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Textual Ecology, Collaborative Tasks, and Genre Systems: Using PDE to Teach STEM Career Awareness/Intent

Philip J. Piety, PhD

University of Maryland

Abstract

The paper discusses the use of *Productive Disciplinary Engagement* (PDE) for a curricular project that features a technology-based alternate reality game (ARG) with the objective of teaching undergraduate students about the collaborative nature of STEM careers. Much of the PDE research uses PDE as either a design-principle or as an analytics lens. This project does both. Most of this extant research focuses on spoken discourse to teach disciplinary knowledge. This project uses workplace documentary texts that are embedded within a semester-long undergraduate course designed to teach students collaboration skills using the context of natural disasters. A range of texts are used in this design from didactic to disciplinary. Students learn about professional work through educational renditions of professional cultural historical activity systems. This paper focuses on design decisions and illustrates some ways that workplace documents can be used in education.

Introduction

The paper discusses the use of *Productive Disciplinary Engagement* (PDE)for a technology-based alternate reality game (ARG) with the objective of teaching undergraduate students about the collaborative nature of STEM careers as part of an NSF funded research project. The game technology is called a Playable Case Study (PCS) and utilizes a narrative that unfolds over virtual days (Winter et al., 2020) and where player actions alter the course of the game. Balzotti and Hansen (2019) and others have developed and researched multimedia online case studies that simulate an organization virtually. Similar the approach used by popular collaborative board games such as Pandemic and Forbidden Island, this project extends that work by placing the players in a team setting and structuring their joint work around common problems that they all get credit for addressing.

The PCS has a literary pedigree. It uses a strong narrative design and cooperation rather than expensive high-technology approaches with hyper-realistic graphics. The fictional scenario is designed as a transmedia text where a variety of sub-texts common to workplaces such as chat, email, video, and player-specific datasets simulate a professional environment. Prior PCSs were usually single player. This version is multiplayer designed around a fictional disaster response narrative where players take various complementary roles and they work collaboratively to solve challenges as a team. The goal of this simulation is to increase student career awareness and career intent using this narrative and simulation.

This paper begins with a discussion of the theoretical background for this project and why texts are used both as a central concept in the PCS and how PDE relates to this research project as a way to communicate about professional work. It then presents more details about this particular project's goals and design and focuses on the *textual ecology* that is being used to teach the students about this work and discusses the activity structures (Cole & Engeström, 1993) in which the textual practices are situated before a brief discussion of the implications of this design study.

Theoretical framing

PDE in is an approach with strong linguistic and semiotic roots. Engle and Conant (2002) present PDE using four principles for student learning: 1) Students engaging with problematized subject matter. 2) Students having authority to address problems. 3) Students' work being accountable to others and to disciplinary norms. 4) Students are provided with sufficient resources to do this work. On the face of it these principles seem performative and focused on opportunity and behaviors rather than communication. However, these principles were then and have been since used in the context of expressing knowledge and interacting with knowledge in the form of conversations or textual practices. The disciplinary engagement has generally been of a symbolic and performative nature.

This project then continues prior work in PDE and other approaches to using language as a tool to teach professional understandings, scientific discourse, and problem-solving (Duschl & Osborne, 2002; Engle & Conant, 2002; Mercer-Mapstone & Kuchel, 2016). While much of the extant PDE literature focuses on spoken discourse, this project utilizes written communication in the form of professional documents as pedagogical scaffolds. This approach to the written semiotic artifact aligns this work with the concept that reading and writing are socially-mediated, situated processes wherein authentic participation and apprenticeship are common (Bazerman, 1997; Gee, 2001; Vygotsky, 1978). Students in this project are apprentices in both the scenario they engage with and with the textual practices they are exposed to.

Genre systems and activity systems

We draw off of the idea that workplace communication is formed within *Genre Systems*—communicative acts sequenced around purposeful action (Yates, Orlikowski & Okamura, 1999). Additionally, we frame this work in the context of what Gee (2003) has called the "design grammars" of a "semiotic domain" and Reuter & Lahanier-Reuter (2009) and others have termed "disciplinary consciousness." Yates and Orlikowski (1992) who describe the relationship between activity and communication in these terms:

> A genre of organizational communication (e.g., a recommendation letter or a proposal) is a typified communicative action invoked in response to a recurrent situation. The recurrent situation or socially defined need includes the history and nature of established practices, social relations, and communication media within

> organizations (e.g., a request for a recommendation letter assumes the existence of employment procedures that include the evaluation and documentation of prior performance; a request for a proposal is premised on a system for conducting and supporting research). The resulting genre is characterized by similar substance and form (p. 301)

This view of a system of texts within a system or activities aligns with some of the kinds of collaborative textual practices that have appeared in recent years. The practices include students working together on a final project where they write and comment on each other's writing in a shared document, coworkers developing a plan for responding to a crisis where they comment on a prior document and then write and edit new material for submission. While those practices use documents that feature a lot of traditional orthographic writing, the representational and interpretive practices we propose to study will include more than prose. They will include images, figures, and tables. Indeed, these practices can occur on tabular documents (spreadsheets) and presentations ("slide" decks) and other kinds of documents.

Congruent with and supporting this view of genre systems is the concept of Cultural Historical Activity Theory (CHAT) Systems (Cole & Engeström, 1993) that shows activities exist not as discrete and unique events, but in systems of temporal reproduction. This repeated nature of these systems of activities is found in classrooms and in professional work and in classrooms that are intending to replicate professional work using discourse from the field that the instruction is attempting to develop competency in . This approach contrasts with traditional didactic methods that involve textbooks and other material developed specifically for the classroom and where evaluation of success is often in the form of tests.

What counts as a text?

Entering into a project that focuses on texts raises fundamental questions about what counts as a text. At one time, books and other orthographic productions—written and printed—would be considered the texts while those uses of language that occur orally would be considered speech or conversation. Things are quite different today. Conversations occur using characters on a screen rather than speech and spoken interactions can become inscribed through recording equipment and then studied and interpreted the way books once were. Furthermore, textual genres such as reports that were historically unidirectional and non-conversational can now be interactive when readers and authors make joint meaning with the assistance of digital comments that are put in by one person and then responded to by another. These digital texts are increasingly interactive spaces in both schools and professions.

This project provides opportunities to ask questions about how we see talk and text working with individuals and groups attempting to learn about a profession that is itself highly textualized. CHAT and genre systems theories help us to understand what a text is. A text is a reproduced semiotic artifact (a genre system) that is used within a specific kind of social performance (an activity system).

Careers in Play: using community-scale STEM to teach career awareness and intent

Careers in Play is the informal name for a project titled *Collaboration in the Future of Work: Developing Playable Case Studies to Improve STEM Career Pathways* (NSF Award 1915563). The project seeks to understand how a digital simulation can teach students about the nature of STEM careers. It is being designed to help students' career awareness and career intent. It uses a hybrid instructional model where the PCS simulation is embedded within a traditional undergraduate course. This work will add to the knowledge base about how games can be used as an adjunct to traditional course designs as well as develop understandings about student collaboration in structured settings. In this game, students collaborate and work together in interdisciplinary teams to solve issues in a community in ways that parallel professional work the students could do in a future STEM career.

The project's learning model draws upon the National Academy of Science's Reports How People Learn and the 2018 update How People Learn II. Specifically, it uses a socio-cognitive approach called expansive framing that gives students opportunities to take ownership of their learning by framing problems themselves and in their own words. This project combines design-based research and quasi-experimentation to answer three questions:

1. **How do PCSs support STEM learning, engagement, career awareness, and career intent; and how does this vary for different kinds of students?**
2. **How can a situated learning simulation (e.g., PCSs) be augmented by expansive framing to increase near and far transfer of STEM knowledge?**
3. **How can a simulation with an analytics engine and embedded assessments present meaningful student feedback about their interdisciplinary, team-based STEM work?**

This project advances concept called *community-scale STEM*. A STEM career and STEM work could be used for any of the areas that the STEM acronym stands for: science, technology, engineering, and math. There remains considerable variation in how the term STEM is used. Community-scale STEM is a way of clarifying STEM activity at a human and temporal scale organized around groups of people and organizations in specific contexts, where tensions exist among the various stakeholder interests. Public land use, environmental policy, election interference, and public infrastructure development are examples of issues affecting whole communities and requiring diverse STEM expertise, such as epidemiology, biology, healthcare, computer science, data science, engineering, etc. This project feature two community-scale STEM scenarios: (1) human-centered cybersecurity and; (2) disaster response. This paper draws upon the disaster response scenario in a class that teaching undergraduates about management, organizations, and teamwork.

Research in undergraduate classes

The project was designed to be implemented in actual undergraduate classrooms where the PCS is integrated with the regular lessons. The project proposed testing with two different kinds of populations in different universities. University A is a large public institution on the East Coast serving a range of student types, including many first generation students. University B is a private university in a Western state serving a student population with a strong religious program and less economic diversity as shown in Table 1.

Table 1 - Research sites

Site	Topic	Course Title	Size	Sections
University A	Disaster Response	Management Teams and Organizations	100	3
University B	Disaster Response	Foundations of Global Leadership	70	4
University A	Cybersecurity	Introduction to Information Science	50-100	4
University B	Cybersecurity	Cornerstone: Information Technology	35-40	2

This paper draws largely off of the work done for the University A. The course chosen is a required course for the undergraduate major in a BS in Information Science. Historically, it has not been a popular class as it teaches students about concepts such as management and organizational structure that are unfamiliar to many students and where the career value is not as obvious as more technical classes involving programming and database development. The course is important in the student's development as an opportunity to teach them explicitly about working well in teams--an essential skill for success in an undergraduate program that features many group projects. The PCS approach and the course are in a symbiotic relationship with the course providing an opportunity to evaluate the game and the research questions the game is developed to help address and the game holding potential to make a challenging required course more interesting and more effective in terms of teaching teamwork.

Jigsaw puzzle design

The instructional design of this project is a form of jigsaw pedagogy that features students collaborating as they assume specific professional roles. This is an evolution of the classical jigsaw approach with potentially important pedagogical features for certain kinds of topics. Jigsaw approaches fall within a larger framework of "socio-constructivist" cooperative learning documented in a seminal review now thirty years old that included a rich typology (Slavin, 1980). Over the years the term jigsaw that Slavin classified as two of the nine variations of cooperative learning has been used in a number of different ways by various researchers.

In the traditional jigsaw method, students are arranged into small groups where each student in the group studies a different aspect of a lesson and then when they work together as a small group the students realize that each of their peers knows things that they do not and that help build larger integrated knowledge (Aronson, 1978). This approach was developed for primary and secondary classrooms and was used commonly with topics such as social studies and history where a larger lesson could be decomposed into semi-independent areas. The jigsaw method emerged during school desegregation. It was used as a response to different communities being in the same schools and a need to provide an appropriate social model for students to learn about the value of differences between students.

Through the years, the idea of a jigsaw pedagogy has been conveyed through a wide range of educational contexts, including biology (Colosi & Zales, 1998), economics (Chu, 2014), electrochemistry (Doymus, Karacop, & Simsek, 2010), entrepreneurship (Holloway, 2008), and medicine (Fryman, et al., 2018). While in none of these fields does it seem that the approach inspired by Aronson has become the dominant method, the influence of Aronson's work has been broad. In the area of educational technology, the jigsaw method has been used as an inspiration for a number of research projects, including Lai & Wu (2006) who took the traditional jigsaw approach and used it with small groups learning about nursing to see the effect that handheld technology would have on their learning of nursing. A project with direct application to the case study discussed in this paper was the *Alien Contact* augmented reality (AR) game discussed by Dunleavy, Dede, & Mitchell (2009) that arranged students into specific roles:

> Each team has four roles: Chemist, Cryptologist, Computer Hacker, and FBI Agent. Depending upon his or her role, each student will see different and incomplete pieces of evidence. To successfully navigate the AR environment and solve various puzzles, the students must share information and collaborate with their teammates. (p.10)

In that study, the use of the technology and its impact on the engagement and learning of students was highlighted as was a similar AR project discussed by Klopfer & Squire (2008). The studies, while conceptually related to the original jigsaw approach developed by Aronson, represent a novel line of work where the technology plays an important role providing different students individualized views of information that reinforced the jigsaw model. This project draws off of that line of work involving technology and information to support the collaboration.

The Disaster Response narrative

The Disaster Response (DR) narrative is a fictional story about a seasonal storm that occurs in a fictional community named Bronze Falls. Bronze falls has been designed as a small city situated on a river and divided into seven different districts as shown in Figure 1. The community is designed to support certain kinds of scenarios that are common with storms, including flooding.

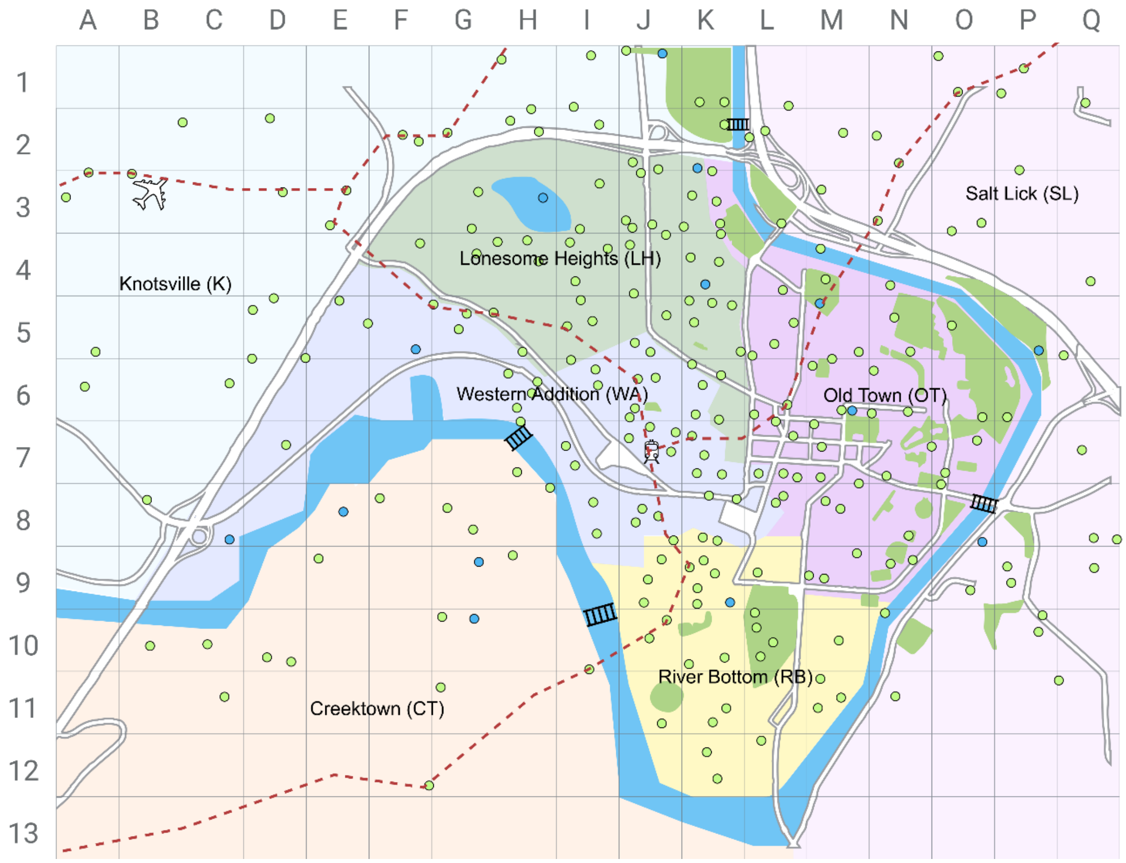

Figure 1 - Bronze Falls map

The narrative unfolds over a sequence of stages where the students are introduced to the concept of disaster response and the professional roles that they will play in this project. As illustrated in Figure 2, the narrative five phases. Three of those phases (1, 2, and 3) are performed while the students are in their roles. Each student is assigned to a role in Phase 1 and then in Phase 4 they will provide an individual reflection based on their experience with the game. The action of the game when the players can respond to the disaster occurs in Phase 2.

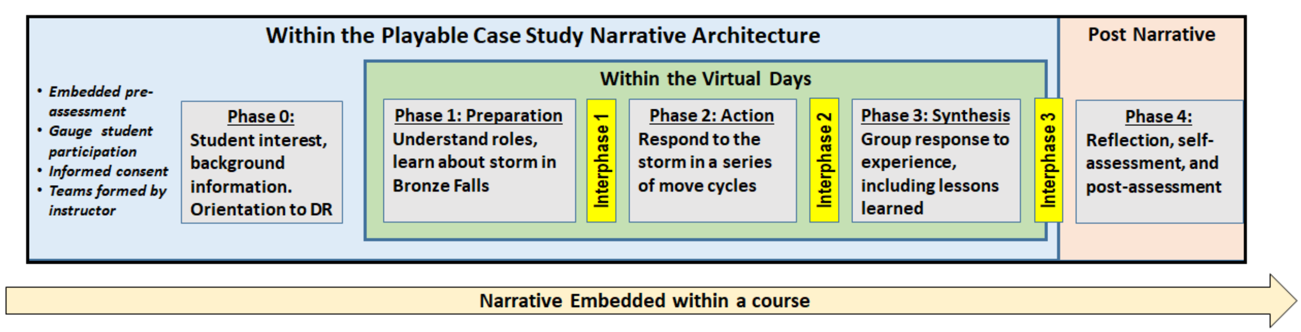

Figure 2 - Disaster Response Phase Structure

Similar to the work of Dunleavy, Dede, & Mitchell (2009), this project will have the students assume one of four roles. The roles will provide the student players with access to certain information about the evolving disaster and certain abilities to respond to the kinds of circumstances the narrative presents. Within this narrative, there are four roles that each are designed to represent one STEM dimension as illustrated in Table 2.

Table 2 – Narrative Role Structures

	Role	STEM Area	What they Control
Action Orientation	Public Health (PH)	Science	Medical Team, Fire Crew
	Public Works (PW)	Engineering	Repair Team, Police Crew
Information Orientation	Public Information Officer (PIO)	Technology	Reporter, Community information news feed
	Data Scientist (DS)	Math	Inspector, Special data analyses

Each of these four roles has similar characteristics. To understand the differences between the roles and why two have more of an *action orientation* and two have more of an *information orientation*, it is important to understand the central game mechanic that involves mini-cases also called *caselets*. Throughout the fictional community there are many locations where there can be incidents related to the storm. These incidents are known as caselets and they require a particular role to resolve or in some cases more than one role to resolve. Each caselet has scores associated with it. As players resolve caselets then their collective team score is updated. Players can learn about caselets that relate to their role and they can also learn about caselets relating to other players on their team. This learning about other player's caselets is one way in which collaboration opportunities exist in the game because part of collaborating is sharing information.

Initial design testing contributed to the split between the action and information oriented roles. The information roles of PIO and DS have access to information about the caselets that other players do not. The architecture of the game is such that each team has a set of caselets that are active at any point in the game. The active caselets for one team may differ from those for another. In this way the narrative while structurally identical is different in detail from one team to another. At any given point in time, players only know about some of the caselets that are active and they learn about others as they take actions in the community. The information oriented roles have access to other information about caselets than the more action oriented roles have. The more action oriented players of PH and PW have more they can do on the map so there is general balance between the roles while also achieving some specialization.

The curriculum design and disciplinary text questions

From a curricular perspective, the PCS simulation is one element in a larger design intended to help students understand about professional STEM careers. Given that many of the undergraduate students from University A are first generation college students and may not have family members who work in STEM careers, this program needs a strategy to communicate about STEM professional communities. PDE is that approach. Many PDE projects focus on natural sciences and spoken discourse, including argumentation from evidence that is an essential part of the scientific process. However, disaster response is different from pure science. It is applied. It is a complex multidisciplinary activity and rich in documentary texts. The texts that are available come from national, state, and local levels and describe various roles and partnerships. Appendix B shows some of the texts being evaluated for use in this curriculum

The concept of disciplinary texts seems simple at first. Drawing off of historical classifications of language either spoken and written, conversational or documentary, this project began to explore the latter. Using the curricular area of disaster response provided a criterion for a search for relevant documents that professionals in a responding to a disaster might encounter. Because disaster response is is often a government function, there are many documents that are available from federal, state, and local sources. These documents range from manuals to training guides to case studies to interactive websites. Making the decision to utilize texts as a way to communicate about the nature of collaborative STEM work raised new questions about the texts to use and how to utilize them. Some of the design questions include:

1. **What counts as a disciplinary text?** Would any document used in a disaster response activity from an email to a reference document equally support learning about the profession? Do we need criteria to select disciplinary texts for consideration?

2. **How should the texts be integrated instructionally?** With spoken discourse, a natural way to integrate into the classroom is to have students perform the discourse in public allowing for modeling of proper approaches and formative feedback. This approach is unlikely to work with professional documents. Some of these are large and were produced in specific activity structures for use in other activity structures.

3. **How can we use texts that are both authentic and instructionally appropriate?** Many of the texts used in STEM professions are complex constructions with many specialized terms that may be unfamiliar to students in a class. Bridging the real-world of professionals and the learning progressions of students requires some decisions that are related to the kinds of texts and instructional approaches.

These questions loomed over the design approach taken for the Disaster Response module's curricular plan. There is an important design constraint that whatever texts support one role there must be parallel texts to support other roles even if those texts come from different sources.

Designing for data collection

While creating a good educational experience for the students is an important goal for this project, being able to efficiently collect information about how their collaborative processes work and to understand how these relate to the project's research goals is an important design consideration. Designing for a regular course brings additional issues such as that students may add or drop the course leading to potential changes in student teams if teams are created too soon and, importantly, covering the material the course needs to cover that is now part of the research project. The plan shown in Figure 3 integrates existing curricular material and the research project. It shows research activities coming in the middle of the course when the roster is stable and before the end of the term that is typically challenging because many students have competing priorities with class final projects.

Grade approach		Participation									Participation	Annotation Criterion for Job Applicants		Annotation Criterion for Role-specific doc.		Annotation Criterion	Participation	Training Quiz	Game engagement	Training Quiz	Game engagement	Training Quiz	Game engagement	Collaborative writing		Individual writing	Participation					
Group		Individual									Small Groups			Role Group		Disaster Response Team										ind	Role Group					
Activity In-class and Homework	Introductions	Discussion, classroom activity, possible quiz								**Midterm Exam**	Discussion of Hiring Committees	Expansively Framed discussion		Social annotations		Social annotations	Simulation	Training	Simulation	Training	Simulation	Training	Simulation	Collaborative Writing	**Thanksgiving**		Discussion, classroom activity, possible quiz					**Final Exam**
Text Type	--	Didactic(textbook)									Synthetic Disciplinary			Authentic Disciplinary			NA	Hybrid Didactic/Disciplinary						NA		NA	Didactic					
Topic Reading	NA	Introduction to Principles of Management	History, Globalization, and Ethics	Organizational Structure and Change	Managing Groups and Teams	The Essentials of Control	Personality, Attitudes, and Work Behaviors	Motivating Employees	Conflict & Negotiation		Document on a hiring committee	Resume Ranking Activity	**Roles Assigned** Resume Ranking Activity	Role-specific document	Role-specific document	**Teams Created** Pre-disaster Recovery Planning Gu	Simulation Orientation	Communication	CiP Communication	Leading People and Organizations	CiP Collaboration	Goals and Objectives	CiP: Problem Solving	Recommendation Memo		Debrief on Simulation	Platforms	Sharing Economy	Introduction to Project Management	The Project Life Cycle	Agile and Holocracy	
Session	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	F
CiP Phase											0			1				2a		2b		2c		3		4						

Figure 3 - Curricular plan for Disaster Response module

The data collection planned for this project includes several approaches, including evaluating survey responses and test items, discourse analysis of student communication, and focus groups/interviews with students after the experience. A new form of data collection that is important for understanding how students interact with texts involves the comments that students make on a document. Some have referred to these comments as *social annotation* (Novak, Razzouk, & Johnson, 2012). In this project, we will be using features made available for documents stored in a Google drive where students will be able to make comments that can be harvested for grading and analysis.

This student's assignments for these parts of the curriculum will involve reading a PDF document and making comments in it using the Google comment feature (Singh, et al., 2021).

Activity system structures

The curricular design is built around five different activity structures. Following CHAT we design the simulation work the students do, even outside of the PCS technology, as mini-activity systems or as models of professional work. Each activity system has a goal and a central mediating artifact.

Resume ranking activity (Phase 0).

This is one part of the design where a goal for the course that preceded this research project is included in the design. Because many of the undergraduates in University A's do not come into the university with a strong sense of how to become attractive applicants for future employment, there was a desire to include more emphasis on preparing for a future career into this course. The resume ranking activity has the students pretend to be on a hiring committee and reviewing fictional applicants for a fictional job description. Their ranking and justifications of the ranking is an opportunity to use expansive framing (Engle & Conant, 2002) and to begin to introduce the students into the fictional world of Bronze Falls.

Research role-specific disciplinary documents (Phase 1)

Once the students are given their roles they will be assigned to role groups. These will be clusters of 4-5 students who all have the same role, but at this point do not know what team they will be on or what their role will have them do in the simulation. These documents are not synthetic, but instead drawn from professional work and are typically around 100 pages and composed for people with some training in disaster response. This will be an opportunity for students to see professional work through the lens of these documents.

Comment on a shared interdisciplinary document (Phase 1)

This activity will also use an authentic document that is a guide from FEMA on community response. This work will be done by different roles in the same project group. This group will be the same one that will work together to collaborate on solving problems in disaster response. This social annotation activity will serve as an instructional bridge into their PCS role and ask them to comment together on issues raised in the document. It will also provide a baseline of their communication patterns that may relate to the kinds of communication patterns that are seen in thea action of Phase 2 and the reflection of Phase 3.

Learn from training documents with embedded FEMA case studies (Phase 2a-2c)

When the students are working in Phase 2 they will be fully immersed in the narrative and playing their roles within stable teams. The three Phase 2 cycles will act like levels for the players in that the challenge will increase and with that challenge will come additional training about the learning objectives that the phase is to cover (see Appendix A). Phase 2a will involve the players responding to caselets that they learn about through various means. Phase 2a will familiarize the players with the scoring and how they will communicate with each other. Communication is the focus of the training that will occur in this phase segment. Phase 2b will increase the challenges for the players so that they will find caselets that can be addressed by multiple players. The focus of this segment is collaboration and the training will cover those topics using FEMA case studies for examples. Phase 2c will focus on problem solving. In this phase, students will deal with the same kinds of caselets they encountered in the earlier phases, but they will encounter some additional ones that are interrelated in important ways. These caselets will have a common hidden caselet that the team has the opportunity to recognize and respond to.

Recommendation memo (Phase 3)

In Phase 3, the response to the flood scenario is past and the team will collaborate on a small memorandum that makes recommendations for how the community of Bronze Falls can operate differently in the future. This is a short assignment that could be lengthened if the curriculum allowed more space for this simulation. It is a way to see not only their product, but also some of their process in collaborating on a document.

Individual reflection (Phase 4)

This is an individual assignment intended to elicit important information about the team dynamics and lessons learned. Combined with the other measures the project is collecting, this data will provide insights on the teamwork processes.

Kinds of disciplinary texts used

This project illustrates some of the ways that documentary texts can be used in an educational program and some of the decisions that designers can make regarding the use of professional documents to teach about a profession. Table 3 shows the kinds of texts this project used. They are exemplars of options rather than being than a pure taxonomy.

Table 3 - Text types in Disaster Response module

Category	Definition	Example	How Used
Didactic	These are traditional textbook chapters or material that serves the same purpose to tell students about a topic in the course.	Textbooks	To explain information that can then be tested
Authentic Disciplinary	Texts that are taken directly from professional practice. Appendix B shows some of the documents that were considered for inclusion	National Incident Management System Basic Guidance for Public Information Officers (Phase 1)	Provides overview of the role for one of the players
Synthetic Disciplinary	A document created from authentic documents, but modified in size, level, or identifying information	Fictional position description and resumes (Phase 0)	To orient students to social annotation
Hybrid	Utilization of authentic texts and text elements within a didactic structure	Training guides (Phase 2)	To teach project learning goals

Discussion

This paper draws from one research project designing a curricular intervention utilizing disciplinary texts as well as a digital simulation where students take on roles related to science, technology, engineering, and math (STEM). This STEM curriculum is designed to help students understand what a career in a STEM profession might be like and to increase their intention to pursue a STEM career. Language plays an important role in this curriculum and various texts are used that are alternatives to the didactic textbook that is used in other versions of this class. Because STEM disciplines can be textually rich with various forms and reports and other kinds of documents that inscribe professional understandings, this project is attempting to use not only texts, but texts that are authentic to professional contexts. Drawing off of Productive Disciplinary Engagement (PDE), an approach of providing students to engage with their learning with agency and authority and the related concept of expansive framing that helps students make connections between classrooms and the real world.

The project, in its developmental stages, shows how this simple concept of using disciplinary texts requires other decisions to be made. While some authentic texts can be easily used to teach from—to provide a lens into the vocational world—this study shows there are situations where this can be a complex process. In some cases, the authentic documents may contain sensitive information and a synthetic substitute may be needed. In other cases, the documents may be at an advanced level and longer than texts students would normally encounter. Still in other cases, as this project also shows, a designer might create a hybrid text that has didactic elements that includes portions of authentic disciplinary texts.

This research benefits from technology. While it is difficult to understand the reading processes of any individual, when the texts are in digital form it is possible to collect information about the interaction readers have with a document, including the comments they make in it and where and when those comments are left. This kind of data harvesting provides new insights into student processes that may relate to learning as well as providing a way to see how students work together. There are also features to see how authors write together. While not all of the data desired about collaborative writing is available, the data that can be provided shows group processes and who is writing at what time in a shared document. These data will also help understand how students are learning STEM practices when in a team situation.

As a design study, this paper is making a promise to provide data when the design is used with students. This project has the potential to illuminate some new practices and some approaches to longstanding challenges in STEM education while leveraging some of the best theory and prior research into the use of language to teach.

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Appendix A Disaster Response Learning Goals

Goal Area	Subgoals (exhibited by)
CO: Communication **At the end of this unit, students should be able to:** Understand some ways that professionals communicate in terms of tools and styles	1. Effective teams have a flow of information from all members. 2. Workplace genres are used to optimize the communication in teams. 3. Specialists often translate specialist language into general language.
UR: Understanding of Roles **At the end of this unit, students should be able to:** Understand how issues are to be handled by a particular role and utilize the informational strengths/resources of other roles in their team	1. Recognizing the relationship between a role and role-specific abilities (This is unlike many student and non-professional jobs where a team or crew includes people who can alternate for each other.) 2. In multi-role teams, different specialists often handle specific issues. 3. In mixed-specialty teams, the expertise of team members are complementary to allow them to solve big challenges.
CD: Collaboration **At the end of this unit, students should be able to:** _Make decisions for the group—based on individual and shared information while managing limited resources to competing priorities	1. Collaboration is when two or more people, entities, or organizations work together to complete a task or achieve a common goal. 2. Collaboration requires cooperation--supporting group or common goals over individual goals 3. Collaboration usually involves some form of leadership or process of coordination so people know what to do when.
PS: Group Problem Solving **At the end of this unit, students should be able to:** Sort through different information and alternatives to understand ways different events are related and the different response/ solutions that may be possible	1. Problem solving often involves a process that includes steps of defining/understanding, identifying possible causes, considering different responses, and developing a plan 2. Teams can often be successful in solving problems because there are usually more than one solution and different team members can see different solutions. 3. Sometimes the cause of a problem is not immediately evident and multiple sources of information can be used to understand the root cause.
DR: Disaster Response **At the end of this unit, students should be able to:** Describe the basic processes involved with a response to a disaster or crisis.	1. Understanding the kinds of organizations typically involved with responding to a disaster. 2. Current thinking defines four phases of disaster management: mitigation, preparedness, response, and recovery 3. Disasters and crises are related. Crisis is a perceptual state and the perception of a population may differ from the reality.

Appendix B - Disaster Response Candidate Documents

This appendix gives some examples of the kind of documents that are being considered for the design.

PDE Relevant Texts	**Pages/ Items**	**Role(s)**	
Job Description	1 page	All	
Job Applicant Packages	4 at 5 pages	All	
FEMA Cases	4-5 pages	All (see below for examples)	
FEMA Emergency Response Plan		All	
State of Maryland Disaster Recovery Operations Plan (SDROP)	86	Public Information Officer	https://mema.maryland.gov/Documents/FINAL-SDROP.pdf
FEMA Decision Making and Problem Solving Study Guide	122	All	
Public Health Emergency Preparedness and Response Capabilities	176	Public Health	https://www.cdc.gov/cpr/readiness/00_docs/CDC_PreparednesResponseCapabilities_October2018_Final_508.pdf
National Incident Management System Basic Guidance for Public Information Officers	31	Public Information Officer	**https://www.fema.gov/sites/default/files/documents/fema_nims-basic-guidance-public-information-officers_12-2020.pdf**

Case Study Documents

Name	Disaster Type	Location	Learning Goal(s)	Link	Relevant	Description
Colorado Watershed Coalitions	Flood	Colorado	Collaboration	https://www.fema.gov/case-study/colorado-watershed-coalitions	M	The event itself relevant (very similar to what was in the game), talks about collaboration between various levels of governance.
Community Flood Risk Reduction		Galena, Alaska		https://www.fema.gov/case-study/community-flood-risk-reduction	N	
Energy Generation		Galena, Alaska		https://www.fema.gov/case-study/energy-generation	N	
Connecticut's Crumbling Concrete	Infrastructure	Connecticut		https://www.fema.gov/case-study/connecticuts-crumbling-concrete	N	Example of multi-level inter-agency collaboration and cooperation going well
Yarnell, Arizona Wildfire Recovery	Fire	Yarnell, AZ		https://www.fema.gov/case-study/yarnell-arizona-wildfire-recovery	N	Small locality had to find its own recovery without much held from state or federal ; example of financial accumen ? not something players will be paying much attention to
The Galena Ball Field	Ice Flood	Galena, Alaska		https://www.fema.gov/case-study/galena-ball-field	N	Building community morale and importance of recreation. A little bit about collaboration but not much.
Risk MAP Success Story: Blaine County, Idaho: A Reservoir of Effective Communication				https://www.fema.gov/node/478939	N	
Risk MAP Success Story: New York Catskills Watersheds – Partnerships and Products for More Resilient Communities				https://www.fema.gov/node/478936	N	
Pre-Planning and Community Participation	Flood	Ellicott City, MD	Communication	https://www.fema.gov/case-study/pre-planning-and-community-participation	Y	The items listed in the lessons learned focus on communication techniques post-disaster between government and populacce
Locally Executed, State Managed, Federally Supported Recovery	Hurricane Irma	Florida	Collaboration; Communication; Role Understanding	https://www.fema.gov/case-study/locally-executed-state-managed-federally-supported-recovery	Y	Importance of clear lines of communication, project management, having the right mix of subject matter experts
Mitigation Changing the Tide: A Case Study of the 56th and Morton Flood	Flood	Lincoln, Nebraska	Collboration/ Communication	https://jeo.com/sites/default/files/inline-files/56th%20and%20Morton_Case%20Study.1.10.19-compressed.pdf	Y	Collaboration between the city and other departments, importance of communication daily, able to get funding for project

Risk Reduction Project						
Risk MAP Success Story: Robust Outreach Leads to Expedited Updates to the Flood Insurance Rate Maps for the New Orleans Area	Storm/Flood	New Orleans, Louisiana	Collaboration	https://www.fema.gov/node/478906	Y	Gives examples of how stakeholders collaborated, in more detail than other case studies
Colorado United Recovery Symposium	Flood	Colorado	Role understanding / collaboration	https://www.fema.gov/case-study/colorado-united-recovery-symposium	Y	Similar flood event; example of an early step in recovery efforts : a nalysis on the symposium method of organizing recovery response and figuring out who does what and who's involved
Gwinnett County, Georgia Revamps Stormwater Infrastructure Improvement Plans						
State of Maryland Disaster Recovery Operations Plan (SDROP)			Role understanding	https://mema.maryland.gov/Documents/FINAL-SDROP.pdf		p.37 (role structures); p.47 onward - role descriptions; p.50 PIO

Appendix C – Example case study being developed for Phase 2c

The following is an example of a case study that is drawn from FEMA materials to be used within the Phase 2 training cycle.

Contaminated Water Supplies: Quiet but Deadly

Everyone needs access to clean water. In America, most water is safe to drink straight from the tap thanks to huge systems of pipes and water filtration plants. These systems are sturdy but many of them are old, and once damaged can takes years to fix. Freshwater is easy to take for granted until something threatens the water supply.

Natural disasters can damage water infrastructure and cause widespread health problems. **Water contamination** from storm runoff or sewage pipes can spread bacterial illnesses like cholera. If there are factories, toxic chemicals and gases can leak into the water and poison people. After Hurricanes Katrina, Harvey, and Irma surveys caught industrial chemicals like mercury and arsenic polluting neighborhoods and people reported staph and strep infections from wading in dirty water.

Famously, the **Flint Water Crisis** was a result of old lead pipes leaking into the drinking water at dangerously high rates. Drinking lead can cause birth complications, death, behavior and learning problems, and damage to the nervous system. Fixing Flint's crisis will take years, over $500 million dollars in aid, settlements, and infrastructure investments.

To learn more about water contamination watch these videos by:
Vice
New York Times