The Use of Game Design, Social Learning Networks, and Everyday Expertise to Engage Youth with Contemporary Science

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Abstract: Developments in information technology and digital media offer the opportunity to dramatically reorganize the curricular experiences available to students. This symposium explores elements of a next-generation high school biology course design, development, and implementation project that utilizes a social networking/media platform, facilitates youth participation in contemporary science, and networks youth with scientists and professionals. Specifically, we aim to study aspects of the platform that allow us to investigate learning related to: (a) the integration of game mechanics into the design of instructional materials, (b) youths' engagement in contemporary scientific practices, and (c) platform features that make youths' interests, expertise, and experiences visible so that they can be leveraged in instruction. We explore how to promote generative conditions for expertise development within these technology-mediated social learning networks and the effects of those experiences on student participation, identification, and learning of knowledge, skills, and practices.

Introduction

This symposium explores elements of a next-generation high school biology course design, development, and implementation project that utilizes a social networking/media platform, facilitates youth participation in contemporary science, and networks youth with scientists and other relevant professionals. Disciplinary experts give students feedback on their projects and share their career and educational trajectories. In this symposium, researchers present conceptual frameworks associated with the various aspects of the project model, as well as preliminary data, using the course's infectious disease and genetics units as a case study. Specifically, we aim to study aspects of the social networking/media platform (henceforth referred to as the "learning platform") that allow us to investigate learning related to: (a) the integration of game mechanics into the design of instructional materials, (b) youths' engagement in contemporary scientific practices, and (c) platform features that make youths' interests, expertise, and experiences visible so that they can be leveraged in instruction.

After an overview of the project writ large from which this case study stems, we present three elements of the case study units, including the associated conceptual frameworks guiding design and development, and some preliminary analyses. The first presentation examines the conceptual terrain of a badge system designed for both the infectious disease and genetics units. The second presentation examines the conceptual terrain associated with youths' engagement in contemporary scientific issues and practices and presents a preliminary analysis of participating youths' explorations in this arena.. The third presentation examines the conceptual terrain associated with design strategies that attempt to bridge youths' out-of-school interest-driven pathways with their in-school mandate-driven trajectories and how the learning platform can serve as a bridging object.

Developing and Studying a Social Learning Network Model in the Context of Next Generation High School Courses

Developments in information technology and digital media offer the opportunity to dramatically reorganize the curricular experiences available to students (United States Department of Education, 2010). Collectives of students and teachers can engage in sustained, collaborative projects through cultivated social learning networks. Students can use social media to more easily connect to disciplinary experts and receive feedback and mentoring. They can use information technology to meaningfully participate in contemporary disciplinary pursuits, allowing for more participatory forms of project-based learning (e.g., citizen science, participatory youth models). Digital media technologies allow students to consume and produce a broad variety of rich media sources that relate to their learning investigations. Students can also use pervasive technologies to extend their learning experiences across the settings of their lives. We are developing an educational enterprise that integrates these learning affordances into three next-generation courses in the subject areas of biology, English language arts, and algebra. We have leveraged and customized the Remix platform to provide a cloud-based technological infrastructure for our social learning network (cf. Nichole Pinkard, 2007, http://remixlearning.com/). In this symposium we use two units in the biology course (infectious disease and genetics) as case studies to explore theoretical terrains associated with some of our design principles.

Building upon a history of research on leveraging Internet technologies in instruction in the science classroom (e.g., Linn, Davis & Bell, 2004), we approach the cultivation, study, and refinement of social learning networks as design-based research (Bell, 2004) that sets the stage for large-scale design-based implementation research in the near future (see Penuel, et al., 2011). We pursue a sociocultural learning perspective to attend to the development of everyday expertise across social settings and networks of actors over developmental timescales (Bell et al., in press). We build upon theoretical traditions that highlight sophisticated learning as participation in repertoires of practice (Gutiérrez & Rogoff, 2003) and apprenticeship processes, which occur within a nexus of structures of critical social practice (Dreier, 2009; Lave & Wenger, 1991). Youth are positioned as developing experts who express agency through extended projects designed to overlap with practices and interests of their home communities. We leverage the sense-making practices of youth and relate them to the practices of disciplinary fields. Youths are brought into sustained social interaction with networks of disciplinary experts who model expertise and guide youths' project work. Youth authentically engage in interdisciplinary intellectual work and report their results to peers, teachers, disciplinary experts, and community members through multiple mechanisms.

Research Program and Scholarly Significance

A multifaceted research program explores: (a) how to promote generative conditions for expertise development within these technology-mediated social learning networks across classrooms and (b) the effects of those experiences on student participation, identification, and learning of knowledge, skills, and practices. We leverage the affordances of the technology platform to develop case studies that document and help visualize relevant phenomena, supplemented with video recording of classroom life and artifacts associated with the project work of youth. Through these efforts, we hope to develop an educational model for promoting sustained disciplinary learning across settings that builds on the social and intellectual capital of youth and extends their educational pathways.

Paper 1: Designing Badges for Use in a Project-Based Learning Curriculum Facilitated by a Social Media Platform

The use of video games, games for learning, and game-based education is increasing in formal and informal educational settings (Salen, 2008; Gee, 2009). Also garnering more attention is the related gamification movement, using game mechanics in typically non-game learning environments to increase motivation and participation (Deterding, et al. 2011). Though games and game mechanics have prompted innovative applications in education (most recently the Mozilla Open Badges https://wiki.mozilla.org/Badges and Digital Media and Learning competition http://dmlcompetition.net/Competition/4/badges-competition-cfp.php), the practices for how to do so successfully remain elusive and can benefit from further investigation. Designing games for learning is a complicated endeavor that leverages the practices of game design and instructional design combined to create engaging opportunities for students to learn without compromising the depth of instruction or the authenticity of the disciplines. Though this sounds ideal, actual implementation is filled with complex challenges. This paper examines one such combination of game and instructional design through the conceptual design and partial implementation of a badge system in a project-based curriculum facilitated by a social networking/media platform. This paper attempts to address issues which may contribute to answering the following questions: (a) How can we successfully design a badge system for educational settings?, and (b) What are the strategies for successfully reconciling differences between game and instructional design without compromising the qualities of game play or the opportunities for students to make meaningful contributions to contemporary scientific issues?

Research Focus

To answer these questions, the focus of this research examines three key components, which informed the conceptual design of the badge structure. First, we detail an analysis of existing badging systems in order to glean the appropriate design strategies to meet the needs specific to the curriculum. This includes an account of military and scout badges and the structure of achievement systems and badges in different video games to better understand the purpose of badges in specific settings.

Second, we explicate a detailed framing of the instructional strategies and learning objectives that the infectious disease and genetics units are designed to address. In addition, the project has a commitment to provide students learning opportunities that put the learners at the forefront of contemporary scientific issues and knowledge production by positioning learners as developing experts. These components need to be accounted for in the design of the badge system and the question that remains is how. Lastly, we examine constraints and affordances of the social media platform itself including the technical capabilities as it informs the design of the badge system relative to the curricular demands.

Conceptual Framework and Study Design

The conceptual framework for this paper is rooted in game design (Crawford, 2003; Rollings & Adams, 2003; Salen & Zimmerman, 2003; Schell, 2008). This sets the foundation for considering the tensions created by combining game design with instructional design practices in designing a badge system. Though there are many methods and multi-faceted purposes to both game design and instructional design, this conceptual framework is limited to considering general purposes of each and the implications to design decisions. A comparison of the general purposes of game and instructional design leads to discussions on approaches to systems design, the tension between innovation and standardization, and designing a badge system that serves the unique needs of the curriculum.

The study design is a combination of design based research (Design Based Research Collective, 2003) and conceptual analysis. The research consists of iterative cycles of integrating game design theory with instructional design practices in designing and partial creation of a badge system and then enacting it in the infectious disease unit and genetics unit. The infectious disease unit is a five-week unit that was piloted twice; in both the Spring and Fall of 2011. In the unit students designed and carried out investigations of local or global transmission of infectious disease using contemporary scientific software tools and the learning platform. The genetics unit is a six-week unit piloted in the Winter of 2012. The conceptual analysis includes a closer examination of the anticipated purposes of the badge system (inspire, mark interest and student identification, provide diagnostic feedback, acknowledge accomplishments, and make learning pathways visible).

Preliminary Data and Badge System Specifications to Date

This paper presents preliminary data and system specifications given the unit and badge system are still in enactment at the time of writing. The conference paper will expand on this analysis and discuss preliminary results. The design of the current badge system in development strategically awards badges to students (a) at significant moments in project progression, (b) when they make connections across disciplines, and (c) during instances of practice related to learning platform use and out-of-school community involvement. At the core are four main badges that represent culminating moments in the curriculum. For example, the *scientific investigator badge* is awarded to students for participating and completing project work in either global epidemic modeling or local social network analysis. To earn this badge, students must generate a testable question and propose a research design to progress in their investigation and reflect on how they would pursue future studies at the conclusion of the unit. The culminating *scientific argumentation badge* involves incremental levels of badges awarded during all aspects of argumentation work built into the unit. These levels include: (a) identifying and describing how argumentation is built into an activity with which they claim they have deep expertise, (b) identifying the "rules" of argumentation in their self-identified activity, and (c) utilizing the class-generated set of scientific argumentation rules to craft a scientific argument related to his/her project research and findings. There are four additional badges that act as support structures to these core badges and reinforce learning platform and community involvement. Two additional badges requiring work above and beyond the coursework are designed to be particularly difficult to acquire. With the exception of these last two difficult badges, all groups of badges consist of mandatory tasks (required to achieve the culminating badge) and optional badges (as opportunities to pursue additional interests). Other badge attributes such as hidden, automatic, peer-awarded, teacher-awarded, expert-awarded, repeatable, unlocking, emergent, limited, and expired are distributed through the badge infrastructure. Iterative design and conceptual rework of the badge system as we move through enactment cycles will continue to inform the system design.

Implications for Designing Educational Badges

We anticipate the process of interpreting previous badge systems, instructional framing of learning objectives through core ideas and practices in contemporary science, and the technical support and restrictions of the platform as central to understanding the success of a badge system. At the conclusion of enactment and through the iterative design of the badge system refined by student feedback, analysis of student work and badge artifacts, and design analysis, we will report upon the following conditions for designing educational badges: Defining a clear purpose of the badge system, determining which pieces of student activity are badge worthy, complicating the learning space to bridge connections not otherwise visible to learners, and lastly, examining design consequences of keeping within the technical restrictions of the platform functionality.

Calling attention to specific attributes of learning through the incentive of a badge system offers a unique opportunity to make explicit learning that may otherwise go unnoticed. It is also an opportunity to shape and influence the way in which students engage in the curriculum both for individual activities and with the curriculum unit as a whole. However, it is important to recognize that neither game design nor instructional design approaches, independent of each other, meet the design needs of an educational badge system. It is the integration of both approaches, unique to each context that will most likely produce the desired results.

Paper 2: Networked Learning and Engagement in Contemporary Scientific Practices

Student participation in contemporary scientific practices, such as global epidemic modeling, requires intensive engagement within networked learning contexts. Learning analytics provide a set of tools to allow educators to trace students' learning pathways as they gain competence with the scientific practices. The field of learning analytics represents a new analytic direction in education, its roots stemming from web analytics and business intelligence (Shum & Ferguson, 2011). Researchers collect data such as learners' interests, learning preferences, interaction dynamics with resources, disciplinary experts, educators, and fellow learners, and sense-making strategies and routines (e.g., Retalis et al., 2006). Because this is a new analytic direction in education, few researchers in K-12 education are working in this arena to date. We highlight the conceptual terrain of a learning analytic approach used to study student learning of contemporary scientific practices in a six-week infectious disease unit and a six-week genetics unit. In addition, we present preliminary analysis guided by two research questions:

(a) How does participation in the social learning network provide opportunities for deepening participation in disciplinary practices?
(b) How is exploration, sharing, and deepening of interests evident in the social learning network? (Nacu & Pinkard, 2011)

Theoretical Framework and Methodological Approach

Emphasizing mastery of contemporary scientific practices helps foster deep understanding of the construction of scientific knowledge (NRC, 2011). Learning trajectories represent the available sets of learning experiences students can engage in to gain expertise relative to their interests. Exploration of trajectories within online learning environments allows for scaffolding integration of students' experiences and expertise while making visible pathways for students to increase their domain-specific competencies and at the same time resourcing those pathways by connecting students to disciplinary experts, literature, materials, and tools (Pinkard & Schmidt, in preparation). This framework emphasizes the need to instructionally integrate a focus on scientific practices with possible learning trajectories in order to understand how to support learners' engagement in communities of contemporary scientific practices.

The six-week infectious disease unit, in which students investigated local or global transmission of infectious disease, was piloted twice; in both the Spring and Fall of 2011. In the six-week genetics unit piloted in Winter of 2012 students investigated and identified species using DNA barcoding and participated in a Foldit protein folding contest. This study reports on fieldnotes of classroom activity, criterion-based analysis of student products, artifacts of student – expert communication, and metrics tracking students' interactions with online and offline technologies, their peers, and curricular resources. We employ both qualitative accounts and quantitative analytics to examine learning trajectories over the unit.

Conceptual Constructs of Learning Trajectories & Preliminary Analysis

In order to map the conceptual terrain, we lay out constructs specifically developed to direct learning analytics research on students' expertise development in interdisciplinary science. Given a focus on fostering student engagement in contemporary scientific practices with the goal of producing knowledge and artifacts that make meaningful contributions to the disciplines, the constructs outline possible ways to account for student participation and learning in social learning network contexts. We hope to contribute to thinking about the applications of these constructs to the analysis of learner behavior on social learning networks specifically related to disciplinary science learning over relatively long timescales (months to years). The development of these constructs was modeled after Nacu & Pinkard's (2011) conceptual framework for analyzing social learning networks that support youth's practices of critical consumption and active production of digital media. Here we focus on some similar constructs and other constructs that are uniquely associated with science learning including: interest, participation in practices, knowledge-linked expertise, identity, engagement in learning, networked learning, production and contribution.

In the preliminary analysis of the infectious disease unit, students engaged in a practice of iterative model building and simulation execution using software designed to model global disease spread. They drove this practice through use of online resources, scientific journal articles, and consultation with peers, educators, and experts. In addition, they began to see biology as a predominately interdisciplinary science (NRC, 2009) and through participation in these practices and interfacing with experts, students recognized career opportunities that require expertise at the intersection of disciplines.

Two representative examples demonstrate student engagement in the intellectual work of contemporary science as they interface with disciplinary experts in ways that direct their present and future learning trajectories. First, Julie talked about her interests in mathematics and computer science. She was on the robotics team at the high school and used her involvement with the team to develop her computer programming skills. She reported that her mother, a biologist, often talked with her about pursuing a career in the biological sciences. Julie did not see the connection between biology and her interests in computer science and mathematics until she began to work on computational modeling of infectious disease spread across the globe. Through iterative development and tweaking of her team's epidemic models, she worked to identify the underlying mathematical expressions that fuel the software-generated simulations. Her daily project work always focused on understanding how her team's research about the effects of airline travel on disease spread could be explained mathematically. She guided her team in comparing their infection curves generated from the modeling work with published data from research at the Centers for Disease Control she found online. After interacting with a computer scientist who uses computational models to study infectious disease scenarios, Julie told the researchers about how her mom has always pushed her toward biology but she did not see the connection between biology and her interests in programming until she participated in this unit. Through deep engagement with technological tools, Julie's learning trajectory was driven by her interests and resourced by the curriculum, educators, and disciplinary experts in ways that allowed her to access knowledge about extended learning pathways that lead into careers at the intersection of biology and computer science.

Second, the unit allows students to engage in collaborative knowledge production at the edges of the current research in the disciplines through access to the software tools and expert users of those tools. During the Spring 2011 unit enactment, a team chose to study the effects of poverty on the spread of infectious disease but the software's design did not offer a straightforward way to accomplish this. Instead, the team decided to alter parameters in the model to simulate poverty. They shared this work with the principal investigator and designer of the modeling software, and he told the team that this was an excellent choice of study design given the limitations of the system. He also let them know that his team is addressing this limitation and is working on building this capability into the software. During his final review of their research he commented, "The inclusion of economic and health infrastructure indicators in large-scale simulations is an interesting direction at the forefront in the research field." The technology platform allows students to connect with disciplinary experts and resources as they deepen their participation in contemporary scientific practices while tackling relevant problems in the field.

Implications for Sustained Disciplinary Learning

Learning analytics have affordances for researchers, educators, and learners. Online learning technologies that foreground social networking capabilities allow for data collection and analysis related to learning in ways that are powerful for (a) documenting learning, and (b) formatively giving insight to educators and learners about the learning process and personal progress. This is especially important in learning environments that support complicated and complex participation in contemporary scientific practices. In addition, aggregate learning analytics will highlight patterns and can be used to understand differences in learning influences based on instructional supports and specific learning cultures. These patterns will help identify the variety of pathways students can pursue towards expertise in contemporary scientific practices which in turn can lead to improved design and implementation of learning experiences embedded in social learning networks. Additionally, it is the first-step toward tracing the development of student identities by understanding how social learning networks connect students to scientists and other professionals and resources that provide them social capital and degrees of freedom to pursue learning pathways related to developing contemporary and interdisciplinary scientific expertise.

Paper 3: Leveraging Youths' Everyday Expertise in Service of Engagement with Contemporary Scientific Practice: The Case of Argumentation

This paper highlights how researchers used the learning platform to surface youths' interests, experiences, and expertise, which researchers then leveraged in the infectious disease and genetics units in service of engaging youth in scientific practices, such as the construction of scientific arguments. As previously discussed, one goal of the biology course design effort from which the papers in this symposium stem is to engage youths with contemporary scientific practices. One such practice is argumentation given its knowledge-shaping function in the sciences (e.g., Latour and Woolgar, 1986; Toulmin, Rieke, and Janik, 1984). In the infectious disease and genetics units, youths construct written products (e.g., a scientific research abstract, a proposal for funding) in which they argue scientifically using various rhetorical forms common in the sciences.

Researchers working on this aspect of the biology units have a history of engaging youth with how to argue scientifically, as well as documenting youths' everyday argumentative practices (see Bricker and Bell, 2011). Scholars have reported that it is quite difficult for youth to engage in scientific argumentation (e.g., coordinate evidence with theory) (e.g., Kuhn, 1993) and in the first iteration of the infectious disease unit, we saw evidence of this difficulty. When writing their research abstracts, youths had no difficulty constructing claims relative to their research but they did not always utilize applicable evidence from their research to support their claims.

Given our research on youths' everyday argumentation, we have argued elsewhere (Bricker and Bell, 2008) that a helpful design strategy might be to surface youths' everyday argumentation practices and then help them code switch in order to craft scientific arguments (cf. Gumperez and Hymes, 1986). We designed opportunities into the infectious disease and genetics units to test our assertions relative to engaging youth with scientific argumentation through the use of their everyday argumentation expertise. In this paper, we outline the conceptual terrain associated with these design strategies and report preliminary data.

Using the Learning Platform to Surface Interest and Everyday Expertise

At the beginning of both the infectious disease and genetics units, youths created "About Me" profiles. They selected an avatar to represent themselves (e.g., a symbol, photographs that represented a particular interest, drawings that the youths themselves created). In addition to whatever they wanted to write about themselves, we asked them to address the following question when creating their profiles: What are you an expert at doing and/or what do you do often as a hobby/hobbies? Youth noted activities such as playing sports, playing instruments, reading, writing, socializing with family and friends, watching TV, and playing videogames.

In prior research – an ethnography of youths' science and technology learning across settings and timescales (see Bell, et al., 2006) – once we identified youths' areas of significant interest and expertise, we asked them about argumentative practices that were embedded within their activity. The youth participating in the ethnography identified specific argumentative strategies that they utilized within any given activity context. For example, youth identified strategies for arguing with parents in order to obtain a desired object or outcome (tell the parents only the affordances of the object or outcome and leave out any cons). In another example, they identified strategies for argumentation in their sports play (e.g., make certain that argumentation contains elements of critique so that it serves a learning function in service of helping self and others improve). In addition, we gave ethnography participants digital cameras and asked them to document the various meanings they associated with argumentation-in-context-of-everyday-expertise (cf. Clark-Ibanez, 2004).

We embedded many of these same activities into the design of the infectious disease and genetics units. Using areas of interest and expertise culled from youths' "About Me" profiles, we asked youth to explicate the rules of argumentation, particularly rules related to discourse, as argumentation takes place within their areas of everyday expertise. We also asked them to photograph images related to their areas of everyday expertise and the argumentation within those areas. Once we (the community of learners participating in the unit – youth, teachers, and researchers) fully explicated the details of our everyday argumentation practices as they are situated within specific activity, we created rules for scientific argumentation, which we coded as simply another type of argumentation practice situated within a specific activity (science). We utilized the platform for this activity as well by using it to communicate with participating scientists and other professionals about their scientific argumentation practices. We report preliminary findings as part of this paper.

Implications

Utilizing youths' interests, expertise, cultural practices, and experiences in the designs of learning environments is a well-documented learning strategy (e.g., González, Moll, and Amanti, 2005; McIntyre, Rosebery, and González, 2001; Nasir, et al., 2006). The use of social networking and media platforms enable learners to easily surface, share, compile, and trace everyday expertise. Learners can then utilize this as a springboard to learn complex disciplinary ideas and practices.

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