The Familiarity Trap:

Collaborative Research and Teaching Lessons from 6 Interdisciplinary Projects

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ABSTRACT

Interdisciplinary projects can be surprisingly challenging for experienced academic collaborators socially, intellectually, and practically. Within disciplines, common sets of philosophical assumptions, practical knowledge-bases, and professional goals can help groups to wrestle through interpersonal differences in attitudes, ideas, priorities and work habits that each participant brings to the table. However, in projects that *span* disciplines, even those basic commonalities cannot be relied on as members coordinate their plans, integrate their approaches, and disseminate their findings. By creating an intensive one-year model for interdisciplinary research-into-teaching projects, UCSB's Crossroads program has been able to compare reported experiences from six groups progressing through common phases of interdisciplinary collaborations and the predictable challenges that arise during such work. Many of the groups' reported needs for dedicated planning and preparation may sound obvious or tedious to academics who have not experienced the unique demands of interdisciplinary research and teaching. That is the “familiarity trap” highlighted here: those communication and coordination pitfalls most likely to sneak up on diverse groups of experts, confident in their own fields, working under pressure.

INTRODUCTION

Interdisciplinarity Magnifies the Difficulty of Academic Collaboration

Two heads are better than one; they are also exponentially more difficult to synchronize thoughts and actions between. This is the defining challenge and the ultimate strength of collaborative academic scholarship: getting intelligent, motivated, critically minded people to point their minds and efforts in complementary directions toward a commonly valued end. Within any given discipline in academia, established structures and conventions facilitate this process: predictable expectations during peer-reviews, meticulous definitions of specialized terms, and standard canons of scholarship help experts strategically plan their research/writing, efficiently express their ideas, and prepare future generations to contribute and collaborate in the field. But what happens when each individual's research values and publication goals are distinct, when one term refers to multiple slightly (or very) different things in the minds of other participants, and one person's “I thought this was obvious” evokes a dozen surprised questions from the group? That, in a nutshell, is interdisciplinary research.

Interdisciplinary research and teaching has become increasingly popular in higher education. Current research increasingly emphasizes interdisciplinary problem-solving (Begg & Vaughn, 2011), interdisciplinary papers notably impact current scholarship (Chen, Arsenault, & Larivière, 2015), and 21st century employers increasingly seek out individuals with skills that interdisciplinarity develops—i.e., complex thinking, fluent communicating, and comfortable collaborating with specialists across

diverse fields (National Academies of Sciences, Engineering, & Medicine, 2018). All these factors have led to a rising demand for interdisciplinary faculty experience, graduate student training, and undergraduate coursework.

Accordingly, universities are actively seeking new routes for supporting educational dialogs that cross and connect academic disciplines: from synthetic courses to integrative programs to multi-departmental research initiatives, (National Academies of Sciences, Engineering, & Medicine, 2018). Where interdisciplinary endeavors have managed to make that leap from concept to practice, institutions of higher learning have seen many tangible benefits. For example, discipline-crossing courses like “Environmental Studies” or “Science and Technology in Everyday Life” (Krupczak et al., 2005) draw large undergraduate enrollments, with their real-world topics and inclusive teaching styles for communicating to non-majors, and yield notable benefits in both students' engagement and learning (e.g., Krupczak & Ollis, 2006; Malavé & Watson, 2000; Olds & Miller, 2004). Interdisciplinary research projects also draw active interest from graduate students and faculty in fields from engineering and biomedical research to social sciences and humanities (Chen, Arsenault, & Larivière, 2015), providing opportunities to expand professional networks and develop interdisciplinary leadership capacities (Calatrava Moreno and Danowitz, 2016; Graybill et al., 2006). Interdisciplinary programs like Cognitive Science, Feminist Studies, and Bioethics draw in prospective students who are interested in professional fields where employees need complex understandings and adaptive skills that these programs foster (e.g., software design, international business, biomedical engineering). Some of these “interdisciplines” are now becoming disciplines in their own right (Eddy 2005), and the number of students majoring in these discipline-crossing fields of study has increased 37 percent in the United States between academic years 2008 and 2013 (Snyder, de Brey, & Dillow 2016).

Despite this clear value and appeal of interdisciplinary research and teaching, differences among disciplines can make such collaborations difficult to establish and maintain. Even before a project begins, the existing structural and social separations of departments in most higher learning institutions can make discipline-crossing studies, courses, or programs difficult for administrators and faculty to coordinate. Established department locations, social events, course-approval procedures, and professional advancement requirements often tacitly favor and facilitate within-discipline collaboration. Yet many of the challenges that interdisciplinary groups face are intellectual and interpersonal: a natural and predictable consequence of participants encountering unique issues of learning from and working with people who think, speak, and draw on disciplinary expertise that is academically unfamiliar to them (Boix Mansilla, Lamont, & Sato, 2015; Gamse, Espinosa, & Roy, 2013; Turner, Benessaiah, Warren, & Iwaniec 2015).

Within each academic field, a set of established values and priorities, terms and basic knowledge, standards of evidence and technically detailed research methods make communication and practice a highly specialized and intentionally detailed social exchange. Those core concepts and technical approaches that define a discipline can be extremely hard for outsiders to understand, and (until that confusion surfaces) easy for disciplinary insiders to assume is just “obvious and normal” to specialists in other fields. This is the *familiarity trap* that interdisciplinary collaborators must perpetually address: when a group of experts cannot assume and rely upon a shared disciplinary understanding to mediate their vastly different perspectives, interpretations, and opinions about their subject of study, reliable pitfalls will arise in trying to communicate clearly and operate together as a group.

Recognizing the Importance of Pedagogy in Collaborations

As with any group work, interdisciplinary collaborations are *social learning processes*. As such, they rely on prepared leadership, goal-oriented task management, and clear communication among all participants to coordinate everyone's understandings and guide group progress in a unified, agreed-upon direction. What distinguishes the interdisciplinary learning process is the extent to which differences can catch all participants off-guard, including experts and leaders if they have not worked through such cross-disciplinary learning trajectories before: coming to appreciate varied beliefs about valid forms of evidence, clarifying discipline-specific meanings for common terms, combining distinct fluencies with data-collection and analysis methods—and accepting the *considerable time and effort* required to achieve that complex understanding in a diverse group.

These challenges make sense when one considers how faculty and graduate students learn to communicate and function fluently in their fields. All members of a discipline begin as novices in a community of practice (Tuomi-Grohn, Engestrom & Young, 2003), participating in activities and conversations until they understand how to behave and contribute as experts in that field. Engaging fully in an academic discipline requires individuals to grasp that field's “threshold concepts” (Meyer and Land, 2006): notions which irreversibly transform the way a person looks at the world, extend and enhance the language that person uses, help integrate various ideas into a larger framework of understanding, and often define boundaries where they meet with other thresholds. Thus, emerging experts develop skilled (and often implicit) intuition within the bounds of their field (Fiore, Hoffman, & Salas, 2008; Kahneman & Klein, 2009). In this way, these same experts can become quickly uncomfortable or confused where they encounter another discipline's ideas, terminologies, and practices.

Ergo, before interdisciplinary groups can produce integrated scholarship and educational experiences for others, those collaborators must first plan out their own pedagogical process: teaching and learning from one another. Guidelines for success emerging from interdisciplinary programs (e.g., Derrick, Falk-Krzesinski, & Roberts, 2012; Gilkey & Earp, 2006; Graybill et al., 2006; Welch-Devine, Hardy, Brosius, & Heynen 2014) consistently reflect the aforementioned interdisciplinary learning pitfalls: unexpected difficulty of explaining fundamental reasons behind their own practices, listening openly, and asking for clarification on basic issues when collaborating outside their realms of expertise. Methods for supporting such socio-technical integration within diverse groups commonly center around the elements of observation, dialog, and inquiry among participants (Fisher et al., 2015). For example, the “toolbox” method uses questions to facilitate explicit philosophical dialogs among cross-disciplinary researchers about their motives, methods, evidence, and values (Eigenbrode et al., 2007; Donovan, O'Rourke, & Looney, 2015).

When it comes to disseminating these learning experiences as integrated academic content in universities, interdisciplinary courses and programs commonly emphasize these details:

- (1) **prepared leaders**, who can link a broader educational vision to some practical situation;
- (2) **current/local** societal issues;
- (3) **coordinated aims** and **clear tasks**, that delineate a path for scholarly progress within that situation;
- (4) group research, problem-solving, teaching, or public outreach as means for students to **practically apply** content they learn.
- (5) **proactively inclusive communication** and **open dialogs**, to ensure that everyone in the group shares a common understanding of those activities and their purposes; and
- (6) **progressive support**, to foster continuing participation by all members as the group is learning and progressing along that path.

While these fundamental aspects of pedagogical guidance in interdisciplinary work are explicitly mentioned across program reports and reviews (National Academies of Sciences, Engineering, and Medicine, 2018), such literatures tend to foreground insights about what works over where the process falters. Thus, the challenges of interdisciplinary learning that *necessitate* these elements of pedagogical guidance are often less explicitly detailed. Furthermore, since interdisciplinary research at the graduate level and integrative courses at the undergraduate level tend to operate as distinct academic endeavors, any *links* that might exist between the principles of interdisciplinary research and integrative teaching are, likewise, implicit—if mentioned at all. In sum, interdisciplinary groups need informed, stage-by-stage guidance as they prepare for integrative research and teaching. What constitutes the “right” time and place for interventions within an interdisciplinary collaboration, however, may not be clear for groups that are just beginning this work.

To complement this growing literature on specific strategies and general advice for fostering interdisciplinary collaboration, this paper delineates the practical phases involved in such work, and the specific needs that arise for participants at each stage of that process. Specific attention is focused on those surprises or challenges that participants in interdisciplinary projects have marked as most difficult to anticipate and actively address. Hopefully, this will help new interdisciplinary groups to notice and surmount the “familiarity trap” in their own projects, pinpointing *where* such strategies and advice come into play (i.e., *when* to prepare for issues, and *what* support to offer the group on its learning trajectory) as participants work to share and combine their understandings and approaches to a commonly valued topic, asking themselves:

“How do we prepare to talk across fields of expertise, bringing confusions to the surface and resolving them, so that we can then combine our ideas and methods in a mutually useful way for all disciplines involved?”

BACKGROUND AND METHODS

University of California, Santa Barbara's Crossroads Program takes a comprehensive approach to integrating disciplines in higher education, explicitly linking graduate research with undergraduate education. Thus, projects systematically progress through all the major phases of interdisciplinary integration: group formation, research and course/lesson development, and educational exchanges beyond the group with students and other target audiences. The data collected from these projects provide a useful overview of the specific kinds of support and guidance that groups generally need when progressing through the essential phases of an interdisciplinary collaboration.

When the Crossroads Program was conceived, there was no existing roadmap for this model of interdisciplinary groups intentionally transitioning from producing new scholarship at the graduate level to creating educational innovations at the undergraduate level. By funding six diverse interdisciplinary projects to create and execute their own versions of this research-into-teaching process, and comparing their learning experiences, the Crossroads program gained a much clearer procedural understanding of the *pedagogical needs* endemic to collaborations that cross disciplines, and the *pedagogical principles* for addressing those learner's needs in both interdisciplinary research and integrative education.

The Crossroads Model of Interdisciplinary Teaching and Learning at UCSB

The Crossroads program began in 2012, with the general goal of fostering interdisciplinary collaborations and learning across the UCSB campus, mobilizing the university's existing diverse experts and collaborations by funding structured 1-year collaborative projects with that explicit research-into-teaching goal. The program model emphasized producing original scholarly work and classroom innovations, providing graduate fellows with hands-on leadership experience as researchers and educators, and enhancing undergraduates' learning through project members' educational materials and hands-on teaching.

Groups had flexibility to tailor their process to their specific research goals and their departments' classroom environments, yet every accepted Crossroads project proposal adhered to a few fundamental tenets. First, each project had to fit into three consecutive academic terms: one focused on learning fundamental information and coordinating research/study plans, the next on doing research and preparing educational innovations for undergraduate (or professional masters) courses, and the final term on implementing those classroom plans and finalizing study results. Second, faculty leaders (drawn from at least two distinct disciplines) had to maintain a team-taught interdisciplinary research seminar across those three terms, keeping the group connected and coordinated as project advanced. Third, graduate fellows (selected by that group's lead faculty) had to be substantively involved in the research, educational design, and teaching components of the project. Finally, each project's faculty produce a final report of experiences and outcomes (see prompts, Appendix A).

These guidelines were put in place to facilitate efficient, productive group collaboration; to ensure that collaborations were truly interdisciplinary (i.e., not just sharing disciplinary knowledge, but actively synthesizing those diverse methods and data); to provide graduate students real opportunities to lead and make decisions as interdisciplinary scholars/educators; and to collect organized reflections about participants' experiences and needs in such interdisciplinary work.

Crossroads participants all found their project experiences worthwhile. Faculty particularly valued the productive working relationships they forged with scholars beyond their disciplines, while graduate students deeply appreciated opportunities to create lessons and teach from their own research expertise and interdisciplinary experiences. Moreover, because Crossroads' comprehensive research-into-teaching model brought faculty and graduate students systematically through so many phases of disciplinary integration, participants' reports and reflections allowed the program to recognize some common patterns of difficulties as those projects progressed from planning foundational literatures, to directing research and analysis, to creating classroom lessons and conversations. Based on these, we propose types of support and preparation needed for projects of this type.

The first six Crossroads projects spanned a variety of disciplines. Each group came together to address an intellectual/educational issue salient to all disciplines involved, and combined their respective knowledge-bases and skills to pursue those areas of interest more deeply. The projects were as follows (fuller descriptions, appendix B): **Psychology, Environment, and Public Policy** (PEPP - Environmental Political Science, Social Psychology) used psychological theories to better understand the actions and attitudes that result from environmental messaging. **Climate Justice Futures** (CJF - Film Studies, Sociology, Feminist Studies, English) explored how marginalized communities respond to and influence the international dialog around climate change. **Borderlands** (Archaeology, Sociocultural Anthropology, History, Religious Studies) examined the forces that lead to peace or conflict among cultural or ethnic groups in regions without strong state control. **Religious Experience and the Mind** (REM - Religious Studies, Psychology) studied the interaction of religion, experience, and mind in people's perceived religious experiences across traditions and cultures. **The Politics of**

Race and Language in Learning Contexts (SKILLS - Linguistics, Education, Chicana/o Studies) extended from the outreach program “School Kids Investigating Language in Life and Society,” understanding the way issues race and language are negotiated within educational environments. **Materials, Mechanics & Medicine** (M³ - Chemical Engineering, Bioengineering, Mechanical Engineering) developed bridges between knowledge of colloidal materials, cellular mechanics, and regenerative medicine to understand interactions between cells and materials.

Despite these six projects' unique topics, all groups progressed through comparable phases of interdisciplinary integration: first defining project aims and plans, then learning and researching together, and ultimately teaching and publishing from those interdisciplinary experiences.

This Paper's Method and Structure

In this paper, we divide the basic tasks that most discipline-crossing groups will have to work through into three procedural phases—*coordinating* plans, *integrating* approaches, and *disseminating* outcomes—and describe the difficulties that groups can expect to encounter in each phase. The paper is intended to serve as a functional resource for future program administrators and project leaders. With that in mind, a few notes about its structure and method:

First, the three phases into which this paper is divided are not theory-based; they simply reflect the *practical order* of operations that discipline-crossing collaborations progress through. Second, this is a *post-hoc* study: an observation-driven report of useful patterns across diverse interdisciplinary projects, based on summative project reports from lead faculty and a summary report of exit-interviews with five faculty and four graduate students. The data informing this paper are a constellation of participants' reported experiences, varying both in level of detail and level of inference (i.e., describing *challenges*, versus explaining perceived *needs*, versus offering *suggestions* for future support). These help us to evaluate the reported challenges, yet are ultimately subjective. Third, this paper aims to be broadly relevant, but is specifically rooted in six interdisciplinary research-into-teaching collaborations. Challenges and needs may vary for groups that want to merely hear about others' disciplines (crossdisciplinary), work in parallel (multidisciplinary), synthesize knowledge and methods as Crossroads projects did (interdisciplinary), or unify intellectual frameworks into a new disciplinary perspective (transdisciplinary) (Jensius 2012).

Crossroads' aim is not to unify disciplines, but to facilitate productive dialogs between them. Furthermore, the Crossroads model is centrally focused on *research-into-teaching*, facilitating the transition from advanced research into foundational education. As a result, Crossroads faculty and student reflections on interdisciplinary work are particularly comprehensive, encompassing the research and teaching aspects of integrative education as a unified process (Whereas in other programs, collaborators are likely to focus on research or education independently). In the following sections, we present an overview of the fundamental phases in that interdisciplinary process, describing core tasks and associated challenges that can be expected during those phases, and the types of pedagogical guidance that participants request as they progress through their interdisciplinary collaborating experiences.

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PRACTICAL ANATOMY OF THE INTERDISCIPLINARY RESEARCH-AND-TEACHING PROJECT

Phases of Development and Lessons learned: An Overview

The trajectory of an interdisciplinary project can be divided into three broad phases: the group-defining phase (where projects' aims, members, and format are coordinated), the collaborative learning/researching phase (where core disciplinary literature, individual research tasks, and group understandings of findings are integrated), and the educating phase (where information is disseminated, both as curriculum and as classroom dialogs).

Participants generally described areas where they struggled in terms of insufficient leadership and preparation for their group's educational dialogs. Phrases such as “greater than anticipated” “scale back the scope” “logistics of coordinating” and “order in which we should present material” all point at two common ways that disciplinary experts can get caught in an interdisciplinary project's Familiarity Trap:

- (1) a lack of logistical coordination among faculty beforehand, thinking that things will “become apparent.” This results in substantial time and effort lost to miscommunications and ad hoc negotiations during a group's already-demanding coordination phase. And
- (2) a lack of intentional pedagogical structure during cross-disciplinary dialogs, thinking “these people are smart academics, they will understand my discipline.” This prolongs moments of confusion and disrupts group momentum toward defining and pursuing its outcomes.

Regarding advice for how a University's program structure can proactively facilitate interdisciplinary projects, participants repeated three key points. Firstly, programs should be realistic about *time*: moving from learning to producing knowledge across disciplines may require years to do in earnest, and a gradual time-scale allows a group's culture to develop and its research initiatives to gain momentum before transitioning into creating educational materials. Secondly, interdisciplinary programs need a degree of *flexibility*: providing general funds and broad outcome expectations lets groups shape their process and products to fit their particular group. Yet such freedom, without structured guidance and pedagogical support, leaves groups feeling uncertain about how to proceed, often missing opportunities to progress efficiently toward their goals. Therefore, thirdly, interdisciplinary programs need to provide *structure*: regular check-ins or requests for reports to help groups maintain focus and document process, a contact-person to help faculty navigate program requirements, use resources, facilitate task planning, and provide pedagogical training.

The more specific challenges within each phase of these interdisciplinary projects are highlighted, along with details that helped or were suggested for addressing those needs in an interdisciplinary collaboration.

The Group-Defining Phase: Coordination

In the **group-defining phase**, lead faculty define the project aim, deliberate on which individuals might benefit and contribute most as project members, and plan out details of the initial curriculum and timeline toward eventual end-products. Crossroads participants emphasize that establishing this base takes more time and focus for groups that are combining diverse disciplines: coordinating among multiple departments' teaching loads, multiple faculty's ideal outcomes, and multiple graduate students' background knowledge-bases means that such details cannot be taken for granted or left to work out in-process.

Coordinating: the project aim.

The first task in any interdisciplinary project is negotiating a *Well-defined Project Aim* – a specific guiding question, research focal area, or practical challenge that is of common interest to multiple disciplines. Negotiating a group's mutual goals often begins with a more-or-less informal exchange whereby potential collaborators discover or define areas/topics of shared interest. Laying out an array of possibilities provides a raw bulk of ideas that can then be critically debated and refined into a more focused, tenable set of group priorities. That transition from shared interests to defined aims often takes place through *collaborative proposal writing*. Such exchanges help to crystallize objectives, making sure that the group's general values and ideal outcomes are duly reflected in the project's concrete structures.

Common challenges and suggestions. Noticing, understanding, and accepting *complementary differences* among one's fellow collaborators is an important initial step in this process of defining the group's aim. Individuals who are not used to interdisciplinary collaborations may be surprised at how explicitly they need to express themselves in these early discussions of a project's guiding goals and general approach, since experts in different fields rely on distinct bodies of knowledge, specialized vocabularies, and implicit cultural attitudes (e.g., what is “valid” evidence, a “useful” finding, or “good” writing).

In order to avoid the time-waste and social friction of discovering miscommunications and misunderstandings after the project is underway, groups must discuss *explicitly* these key elements of their project (where, why, how/toward what ends they are working together) before doing further, more detailed practical planning. As one of the Crossroads graduate students explained during an interview:

“I’ve learned the importance of talking to people about what their basic epistemological and methodological foundations in their field are, because often I think we’re completely unaware of where everyone begins. If you’re aware of where people are coming from, I think you can have better opportunities for collaboration and cross-disciplinary conversations.”

This process of coordinating disciplinary viewpoints and individual goals can take significant *time*. One faculty member suggested the practice of “abstracting up” in conversations to create a shared vocabulary within the group, explicitly clarifying disciplines' definitions of terms (e.g., “altruism”) for one another by beginning with a select case study or concrete phenomenon and asking “What is this an example of?”, thereby moving from specific actions and situations to those general terms that describe them.

Coordinating: core group members.

The next step in an interdisciplinary collaboration, after setting an agreed-upon vision, is forming a *Cohesive Group* – individuals who can work together, coordinating their roles and specialized backgrounds, to enrich whole-group understandings of the project's focal issue and share research tools to explore that issue more expansively. Deciding which individuals to invite means deliberating seriously about who can realistically contribute to the group's aims: who is interested in the project, has some base of knowledge and skill related to that focus, is inclined to learn about other fields' approaches, and has sufficient time/energy to actually support the project.

Participants may include lead faculty and graduate fellows, plus interested faculty and graduates from other departments who are more casually involved with the project. In addition, remote/visiting scholars from other projects can make valuable contributions, especially if they provide *models* of what

interdisciplinary interactions could look like, what directions such scholarship might take, and the eventual payoff of such collaborative work. One faculty member described two particular guest groups as helping members “envision directions they could take” by sharing their first-hand experiences with incorporating experimental research into religious studies, explaining in detail their integrative research methods, and honestly recounting their difficulties in that collaboration. One student reflected that these presentations “led to a lot of lively debate and strengthened my own understandings” of fields beyond his own. Another student explained that these presenters gave her “a vision for the kind of exciting work possible at the intersection of the humanities and the sciences.”

Common challenges and suggestions. Not everyone involved in an interdisciplinary group has to be a full-fledged participant. However, group leaders should keep in mind that the less involved a participant, the less aware they will be of the project's evolving aims and working relationships, and so the more potentially disruptive they can be if they overstep their role as a visitor in group conversations as the group develops and progresses. The same is true of full-fledged participants who are consistently present, but not prepared to join in: they can easily disrupt the coherence and momentum of an already-challenging project. As one project experienced:

“The biggest challenge was not interdisciplinarity, but how to deal with a couple of students who lacked any academic background in the study of race and racism and thus had difficulty participating productively in the class. These students chose not to continue the seminar in winter and spring.”

Thus, projects' participants emphasized how important it is that *everyone* in the core group has some basic mastery of at least one field's disciplinary skills: where everyone is being challenged to learn about unfamiliar fields, having a sense of certainty, comfort, and fluency in at least one area is essential both educationally (to prevent confusion, stress, and mental burnout) and socially (to allow for a sense of self-efficacy, progress, and belonging within the group).

To ensure that an interdisciplinary group consists of individuals who will both bring the most to the collaboration and get the most out of that experience, participants strongly emphasize the importance of a *review process* for selecting members. Lead faculty in one Crossroads group created an application-and-interview process, which required them to come together and discuss what qualities they were looking for in graduate fellows. Interviewing as a panel, with each faculty member presenting a question from their disciplinary perspective to test the fit of potential members, has also helped group leaders to quickly access the project-specific merit of individuals. What is important here is that the project's leaders are intentional and explicit about what qualities they are looking for in the group's participants, creating a *consensus* about their working vision for group as it forms.

Coordinating: project format.

A final step for project leaders preparing to collaborate across disciplines, after defining project aims and criteria for core group members, is planning the initial *Structure of Collaborative Meetings* – a time/place and method for the group to learn, share, set tasks, and decide on future directions. As Crossroads projects progressed from foundational group learning toward researching and publications/teaching, group leaders commonly found themselves adjusting seminar structures to match that ongoing progress, e.g., by holding meetings less frequently and for longer periods, by doing progressively less group reading work and more independent research presentation, and by pivoting discussions from comparing disciplinary theories and practices to workshoping the group's interdisciplinary findings and communication (i.e., authoring papers, developing presentations, producing course curricula, testing out classroom activities).

Common challenges and suggestions. One practical problem that arose consistently during projects, and for which faculty emphasized a definite need to plan at this preliminary stage, was *dividing labor clearly and fairly* among the project leaders. Some faculty found themselves not expecting the amount of organizational work required, or felt forced to take on a disproportionate share of the workload, and wished that they had been informed and prepared for those expectations. All agreed that projects function more effectively when there is explicit understanding and agreement about workload from the whole group. So groups would be well-advised to spend time early on (first with faculty leaders, then later with all core participants) plotting out the various kinds of work that will be required to accomplish the project's goals, and coming to initial agreements about who will take on those various tasks.

Additionally, multiple groups emphasized the need to move *slowly* from learning about others' disciplines to actually planning research collaborations that integrate those disciplinary approaches. For example, PEPP's structure pushed students to develop research proposals within the first quarter, which was difficult for participants (and led to one pair abandoning their initial plan), whereas REM's gradual structure of readings and whole-group conversations allowed time for psychologists to become familiar with the complexities of ethnographic/historical research and for humanities scholars to learn a structured approach for reading psychological literature, which gradually fostered deep conversations and yielded many collaborative possibilities between cognitive science and religious studies. Faculty noted that discussing specific, real-world situations and pairing individuals across disciplinary lines provided raw materials and social opportunities for individuals to develop shared understandings and project ideas:

“Pairing students across disciplines worked very well, leading to productive discussions and collaborations.” “Begin the course with a single case–study ... and work through that case before broadening out to a more global approach.” “We discussed psychology in the first quarter (psychological antecedents of environmental problems) and political science in the second quarter (environmental policy and political barriers to sustainability). It may have been better to switch the quarters—to address the problems and then to address how psychology can help form interventions and potential solutions.”

Complimentarily, the SKILLS group recognized the value of discussions and activities that clarify the more general overarching theories of the project: as participants immerse themselves in the logistics of fieldwork and exploring data from different disciplinary perspectives, such essential theoretical notions can fall into the background. Thus, SKILLS' leaders suggest planning to “integrate the theoretical component more consistently throughout the class,” particularly when students are beginning their research.

A note for providing pedagogical support: coordination phase.

During the early stages of an interdisciplinary project, group leaders commonly report underestimating how explicitly they have to communicate when deciding the group's aims and division of labor, how much preparation and support some group members will require to participate, and how methodically the group meetings will need to be structured to help that diverse group progress together. Programs can help groups to manage these familiarity traps by mandating or incentivizing dedicated time early on wherein groups can talk through and troubleshoot their plans, focusing specifically on stating prioritized aims, crafting a preliminary workflow, and recognizing the learning curve of all participants

(see appendix C).

The Collaborative Learning/Researching Phase: Integration

In the **collaborative learning/researching phase**, participants explore one another's disciplinary views of the project topics through core readings and group discussions, allocate research tasks for project sub-groups, and present findings back to the whole group for feedback. During this phase, participants note particularly the challenge of maintaining unified focus while sorting through different disciplinary tools available to the group, and making steady progress toward project deliverables. Some groups facilitated this synchronizing process by crafting “questions of the day” to start conversations, assigning daily discussion leaders, and providing social bonding opportunities for participants. Essentially, this phase is the time for group members to build and leverage interpersonal connections and cross-disciplinary understandings in service of openly questioning and informing one another's contributions to the group's interdisciplinary research.

Integrating: readings, discussions.

Since interdisciplinary projects are also usually cross-departmental and cross-campus, the working culture of a group can be somewhat a tangle on the proverbial “first day of class.” Participants will be looking for patterns in the flow of social interactions and tasks, but the multiple faculty from different departments may have uncoordinated ideas about the best pedagogical approach, and *Implicit Standards for that Group* – who speaks first, who leads discussions, what questions are encouraged, how tasks are selected, what each person needs to contribute. Therefore, interdisciplinary project leaders may want to dedicate some time preparing how they will lead, evoke, and model participation and discussion when the group convenes in social space. Are lead faculty more like bosses or co-investigators; are students directed workers or creative collaborators? These roles need to be stated and agreed on, but also personally demonstrated and actively encouraged during a group's interactions.

According to Crossroads participants, the first most basic step toward integrating their fields' diverse ideas and methods is to read about and discuss relevant topics from one another's areas of expertise. Intentionally ordered *Readings* are a vehicle for informing the group, exposing members to each participating discipline's scholarship regarding the project's focus. Complimentarily, *discussions* are a vehicle for synchronizing participant understandings, allowing faculty and students to coordinate their vocabularies around that topic. By these exchanges, groups create a *mutual learning relationship* where everyone takes the role of both an expert and a novice: alternately sharing knowledge with others and expanding their knowledge-base with the help of others.

Common challenges and suggestions. Both faculty and student participants generally expressed consensus that the best use of an interdisciplinary whole-group meeting is to explore *in-depth* the epistemologies, methodologies, knowledge and vocabularies from one another's disciplines: using seminal literature as a way to forge the group's interdisciplinary awareness, common working vocabulary, and collaborative social culture. This group synchronizing takes energy to navigate and time to process, so early project meetings will likely require an unexpectedly large investment into such foundation work. These laborious exchanges have value: as one Fellow described,

“Being in a class with [students from different disciplines] really helped me check the expert blindness than can develop in grad school really early on, because you can't take any concept for granted ... It helps you realize what is crucial to say to a broader audience.”

Regarding group power dynamics, many faculty noticed that their general presence seemed to intimidate students, at least initially, keeping them from fully taking ownership of materials and conversations. This highlighted a need for faculty self awareness and cross-talk about their pedagogical goals and strategies for addressing such social roadblocks to learning. For example, the Borderlands group began placing graduate students in teams of two to lead discussions, which “improved intellectual exchanges.” Similarly, the CJF group encouraged students *to meet with one another outside the group*, without faculty, to build their solidarity and confidence as a group of autonomous intellectuals. Other faculty have similarly recommended organizing events outside of official group meetings—e.g., field trips, happy hours, attending talks together—as ways to promote relationship development among students. Even in small project cohorts, breaking into *smaller group discussions* (3-4 people) created a more intimate, lower-stakes social space within group meetings. One student from PEPP explained that:

“[small group discussion] can help get everyone on the same page, and people unfamiliar with things from the other field (what is equity? Is a sample of 45 really small? social identity theory?) can ask these questions and get them answered quickly thus making our larger group discussion later more focused on key issues or the question of the day.”

As group discussions matured over the course of Crossroads projects, graduate students noted that their relationships across disciplines help them to (A) become more open-minded and creative in thinking about familiar research topics, and (B) communicate effectively with scholars from other disciplines by finding a common language of ideas and examples from which to build mutual understanding. Faculty observed participants integrating one another's ideas and approaches progressively in ways indicating that interdisciplinary learning was taking place.

Integrating: research, group work.

Once an interdisciplinary group generally understands one others' perspectives and approaches, the next step is to *Synthesize their Academic Working Styles* – transitioning from merely reading about and discussing one another's methodologies and findings as observers, to actually combining those principled strategies in *practice* as collaborators. Here, group members often break into smaller teams and divide tasks to serve the project's larger end-goals, putting to the test the group's cohesiveness. During this part of the research cycle, the challenge becomes *maintaining individuals' process of expanding beyond their zones of expertise*. Participants may feel tempted to hole away and produce more work faster by reverting to the familiar approaches of their own disciplines, especially if they feel pressured by the workload or nervous about incorporating ideas and methods from other fields. So group members will have to put effort and focus into *incorporating knowledge and methods* that they are less fluent with, that complement their own.

Common challenges and suggestions. The Crossroads groups described three operational details that support group members integrating their disciplinary approaches during research. The first is *paring down the workload* to what is essential, and setting *realistic expectations* for what the group can accomplish in the timescale available. This creates a context where interdisciplinary integration is actually possible; where diverse teams can adequately synchronize, design, and implement their contributions to the larger research study. As one graduate student described, when leaders assign too many activities and projects,

“often the project seemed to *require* that we not take full advantage of

interdisciplinarity! ... instead of delivering a few multi-disciplinary projects, the number of classes and events we attended and put together (combined with our existing research commitments) required that we all stick to our 'expertise' in order to use our energy most efficiently.”

How much extra time and effort a given group will have to allow for initiating truly interdisciplinary work will crucially depend on two factors: the group's stage-of-development and the similarity or dissimilarity of collaborators involved. For example, have faculty been collaborating for years, or have all participants signed on to a novel initiative? Are they all from various branches of the Humanities, or all from Physical Sciences, versus a team from Philosophy and Molecular Biology?

The second operational detail that participants describe as important for integration is assigning *cross-disciplinary working groups*: this helps participants to continue a microcosm of the full group's integrated dialogs. For example, graduate students from the CJF group described how cross-disciplinary interactions in their groups “pushed” them to consider the spatial and visual dimensions of activism and “required” them to learn about contemporary mapping technologies. The third detail that participants emphasized is having *faculty leaders meet regularly*. Since interdisciplinary faculty may not be in the same departments, these meetings can be hard to arrange, but maintaining communications about current group goals and immediate next tasks helps to keep all participants' and sub-teams' progress informed and synchronized during stages of independent research.

Integrating: presentations and feedback.

After diverging to produce the parts of interdisciplinary research, the group's next step is to reconvene as a whole and discuss how those pieces can be further refined and/or combined to yield a more integrated piece of scholarship. This is done through *Presentations and Workshopping* – informal or semi-formal sessions where participants share their emergent data and analysis, exchange questions and explanations, discuss how that work connects with the project's core aims, and consider strategies for effectively disseminating such findings. These sessions provide a forum for interdisciplinary peer review, where experts from different disciplines can assess one another's contributions, checking that data meet fields' standards of validity and are making useful conclusions from those data. At a communication level, these sessions also give project members a chance to practice presenting their work: learning how to explain effectively to others what they've done, finding those descriptive terms and concrete details that work best to engender understanding in an audience with mixed levels of knowledge and experience.

Common challenges and suggestions. Project leaders generally emphasized in common that a *combination of individual and group workshopping*, done in an *informal* manner (i.e., socially relaxed and structurally flexible to meet the needs of the group from week to week), helped the groups to take full advantage of their combined intellectual resources in shaping final research products. In REM, whose goal was to help students on a variety of project-related scholarly contributions, instructors asked participants to present work briefly “at a stage when they genuinely wanted feedback,” with a focus on the issues they most wanted the group feedback about, and allowed the audience to offer questions and comments throughout. Leaders noted that this “culture” of conversational, supportive presentations developed among group members over time: whereas presentations from visiting scholars took a more formal structure, the core group's presentations could be more fluid because of their established roles, rapport, and trust.

Attendance by all faculty, together, during presentations is crucial for ensuring these products' interdisciplinarity. As Crossroads' assessment coordinator was told by a graduate student:

“Connecting with faculty from outside of their fields was particularly helpful for Fellows, as faculty were able to push them to think differently about their own research, and connect them to resources they may not have learned about otherwise.”

In the M3 project, where faculty did not regularly attend the group's interdisciplinary seminar together, graduate participants clearly expressed missing those faculty members' *cross-disciplinary perspectives and feedback* on their research presentations. While the project “really fostered interactions among students from various backgrounds with common interests in bioengineering,” their work with the faculty was isolated. Participants did learn new research methods in their individual collaborations but never came together as a full group to explicitly connect these parts, nor to translate those lessons about interdisciplinary research into classroom materials. Thus, the group recognized that by not debriefing together about their various research sub-projects, they missed a key opportunity for conceptually integrating their work and crafting that core message in a clear way for others beyond the group.

A note for providing pedagogical support: integration phase.

During the middle stages of an interdisciplinary project, group participants commonly report either getting overwhelmed by timelines that expect interdisciplinary research to follow a similarly efficient trajectory as disciplinary research, or getting lost in teasing out the details of variation between one another's disciplines—which could theoretically go on indefinitely until everyone is an expert in every field. These familiarity traps can tempt participants to fall back into just working within their disciplinary expertise, or leave the whole group feeling frustrated with a lack of progress. Programs can prepare groups to navigate through this experimental and exploratory phase effectively by making sure that the group has explicitly defined end-products to focus their inquiry toward, an intentionally progressing series of learning and research activities that builds toward those end-products, and a continuous line of communication among faculty leaders as well as the whole group to maintain a cohesive interdisciplinary perspective as individuals work on respective tasks (see appendix C).

The Educating Phase: Dissemination

In the **educating phase**, groups turn their focus to pedagogy: faculty and graduate students plan courses/lessons that incorporate the project's interdisciplinary perspectives and findings, receive pedagogical guidance and feedback from the group, and engage in educational dialogs with students or others outside the project. Graduate students in Crossroads described crafting classroom activities and conversations as “transformative” and a “privilege,” faculty admired the creative innovation and engaging energy they brought into their educational exchanges with students, and undergraduates found project participants' breadth of knowledge impressive and that window into current interdisciplinary research exciting. Faculty and graduate students both emphasized the importance of close mentoring relationships, pedagogical preparation, rounds of workshopping and feedback during this phase, all supporting graduate students' ultimate autonomy as they bring interdisciplinary ideas and findings into undergraduate courses.

Disseminating: planning courses, lessons.

The first step in disseminating a project's findings beyond the group is *Planning Lessons and Courses* – group members reflecting on their own interdisciplinary learning, then deciding how to best present those insights to students or other audiences. In a way, the group has already done much of the foundation work for teaching: as they've read and discussed one another's disciplines, explaining terms and showing examples to help one another, the group has been (A) going through the student's

interdisciplinary process and (B) testing out strategies for making their own fields comprehensible to others. In Crossroads, graduate students take the lead in this process, working with faculty guidance and peer feedback to incorporate their interdisciplinary understandings and project research into course curricula, discussion sections, hands-on activities and/or guest lectures.

Common challenges and suggestions. Graduate students reported emphatically how valuable they found *the process of thinking through designing a course*. This opportunity to reflect on their interdisciplinary understandings and to organize those insights into lessons and activities served as both practice in interdisciplinary communication and professional experience in teaching. As one SKILLS faculty explained:

“Serving as a Teaching Assistant for the cross-listed undergraduate course served as a key training element for Crossroads Fellows. ... [allowing] them to *read* undergraduate material from different disciplines, *hear* via lecture how race and language were approached from different disciplines, as well as *teach* these relationships to students.”

However, faculty pointed out that this work was also extremely demanding, both for graduate students and the faculty who provided them with necessary support. As the M3 project found, without *close faculty guidance*, graduate students struggled to integrate their research into their teaching positions: selecting and arranging information into a functional lesson structure requires some prior teaching experience and awareness of students' needs. Some faculty felt that they were able to provide sufficient support and training for interdisciplinary teaching strategies, while others felt that additional resources (e.g., instructional development support staff, or example materials from past projects) would have benefitted the fellows. Fellows consistently expressed appreciating any such support and experience-based advice they received from faculty.

Ultimately, graduate fellows consistently found their teaching experiences worth the effort: an opportunity to plan and deliver lessons, to conduct activities and discuss ideas with students, feeling personal *ownership* over educational materials and developing *confidence* with their skills as interdisciplinary communicators. This was true whether they were designing a single lesson or (much more labor-intensively) plotting and running a whole course. For this reason, many faculty suggested easing into teaching requirements, being a TA/guest speaker rather than a lead lecturer. These positions still allowed graduate fellows the experiences that they valued, without the logistical hurdles and considerable time investment of running a new course. The real value for the graduate fellows was not in the teaching title, but in *the process of creating and refining lessons* based on their own interdisciplinary experiences.

Disseminating: classroom dialogs.

After developing educational enrichments within the interdisciplinary group, the final step is to deliver that message through *Presentations and Conversations* – introducing students or public audiences to the project's outcomes in a way that helps those novices perceive where and how disciplinary approaches can be integrated to advance academic understandings and practical solutions. These educational exchanges can be single presentations or course-length interactions, taught by teams or individuals from the project.

Common challenges and suggestions. Both graduate fellows and project leaders recognized the need for the group to stay in contact while members were teaching interdisciplinary material. As one fellow from Borderlands noted, deciding how to represent the group's diverse intellectual dynamic on

one's own, in a classroom, can be challenging:

“[the Borderlands] seminar was fantastic for interdisciplinary theory/methodology/idea exchange, but it was a little harder to carry over that interdisciplinary element into the Spring quarter classrooms, as there were several different interpretations of the [project's] theme based on discipline and personal research interests.”

Generally, groups addressed this challenge by providing timely feedback to individual teachers. In Borderlands, once the fellows began teaching their own courses, the group met weekly to workshop lecture content, readings, writing assignments, and assessment. In the SKILLS project, where all fellows TAed for the same large interdisciplinary course, the faculty instructor chose not to appoint a lead TA (which is typical for larger courses) to facilitate closer relationships and communication with the fellows as they taught. The instructor also observed TA's sections to get a sense of questions and conversations occurring with students in the course.

Graduate fellows explicitly appreciated faculty's experience-based support, from general discussions about pedagogy to specific insights for teaching across disciplines, as this CJF fellow described:

“proposing and preparing to teach an undergraduate [Feminist Studies course] under the guidance of [a Film/Media Studies Professor] taught me that there are many overlaps and disjunctures in our disciplines' pedagogies, and these points of continuity and difference are equally useful as teaching tools. Teaching in a department other than my own (English) gave me an oblique perspective on the material that I was able to share with my students and has served as the basis for an article that I am currently writing.”

Along with such direct guidance, faculty also generally gave graduate fellows a degree of creative autonomy in their classrooms, which *encouraged individuals to teach from their strengths and experience*. For example, in Borderlands, fellows “included case studies in archaeology, history, and ethnography drawn from their own work.” In PEPP and CJF, fellows created innovative classroom experiments, role-playing labs, and group teaching activities drawn from their home-disciplines to immerse students in the practical realities of those projects. In M3, fellows used their research experiences to make course literature seem more relevant for students, and to answer technical questions with first-hand examples.

Disseminating: listening to feedback.

The last step in interdisciplinary education is *Evaluation* – observing the impact of lessons and activities on an audience, comparing that to intended learning outcomes, and discerning the overall benefit of that exchange. Some goals for interdisciplinary lessons might include students recognizing real-world practical applications of disciplines in combination, seeing how disciplinary understandings compliment one another, and getting excited about the way their specific interests contribute to larger movements addressing global issues. Such outcomes are not always directly “testable,” but evidence of such outcomes can be observed both in classroom exchanges and in student reflections.

Common challenges and suggestions. Students' term-end reviews, faculty's course observations, and graduate fellows' self-reports of courses enriched by interdisciplinary research described a consistent pattern: graduate students emboldened by a sense of course ownership and content expertise, drawing on their areas of academic interest, engaging undergraduates in energetic, innovative, and relevant learning activities. As one student conveyed in an email to their TA from the REM project, being exposed to active research collaborations on campus can bring a sense of relevance

and aliveness to a course:

“I thoroughly enjoyed being in your class and am very excited about the interdisciplinary work that you and the other graduate students are doing on campus. I wish that more undergraduates were exposed to this type of work and I hope that more classes of this type are offered in the future.”

Faculty assessments of graduate fellows' classrooms also point to the efficacy of these interdisciplinary educational environments. Their reports noted high levels of student participation and group affiliation (“students fully engaged” “comfortable with their peers and the TA”), academic rigor and learner retention (“drew heavily on newly published research ... but was very practical and accessible to the Master's students” “students demonstrated a remarkably sophisticated understanding of difficult concepts regarding race, language, and education”), and students appreciation of the interdisciplinary course content and its delivery (“teaching evaluations were off the charts” “One [student], a psych major, appreciated that cog sci and psych theories were explained in a degree of depth that surprised him in a 'humanities class'”).

One challenge was that graduate fellows had a tendency to be overly ambitious in imagining course content and projecting student learning expectations for their 10-week courses. Another was the aforementioned difficulty of representing an interdisciplinary perspective when teaching a course alone. Both of these issues were aided by having courses occurring in terms concurrent with projects' research seminars, providing a reminder of how their disciplinary perspectives connected to the project's larger interdisciplinary purpose. REM fellows connected their individual courses to the project's religion and psychology themes in various ways: creating an essay assignment where psychology students evaluated real-world supernatural phenomenon in terms of basic psychological principles, using the novel *Dune* to analyze how fictional/religious/virtual worlds act on human cognitive systems, and assigning research projects that incorporated humanities and science readings relative to possession-type experiences. Fellows in SKILLS had clearer directives for tying their classroom work to their interdisciplinary project: they guided students through writing personal linguistic autobiographies, analyzing language in media, participating in research assistantships with SKILLS, and ultimately presenting that research in poster sessions and presentations at the university.

A note for providing pedagogical support: dissemination phase.

During the later stages of an interdisciplinary project, faculty leaders may be surprised at how much hands-on support and group feedback graduate fellows (or even fellow faculty) will require when preparing educational materials. Maintaining that multi-perspective voice of the collaboration can be difficult as a participant moves into classrooms or other venues by themselves. Teaching material that is partially beyond one's area of expertise amplifies the regular stresses of leading a course and addressing student's confusions, especially for graduate students who have little prior teaching experience. These challenges can be mitigated by practicing for educational dialogs beforehand: running course materials by the group for feedback, troubleshooting potential questions from students, testing activities and observing one another's teaching. All of this helps to build confidence and maintain a collaborative spirit when disseminating interdisciplinary findings (see appendix C).

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DISCUSSION & FUTURE DIRECTIONS

Interdisciplinary Research and Integrative Education: Parallel Learning Processes

Across these six projects, spanning science and humanities disciplines, Crossroads participants experienced that interdisciplinary research is an inherently pedagogical activity. Everyone in a diverse group of collaborating specialists takes on the role of both a learner and a teacher, asking questions to figure out how other's fields operate and trying different ways to communicate about their own fields. As UCSB Crossroads' first round of interdisciplinary research-into-teaching projects concluded, we asked groups to share what they saw as the most successful and least successful aspects of their projects. Participants by-and-large described the success of their projects in terms of *dialog*: “conversations” “discussions” “working and talking together” “working closely together” “learn from one another” “engaging each other in ideas” “intellectually stimulating” “spurring ideas for teaching” “creat[ing] new courses and teach[ing] others” and “[impact] on the undergrads.”

Integrative education traverses that same pedagogical path, with teachers guiding learners toward more complex and synthetic understandings of subject-matter by offering accessible explanations that predict participants' questions and confusions (National Academies of Sciences, Engineering, & Medicine, 2018). In this way, the struggles that interdisciplinary collaborators encounter in their dialogs with other experts helps to prepare them for teaching these complexly integrated ideas to novices. The Familiarity Traps in interdisciplinary collaborations catch faculty off-guard, leading them to scale back and slow down, to define their terms more simply, to describe their processes more concretely, and to think more intentionally about the order for introducing fields' concepts and knowledge into their project. Each of those traps then becomes a lesson for expert collaborators about how to guide others through that same complex learning path.

So one important realization that Crossroads' comprehensive research-into-teaching model made visible is that *interdisciplinary research principles are also integrative pedagogical principles*. Crossroads participants reported that the approaches they developed for learning and communicating with one another prepared them for teaching and discussing such material effectively with students. Restated simply, these participants realized that—even as experts in their respective fields—interdisciplinary research requires them to learn like novices, and to teach one another as novices.

The expert's established mental frameworks of concepts and experience, which expedite their learning processes in their own fields, are context-specific (Kahneman & Klein, 2009). Crossing into other fields, those frameworks must be expanded or even altered. So experts out-of-field must take time, like a beginner, to understand those fields' epistemologies: to grasp their methods and threshold concepts, to integrate those new ideas and pieces of evidence with their own ways of interpreting the world (Meyer & Land, 2006). Thus, pedagogical success within both interdisciplinary research and teaching depends on educators learning how to communicate knowledge concretely across bounds of understanding, and recognize where/how novices need most help in crossing those conceptual thresholds. As educators, experts must:

- *Reflect* on their personal knowledge, retracing the learning experiences that helped them to reach that understanding, and deciding what key experiences and core concepts to prioritize in educating an outside audience.
- *Operationalize* various parts of that learning process, connecting stories and activities into a coherent sequence to progress learners toward a fuller grasp of the subject-matter.
- *Dialog* with novices, looking for areas of mutual interest and understanding from which to build

a shared sense of group knowledge and educational purpose.

This holds true whether mobilizing the expertise of diverse scholars in interdisciplinary research or teaching those complex insights to fresh-eyed audiences. By highlighting how interdisciplinary research experiences prepare individuals for teaching multi-disciplinary subject matter, and how teaching helps to clarify researchers' communication of their work, we hope to encourage future interdisciplinary programs to connect research and teaching initiatives—for the benefit of graduate students, undergrads, and the academic community in general.

Interdisciplinary Collaboration: Some Principles for Providing Pedagogical Support

The six Crossroads projects demonstrated not only the variety of structures that can work for supporting an interdisciplinary project (Derrick, Falk-Krzesinski, Roberts, et al., 2011; Gamse, Espinosa & Roy, 2013), but how dynamically that group progress in its dialogs together (Fisher, O'Rourke, Evans, et al., 2015; Gilkey & Earp, 2006). Differentiating the needs that rise to prominence in each progressive phase of an interdisciplinary project is crucial for understanding *how* to properly time and administer pedagogical support. Issues need to be addressed *as* they arise: offer help before a group sees the need for it, and they may resist or devalue that intervention; offer help after a struggle begins, and the group may not benefit from that intervention. Just as important, however, is recognizing the common patterns that hold across all these phases: the *Familiarity Traps* that predictably and reliably snare collaborators in interdisciplinary projects.

- 1) People from different disciplines will likely under-explain, misinterpret, and feel the urge to undervalue or resist others' words, ideas, and suggestions in a collaboration more often than they would with members of a similar discipline;
- 2) People from different disciplines will likely take longer to transition in conversation from abstract ideas or general plans to concrete tasks and procedural goals than members of disciplines who use similar working methods and create similar products; and
- 3) People from different disciplines will likely revert to their areas of expertise, where they feel most confident and productive, in response to social stress or practical pressure in an interdisciplinary collaboration.

Understanding these common inclinations in people as they learn how to collaborate across diverse disciplines, then, highlights some basic working principles for facilitating that learning process. These principles are simply the challenges listed above, restated inversely as positive, proactive steps that can be taken to mitigate these interdisciplinary challenges:

- 1) **Foster Collaborative Mindsets** – seeking sense in others' ways of thinking and talking about an issue, and looking for ways in which different methods compliment one another in addressing that issue, helps diverse groups to connect their intellectual space.
- 2) **Prepare for Concrete Actions** – planning in terms of doing and producing (e.g., read A to support B conversations, do C group work to prepare for D research proposals) helps diverse groups to progress steadily from coordinating ideas to collaborating on practical tasks and goals.
- 3) **Provide Explicit Room for Confusion** – offering ample time and active encouragement (e.g., verbal validation, personal modeling) as participants think, ask questions, and share emerging ideas or struggles helps diverse groups to learn and grow together, with all members practicing publicly both how to teach/explain and listen/interpret with others perspectives in mind.

How a program goes about supporting its own institution's collaborations will depend on a number of institutional, departmental, and interpersonal factors. A certain proportion of trial-and-error will probably also be necessary for designing and refining activities and guidelines that groups will find least disruptive and most beneficial for propelling their interdisciplinary work in that environment. Yet those interventions, whatever form they take, will likely reflect these fundamental needs that experienced practitioners recognize, in reflection, an interdisciplinary project needs to expect, accept, and address.

In Crossroads, collaborations operated most satisfactorily for participants where the groups focused on fostering mutually appreciative and collaborative attitudes, preparing thoughtfully organized series of tasks to accomplish group goals, and encouraging curiosity and conversation throughout those purposeful processes. Those actions lead groups to expanded perspectives, new lines of inquiry, original research, publications, new courses, ongoing working relationships, and increased confidence and skill with engaging methods and ideas across disciplines. In this way, these groups demonstrate the promise of interdisciplinary collaboration. Such benefits may be expedited, amplified, and sustained with effective pedagogical interventions. This study provides some experience-based principles to inform the substance and timing of such guidance and support for interdisciplinary learning.

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APPENDIX A

Prompts for Crossroads projects final reports of experiences and outcomes:

Research Seminar:

(a) “Describe the topics addressed across the three quarters of the research seminar. How did this differ from your original plan?” (b) “Describe the activities in the research seminar (discussions, research presentations, etc.) Which worked particularly well?” (c) “Summarize the feedback from the Crossroads Fellows and other graduate students, incorporating both formal course-end evaluations and informal responses.” (d) “How did you foster interdisciplinary interaction and scholarship? What would you change if you could do it again?”

Teaching:

(a) “Describe the roles played by the Crossroads Fellows during their instructional quarter.” “What were the enrollments in each course/section taught by Fellows?” (b) “Describe the activities taken by the Fellows to bring the research outcomes into the classroom. Attach syllabi, lesson plans and exercises as appropriate.” (c) “Describe the training you provided to the Fellows to help them develop and implement their teaching activities.” (d) “How effective were the various teaching activities undertaken by the Fellows? Base your assessment on direct observation, feedback from the Fellows, and relevant comments from course evaluations.”

Outcomes:

(a) “List the scholarly products from the research seminar.” “List the new teaching activities that you are likely to continue employing in your undergraduate or professional master’s courses.” (b) “Were any of the [graduate students or faculty] influenced in their research directions by participating in the program? If so, how?” (c) “Do you plan to continue offering the interdisciplinary research seminar? If so, briefly describe your plans for next year.” (d) “Do you anticipate any significant long-term outcomes from this project, such as new research directions that will be explored, the likelihood of long-term research collaborations, extramural grant proposals or other projects, the development of new curricula, etc.”

Summary:

(a) “What was the most successful/exciting aspect of your Crossroads Project?” (b) “What was the least successful aspect of your project?” (c) “Where there any aspects of the structure imposed by the Crossroads program that you found particularly helpful or particularly unhelpful?” (d) “What advice do you have for the teams that are beginning new Crossroads projects this fall?”

APPENDIX B

The six Crossroads projects, full descriptions:

Psychology, Environment, and Public Policy

The PEPP project brought together faculty and students from Environmental Political Science and Social Psychology to explore how the way in which environmental issues are presented influences individual and collective reactions. Their goal was to enrich academic understanding of the effects of message framing about the environment, and to provide hands-on experience and theoretical context for undergraduate and professional masters students interested in environmental communication. The group pursued these goals through collaborative research, using psychological theories to better understand the actions and attitudes that result from environmental messaging, and then teaching new courses. These courses exposed environmental masters students to techniques for effective persuasion and psychology students to key issues in environmental sustainability, while the research led to multiple academic papers and dissertation chapters by PEPP participants.

Climate Justice Futures

The CJF project brought together faculty and students from Film Studies, Sociology, Feminist Studies, and English to explore how marginalized communities respond to and influence the international dialog around climate change. Their goal was to deepen both academic and public understandings of this topic, and to provide engaging classroom work and film-making opportunities to undergraduates interested in environmental justice and climate change. The group pursued these goals through deliberations about the meaning of “climate justice” and the interactions between media and the environment. These deliberations then led to co-creating three new undergraduate courses which introduced students to approaches for critically evaluating media and used role playing to give students first-hand experience in dealing with climate justice issues. Additionally, these interdisciplinary group discussions contributed to two academic books.

Borderlands

The Borderlands project brought together faculty and students from Archaeology, Sociocultural Anthropology, History, and Religious Studies to examine the forces that lead to peace or conflict among cultural or ethnic groups in regions without strong state control (“borderlands”). Their goal was to add to the academic understanding of this problem in a variety of ancient and modern contexts, and to provide undergraduates with hands-on experience in performing research using methods from the social sciences and humanities. The group pursued these goals by reading broadly to develop a shared interdisciplinary understanding of the subject, followed by developing individual research projects related to the broader theme. From that foundation, the group created and taught new courses that introduced borderlands theory to undergraduates majoring in each of the participating disciplines.

Religious Experience and the Mind

The REM project brought together faculty and students from Religious Studies and Psychology to understand the interaction of religion, experience, and mind across traditions and cultures. Their goal was to integrate scientific methods (drawn from the behavioral sciences) with historical, linguistic, and ethnographic methods (drawn from the humanities) to enhance both research and undergraduate teaching about people's perceived religious experiences. The group pursued these goals through reading broadly to develop a shared understanding of psychology's and humanities' study of religious experience, developing research projects that drew on this shared understanding, conducting research leading to academic publications, and bringing insights from their interdisciplinary understanding into both existing undergraduate courses and newly developed courses that exemplified their approach.

The Politics of Race and Language in Learning Contexts

This project, an extension of the existing collaborative outreach program (School Kids Investigating Language in Life and Society), brought together faculty and students from Linguistics, Education and Chicana/o Studies to understand the way issues race and language are negotiated within educational environments. Their specific goal was to understand how the languages and dialects that racialized minority children bring from home are seen as obstacles or deficits by educational institutions, and to train graduate and undergraduate students to conduct research in the schools, in which high-school students document their own languages. The group pursued these goals by reading original research on topics such as race and racism, language, and politically engaged pedagogies. This then informed the group in conducting research, and developing a new course that prepared undergraduate students to mentor high school students in research. The group also helped to prepare low-income Latino youth for college by training them to carry out original research on language use in their peer groups, families, and communities – as well as writing scholarly articles on this research. The faculty and graduate fellows' research also lead to scholarly academic publications.

Materials, Mechanics & Medicine

The M³ project brought together faculty from Chemical Engineering, Bioengineering and Mechanical Engineering to develop basic scientific understanding relevant to uses of materials in regenerative medicine. The group's academic goal was to inform the development of novel therapies for regenerative medicine by developing bridges between scientific knowledge in colloidal materials, cellular mechanics, and regenerative medicine to understand interactions between cells and materials. The project's lead faculty further hoped to develop a new generation of graduate students who excel in interdisciplinary research and can translate their research findings to undergraduate education and clinical applications. The group pursued these goals by developing novel research collaborations across disciplines, engaging with visiting scholars in bioengineering, and broadening an existing undergraduate course in bioengineering to include interdisciplinary insights from the project. These collaborations developed graduate students' skills in communicating across disciplines, enabled them to bring new research skills more effectively into undergraduate teaching, and were subsequently incorporated into some of their dissertations.

APPENDIX C

Notes for providing pedagogical support, through the phases of interdisciplinary research and teaching:

COORDINATING

Defining the Project Aim.

Groups that established goals and interpersonal connections *prior* to their current project (e.g., based on previous collaborations) progressed faster toward their outcomes. Interdisciplinary programs might facilitate timely conversations among project leaders by:

- Providing incentives/opportunities for project leaders to discuss high-level goals and possible paths for achieving those goals *before* the formal project launch (e.g., a teaching release or Summer salary).
- Making sure the project leaders recognize the practical importance of developing *relationships, a clear shared motive, and a method for doing research together*. This “little bit of infrastructure” will allow them to use program support more immediately to pursue their specific project goals (as Crossroads faculty reported).
- Offering resources to help leaders engage in and structure these conversations. Faculty suggested that the Crossroads program provide *someone to coach* interested groups, making sure that faculty can articulate a vision about their project and about division of labor among them. *Printed guidelines* could also highlight key talking points, such as (A) disciplinary differences in terminology, knowledge-bases, research methods, and epistemology around a set issue; and (B) concrete ways that those different approaches can be mobilized productively together to address participants' most prioritized motives or outcomes.

Selecting the Core Group Members.

Faculty and graduate students have offered specific suggestions about what might constitute an *adequately prepared* member in an interdisciplinary project. Interdisciplinary programs might encourage project faculty to select members who:

- Have a general level of *competency/literacy with academic thinking and discourse* in their discipline, and ideally some exposure to relevant threshold concepts from the other involved disciplines.
- Are at stages of progress with their degrees that *fit* the project/group. Crossroads participants reported that graduate students at early and later stages of their degree progress are beneficial to a project in distinct ways: pre-dissertation graduate students bring enthusiasm and energy to their groups and are more likely to utilize their interdisciplinary experiences in shaping their dissertations and future research; senior graduate students are much more fluent in their discipline's approaches and can make excellent mentors and team-leaders, working comfortably in conjunction with both junior graduate students and expert faculty.
- Are *confident* in sharing their knowledge and their uncertainties/questions as they arise, and *cooperative* in seeking out and respecting others' perspectives as the group learns and works together. Crossroads participants consistently attribute their projects' progress and efficiency in

later stages to group members establishing trust, honest and open communication, and mutual respect.

Planning the Project Format.

Participant reflections and advice about planning an interdisciplinary project's format center on enumerating specific-but-flexible outcomes which can be translated into a consistent-but-adjustable project format with cohesive steps toward achieving those goals. Programs might provide resources/facilitators to help faculty play out and troubleshoot how their plans will progress toward their end-goals. These resources might include specific considerations, offered by Crossroads participants, to keep in mind when structuring seminars to support interdisciplinary collaborating:

- *Specific real-world situations* provide a practical foundation in that process of bridging perspectives, from which the group can broaden to a more global perspective.
- Meta-level literature on *interdisciplinarity and theory* provides useful conceptual frameworks to guide later discussions as the project turns to more research/data-driven tasks.
- Less experienced project participants (e.g., junior graduate students) may need *preparation and continued support* to fully participate in discussions and activities, from understanding concepts and applying research methods to crafting lessons and teaching students.
- Fostering *mentor/mentee relationships* among graduate students at different levels of progress is an organic way to support these participants throughout the project.
- *Pairing students across disciplines* works well for stimulating productive discussions and task collaborations.

INTERGRATING

Managing Readings and Discussions.

In general, participants recognized the benefit of, or suggested the need for, keeping group discussions intentionally focused and forward-moving toward *fostering relationships* and *developing group communication abilities*. Programs can help faculty to lead these interactions in ways that purposefully progress the project group from having separate, mutually incomprehensible understandings of a topic to having shared interdisciplinary view of their topic, specifically with techniques such as:

- Keeping reading loads lighter (about 3-4 academic papers or 50 pages per week) to allow for more focused in-depth discussions about those readings. Any more material than that, one fellow described, can make discussions feel “hurried as people try to cover all the articles.”
- Combining informal small-group and structured whole-group discussions so that disciplinary understandings, questions, and clarifications can be worked through in depth.
- Blending or alternating disciplinary literatures, leading to discussions where all participants feel comfortably familiar with at least some of the material, giving them confidence (and often excitement) about learning beyond their fields.

- Foregrounding discussions of interdisciplinarity, both by including research reviews and integrative theory readings, and by presenting real-world scenarios wherein each discipline's perspective may be concretely discussed.
- Actively encourage students to practice interdisciplinarity in the group by “regularly inviting students to speak from their disciplinary expertise and to learn from each other” in group meetings, as well as well as having faculty acknowledge their own lack of expertise in other disciplines, which “helped alleviate student anxiety regarding gaps in their knowledge.” (SKILLS)
- Actively encourage students to extend their discussions beyond the group. Several groups' faculty encouraged students to engage in scholarly conversations about their projects by announcing campus talks and other educationally enriching events throughout the year, as well as using funding to invite guest speakers or send participants to conferences. Students vocally appreciated such acts of encouragement and validation from the group leaders.
- Divide or tier the project group into different generations as it matures, since groups' dialogs progress together: e.g., an introductory cohort that talks through core readings to form their interdisciplinary understanding together, and an experienced cohort that can focus on more directed reading geared toward research and educational tasks.

Doing Group Research Tasks Independently.

Interdisciplinary projects can facilitate true interdisciplinary research, but participants note that this is only feasible when group timelines and resources facilitate participants' efforts to extend beyond their comfort zones and incorporate other disciplines' ideas and methods. Programs can help ensure that projects provide their participants with this necessary leeway and support by passing on observations from past project groups, such as:

- Tenable goals and timelines, agreed upon by all in the group (especially more junior members who are learning to do new tasks), free up the *time* needed to explore and apply other disciplines' methods, and reflect on those learning experiences.
- Shared literature and other resource repositories facilitate that personal expansion. Vocabulary lists, referenced website links, and contact information for available scholars from other disciplines can all help participants more proactively and confidently integrate aspects of those fields in their individual work.
- Cross-disciplinary research sub-teams push participants to think about research topics from new angles, consider alternative methods for exploring those topics, and explore literatures/resources they likely would not have learned about otherwise.
- Continuous communication among leaders allows the group to retain a cohesive sense of progress, even as individuals make progress on their separate tasks. Faculty recommended dedicated *weekly meetings* among leaders to “keep the project on track and to ensure that everyone has the opportunity to fully contribute their ideas to ongoing project development.”

Giving Presentations and Feedback in Group.

Interdisciplinary groups that developed concrete plans for their end-products—i.e., knowing who their

real-world audience is and what impact they want to have in that area—could they apply that focused direction in their workshops, utilizing the full breadth of cross-disciplinary expertise in their group to help improve individuals' contributions to those end-products. Programs can help interdisciplinary project leaders to reverse-engineer their plans for group presentations and feedback by beginning with a list of achievable outcomes toward which to aim workshop activities when the group comes together:

- Graduate student development will come from them receiving guidance and feedback from individuals beyond their department/university on their academic works-in-process (research presentations, papers, dissertations), where faculty can help them functionally incorporate new ideas and data into their own field's work. This will also help them establish ongoing professional relationships and channels for collaborative research.
- Faculty progress on collaborations will come from new group members bringing insights and resources to stimulate existing projects, opening new lines of scholastic inquiry, providing a diverse test-audience for presentations, and co-authoring publications.
- Scholarly products will come from dedicated work sessions with particular conferences and symposia, journals and books, grants and markets in mind.
- Educational products will come from talking through and testing out syllabi, lesson plans, activities and presentations to disseminate project knowledge and experience.
- Interdisciplinary meta-awareness will come from participants sharing reflections on their learning process: first-hand struggles to comprehend and communicate across disciplines in the group, realizations about language and examples that make interdisciplinary subject-matter accessible for outside audiences (e.g., how to explain a concept's practical importance, a method's essential process, or a finding's immediate value to someone from another field).

DISSEMINATING

Planning Courses and Lessons.

Every institution and department therein has its own structural demands and instructional supports. Crossroads projects found various ways of integrating interdisciplinary materials into undergraduate instruction; ways that fit existing department structures as well as teaching fellows' specific interests and knowledge. Interdisciplinary programs can encourage project leaders to think creatively within their disciplinary structures, naming available resources and opportunities, and experimenting with lessons and activities before courses begin to help ensure these interventions' success:

- Consider what types of educational enhancements will maximize impact on learners, in ways that enrich rather than distract from departments' core learning objectives for students. When in the course, what content, and how connected to existing materials: these will all be important points to explore.
- Discuss what formats for conveying that interdisciplinary content will be feasible and effective within a given course. Effective approaches might include: creating online videos or presentations to assign as viewing material or insert into existing courses; altering lessons or thematically tailoring major assignments in existing course curricula; creating new courses

around fellows' or project groups' research areas; involving project participants as guest speakers, teaching assistants, or co-instructors.

- Test and refine educational activities as a group. Hold planning sessions to decide what interdisciplinary content to disseminate; pedagogy sessions about how to share that content effectively; one-on-one faculty/graduate fellow meetings to select readings and refine lesson plans together; full-group trial runs to give feedback on planned lectures, case-study overviews, practical demonstrations, and/or other learning activities for students.

Leading Classroom Dialogs.

Understanding interdisciplinary content is only half of being prepared to teach interdisciplinarity; understanding how to use teaching theories and practices to help students learn that content is its own area of knowledge that participants will need. While Crossroads fellows cited their groups' weekly research discussions as important practice for thinking about their work “in terms that were translatable across disciplinary boundaries,” they also recognized the distinct importance of meetings focused on pedagogy, that specifically helped them to “think through how to pass on what [they had] learned through the Crossroads projects to [their] undergraduate students.” Interdisciplinary programs can offer guidance to project leaders in providing that pedagogical support, so that participants are prepared to lead those educational dialogs beyond the group:

- Be hands-on in sharing your teaching expertise. One-on-one interventions, group workshops, and observation-based feedback sessions with experienced teachers play a key role in graduate fellows transitioning from being interdisciplinary practitioners to bringing that integrated perspective to students in classroom environments.
- Allow graduate fellows leeway to teach from their experience. Crafting lessons and leading conversations based on their own research and interdisciplinary knowledge creates a rich integrative learning opportunity for the fellows (and for the students they teach).
- Provide informed and experienced individuals to support fellows continuously in teaching beyond their disciplines. The details of running a course (how to discuss readings, introduce lectures, link activities, allot ample time to cover material) vary by discipline, and require some general sense of what students need when learning that field; if fellows do not have the experience to guide themselves, make sure someone can provide them that guidance.

Listening to Learners' Feedback.

The positive outcomes of Crossroads' interdisciplinary educational enrichments—engaged classrooms, students applying complex ideas, outstanding teaching reviews—took significant time and effort to achieve, with both faculty and graduate fellows working together intentionally to translate their own often messy-and-confusing interdisciplinary learning progress into structured, concise, comprehensible, and relatable educational materials for novice audiences. Interdisciplinary programs can help projects to focus their educational self-assessments by emphasizing a few common points that marked teaching in courses as successfully interdisciplinary:

- Perceiving the larger relevance of specialized disciplines. Students communicated being motivated by seeing where different disciplines contribute their specific knowledge-bases, perspectives, and methods to help society more fully understand complex problems.

- Recognizing the real-world benefit of disciplines working together across differences. This point is easy to leave implicit when teaching interdisciplinary content, but students see it more clearly when explicitly emphasized: disciplines working together can address real-world issues with greater accuracy or dimensionality than they could as individual disciplines.
- Expressing interest in learning cooperatively with individuals who have alternate backgrounds, and showing some ability to discuss complex cross-disciplinary issues with others. Both interdisciplinary values and integrated knowledge are promoted among students by having research-driven course dialogs about the process (not just the products) of interdisciplinary work.