT external evaluator administered the NRT capstone survey to 16 students through a survey link sent to the NRT staff, who shared the link with students on Canvas on May 13, 2021, after they completed their final presentations. The survey link remained open until May 18, 2021 and fourteen students completed the survey. Quantitative data analysis involved calculating arithmetic means and standard deviations, and then describing results using bar graph comparisons; qualitative survey data analysis of written feedback involved synthesizing responses and then coding them to identify themes and patterns. To improve validity of the analysis, results were discussed during a co-interpretive session with NRT program leaders.

The strongest theme that emerged from the evaluation was how students valued working in interdisciplinary teams, despite challenges with the final research product. Written comments got at how interdisciplinary teamwork gave them opportunities to practice 'real' interdisciplinary work that involved, for example, 'work with teammates outside their discipline' and 'relating key variables from each field and discussing how results will be combined to produce an integrated product' [15]. In addition, working in interdisciplinary teams enabled trainees to gain an in depth understanding about how to build relationships, requiring them to develop their interdisciplinary communication skills.

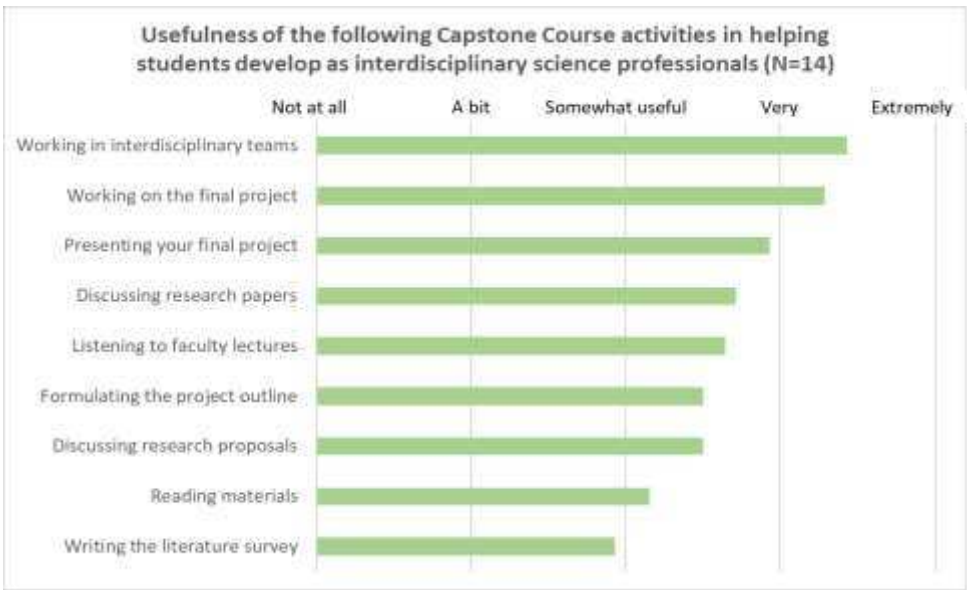
To evaluate students' gains in three skill areas, the survey asked them to rate their ability to write a literature review, produce research products and work in interdisciplinary teams both before and after participating in the NRT capstone. Ratings for these abilities before students' participation in the capstone course showed students thought they were 'somewhat' able in these areas. After-course ratings showed improvement for each ability to 'very able,' as seen in Figure 1.

Figure 1: Students’ perceived gains in three abilities to carry out research activities before and after participating in the NRT Capstone Course



To elicit feedback about which Capstone Course activities were most useful for students’ development as interdisciplinary professionals, the survey asked students to rate a short list. As shown in Figure 2, average ratings from survey respondents for all activities ranged from ‘somewhat useful’ to more than ‘very useful.’

Figure 2: Usefulness of the following Capstone Course activities in helping trainees develop as an interdisciplinary science professional



Other Capstone Course activities that students wrote about as being valuable were the opportunities to work with teammates outside their discipline, developing communication skills, and networking. Suggestions from students about the literature review and project topic selection appear to hold the most promise for fine-tuning the course experience. Responses indicated that the goals and timeline for the literature review could have been tied more closely to research projects. Regarding team research topic selection, a handful of students would have liked topics to relate more closely to their academic backgrounds. During co-interpretation of evaluation results, NRT faculty discussed how fostering interdisciplinary communication skills and aligning team research topics with all students' academic backgrounds are challenges that they expect to encounter in future semesters.

### **Discussion - Challenges and lessons learned**

We will continue to learn and seek ways to improve the NRT capstone experience. There were challenges in bringing together students from diverse disciplines into teams that take on a complex interdisciplinary problem. Even though the NRT capstone offered sessions about team communication and collaboration, where teams were advised to set team norms and goals, the students faced challenges with team logistics such as delegating and sharing project tasks, project pacing, and peer interaction. This was further impacted by our two-week remote start and the constant need for flexibility with respect to virtual participation. The success of interdisciplinary research requires collaborators to develop a consensus in terms of topic, methods, and outcomes at the beginning of the project [4]. To enhance team collaboration and communication, for the next iteration of the NRT capstone, more team building activities will be done at the beginning of the semester. This may include the “Listeners and Talkers” activity in which students practice communication within groups. Mango Singham from Case Western Reserve University [16] has developed the Listeners and Talkers activity. The goal of the “Listeners and Talkers” activity is to increase participation with no coercion. To this end, students are asked to self-identify as either “talkers” or “listeners”. Then, all students who identified as talkers are asked to sit together in one part of the class, and discuss what made them become a talker, how they can develop their listening skills, and how they can help listeners talk more. All students who identified as listeners are also asked to sit together in another part of the class and discuss what made them become listeners, how they can develop their talking skills, and how they can help talkers to listen more. After 20 minutes of group discussion, the two groups report to each other [16]. Another logistical problem was scheduling. To overcome scheduling conflicts, the NRT capstone incorporated from the start of the semester workdays into the course schedule. Although these workdays were useful, successful teams needed to meet outside of the course time and find common meeting times.

Several lessons have been learned from the faculty perspective. First, disseminating interdisciplinary research poses challenges outside the course. Finding the right audience (e.g., journal or conference) for interdisciplinary research was challenging for both faculty and students, as many conferences and journals are discipline-specific. One semester may not be sufficient to submit final research product for journal publication. Literature review papers may be more suited to being completed in the one semester period. The two projects, which include laboratory-based

experiments, required additional time beyond the course, and student teams may not have the ability to complete them. During the spring 2021 semester, there was a lot of uncertainty about conferences modes (virtual, hybrid, or in person) and with conference deadlines six months or more before the conference, these factors may have steered students away from selecting a conference paper as a product. Students were motivated by the opportunity to publish an interdisciplinary journal paper and add it to their curriculum vitae, but conference papers may be a viable option teams during the next offering of the NRT course.

Team formation is critical to the success of the students. The NRT team held a virtual mixer at the end of the fall 2020 semester for students enrolled in the NRT capstone course to network about potential projects. In early January 2021, prior to the start of the semester, the NRT faculty asked students to suggest possible teams and topics that they were interested in within FEW systems. NRT faculty held a virtual meeting the week before the semester started to form Capstone teams. When forming teams, it was important to consider doctoral students and master's students, interest in final products, and proximity to graduation. For example, it may be difficult for master's student close to graduation to submit a journal paper in one semester.

It is also important for teams to work on a topic of interest relevant to their research and career goals, but it was challenging for faculty to align team research topics with all students' academic backgrounds, and NRT leaders have recognized that alignment team research topics will always be challenging. To this end, NRT leaders are exploring how to make interdisciplinary research more central to graduate work, and examine if departments will accept chapters in theses or dissertations that were team produced. This can be a challenge based on the potentially different views of student's committee members and the views of the student's home discipline. Even though students may want to pick their own team, it might be better if faculty have the final say, as faculty are familiar with students' strengths, weaknesses, and research foci, and can better integrate students into effective teams. In the NRT Capstone, faculty assigned students to teams based on their interdisciplinary NRT research theme.

Co-teaching and developing an interdisciplinary curriculum requires communication and learning by the faculty. Developing an interdisciplinary capstone requires faculty to move beyond their own comfort zone of teaching. The NRT capstone incorporates readings, lectures, and activities that enhance students' understanding of different disciplines as well as interdisciplinary collaboration.

## **Conclusions**

The NRT Capstone Course was offered in spring 2021 with three teams of 5-6 students each. The course combined theory and practice, with a mix of lectures and workdays throughout the semester. The lectures provide students with the knowledge to conduct interdisciplinary research while the workdays provide students a place to work within the team on the final product. Students valued working in interdisciplinary teams despite challenges on their final research product. Through working in interdisciplinary teams and on the final research product, students could practice 'real' interdisciplinary work that involved things like 'relating key variables from each field and discussing how results will be combined to produce an integrated product' [15]. Students developed their ability to write a literature review, produce research products and work in

interdisciplinary teams. The authors discussed lessons learned about team formation, facilitating communication between students, and the challenges in publishing interdisciplinary work.

### Acknowledgment

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