

Zachary O. Dugas Toups - Research Statement

Games function as tools for learning and social spaces [3, 4]. Game play impacts problem-solving methodologies, mental models of the world, and communication. Complementary mobile and mixed reality technologies enable interaction beyond the desktop, supporting human-human interaction, pervasive play, and education. Games impart learning to players¹ by providing fun environments in which players exercise skills and learn new concepts; mixed reality is a medium that enables exciting new modalities of play.

My research investigates how people create meaning through game play, supporting human education and memory through engagement. My *media* for creating and evaluating these experiences are game mechanics, moments in game play when players make a decision to take action and the game system responds based on its rules [4]; storytelling through game narrative; lightweight sensors that enable mobile and mixed reality, such as the global positioning system and accelerometers; and small display and audio technologies, such as personal projectors and head-mounted displays. My *long-term objective* is to discover novel ways in which meaningful mixed reality social game play can engage learning and memory while supporting human collaboration. My first step toward this objective develops educational *zero-fidelity simulation* games in which participants learn to coordinate as a team; my current research extends zero-fidelity simulation into mixed reality. I am developing a portfolio of game-related research projects. This document outlines my research accomplishments and agenda, and experience grant writing and supervising.

RESEARCH ACCOMPLISHMENTS

My dissertation research *investigated fire emergency response work practice* to develop team coordination education through zero-fidelity simulation games. This work is an exemplar of my approach. We employed ethnographic fieldwork to understand work practices of human-human and human-system interaction [6, 8]. From the investigation, we developed a zero-fidelity simulation game in which players practice team coordination through game mechanics and computer interfaces [6, 9, 10]. *Zero-fidelity simulations*² are operational environments in which participants exercise skills from work practice in an alternative environment that does not directly recreate concrete aspects of the source world. This runs counter to the constant push toward high fidelity [1]. We successfully showed that players develop team coordination skills in an enjoyable game environment [6, 7].

Ethnographic Fieldwork. My ongoing research incorporates ethnographic investigation of team coordination in emergency response practice. This work uncovers skills used by responders to communicate and maintain situation awareness based on qualitative data from interviews and participant observation of burn training. To develop these skills through education, we identified design principles [8]. One is *information distribution*, where each team member accesses different perspectives on the same task environment. Another identifies the need to *mix communication modalities*, so participants dynamically balance the most effective means of sharing information, such as face-to-face communication or radio, against the affordances and constraints of the task environment.

Developing Zero-Fidelity Simulation Games. Based on the design principles for team coordination, we developed and instantiated the



Figure 1. Cooperation in T2eC. The purple seeker (top) is cooperating with the orange seeker (bottom) to collect a goal. The coordinator (bottom) monitors the situation and warns the seekers that more threats are approaching. Team members access different pieces of an information picture and must communicate to succeed.

¹ While the phrase “serious games” is often used, I do not believe games need to be “serious” to have significance.

² Previously, we referred to this model as “non-mimetic simulation”, but to situate our work within the simulation literature, we have revised to “zero-fidelity simulation.”

zero-fidelity simulation model through the Teaching Team Coordination game (T²eC). T²eC game mechanics are derived from work practice to engage and immerse players in processes of team coordination. The mechanics simulate the human-human interaction and information transformation properties of emergency response, but not the concrete environment. T²eC players take on one of two roles over which information is distributed: seeker or coordinator (**Figure 1**). *Seekers* play an avatar in a virtual world, while a *coordinator* observes a low-detail view of the same world. Team members communicate using either face-to-face or radio communication. T²eC user study findings led to design principles for cooperative games [9] and zero-fidelity simulation [6, 7, 10].

Game Play Beyond the Desktop. Mixed reality enables freedom to mix communication modalities in teams. My present research develops a wearable computing platform for playing T²eC (**Figure 2**). Seeker players move in the real world, while sensors track players' locations and place them in a virtual world. The wearable shows the seeker's view on a head-mounted display. Radio hardware allows seekers to communicate with the team. The sensors, radio, computer, and interconnects are built into to an ergonomic, modular pack co-designed with Mystery Ranch [<http://mysteryranch.com>].

RESEARCH AGENDA

I am developing a research agenda using game play for education and memory recall. In this section, I outline three planned research projects: rediscovering and restoring lost memories through game play, developing community-centered mixed reality experiences to retain heritage, and hybrid casual and event-based games for team education. All projects contribute to an overall investigation of the intersection of games and human-computer interaction.

Game Play to Stimulate Memory. I hypothesize that games can serve as a stimulus for recalling lost memories. I will investigate the use of game play as a probe of personal and collaborative history. In this work, participants will engage in both digital and tabletop games that they have played in the past, preferably long past. Participants may capture memories through augmented game interfaces as they are recalled. Through multi-player games with family and friends, participants collaboratively reconnect with their shared pasts. For example, one might engage in a game of *Settlers of Catan* [5] and recall a late holiday evening with family many years before.

Recorded memories will be combined with digital capture of game play, creating personalized visualizations that incorporate the captured memories. The artful visualization serves as a way of recalling the past, much like photo albums and other devices. Engineering elements of this line of research involve augmenting existing digital and tabletop games to capture state and designing and implementing interesting and usable visualizations of state over time.

Mixed Reality Narrative Experiences for Communities. Another line of research will develop mixed reality, location-based narrative experiences to refresh and retain community memory, particularly in the wake of disasters. Building on the valued aura of a real-world place [2], this work will enable community members to respond more effectively to disasters and maintain and record heritage. Such experiences will be authored from the stories of community members, using their captured media, historical data, and locations. Development will involve the creation of historical fiction narratives as well as game mechanics.



Figure 2. T²eC mixed reality wearable computer. The head-mounted monocular display includes a forward-facing compass. The custom, modular pack houses a netbook computer, radio, GPS, custom radio controller and interconnect, and cabling.

Hybrid Casual and Event-Based Team Game Education. I will investigate hybrid casual everyday play combined with large collaborative event-based play. In such designs, short, day-to-day interaction with a game on a mobile device impacts the game mechanics of a later game event that is played in real time with multiple, co-located participants. I hypothesize that this mode of game play will be an effective means to educate teams, especially teams that must be combined on the fly under stress.

Game Interfaces. I plan to explore game interfaces in terms of human-computer interaction. How are effective game interfaces designed? Game systems share many things in common with traditional HCI, such as a need to provide a player with clear affordances for action and feedback about activity and status. At the same time, game interfaces pose an interesting challenge to the designer: much of game play involves *discovery*, which is at odds with the traditional need to *make visible* information in the interface. Each of the proposed projects serves as a testbed for game interface design and will uncover valuable insights for the computer-human interaction research community.

GRANTWRITING AND SUPERVISING

Through my career as a student and postdoc, I have co-authored funded grants and co-directed a team of student researchers creating educational games. I worked closely with my advisor, Andruid Kerne, in writing two NSF proposals, IIS-0803854 and IIS-0742947 (>\$600,000) by formulating questions, developing research plans, and synthesizing background. I assist directing a team of two graduate students and one undergraduate. Together, we developed the T²eC zero-fidelity simulation team coordination game.

CONCLUSION

My research accomplishments focus on developing game mechanics for education, making meaning through play. I discovered design principles for teaching team coordination from a basis in fire emergency response work practice, including the model of zero-fidelity simulation. Through user studies, I developed design principles for crafting simulations and cooperative games. Through user studies with emergency response students, I have shown that zero-fidelity simulation games are effective for teaching team coordination. Ongoing work investigates the value of mixed reality game play.

I plan a series of projects in which participants learn and rediscover memory through collaborative game play. These projects are each interconnected and will provide valuable insight into the role of games in everyday and professional life. Each project will serve as a way to study computer-human and human-human interaction.

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