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Mapping as a Way of Understanding Complexity

Rhonda Davis
Northern Kentucky University

Abstract: This article describes the use of mapping strategies in an interdisciplinary course using *Interdisciplinary Research: Process and Theory* (Repko & Szostak, 2021). The use of interdisciplinary mapping took place in a 300-level undergraduate course and focused on maps presented in the textbook, including the system map (and systems thinking), the research map, the concept or principle map, and the theory map. Mapping strategies guided students in developing a specific complex problem for the senior research project. This article emphasizes systems thinking and system mapping as a strategy to better understand qualitatively oriented complex problems. This discussion also includes examples of student work and an analysis of the impact of the mapping experience on students' experience of interdisciplinary learning.

Keywords: interdisciplinary thinking, interdisciplinary research process, systems thinking, interdisciplinary mapping, integrative learning

Mapping as a Way of Understanding Complexity

Mapping as a strategy for understanding has been employed in a variety of ways, ranging from technical uses such as mapping collaborative approaches to socio-technical integration (Fisher et al., 2015) to broader applications that can be used in a variety of ways such as actor mapping, trend mapping, and timeline mapping ("FSG Reimagining Social Change," 2021). Mapping can also take a variety of forms such as mind mapping (Miranti & Wilujeng, 2018), sociocultural mapping (Kopiyevska, 2018), and cognitive mapping (Whyte & Lamberton, 2020). Mapping helps build better comprehension by revealing connections and relationships. This is particularly important when one is investigating complex problems. In interdisciplinary studies, the mapping strategies used include systems thinking and the system map, the research map, the concept or principle map, and the theory map (Repko & Szostak, 2021).

The course in which I have used Repko and Szostak's (2021) *Interdisciplinary Research: Process and Theory* textbook is a 300-level undergraduate

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course called Interdisciplinary Inquiry that focuses on developing skills for research and literacy across disciplinary fields and applying strategies for creating a research proposal. The culminating research proposal is part of an electronic portfolio (ePortfolio) that includes critical reflection on the student's coursework at the university and the complex personal, professional, or community problems that interest them. The research proposal prepares students to move into the next course, IST 497 Capstone in Integrative Studies, where they conduct their research. The student learning outcomes for this prior course include understanding of the concepts and practical application of integrative thinking, critical thinking, communication, and information literacy.

Northern Kentucky University (NKU) is a regional comprehensive four-year school situated in the greater Cincinnati metropolitan region. One of the fastest-growing universities in Kentucky and serving over 16,000 students, the university offers more than 80 major areas of study. Integrative Studies at NKU requires students to have at least three disciplinary areas of focus and to complete three courses in the program that address interdisciplinary theory and practice, IST 185 Introduction to Integrative Studies, IST 397 Interdisciplinary Inquiry, and IST 497 Capstone in Integrative Studies. The latter two courses are referenced above.

As I have suggested, IST 397 focuses on helping students develop skills to engage in the interdisciplinary research process (IRP) as presented by Repko and Szostak (2021), and the text is required in this course as well as in IST 497. To aid in generating research questions appropriate for interdisciplinary inquiry before undertaking mapping exercise that Repko and Szostak describe as an early step in the process, I have students use Augsburg's (2015) IRP exercises worksheet to develop ideas. Augsburg's worksheet includes a unique procedure for engaging students in the IRP. First, Augsburg asks students to become "struck by a confrontation with a complex phenomenon." This is where students can focus on what problems in the world really interest them. Students identify three complex problems and answer the following questions for each (Augsburg, 2015): How/Why is it complex? Why are you interested in this phenomenon/problem? What future relevance does studying this problem have for me? I have found this worksheet helpful because it can spotlight issues with problems students have chosen before they focus on one and begin research in earnest. For example, students will sometimes choose a problem that does not meet the criteria to be a complex problem. When this happens, students must deconstruct the problem and analyze it further to see if it is suitable for using an interdisciplinary approach. Occasionally, this process leads to students choosing a different problem to work with, having come to a clearer understanding of when a problem requires an interdisciplinary approach. Augsburg's (2015) IRP worksheet takes students through additional steps to develop an appropriate interdisciplinary research question for the one of the three problems they would most like to work with, identify relevant disciplinary perspectives and salient concepts needed to understand the complex problem, and evaluate relevant disciplinary insights from their disciplinary focus areas. The worksheet thus gets them ready to undertake the work (in IST 397 and IST 497) that will earn them their BA in Integrative Studies degree. Repko and Szostak (2021) have no IRP worksheet of this kind, making the Augsburg worksheet an excellent complement to their textbook.

Application of Mapping Strategies

Once students have completed the steps in the IRP described in the Augsburg (2015) worksheet, they are well prepared for moving into the "Identifying Relevant Disciplines" chapter of *Interdisciplinary Research: Process and Theory* (Repko & Szostak, 2021), in which students learn about systems thinking and the system map, the research map, the concept or principle map, and the theory map. The system map is the primary analytical tool of systems thinking and makes visual all parts of a complex problem illustrating the causal relationships among them (Repko & Szostak, 2021, p. 108). There are distinct types of system maps, and in the course, we focus on using the causal loop diagram that enables students to visualize the behavior that occurs in a system and the relationships between key stakeholders in the system. The research map makes the purpose of the research clearer and aids in completing the steps of the IRP. The research map is an effective way to understand the perspective and assumptions of each discipline relevant to a problem and may help identify nondisciplinary sources or interpretations that could also be useful in the research (Repko & Szostak, 2021, p. 114).

The concept or principle map helps organize information about a problem after one has identified relevant concepts. Repko and Szostak (2021) refer to this type of mapping exercise as being useful in situations where a large-scale problem is under investigation and students are identifying specific concepts that help frame various aspects of the problem. Asking why specific concepts or principles are important to the study and identifying related concepts aid students in organizing advanced research efforts. The theory map is similar in that students are identifying specific theories that may help them further their understanding of a complex problem, and such a map is often useful at an advanced stage of the IRP.

With the help of Augsburg's worksheet, students come to the Repko and Szostak (2021) chapter and its discussion of mapping having already identified relevant disciplines to be applied to the complex problem each has chosen to investigate. However, the Repko and Szostak discussion helps them find other disciplines and non-disciplinary sources that could be relevant in building their understanding of the problem. As we work with the chapter, we focus on systems thinking and the system map to thus help them "identify the constituent parts of the problem, understand how these relate to each other and to the problem as a whole, and view the problem *as a system*" (Repko & Szostak, 2021, p. 107). A solid grounding in what systems thinking looks like and in principles of systems thinking such as this chapter provides is beneficial before the students launch into the actual creation of a system map. They learn that, as Goodman (2016) says,

> systems thinking is also a sensitivity to the circular nature of the world we live in; an awareness of the role of structure in creating the conditions we face; a recognition that there are powerful laws of systems operating that we are unaware of; a realization that there are consequences to our actions that we are oblivious to. (para 3)

Such understanding provides students with some confidence to not only deconstruct systems but to construct new ones, acknowledging that many complex problems arise and persist due to insufficient understanding of the system in which they exist.

To reach a sufficient level of understanding of system mapping and other kinds of interdisciplinary mapping, we discuss examples presented in the chapter before we practice mapping a complex problem as a class and before students develop their own maps for an assignment. Addressing students directly as they do throughout the text, Repko and Szostak (2021) assert that mapping

> may reveal a gap in your understanding of the problem or establish that you are placing too much emphasis on a few disciplinary components at the expense of other equally important components. Whereas the disciplinarian is often satisfied to focus on a single part or on a few "neighboring" parts of the problem, the interdisciplinarian is concerned with achieving an interdisciplinary understanding of the problem as a whole. (p. 107)

Mapping is a critical tool for students to develop a deeper understanding of what interdisciplinary research involves. As noted, mapping helps them identify the range of relevant disciplinary areas and emphasizes the connections between them, thereby dispelling the "widespread belief that interdisciplinary research is something one can do without consciously pursuing an interdisciplinary research process" (Szostak, 2017, p. 19). As part of the interdisciplinary research process, mapping is a conscious and structured approach that promotes the synthesis of ideas that is the goal of interdisciplinary work.

An often-cited application of systems thinking and system mapping is in engineering and other science and technology fields, but it can effectively be applied in other fields, as well, and to qualitatively oriented problems. System mapping can make transparent important aspects of all kinds of systems that might otherwise be missed. For example, students frequently identify homelessness as a complex problem they would like to discuss in class and work with themselves. Students most often name a lack of affordable housing as the primary barrier to people being housed. However, system mapping, which helps identify critical components such as positive and negative feedback loops and patterns that emerge at different points in time (Repko & Szostak, 2021, p. 107), allows them to gain greater understanding of the complexity of the problem. For the homelessness problem, mapping helps students see other barriers to people being housed such as having access to clean clothing and state identification. Students begin to see that we know what we know about this complex problem through feedback loops such as interviews with homeless shelter workers, first-person interviews and testimonials from people experiencing homelessness, and sociological data on the causes of homelessness.

Even when students do identify the many disciplines that may be relevant to a complex problem with ease, they may not understand *how* a system operates in relation to the problem nor *why* the system behaves the way it does. For example, students may easily identify ocean pollution as a complex problem and see that academic disciplines such as economics, sociology, and political science are necessary to help people better understand the factors that create and perpetuate the problem. They may not, however, know how the system of plastic production, consumption, and disposal works. Students may also not know why this system behaves the way it does, resulting in the dangerous accumulation of plastic pollution in marine ecosystems. Knowing why will involve a much deeper dive into relevant disciplines and into the perspectives of stakeholders such as plastics producers, consumers, environmental watchdogs, and lawmakers. Repko and Szostak (2021) claim that "one should be as concerned with knowing the *why* of the problem as knowing the *how*" (p. 111). Mathews and Jones (2008) state that "systems thinkers do not produce deterministic models but rather models that facilitate an understanding of the interworkings of systems through visualizations of the behavior occurring within the system" (p. 76). After unpacking the how and why of a complex system, as systems thinking and system mapping can help them to do, students have a much clearer understanding of the roles insights from different disciplines (and other sources) can play in the understanding of a problem and how to deal with it effectively.

Before students begin system mapping on their own projects and focus on problems of particular interest to them, we practice mapping as a class using systems thinking methodology as presented in Repko and Szostak (2021).

While there are many mapping software applications available for everyone from beginning researchers to those at the expert level to help with design elements, from the free and user-friendly to the costly and challenging, at the undergraduate level, students do not need high-tech mapping skills. As Figure 1 from Repko and Szostak (2021) shows, a simple document with boxes and arrows works well for visualizing the relationships students need to unpack.

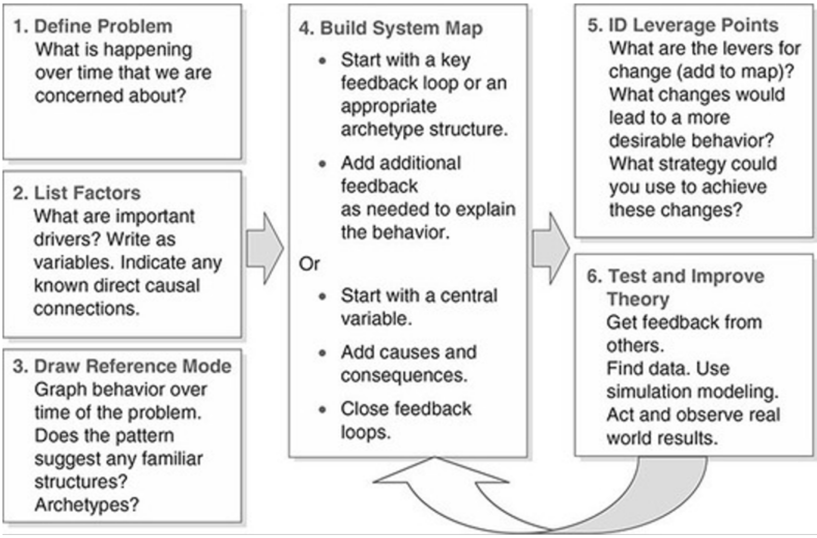

Figure 1. Systems thinking methodology (Repko & Szostak, 2021, p. 112).

Let me offer an example using a complex problem the students chose for a practice investigation in a recent course, ocean pollution. We began the mapping process by defining the problem more specifically. What kind of ocean pollution? Oil spills? Microplastic? Single-use plastics? After discussing the many drivers of ocean pollution, students decided that we should investigate how to reduce microplastic pollution in the ocean. By researching as a class and making a chart that everyone could see and edit (via OneNote's Class Notebook integrated with the Canvas Learning Management System), and by using systems thinking methodology (Repko & Szostak, 2021), we came to a better understanding of what is happening with plastic waste in the oceans, who the stakeholders are that are involved in this problem, and why we are concerned. We next determined what the specific drivers of microplastic pollution are, and listed variables that contribute to the problem. This step in the IRP emphasizes identifying any known causal connections, and students were required to find credible evidence for those connections.

We next attempted a graphic representation of the contributing factors to the problem and how the problem has developed over time. This step also involved identifying patterns and inquiring whether those patterns are familiar in the wider systems in which ocean pollution exists. Of course, this step of systems thinking methodology can be challenging and may require more in-depth engagement with and experience of a problem than students can claim. But students in this course in Interdisciplinary Inquiry are expected to and do gain an adequacy in understanding of disciplinary perspectives and the phenomena disciplines study (thanks in large part to the instruction available in the Repko and Szostak text) and they do gain some necessary insight through research. In this case, for example, my students were able to identify environmental science as an obvious discipline necessary for understanding ocean pollution, and they were aware of and intrigued by the sociological aspects of this complex problem, too. System mapping helped them unpack root causes and contributing factors as seen through both disciplinary lenses. Insights from environmental science included the impacts microplastics have on ocean ecosystems in acting as "vectors for chemical transport into marine organisms causing chemical toxicity (additives, monomers, sorbed chemicals)" (Group of Experts on the Scientific Aspects of Marine Environmental Protection [GESAMP], 2015, p. 48). Insights from sociology were more challenging for students to gather and required further analysis. They learned that sociologists and other social scientists have focused on public perceptions regarding the composition and extent of microplastic in the ocean and its impacts on society (GESAMP, 2015). A persistent question for students was, if scientists know so much about the harm microplastics cause, why are political entities and individual consumers not doing more to reduce plastic waste? They learned through their research that sociologists and other social scientists are asking the same question and that "environmental issues are socially constructed in ways that need to be understood if effective and just strategies for dealing with them are to be found" (Lockie, 2015, para. 4).

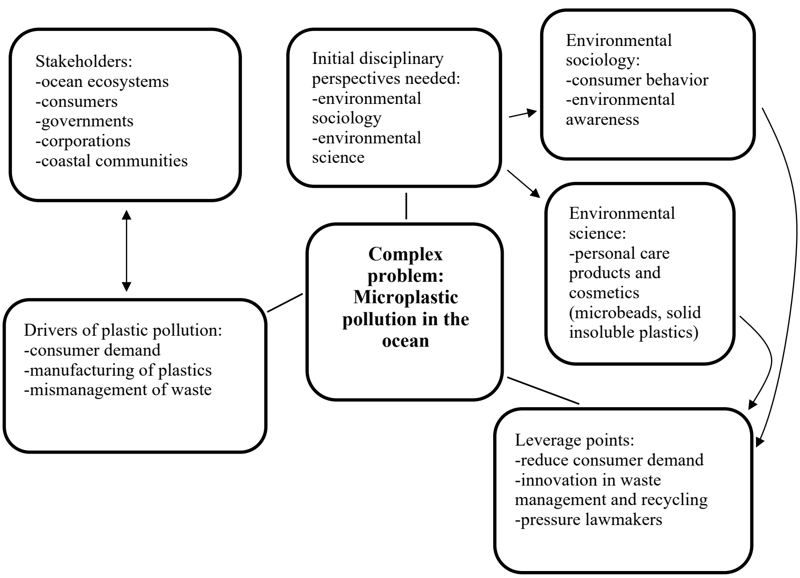

Figure 2. Students developed this system map for microplastic ocean pollution.

Once students achieved a ground-level understanding of the complex problem of microplastic in the ocean, we moved on to building the system map. As explained in the Repko and Szostak (2021) chapter, a system map involves identifying key feedback loops. Feedback loops give us information about how and why a system is behaving the way it does. Since complex problems are interconnected, there are constant feedback loops and flows between the elements of the relevant system. There are several types of feedback loops such as positive, negative, causal, reinforcing, and balancing feedback loops (see Mathews & Jones, 2008, for a deeper discussion of feedback loops). In addition to helping break down a problem into its constituent parts, "the causal loop diagram helps identify which parts of the system are likely to be addressed by different disciplines, subdisciplines, and interdisciplines" (Repko & Szostak, 2021, p. 109). Working with the example we were using in class, we used a causal loop to try to better understand the relationship between the aspects involved in ocean pollution (see Figure 3). Students asked how we know ocean

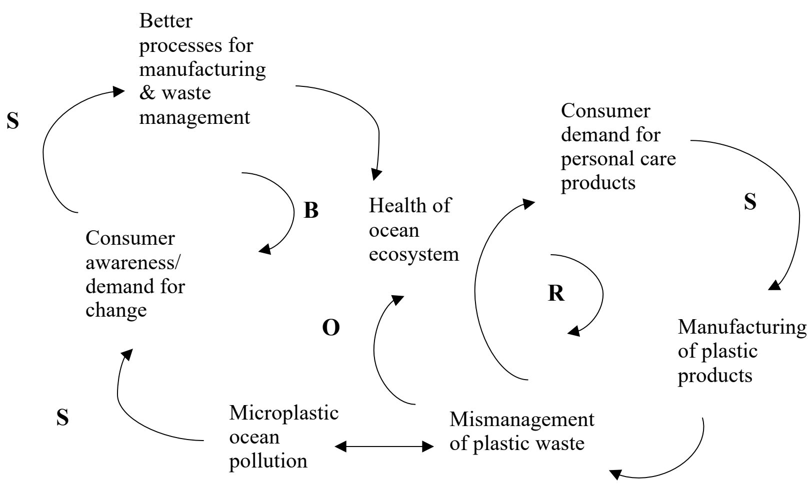

Figure 3. Causal loop diagram based on the work of Mathews and Jones (2008). The letters **S** and **O** indicate whether the phenomena are moving in the same or opposite directions. Consumer demand for personal care products packaged in plastic leads to increased manufacturing of plastic products resulting in mismanagement of plastic waste. This harms the health of ocean ecosystems and can be considered a reinforcing loop, designated by **R**. Microplastic in the ocean can increase consumer awareness about the damage plastic does to the ocean creating a demand for better processes for manufacturing and waste management which improves the health of ocean ecosystems. This is a balancing loop, designated by the letter **B**.

ecosystems are polluted with microplastic, what kinds of plastics are most prevalent, and how they get there in the first place. Students identified causes and consequences of such pollution. For example, research revealed that a primary cause of microplastic pollution in the ocean is the inappropriate and ineffective treatment of post-consumer plastic. Many areas of the United States do not have adequate recycling strategies to cope with the massive amounts of plastic waste.

Work with such a feedback loop enlarged student understanding regarding the relationships between consumer awareness, local and state legislative action/lack of action, constraints of the recycling industry, and economic strategies for dealing with solid waste. This information led to the consideration of leverage points in the system. Students were asked, “How do we create change in this system?” “What changes would lead to a more desirable behavior?” and “What strategy could you use to achieve these changes?” (Repko & Szostak, 2021, p. 112). Developing and discussing the causal feedback loop allowed students to adjust the system map, creating a deeper level of engagement for understanding complexity.

Reflection on Interdisciplinary Mapping

Repko and Szostak (2021) assert that disciplinary adequacy is necessary to become interdisciplinary, and working with their text makes it possible for students—even undergraduate students—to achieve such adequacy. Engaging students in classroom discussions and activities that involve mapping is especially helpful in making clearer what kinds of disciplinary knowledge are needed to deconstruct and deal with a complex problem. According to Mathews and Jones (2008),

> Disciplinary knowledge is essential for the first three steps in the systems thinking process: defining the problem, identifying the factors that influence the problem, and describing the pattern of system behavior over time. The fourth step, building a systems map, requires the disciplinary skills of systems thinking as well as the interdisciplinary skill of making connections across and between disciplinary knowledge domains. (p. 80)

In our case, the system map revealed that ocean pollution involves many stakeholders, multiple contributing factors including the types of plastics produced and consumer behavior, and a variety of potential solutions. These components of the problem are well documented, so students were faced with a plethora of information and evidence. Mapping helped them make important connections and narrow the focus of their attention so that understanding the problem might be more manageable. One of the major strengths of system mapping at the undergraduate level is that it helps students see the importance of the iterative process in interdisciplinary learning. It helps them understand that the research process

> is not a simple matter of moving from point A to point B to point C and on to the end. Rather, when you get to point B, you may discover that you

> need to revisit and revise the decision you made at point A. In fact, revising work performed at earlier STEPS is likely to happen at any given point in the process. (Repko & Szostak, 2021, p. 80)

An example of them making helpful decisions in this iterative process occurred when the class decided that knowing about the seven distinct categories of microplastic pollution in the ocean unnecessarily complicated our understanding of the problem, and that this knowledge need not all be incorporated in our work. We learned that the major contributors to microplastics are synthetic textiles, vehicle tires, road markings, personal care products and cosmetics, plastic pellets, marine coatings, and city dust (First Sentier MUFG Sustainable Investment Institute, 2021). However, students voted as a class to focus only on personal care products and cosmetics, making more effective work possible.

The further students made progress in this research exercise, the more they were confronted with the scale, scope, and salience of the issues. They had to further refine their research focus as new research and thinking came into the picture. Students were encouraged to "add important elements or clarifications as the research progresse[d]" (Repko & Szostak, 2021, p. 108). As students moved ahead, they became more confident in their ability to deconstruct complex problems, identify components of the system that help to create (and could potentially solve) such problems, and achieve a better understanding of how complex problems arise in the first place. They came to see that the ocean pollution they first perceived as a science problem was more than that; it was also a problem that those in the disciplines of sociology and economics needed to weigh in on. Students began thinking of ocean pollution as a matter involving social responsibility and they learned more about the insufficiency of our current economic strategies to deal with plastic waste.

In using *Interdisciplinary Research Process and Theory* (Repko & Szostak, 2021), I would advise instructors to forefront the mapping experience and take it further than we did ourselves. In this section of our course Interdisciplinary Inquiry, the second of the courses required in our Integrative Studies program, we did not work (as a class) with the other kinds of mapping that Repko and Szostak (2021) discuss. However, students in other courses might similarly start with a complex problem and map out the system in which it exists, but then, as their understanding progressed, might move (as a class) to a research map that would help frame the purpose of the research, identify the potentially relevant disciplines, determine disciplinary perspectives on the problem, recognize assumptions of each discipline that might impact the discipline's relevancy to understanding of the problem, and potentially identify nondisciplinary sources of information and insight or interpretations of the problem (Repko & Szostak, 2021, p. 114). Next, students might employ a concept map by identifying concepts essential to understanding the problem. Next, they might attempt a theory map. Through more advanced research, students are likely to encounter theories that could enable investigation of the complex problem in novel ways. Such mapping could also reveal disciplinary conflicts, some real, some apparent, for as we know, some apparent conflicts that create barriers to solving problems (or seem to) may not be conflicts at all. Students might discover that "disciplines will often seem to be disagreeing because they are actually focusing on different relationships within a larger system. The mapping exercise can usefully identify such situations" (Szostak, n.d.).

Once we in our own class practiced systems thinking methodology and system mapping with the complex problem chosen by us all, students were asked to choose their own complex problem, identify the disciplines most relevant to it, and proceed to engage in the mapping process on their own. Students were encouraged to begin with a system map but were then asked to choose and use any of the other kinds of maps from the Repko and Szostak (2021) text that felt relevant and useful for their research projects. One student investigated the complex problem of escalating violence between stakeholders in the criminal justice system, such as community members and police officers, and its effects on health, welfare, morale, and economic conditions. This student chose to use the research map (see Figure 4).

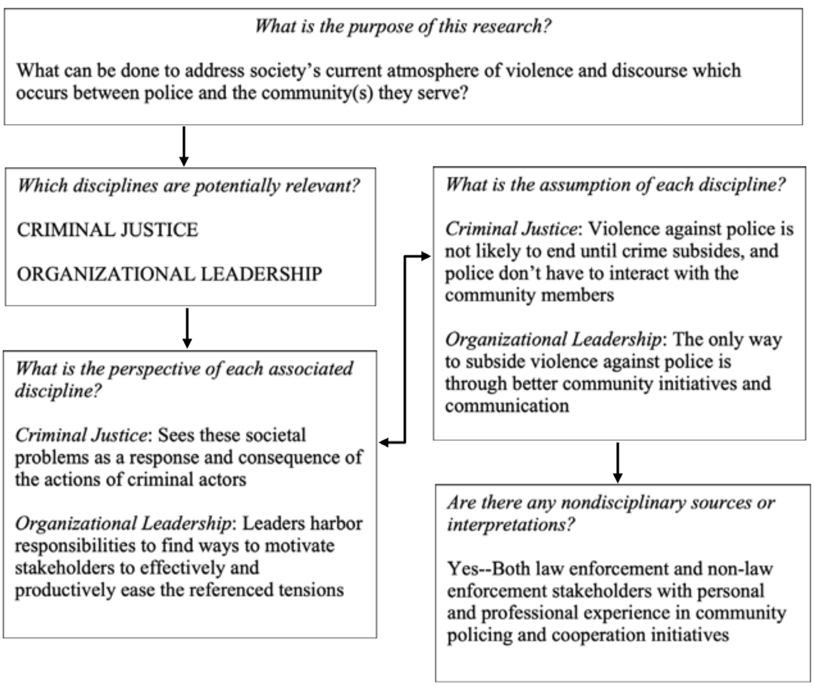

Figure 4. Student example of a research map.

After the mapping process was complete, the student reported that he felt more grounded in his research, had a clearer sense of purpose, and had a better understanding of what it means to engage in the interdisciplinary research process. He also described having a more responsive, thoughtful approach rather than the primarily emotional response to the problem of violence between police officers and community members generated by the fact that he had had personal experience with and had developed strong feelings about this complex problem. He reported an expansion in his thinking as well as his research skills and abilities (E. Slocum, personal communication, October 1, 2021). Having a whole class work together on examples of research mapping and the other kinds of mapping presented in the text might assist all students in achieving such an outcome as they turn to the individual projects they may be pursuing. We did not have the time to do class-wide exercises on these other kinds of mapping in our class. However, the good work students like the one just mentioned did demonstrates that the Repko and Szostak (2021) discussion of these other kinds of mapping is sufficient to enable students to use multiple kinds of mapping to handle their projects effectively.

Conclusion

The focus in this interdisciplinary studies course is to encourage students to find relevant aspects within complex problems of special interest to them where they can see not just other people but themselves making change. Like the student in law enforcement mentioned above, they may be seeking to implement change within a community in which they work and live. They may be hoping to intervene to improve a situation. Szostak (n.d.) says, "If the goal of the research is to suggest ways that the results emanating from the system might be changed, then the mapping exercise may serve to identify the best place(s) in the system to intervene in order to effect change." In our class, students have been able to use mapping to pinpoint places of just this sort—places where they might eventually act to help create the change they wish to see in the world.

The mapping process encouraged interdisciplinary learning as students developed skills in identifying connections between the views of those in different disciplines and of various non-academic stakeholders involved in a problem, contributing factors to the problem, and a wide array of potential solutions. According to the Association for American Colleges and Universities (AAC&U), fostering integrative learning of this kind is one of the most important goals of higher education. The AAC&U asserts that developing students'

> capacities for integrative and applied learning is central to personal success, social responsibility, and civic engagement in today's global society. Students face a rapidly changing and increasingly connected world

> where integrative and applied learning becomes not just a benefit . . . but a necessity. (para. 2)

Mapping like that presented in the Repko and Szostak textbook *Interdisciplinary Research Process and Theory* (2021) is an excellent way to help students develop integrative learning skills that they may apply to complex problems in the real world, including communities they will inhabit as they pursue their future lives and careers.

Biographical Notes

Rhonda Davis, PhD, is a faculty member in Integrative Studies at Northern Kentucky University. She holds a PhD in Environmental Studies and a Masters of Interdisciplinary Environmental Science. Her research interests include mapping as a way of knowing, ecological consciousness and worldview, and narrative inquiry. Her undergraduate courses highlight the importance of interdisciplinary thinking and learning in environmental problem-solving. She can be reached at davisr11@nku.edu.

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