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Work in Progress: Recommendations for Early Career Faculty to Engage in Interdisciplinary STEAM Collaborations

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WIP: Recommendations for Early Career Faculty to Engage in Interdisciplinary STEAM Collaborations

Abstract

Faculty researchers have long been siloed into their own areas of research expertise, such that collaborations often occur with researchers in the same or adjacent fields. Yet, the challenges facing the world require solutions that do not exist within one disciplinary silo and require creative solutions that reach across the boundaries of science, technology, engineering, arts, and mathematics (STEAM) disciplines. One way creativity is sparked is through interdisciplinary collaborations. When conflicting perspectives on a given topic are presented, people seek to overcome these conflicts and through this process, creative solutions can emerge. However, interdisciplinary collaborations are often complicated due to differences regarding disciplinary languages, lack of interdisciplinary training, lack of incentives for faculty to participate in interdisciplinary research, and other factors. Therefore, we sought to understand how early career faculty researchers could overcome these challenges and benefit from interdisciplinary collaborations in order to be well-positioned to meet the demands of society's grand challenges.

Using a case study methodology, we explored how faculty researchers from disparate disciplines built interdisciplinary collaborations. Cohorts of 3-5 faculty researchers from a variety of STEAM disciplines, including engineering, science, education, and the arts, were grouped together and tasked with a series of activities. These challenges included presenting in an interactive way at a science museum, designing a hackathon challenge for high school students, and/or presenting at a science pub. The cohort members worked together to find the similarities between their disciplines to create coherent presentations in each of these events. To support their collaboration, we provided each cohort with a theme (energy, space, movement, or elements) that they could use to motivate the convergence of their disparate disciplines. Interviews were conducted before and after each event with each participant. Transcripts were analyzed longitudinally to understand the process of interdisciplinary collaboration and how the cohorts converged over time. Our analysis focused on the strategies cohorts used, their motivations for collaboration, their identities as researchers, and their desires to participate in interdisciplinary collaborations throughout their careers.

The results presented in this paper are a set of recommendations for early career STEAM faculty researchers to engage in interdisciplinary collaborations. Recommendations are based on common themes that emerged across cohorts from the longitudinal case study analysis, such as the impact of incorporating an arts discipline in STEM, overcoming imposter syndrome, and using storytelling techniques to communicate across disciplines. The results provide implications for early career faculty researchers interested in bridging the divide between STEAM disciplines to develop creative solutions to the world's grand challenges and provide a baseline for future research on interdisciplinary STEAM collaborations.

Keywords: Interdisciplinary collaboration; Science, technology, engineering, arts, and mathematics (STEAM); case study; faculty development

Introduction & Background

Research, particularly that which is conducted within academia, is often confined to a single discipline or to a narrow band of related fields [1]. However, many of the world's most challenging problems are interdisciplinary in nature and require input from experts in a wide range of fields to find creative solutions. These are sometimes referred to as "wicked problems", or problems that are ill-defined, have no clear right or wrong answer, and have multiple stakeholders with competing priorities [2]. While these wicked problems have often come from the social sciences [3], many engineering-related problems hold similar characteristics. For example, the United Nations (UN) has identified 17 sustainable development goals, ranging from "No Poverty" to "Climate Action" [4]. Similarly, the National Academy of Engineering has identified 14 "Grand Challenges" ranging from mapping the brain to personalized learning [5]. Truly meeting any of these goals will require experts from across a breadth of (science, technology, engineering, arts, and mathematics) (STEAM) disciplines. However, this interdisciplinary collaboration is often challenging in and of itself, in addition to the problem it seeks to address.

Interdisciplinary collaboration presents challenges based on multiple factors including differences in disciplinary languages, lack of training in interdisciplinary collaboration, and lack of incentive to participate in interdisciplinary work. For example, most faculty responsibilities, including research, are organized within their own discipline. Because there are significant differences across disciplines when it comes to tools, language, and other norms, collaborating with someone outside of a faculty member's disciplinary home becomes challenging [1]. Additionally, institutional structures, such as the tenure and promotion process, are perceived to not value interdisciplinary work as highly as more traditional research. For example, Hurtardo and Sharkness [6] report that faculty who were engaged in interdisciplinary work felt more anxious than those who were engaged in more traditional research regarding the tenure and process and were often concerned about the 'legitimacy' of their work when compared to their peers engaged in traditional research fields. These and other challenges in preparation and structure often serve to limit faculty researchers' participation in interdisciplinary collaborations.

While interdisciplinary collaboration creates challenges, it also has significant potential to support advancement in solutions to the problems our world faces. As mentioned above, creativity will be required to solve many of these problems, and creativity can be sparked through conflicting and divergent perspectives on a given topic [7]. Creativity can be the impetus to scientific progress [8], [9]and as collaborators seek to overcome their differences, the act of reconciling divergent perspectives can lead to the emergence of new ideas [10], [11]. By leveraging interdisciplinary collaboration, we may be able to make progress on the challenges that lie ahead.

In this study, we sought to facilitate interdisciplinary collaboration and collaborative thinking through deliberately formed cohorts of faculty researchers from disparate disciplines in collaboration around a given topic, which is further discussed below. Throughout the study, we sought to better understand the participant experience through a series of interviews and used the participants' responses to answer the question, "*What behaviors and attitudes help support successful interdisciplinary STEAM collaborations?*" From this data, we synthesized four recommendations, which are further discussed in this paper.

Research Context & Methods

In 2018, our project commenced that facilitated and studied higher education researchers' experiences with science communication with the public on interdisciplinary teams. The project team selected sixteen STEAM faculty members from a pool of applicants at a large, public, midwestern university who expressed interest in participating in interdisciplinary collaborations and engaging with the public around science communication. We targeted early career researchers, and at the time the project began, thirteen of the participants were tenure-track but not yet tenured while three of the participants were already tenured. These sixteen faculty researchers were then divided into interdisciplinary cohorts of 3-5 researchers. Each cohort was given a "theme" to help them coalesce around a topic, find similarities between their disciplines, and engage the public. The themes were elements, energy, movement, and space. The interdisciplinary cohorts and their themes are characterized in Table 1.

Table 1: STEAM cohort themes and disciplines

Cohort Theme	# Members	Disciplines Represented in Cohort	Rank
Elements	4	Chemical Engineering Environmental Science Materials Science and Engineering Theater	1 tenured 3 pre-tenure
Energy	3	Electrical & Computer Engineering Civil Engineering Clinical Psychology	3 pre-tenure
Movement	4	City and Regional Planning Mechanical Engineering Music STEM Education	1 tenured 3 pre-tenure
Space	5	Agricultural Education Astronomy Ecology Geography Integrated Systems Engineering	1 tenured 4 pre-tenure

All research participants went through portal-to-the-public style training [12] as cohorts to improve their public-facing communication and presentation skills. After the trainings, the cohorts practiced their newly learned public communication skills and strategies in a variety of public engagement events over the course of 6-18 months (two cohorts were interrupted by the COVID-19 pandemic). These public engagement events were hosted by community partners and included science museums, hackathon events, science pubs, and community art walks, during which the participants engaged the public in their research (details of these events and STEAM researchers' participation can be found in additional publications [13]–[16]).

We collected data through multiple interviews over the course of the project. We conducted longer, 60-minute interviews with participants both before and after the program, such that one interview was completed before the cohorts began their initial training and another after all the public engagement events had ended and the cohorts had formally met for the last time. We also conducted shorter, 5-15-minute interviews with each participant both before and after their engagement in each of the community events.

All interviews were initially coded at an individual participant level, then analysis was expanded to a cohort level, and finally conducted at a full project level to reveal insights as to how participation in this project that engaged faculty in interdisciplinary teamwork and public science communication affected the identity and motivation of the STEAM researchers involved. While the intent of the overarching project was to understand participants' identity and motivation during interdisciplinary collaborations, we noticed trends during our analysis that revealed the challenges of interdisciplinary work and communication of research with others outside of your own discipline in academia. We began to identify effective strategies that faculty participating in this program used to become more successful interdisciplinary collaborators in their time as participants of this research project. We subsequently decided to re-analyze the interviews with this lens of "strategies used through interdisciplinary collaboration," and excerpts from the interviews were identified and grouped together based on similarities and salient experiences and strategies amongst faculty research participants. The strategies we found through our second round of data analysis and our associated recommendations are detailed in the following section. However, further research targeted specifically at revealing and identifying effective interdisciplinary STEAM collaboration strategies for early career faculty is warranted.

Results

Overall, all cohorts were able to successfully converge their disciplines into an interdisciplinary and collaborative team, particularly evidenced in the success of their final group presentations. While each cohort had unique challenges in the ways that they worked together [17], we found similarities between the cohorts' convergence into an interdisciplinary collaboration. Based on the experiences of the cohorts, we identified four recommendations that were pervasive across all cohorts that facilitated successful interdisciplinary STEAM collaboration. These recommendations work together to allow the cohort members to first accomplish individual growth in their identity within the group, then communicate their research both individually and as a cohort, to be intentional about how to integrate disciplines and ultimately embrace the disciplinary differences across cohort members to be truly collaborative. The four recommendations are:

1. Recognize the value of your own work
2. Be intentional about how to integrate disciplines across STEAM
3. Use storytelling as a communication tool
4. Embrace differences across STEAM disciplines

Recommendation #1: Recognize the value of your own work

In order for the group to be interdisciplinary, each individual member must first recognize the importance and value of their work, particularly in relation to their group members and what each individual can contribute to the team. Some participants struggled with imposter syndrome when they compared the impact and perceived prestige of their cohort members' research with their own. For example, David from the Movement cohort, compared his work in music research with the fields of his group members, first feeling self-conscious that his research did not make as much of an impact as others. However, through the interdisciplinary collaboration activities, he learned to appreciate his research and its impact, particularly "a value to enjoying things for the sake of enjoying things." Then, once each individual member is able to recognize the value of their work and what they are able to contribute to their team, they are able to discern which areas of their work they must compromise, or even "sacrifice," in order for the group as a whole to be successful.

> *It makes you self-conscious sometimes, [James] in our group is just doing amazing cancer research and [Todd]'s doing math education and breaking down all of these stereotypes with math education. And [Amy] is basically trying to make the world a better place through urban planning and aviation design and the space around us. And so in that environment, it's like, what does my music research mean? And so I think there's a tendency to think, well, what purpose does my research serve? And I thought about that a lot over the time when we were meeting. And then I eventually, I just had this, I don't know, a change of heart. And I started thinking my research doesn't actually...I teach people how to enjoy music and how to enjoy beauty. And I think there is a value to enjoying things for the sake of enjoying things. And I think that we often treat research as though it needs some sort of quantifiable and measurable output, like dollars saved or lives saved or something. And all of those are very important, but I also think it's just very important to appreciate the world around us...I think I've become more of an appreciator of beauty for beauty's sake, I think, through our conversations in this group. (David – Movement)*

> *I've just been thinking a little bit about this idea of sort of like sacrificing personal research stakes or something in order to find collaborative sort of balance. There's not, you know, there's a sacrifice involved a bit. You have to kind of maybe let go of what would be in your classroom or your lecture or something, maybe the most perfect idea. But the tradeoff is that you get to something that three other people can support. And so actually in a way it feels like ultimately you give a little in order to actually be sort of buoyed up by even more. So, I've just been thinking about that idea, of like sort of sacrifice. (Doug – Elements)*

Recommendation #2: Be intentional about how to integrate disciplines across STEAM

When including varied disciplines from across the broad range of STEAM fields, the cohorts found it important to learn about other disciplines and incorporate that knowledge into their activities and presentations. While each cohort accomplished this differently, the key was being intentional about how they integrated the disciplines of all cohort members. Two types of intentionality were described by participants: one related to disciplinary content (Movement and Energy) while the other related to team dynamics (Space and Elements). The Movement cohort chose to make individual videos about their research to share with the group, followed by concept maps to visually see how the disciplines were related. The Energy cohort first found a connection between two of their members from related fields before figuring out how to incorporate the third member's more disparate discipline. The Space cohort found that a flat structure, where all team members had equal power, worked well for them, while the Elements cohort acknowledged that Doug, their member from the arts field, was the "glue" that connected all other disciplines together. All cohorts demonstrated successful integration of their disciplines utilizing these two types of intentionality:

> *I think it took a long time for us to move in mechanisms and using particular ways of connecting and collaborating. I think one thing that we did early on was we all made videos, videos about ourselves and our connection to research. And I think that was really powerful, because it really allowed us to asynchronously really tell our story, but also tell our story in a way that's not the same way we would normally talk about it, like an intro or an abstract, using academic language. And then once we were able to do that, then we were able to really hear someone talk about the work that they do and why they're passionate about it. (Todd - Movement)*

> *When we started, I was completely clueless. I'm like, 'it's three people doing three extremely different things. There's no way you can come up with something, you know, to accommodate all three of us.' So, I guess because my research at least, 'wearables,' relates to medical applications. The first thing that triggered my mind was maybe we can combine all this and what [Kacey] is doing with wearables. And then talking and talking I think we found out the smart way to incorporate [Jack]'s research, so the environment. And at the end, surprisingly, we came up with a really good challenge. (Alena – Energy)*

> *I have never participated in a project where responsibility was evenly distributed through everybody...It was less pressure than exists in most... I think the homogeneous distribution of power and responsibility was a new thing and it was pretty interesting. And it totally works. It was very nice. Organically. I hope nobody felt like they were being dumped on with extra work. I don't think so. I don't think anybody was just cringing along for the grade, like you're doing a school project. I think everybody was participating in a way that they felt comfortable with. And nobody was resentful of anybody. It was very pleasant. (Andrew – Space)*

> *[Lesley] kept using, we talked a little bit about some of what I was adding in this third part of our work. Like, she kept talking about me like as a glue or that somehow I was, like, helping to frame or arrange or bind together these three other research streams. I think that it's strange to think about yourself as a researcher in that way. I think as a researcher, you don't want to be glue necessarily, right? You want to be the boards. You want to be the thing. But at the same time, if you don't have a glue or you don't have something to tie these disparate elements together, then the thing won't hold. (Doug – Elements)*

Recommendation #3: Use storytelling as a communication tool

The main communication technique that each cohort leveraged throughout the program was storytelling. The cohorts used storytelling both as a way to communicate their individual research and as a way to collectively share their stories with the public. First, the cohort members learned how to tell their stories individually, such as when they presented their individual research topics to both the public audiences and their other cohort members. Then, once they were able to effectively convey their individual stories, the cohorts converged around their theme (i.e., elements, energy, movement, or space), finding connections between their disciplines, to communicate their shared story as one unit. The cohorts found that good integration across STEAM disciplines requires the use of storytelling as a communication tool.

> *It has helped me think a lot more about the story that I tell and the way that I tell the story when it comes to my research. Just having to think about the public and how to capture attention and stuff, I've always kind of been aware of that, but I've captured attention amongst colleagues and that kind of thing. So, it's a little bit different. Then capturing some random person's attention as they're walking by you. And so, thinking about especially just the way that I tell my research story, I think has changed a little bit because of this project. It's helped me think about how do we have that narrative, I think for somebody who doesn't really understand where I'm coming from. (Maria – Space)*

> *It's not just the story that we describe it in two sentences. We'll have to be more specific. So, then we started talking about now 'how do we involve our actual research?' I mean, yeah, like I am doing wearables. But I'm not doing wearables for autistic kids. Or [Kacey]'s like, 'yeah, I'm working with autistic kids, but nothing about wearables or the environment.' So, um, we spent some time, I would say again like having a story, but then how do, how is that actually research coming into play to some further time? Uh, so that's what we did at the end. It's like, had like kind of a story. But [Kacey] starts like, you know, I'm working with the autistic kids and these are the challenges I have. So then, you know, I took over like, so I'm doing wearables and this is what we could afford. That it was same thing goes for the environment. So, I definitely like the story evolved came up with an original idea, but then the specifics of the are actually needed for the final presentation came together over the course of time. (Alena – Energy)*

Recommendation #4: Embrace differences across STEAM disciplines

Ultimately, interdisciplinary collaboration cannot be successful unless all members of the team embrace the differences within STEAM. It is important to acknowledge and accept that fields seemingly disparate from your own, such as those in the arts, are still valuable. Even though it may seem challenging or daunting, you cannot exclude these fields and the value they may bring. We must recognize that differences exist and identify how these differences are valuable and can be leveraged to strengthen the interdisciplinary team as a whole. Once this is accomplished, teams will have reached their goal of true interdisciplinary collaboration.

> *I think that this experience has helped me reach a bit farther outside my field to create collaborative ideas than I typically would. It has made me realize that this type of collaboration is actually quite challenging and requires a lot of flexibility. Not all topics will 'work' together easily; the collaborative presentation we were able to create touched only loosely on the subject areas that we all studied, because such flexibility was required in order to create a coherent collaborative presentation. (Kacey – Energy)*

> *Finding these things that come together, I think it was listening and listening for these concepts and the other disciplines that resonate as opposed to jumping in and saying, 'No, no, no, no. Mine's about resilience engineering,' and 'No, no, no. Mine's about...' Or 'My tribe says it this way.' Instead listening and say, 'Yeah, that's the same. And maybe here's where I think I could inject something a little different in order to elevate*

> *the discussion,' as opposed to 'Your discipline just doesn't think about this as well as my discipline.' I think that was really critical. (Mitchell – Space)*

Lastly, Mitchell has highlighted the key ingredient to what is making the interdisciplinary STEAM collaboration successful: that all cohort members enjoy working with one another.

> *Well, the good news is, we all genuinely like each other. And that's not trivial. (Mitchell – Space)*

Conclusion & Future Work

The problems facing society are complex and will not be solved by one discipline alone. Researchers must learn to work across their disciplinary silos in interdisciplinary collaborations. They must also learn to engage with individuals beyond academia. Through this project, we observed the strategies used by faculty members to work successfully in interdisciplinary teams. Through our analysis, we distilled the findings into four recommendations to support other faculty interested in this type of work. By recognizing the value of your own work, being intentional about how to integrate disciplines across STEAM, using storytelling as a communication tool, and embracing differences within STEAM, we believe faculty can begin to address the most complex problems we face as a society.

Looking to the future, we urge STEAM faculty to not just work interdisciplinarily but work transdisciplinarily [18]. Interdisciplinary collaborations bring together researchers from different fields to work at the intersection of their domains, but transdisciplinary work moves beyond the walls of a field to create boundaryless new spaces of knowledge. To truly impact the world, we believe this is the next step in STEAM and encourage faculty to push themselves to explore these spaces and collaborations.

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