Learning and Research in the Web 2 Era: Opportunities for Research

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Abstract: Researchers in the learning sciences have long recognized the potential of online spaces to support learning activities; however, the pervasiveness of social media construction typically associated with "Web 2.0" represents a new context for the research of learning and instruction. Wikis, for example, have popularized a social approach to constructing knowledge that was very difficult to achieve with previous technologies. Social networking applications like Facebook that interconnect people according to social or semantic relationships have become integral features of student life. Multi-user synchronous environments like Second Life provide rich, immersive experiences as well as new forms of online community. Such applications are blooming in every corner of society, influencing the ways in which people learn and exchange with one another. These four papers present distinct research applications of such technologies, illustrating how they influence not only our methods, but affect the very nature of our questions and theoretical perspectives.

Paper 1: Learning Information Literacy in the Age of Wikipedia

Andrea Forte and Amy Bruckman

Where does reliable information come from? Young people have difficulty assessing the quality of information sources they find on the Web (Kafai, 1997; Kuiper, 2005). Helping students learn to critically assess sources has sometimes been portrayed as a typical learning problem: expert practices need to be made accessible to a generation of learners. Research has sought to identify differences between expert and novice strategies for assessing information sources (Wineburg, 1991); however, the recent proliferation of user-generated content has complicated matters. Sometimes experts disagree altogether about what constitutes a reliable source. In the absence of agreed-upon expert practices, what should students learn?

Wikipedia sits at the center of this confusion. Students, teachers, parents, and researchers alike often do not understand how to critically assess Wikipedia articles because there is no widely shared understanding of how information production is regulated in a wiki environment. The nomenclature of "Web 2.0" represents, among other things, broad recognition of new, distributed models of information production. Strategies like metacognitive prompts can help novices become more reflective about the sources they use (Stadtler & Bromme, 2007), but without a clear understanding of how publication works, it is unclear that novices can construct useful documents models on which to reflect. Before young people can learn to assess sources like Wikipedia, they need to first understand how such resources are created and maintained.

Our research investigates how new publication models associated with user-generated content create a new context for assessing information online and make new kinds of epistemological demands on students and teachers in the classroom. In the 2006/2007 school year, we conducted the second iteration of a design-based study that examines citation and information use in the context of secondary school student publication on a wiki. We launched the site Science Online (www.scionline.org) to support student publication of a science information resource. While studying their activity on the site, we found that although students frequently use Wikipedia to find information, they have little understanding of how Wikipedia works. They frequently rely on heuristics derived from traditional forms of publication activity to assess information they find online.

How Wikipedia Works

Before we attempted to understand how students think Wikipedia works, we investigated how Wikipedia actually works. We conducted three rounds of interview studies to examine both how people become proficient encyclopedia editors on Wikipedia and how the site is structured socially and technically. Our findings counter the “million monkeys” misconception: Wikipedia is not a receptacle for the random musings of anyone on the Internet, it is a community of cooperative authorship in which policy and tradition govern editors’ behavior and protect the integrity of the resource (Kriplean et al, 2007; Forte & Bruckman, 2008). Policies and editorial guidelines help make acceptable practices visible to newcomers, who become fluent in these practices through legitimate peripheral participation (Lave & Wenger, 1991) as they move from simple copy-editing activities to more complex forms of community involvement and authorship (Bryant et al, 2005). This community and its mechanisms are usually invisible to the casual encyclopedia reader; as a result, misconceptions about the resource and its production abound.

If readers know how Wikipedia works, they can develop strategies for assessing the information in it. One example of Wikipedia literacy involves the awareness of discussion and history pages. Each article on Wikipedia is paired with a discussion page where controversy involving its content can be discussed and consensus can be built (Viegas et al., 2007) and a history of edits; consulting the discussion and history pages can be a useful way of ascertaining how much attention and editing has happened on a page and whether there are any outstanding controversies. Another basic Wikipedia literacy involves understanding Wikipedia policy regarding citation. Although topic-specific citation practices vary, Wikipedia is intended to be a secondary source and facts presented in the encyclopedia should be attributed to other information sources. Every article should have a bibliography.

Note that these strategies for assessing information in Wikipedia are local, not site-wide. Note also that the decentralization of information production in the wiki environment places more responsibility on the reader to assess the extent to which each article has been reviewed and edited than traditional peer-review. These are important features of wiki literacy, because they represent failure modes for student reasoning about the reliability of information they find on the site. Students tend to assess Wikipedia as a whole, not on an article-by-article basis; and they tend to assume that the level of editing and review is constant across articles.

Classroom Study: Students’ Strategies for Finding and Assessing Information

In the 2006/2007 school year, we spent 8 months studying the search and citation practices of 19 students in two Advanced Placement Environmental Science (APES) classes who researched and wrote articles about science topics online. We interviewed students about how they find information on science topics and observed them searching for information while explaining each step aloud. Interviews were transcribed and iterative open coding was used to discover patterns in students’ information seeking practices and source assessment strategies.

The full analysis of interviews, homework, and pre/post test data has suggested a typology of student strategies for deciding what information sources to use and cite. Here we constrain the discussion to a few examples of students’ reasoning about Wikipedia and how to use it. Ten out the 14 interviewees reported using Wikipedia as an information source. Students’ understandings of how to assess Wikipedia as a source tended to reflect traditional publication models and were bound up with credential, expert review, and broad publication processes. Many students voiced a concern that Wikipedia is editable by anyone. One student remarked, she wants to find a source “that seems like it’s a knowledgeable person publishing. Not just like, a normal mind.” Three students mentioned the number of Wikipedia editors as an asset, but still tended to focus on review as a site-wide phenomenon (Wikipedia has many people checking it, therefore it must be ok) as opposed to a local one (this article has seldom been edited, therefore its content is suspect). Only one interviewee alluded to a more sophisticated understanding of how Wikipedia content can be assessed. She remarked that, when reading Wikipedia, if “it’s solidly backed up by a reference, you know, then I trust it for the most part.” She seemed to understand that Wikipedia represents a collection of facts that should have already been established elsewhere in other resources.

Conclusion: Participatory Media is Not Just the Problem—It’s Part of the Answer

Our work suggests that students do not understand how Wikipedia works and are at a disadvantage when it comes to using Wikipedia critically. This study focused on students; however, it is clear that teachers, researchers and other Internet users need to become conversant in new forms of information production so they can critically assess the media that informs their lives. Prohibition is not the answer. The decision of some educators to outlaw resources like Wikipedia in school does not prevent students from using it and, in fact, fails to recognize a critical educational need. Finally, our work on Science Online suggests there is potential for students to learn how to reason about information sources like Wikipedia by participating in their production or in similar publishing activities.

Paper 2: Identities, Stereotypes, and Constructing Avatars for Success in Math

Joey J. Lee, Matthew Gaydos, and Christopher Hoadley

We need to understand how technology-based avatars can support academic identity development and equitable learning in the face of negative stereotypes within domains like math and science (Lee & Hoadley, 2007). Each year, more students are regularly immersed in avatarized environments where they have fluid, malleable identity representations (e.g. World of Warcraft, Facebook, MySpace, Zwinktopia, etc.). They can negotiate, refine and utilize their social identities within online communities (Gee, 2004) and virtual worlds (Yee, 2006). These virtual environments and online communities have been shown potential to be powerful educational tools, especially in constructing positive user identities. For example, work by Shaffer (2005) has illustrated the potential for games to provide epistemic frames through which players can view the world via the adoption of professional identities. Other work by Dodge et al. (in press) has shown that Quest Atlantis, an immersive 3-D game, can have positive, pro-social impacts on students. To design digital virtual environments for education, we need to understand the relationship between a player's virtual representation and their self concept. For example, does creating and enacting a math identity within a virtual world open up new possible selves (Markus & Nurius, 1986) for a student?

We present preliminary findings of a study that utilizes avatar creation and enactment within virtual environments to unpack students' stereotypes of math, including student conceptions of successful math identities and how they personally relate to the math domain. We probed how students construct possible selves in mathematics. In some cases, students constructed ethnic and gender congruous identities of success despite negative stereotypes held about their group. We also explored effects of identity manipulation on math performance, especially upon the invocation of stereotype threat (Steele & Aronson. 1999).

Methods and Procedure

For this study, we used Linden Lab's Second Life virtual environment due to its powerful, flexible avatar creation utility. We created three math exams based on the sample questions and reported results of the Advanced Math GRE exam. We recruited thirty-eight undergraduate students (25 males, 13 females) at a US state university. Of these participants, twenty-six identified as Caucasian-Americans, seven as Asian-American, three as African-Americans, one as Middle Eastern-American, and one as Latino-American. They ranged from twenty to thirty years old. All participants had completed between one to three semesters of college level math. None of the participants were regular users of the Second Life software.

Prior to the study, all participants were asked to answer several five-point Likert-type scale items related to their perceived math ability and level of identification with the math domain. Participants created both a realistic avatar of themselves and a hypothetical mathematician avatar. After each avatar creation, stereotype threat was invoked in a manner similar to Steele et al. (1999). Math tests were administered after each identity manipulation to get participants thinking about math. Finally, a post-questionnaire was administered, in which we asked participants how much they tried to make each avatar look like themselves and how much each avatar resembled themselves, along with as assessment of their math ability and the difficulty of the tests.

Figure 1. Second Life's avatar creation panel.

Figure 2. Examples of successful math avatars created and enacted by participants.

Investigating Academic Self Concept and Possible Selves in Math

We highlight a promising approach that has yielded insights into what it means to be a mathematician identity and how much students align themselves with this identity. Concerning participants' stereotypes of successful mathematicians, very few female mathematician avatars were created. Of 38 avatars, only about 13% (or five) avatars were female. Of 13 female participants, only 4 created female mathematicians. Of 25 male participants, only 1 created a female mathematician. Participants' descriptions of the mathematicians they created were usually negative. Mathematicians (such as Figure 3) were described as: "Lacking in social skills." "Definitely a guy." "He should be a geeky looking, unkempt guy." "Asian, Indian, or European, typically with bad English." "One who is studious, works very hard." "Someone who is balding and unattractive," and similar remarks.

Interesting cases of students who did not perpetuate stereotypes also occurred. Carlton, a male Asian-American student, repeatedly remarked that he was "bad at math" and that he hated doing math. He created a realistic avatar of himself first. Then, when instructed to create a mathematician, he did not modify the avatar at all, reasoning that people often said they thought he was good at math, although he did not feel that this was actually the case (Figure 4). Some students created math avatars that connected very closely to possible selves.

Amy, an African-American student, created a math avatar that resembled an older, more mature version of herself (Figure 5). She described her mathematician as an older, wrinkly African-American woman who "went to grad school" and was unattractive because she "didn't know any pretty mathematicians." Amy created an ethnic and gender congruous identity of future success in math. By considering how students can benefit by taking on successful math identity representations of success, this work has important implications for designing virtual learning environments to support short-term learning performance and longer-term academic identities in math.

Figure 3.Example of math avatar.

Figure 4. Carlton described himself as "bad at math" but felt others perceived the opposite.

Figure 5. Amy, who created a math identity that resembled a more mature version of herself.

Paper 3: Building Wiki-Based Pedagogical Scripts for Knowledge Communities

Vanessa L. Peters and James D. Slotta

Knowledge building is widely recognized as an effective instructional approach that engages students within a community of learners. In knowledge building classrooms, student agency is achieved by giving students responsibility for their learning (Brown & Campione, 1996; Scardamalia, 2001). Through negotiating ideas, the classroom community comes to develop its own knowledge base, supporting individual students in the process of intentional learning (Bereiter & Scardamalia, 1989) and critical reflection (Brown, 1997). However, knowledge building has enjoyed more success in elementary classrooms (Zhang, Scardamalia, Reeve, & Messina, 1996) than it has in secondary ones, mainly because of the depth of commitment required by teachers to implement this method (Hoadley & Pea, 2002). Because of strict content requirements, it is very difficult for high school science teachers to adopt a knowledge building approach.

We have extended the theoretical perspective of knowledge building to enable a wiki-based application where students first engage in collective knowledge building, then participate in scripted activities that are explicitly indexed to the knowledge base. While scripted activities are seen by some scholars as directive mechanisms that take agency away from students, when well designed, they can complement autonomous learning processes – flexible enough to allow students to drive their own inquiry (Fischer, Kollar, Hakke, & Mandl, 2007), yet still guide students toward targeted learning outcomes (Slotta, 2004).

The need for co-design of curriculum, assessments and technology tools

It is challenging to design complex instructional materials that accurately embed a theoretical model while complementing a teacher's curriculum. The effectiveness of any classroom-based research will depend critically on the teacher's understanding and faithful enactment of the materials and approaches. This can best be achieved through a process known as co-design (Roschelle, Penuel, & Schechtman, 2006) where all research materials and instructional designs are developed in close collaboration between researchers and teachers, with each group learning about the values and perspectives of the other. Working together, the co-design team creates materials that address the research questions as well as the teacher's learning goals. The resulting curriculum is likely to be enacted faithfully by teachers, since they were essentially in charge of the design process. While this entails a more intensive process of ongoing design discussions and trade-offs, it does ensure that teachers accurately understand the research and that they firmly believe in all curriculum materials.

Method

We began by carefully designing the knowledge-building environment, including customized knowledge entry forms that students could access via the Web. A wiki provided the ideal functionality for knowledge building, as students could easily access and edit one another's ideas, reorganize pages in order to capture emerging themes, and build connections between related ideas. We thus created a new hybrid wiki application that improved our control over student accounts, groups, editing permissions and other features. While we wanted to preserve the open-ended feeling of collaborative editing that typifies wikis, we needed a simple, structured way for students to create wiki pages so that we could scaffold their treatment of science concepts. We thus developed a capability of "New Page Scripts" that allowed students to simply click a link on a wiki page in order to add a new page – but instead of the usual new wiki page functionality, they are taken to a special Web form (made in Ruby on Rails). The Web form queries students about the name of their new page and collects metadata (using check boxes and radio buttons), then generates a new wiki page, linked to the proper location, with pre-specified headers written onto it and all the relevant authoring and access permissions.

The research began with field visits to the school to learn about the practices that teachers were using in the classroom. For three months, two teachers and two researchers co-designed a 4-day physiology lesson where students first built a collective knowledge base by creating wiki pages about human system diseases. During the design meetings, the teachers learned about the theory and methodology of knowledge building and researchers learned about the values held by the teachers and the specific content requirements related to human physiology. Participants were two veteran high school biology teachers and 104 grade ten students from an urban school in the Toronto metropolitan area. The students were distributed into four sections of grade ten biology (two sections per teacher). All 104 students worked as a community, collaboratively editing the wiki across all four periods.

Students began the lesson by creating a wiki that covers human diseases of three different body systems (respiratory, digestive and circulatory), including the specific biological processes relating to the disease. Students created disease pages in the wiki using a special "New Disease of Disorder Page" where they were able to specify the metadata for the disease (Figures 1 and 2). Students were free to create new disease pages or edit any existing disease page within their assigned body system. Thus, students became specialists in one body system and relied on their peers to adequately prepare the wiki materials for the other two. Students then performed a scripted activity where they applied their knowledge to create "challenge cases" for their peers where a fictitious person was described in terms of physical symptoms that required diagnosis. Finally, students were asked to solve a challenge cases created by their peers in each body system that was not their specialization. This inquiry activity required them to make use of the existing knowledge base in order to achieve a diagnosis.

Figure 1. "Create a Disease or Disorder" Script.

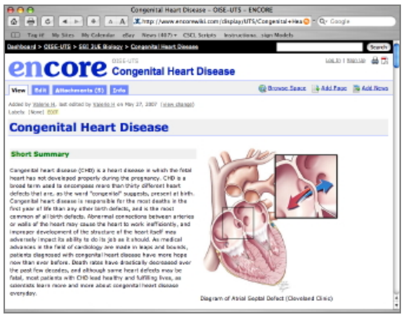

Figure 2. Completed Respiratory Disease Page.

Findings and Discussion

The study analyzed the co-design process, the knowledge building and scripted activity phases, and exam achievement scores. In all four classes, the teachers were able to successfully enact the co-designed curriculum with no interventions from the researchers. During the knowledge building phase, the students co-authored a single corpus of 23 wiki pages about human disease systems. The resulting knowledge base became the students' primary resource when solving the challenge case scripted activity.

The study also investigated the outcome of the lesson on student achievement. To this end, the exam scores of student participants (N = 104) were compared with the scores from the same two teachers' grade ten students from the previous years who received a more traditional physiology unit consisting of lectures and a lab (n = 67) (see Figure 3). In each of the three years, the students completed similar open-ended questions about human physiology. An analysis of the data revealed that those who participated in the knowledge building activity (M = 8.84, SD = 1.59) had much higher scores than students from previous years who were taught with the regular curriculum (M = 9.90, SD = 1.15), p = .011. These promising results made a positive impression on the teachers; both commented that students' exam performance had surpassed their expectations.

Educational Implications

The findings from this research indicate that knowledge-building methods can be successfully designed for high school knowledge communities. In particular, the blend of wiki-based knowledge building and scripted activities that targeted specific learning goals allowed us to use the wider knowledge base as a productive curriculum resource. This has been elusive and made it challenging for teachers to adopt a knowledge building methodology in their classrooms. This work thus responds to an ongoing challenge of how to make knowledge building activities more relevant for secondary teachers, and opens up possible avenues for future research and theoretical models.

Paper 4: Data as a Diagnostic Tool

Jody Clarke

Web 2.0 and similar interactive media offer the opportunities to capture, retrieve, and analyze large amounts of data. Data is a driving force behind decision-making strategies in the corporate world (Davenport & Harris, 2007) and has the potential to shape how we think about teaching, learning, assessment, and research—a potential that is only starting to be realized in education. Yet, with these large data sets and new research possibilities come challenges and questions such as *how can we make sense of all this data? What level of granularity is sufficient*? *How do these questions change based on the audience of the data (teachers vs. researchers vs.be students)?* We are grappling with these questions in our research on multi-user virtual environments (MUVEs) and the data generated by students' interaction with our MUVE-based curriculum. In this paper, we briefly share our experiences on how we are addressing these questions not only as researchers, but also for teachers so that they can use this data to improve their instruction.

Students' Interactions as Data

We developed a MUVE, *River City* (Clarke, Dede, Ketelhut, Nelson, 2006), to teach middle school students science inquiry in the context of disease transmission. From the moment students begin using the MUVE until the moment they stop, the technology records everything they do into "event logs." Each action by the student is noted and time-stamped in the event log. Thus, one can recreate students' movements, behaviors, experiences, and communications through the technology portion of the curriculum. For example, students work in teams and, inside the technology, can only communicate via text-based synchronous chat; the event log captures this chat data. Overall, the River City technology creates a personal history of students' inquiry processes that is captured by their interactions, is not obtrusive to their learning, and provides an objective picture of how they interact with the curriculum within the MUVE. This provides uniquely detailed information about the microgenetics of their learning.

Making Data Usable for Different Audiences

Teachers and researchers have different needs for the various forms of data generated in our project. In the past, teachers who participated in our curriculum wanted to know more about what a particular student was doing in the curriculum on a given day. At the time, students interacted with the MUVE and recorded their work in a paper-based laboratory notebook, which they handed in to their teacher. Teachers had access to student work only via the notebooks and had little detailed knowledge about what each student was doing in the MUVE itself. Thus, teachers could keep up with student progress and learning throughout the curriculum only via written work in the notebooks.

The research team examine and analyze data from the event logs in order to understand students' inquiry learning processes (Clarke & Dede, 2007), but had not found a way to provide this information to teachers in a timely manner that could inform instruction. Similarly, we wanted to know more about individual student responses to their work in the curriculum in a timely manner. Teachers mailed student notebooks to the research team at the end of the project. Due to the time delay and sheer volume of paper, sub-samples of these data were analysed to inform future design, but not for formatively influencing students' learning processes. Embedded assessments were also developed to measure student learning unobtrusively in the curriculum. However, the first iteration of this data was not stored in a manner that made it easy to retrieve. Thus, formative assessment data was analyzed only after all implementations were complete and never shared with teachers.

To move beyond these suboptimal strategies, the research team made design decisions in order to make the data usable to both teachers and researchers in the 2006-7 academic year. The student notebook was redesigned such that students had to submit all answers digitally via an online notebook. This allows researchers to study metacognitive and reflective learning of students while they interact inside the MUVE. Student embedded assessments were also redesigned such that the data was accessible and usable by both teachers and researchers.

To make data usable for teachers, each night, daily reports of student activity in the environment, notebook entries, team synchronous chat transcripts, and embedded formative assessments are generated and emailed to teachers. For example, early Wednesday morning, Teacher X receives 3 email reports. The first email contains summary of their students' individual notebook entries from Tuesday. The second email contains transcripts of team chat from Tuesday. The third email contains their students' embedded assessments results from Tuesday.

Weekly reports of different activities are sent to the researchers to keep track of the different implementations. A detailed tracking system was also built to monitor individual teachers' progress through the different stages of the project. All data is copied into a research database. In addition to the curriculum data described above, the project also collects demographic data on students, schools, and teachers. These data are all stored in separate tables and easily linked via SQL queries. Now we are faced with the possibly of having too much data to fully analyze and must determine what level of granularity is sufficient to help the different audiences (researchers and teachers) understand student learning. Also, we are brainstorming ways we can provide unobtrusive diagnostic data to students during the curriculum. As researchers, we are also interested in whether or not teachers find this data useful and how they are using it to inform their instruction. We administered a survey to all the teachers who participated in the River City project in the 2006-7 academic year. Seventy-three teachers in 52 different schools completed the online survey.

Discussion

As mentioned above, we have been struggling with grain size and how to present this data to teachers in an efficient and timely manner. Some teachers have over 100 students and have time only to skim these reports. During this study, teachers received three emails: one email per each type of report. Each of the reports are organized by class; as a result, the reports are lengthy. However, despite our rather overwhelming method of presenting this information, teachers enjoy receiving these reports: 86% percent of the teachers in our sample liked receiving both the reports of students' chat and individual work, and 81% liked receiving the daily assessments (n=73). Teachers were more likely to read the chat than the notebook and embedded assessments: 81% read chat often or daily, 74% read notebook entries often or daily, and 71% read embedded assessments often or daily. This high level of usage is surprising, given teachers' busy schedules. The teachers who did not read these reports cited time and presentation format as reasons for why they did not read or use the reports to improve instruction. Those that used the reports felt they helped keep track of students' progress (78% agree or strongly agree) and participation (84% agree or strongly agree). However, only 64% felt that the embedded assessments were an accurate reflection of student learning. This is not surprising. The questions were a mixture of multiple choice and open-ended responses, and our presentation of the data required teachers to score the assessments (as opposed to the reports providing scores).

The way we currently provide data to teachers is not innovative nor do we claim it as such. We are exploring innovate ways to provide formative feedback to teachers and students in real time. Our data is highly dimensional: we collect demographic, contextual and assessment data. We also have time series data (event logs), and social networked data (students interact with other students). We have not been able to find a mathematical model or datamining method that can handle these multiple dimensions in combination meaningfully. Therefore, we are developing an information visualization tool that will allow us to explore these dimensions at the same time (Dukas, Clarke, Dede, 2008). The goal of this visualization tool is to present our various data simultaneously in a manner conducive to pattern finding. We hope this will allow us to provide further diagnostic information to teachers about students' patterns and behaviors as they interact with the virtual world.

Conclusion

Sophisticated educational media now enable the collection of very rich datastreams about individual learners (Pellegrino, Chudowsky & Glaser, 2001). As a result, we have data that was not previously available or even possible to collect in face-to-face settings. Yet, a lot of data generated from immersive interactive technologies is not captured in a usable way, archived, or analyzed. Further, very few educational researchers examine these data as diagnostic resources. In our work, we are using data for diagnostic purposes to provide formative information on students' learning and progress to teachers, as well as to understand students' learning processes as they interact with a complex inquiry environment. We believe that, eventually, this type of educational data will be a 'driving force' for teaching, learning, assessment, and research. As a community, we need to leverage the capabilities of datastreams for understanding student learning processes and improving learning and instruction.

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