Cyberlearning Community Report: Emerging Design Themes in US TEL

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Abstract. The cyberlearning community in the United States parallels EC-TEL in Europe; both research communities bring computer scientists and learning scientists together to design and study innovative learning technologies. We report on six design themes emerging across multiple US-based, NSF-funded cyberlearning projects, based on the analysis of a team of over a dozen researchers who worked together in 2016 and 2017 to create a more extensive "Cyberlearning Community Report". This work is driving the need for new learning sciences in areas such as embodied cognition, identity, and affect, and requires advances in methods, such as multimodal analytics, and in computer science, such as in context-sensitive computing. By sharing this overview of US-based work with European colleagues at EC-TEL, we aim to foster international connections and stimulate mutual thinking about next steps in research as well as the potential to strengthen positive societal impacts.

Keywords: Cyberlearning, Design, Context.

1 Introduction

1.1 What is Cyberlearning?

In the United States, the National Science Foundation (NSF) adopted the name "cyberlearning" to describe research projects that combine advances in emerging technologies with advances in the learning sciences [1]. NSF has funded approximately 220 projects that are tackling different aspects of learning with different technologies, and in different settings, concerned with similar issues, such as: What advances in computation and technology are needed to support complex human endeavors such as learning? How can learning with technology increase access, equity, and the intensity of learning across a range of institutions and settings?

The usage of the term "cyberlearning" parallels how "technology-enhanced learning" has been used to describe European projects with similar aims. At the 2016 EC-TEL conference, our community presented a poster aimed at bridging the EC-TEL and cyberlearning research communities [2]. Following the 2016 conference, The Center for Innovative Research in Cyberlearning (CIRCL), which has a role that is similar to a "knowledge network" in European research communities, organized an extensive "Cyberlearning Community Report" to share design themes emerging in cyberlearning research. This poster highlights some of these core themes; readers can download the full report from the CIRCL web site (circlcenter.org) for more details.

2 Six "Genres" of Design

The aspirational goal for cyberlearning research is to understand the implications of a class of designs to inform a range of specific products in the future. To signal this focus on the general and generative, cyberlearning research has adopted the word *genre*. Below we highlight six types of general designs created by cyberlearning researchers that draw upon innovations in learning science and computer science.

2.1 Community Mapping for Learning

Mobile City Science [3] is a curriculum that provides youth innovative mapping and tracking tools to document and share their own lived experiences. MCS occurs "on-the-move," in the city, as well as in classroom and museum spaces. MCS helps young people collect, analyze, and argue from spatial and digital data they collect within different communities, using location-aware and mobile technologies. Youth participating in MCS are generating first person and collaborative accounts of not just living in these communities, but imagining what these places could become from a youth perspective. Designed activities such as historic neighborhood geocaches, mobile augmented reality walking tours, and counter-mapping are not merely novel learning experiences for youth themselves, but "expand[s] adult-centric notions of civic agency and develop[s] participatory mapping practices that elicit young people's knowledge on their own terms" [4]. This genre drives research that connects learning with civic engagement, and has the potential to inform "smart cities" research and technologies to better engage the potential of youth. Methodologically, research about this genre is challenging because it occurs beyond the walls of institutions.

2.2 Playful learning with expressive representations

Projects in this genre focus on developing new forms of play that provide expressive representations. In the Makescape project [5], visitors to the New York Hall of Science play a game-exhibit ("Oztoc") on a digital tabletop. To play the game, visitors must create working electronic circuits which "lure" fish to be cataloged by biologists. The experience emphasizes collaborative play for learning, and a great deal of the exhibit's value is in the discussion that visitors have explaining to each other how to play the game. Another unique aspect of Oztoc is that the project leverages physical blocks on a virtual tabletop so that visitors can see each others' work; by enabling learners to bridge representations, they can engage in deeper scientific and engineering practices while learning to communicate and represent the ideas in ways that feel authentic to them and to the game. Playful learning and expressive representations have long traditions in the learning sciences, but bringing these experiences to less-controlled settings is challenging. The projects press on issues of how interfaces can be designed to support easy entry into playful group engagement while also supporting learning conversations about the play. Using streaming data and AI agents to shape productive play brings forth important technical challenges.

2.3 Classrooms as digital performance spaces

Projects in this genre seek to strongly link play to the process of scientific investigation of phenomena scaled to the size of a typical classroom, where learners adopt roles as collaborative investigators of a shared, public phenomenon [6]. In WallCology, for example, students observe and manipulate biotic and abiotic variables within ecosystems presented as animated habitats occupying the walls of their classroom. The class collectively builds a population relationship web, which they then use as a tool to predict effects of invasive species and environmental change and design sustainable habitats. The investigators showed how embedded phenomena simulations could be integrated with community knowledge construction tools to support multi-week inquiry units. Related work is occuring in informal settings too, for example, with wall sized displays that museum visitors can interact with. This genre re-thinks the role of the spatial context for learning, and puts an emphasis on how multiple people and multiple devices can work smoothly together in the same activity and experience. It pushes HCI research to tackle how combinations of people and machines do productive work together, and learning science research about participation, agency, and the role of spatial context in collaborative learning.

2.4 Virtual Peers and Coaches

Virtual tutors and coaches draw upon sophisticated AI functionalities to create social and pedagogical interactions that support student learning, particularly among youth who may not always be successful in typical classrooms. For example, Justine Cassell and her colleagues have developed artificial agents that help a child tell a story or develop a scientific explanation. The virtual peer can listen and respond to a child in a natural manner and its behavior can be adjusted to explore the effect of peer interaction on learning. Virtual peer technology has been used to explore ways of helping children with autism, engaging children in creating stories, and developing students' language skills in science. This genre drives learning and technology research forward through examination of what it takes for a virtual peer to build *rapport* with a child. Building rapport is technically demanding, requiring multimodal sensing that builds on recent advances in computer vision, signal processing, and machine learn-ing. It also pushes better socio-technical models of how people attend to emotional and social cues while supporting learning [7].

2.5 Remote Scientific Labs

In common with many EC-TEL projects, cyberlearning researchers are exploring the genre of remote scientific labs. Research themes of note include how to support collaboration in remote labs, how to leverage a mix of remote and local labs, and how to support learners with disabilities. See the community report for details.

2.6 Multiuser touch interfaces and collaborative sketching

Another genre concerns how touch surfaces can be used to support groups of learners in creating informal representations to support knowledge building. This is crucial in engineering education, for example, where developing sketching skills is important for conceptualizing and communicating. See the community report for details.

3 Discussion

To inform greater sharing between US and EC technology-enhanced learning projects, we have reported on six genres of designs that are under investigation by the cyberlearning community. For each genre, there are many individual investigators, projects, and designs; in the interest of space, we have shared one illustrative example for each. With regard to the learning sciences, these designs foster our investigation of affect, embodied learning, identity, and learning across settings and within communities. With regard to technological research, we have found that exploring these genres is fertile with regard to how to design for playful interaction that also has a serious purpose, how to design for multiple people and machine-based agents who work together, and how to leverage multimodal data streams for research. Moving forward, we hope to engage with EC-TEL colleagues to identify research questions that can be answered together in the context of mutual research interests.

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