An Interactive Research Experience with Mobile Biology Games

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Abstract: Research shows that educational games can help students build content knowledge and skills but it can be difficult for teachers to effectively integrate game-based learning into their existing curriculum. UbiqGames are browser-based, casual games that relate directly to the curriculum but can be played outside of class time. Designed for mobile devices, the games can be accessed anywhere, anytime and discussed or analyzed back in class. The UbiqBio project is a research study around four UbiqGames designed to teach intro biology concepts. Participants in this interactive conference event will take part in a real-time research experience by playing a biology game with varying amounts of previous content knowledge. This will provide an opportunity to try out one of the games, experience the ubiquitous learning games format, and gain new perspectives on the issues at play when it comes to implementing educational mobile games in the classroom.

The UbiqGames Genre

A growing body of research (Prensky, 2001; Gee, 2003; Shaffer, 2006) argues that games can be powerful tools for motivating and engaging players, and for developing useful habits of mind as well as domain-specific content knowledge. Games can also be effective teaching tools from which students can transfer knowledge and experience gained in the game environment to another context (Gee, 2003).

Teachers must motivate their students with various extrinsic or intrinsic factors but one benefit of games as teaching tools is that aside from beating the game or scoring points, the process of playing the game itself is fun (Prensky, 2002). This is due in part to the idea that gameplay is one way to reach a state of flow, the feeling of exhilaration and deep enjoyment (Czikszentmihaly, 1990). Research has also found that the most motivating and engaging games are the ones that have a balance of "hard fun" (Papert, 1996), which challenges the player to actively participate in order to learn and master the activity. As a result of this type of game, players are not only engaged during the time they're playing the game, but they are also motivated to continue to play and engage with the content over time.

Many studies have been done on video games, simulations, and other forms of computer assisted instruction, which have shown encouraging results. Work by Vogel et. al. (2006) analyzed 32 empirical studies and showed reliably across these studies that attitudes toward learning after using computerized simulations or games were better than those of students who were taught using only traditional methods. Baranowski et. al. (2008) examined health-related video games and stories and found that they led to various desirable outcomes such as knowledge increases, attitude shifts, and behavior changes. As well, Baranowski's research suggested that games do indeed help to drive interest in academic topics. These and other meta-analyses (Bayraktar, 2002; Christmann and Badgett, 1999) show that good video games and technology-based activities can indeed help students engage with and build skills related to content.

While potential benefits can come from playing educational games, effectively integrating digital game-based learning into formal education can be challenging. Given already limited instructional time, adding games to the curriculum can be difficult. Moreover, teachers often have limited access to hardware. Many educational games also have a long and/or steep learning curve, and can therefore be intimidating, especially to some teachers.

But not all games fit this mold. With growing recognition of their popularity, so-called "casual games" (Juul, 2009) are different from many traditional electronic (educational) games. Casual games are typically played in sporadic bursts, have simple rules, and are designed for a broad audience to enjoy with a small initial investment of time or learning of rules. The casual style of gaming has inspired researchers (e.g., Klopfer, 2008) to develop new generations of educational casual games, designed specifically to provide simple, easily accessible, yet rich experiences for players and teachers alike.

Casual educational games in general, and the Ubiquitous Games developed by Klopfer et al. in particular, take advantage of their format to engage players with content related to their classroom studies. Ubiquitous Games (aka UbiqGames) are web-based, casual games designed to be played primarily on mobile devices, but able to be played on any computer with a web browser. On a practical level, by making the games ubiquitous (able to be played on handheld computers as well as desktops and laptops), researchers hope to break down some of the barriers to adoption (Klopfer, 2008). UbiqGames are meant to be learning games, but are not meant to replace classroom instruction. Instead, by being casual games that can be played in the interstitial times of the day, UbiqGames are meant to enhance existing classroom instruction. Theoretically, there are several learning advantages that come by virtue of UbiqGames' casual play style. First, there is the opportunity that

players have for background processing of the material with which they are engaging. Though players will not spend all of their time between game sessions thinking about the material, they will spend some, which increases their time engaged with that material. A related opportunity is the chance to build experience, expertise, and knowledge over time. Rather than playing in one prolonged event, "beating" the game, and disengaging with whatever material they might learn from the game, students playing casual games are invited to engage with material repeatedly over time, which leads to greater opportunity to construct complex knowledge.

Related to, but distinct from this point, is an important design consideration for Ubiquitous Games that sets them apart from many other casual games. In addition to affording casual game play outside of class, UbiqGames explicitly build in reflection tools that a teacher can take advantage of in a more formal setting, i.e. in class. By building tools for reflection on the experiences they have with the material in the games, the designers of UbiqGames hope to take advantage of experiential learning, in which a learner has concrete experiences, reflects on those experiences, and thereby builds more abstract understandings (Kolb, 1984).

The UbiqBio Project

The Ubiquitous Games for Biology (UbiqBio) project, funded by a grant from the NIH, is a web-based mobile simulation game platform designed to help high school introductory biology students (typically 9th and 10th graders) understand important biology concepts with which they often struggle. In addition to a general lack of "scientific literacy" in the US, empirical studies indicate that traditional curricular approaches leave gaps in the domain specific knowledge of many middle and high school biology students (Brown, 1990; Ferrari & Chi, 1998; Lewis & Wood-Robinson, 2000). In order to address this, the UbiqBio project utilizes technology to engage students and promote deep learning of science concepts.

The project encompasses development of four UbiqBio games as well as research on the week-long implementation of each game, during which students are equipped with web-enabled smartphones which they carry with them throughout the day. The four games are designed to connect ideas across scales and subdisciplines, including Mendelian genetics, protein synthesis, evolution, and ecology. Teachers see classmates interacting as parts of a simulated biological system, while the students see themselves "playing" their part in a large-scale, multi-day, whole-class simulation game. (These games can in fact be accessed from any full-fledged web browser, making them truly hardware independent and therefore "ubiquitous"). Each UbiqBio Game is designed to be highly engaging, almost addictively so, such that students "play" the game outside of class, in small increments of time (3-5 minutes) in nondisruptive ways between classes, before or after school, and in the evening as homework. As students play the game, data from the whole class is wirelessly transmitted to a central computer which aggregates the real-time data. Teachers and researchers can log into a simple yet powerful UbiqBio Teacher Portal site to track student progress, identify students who are not doing their "homework", and access the data generated by their students' game play. Since game play largely takes place outside of class, teachers spend class periods using real data drawn from their class's gameplay as the basis for lessons where concepts are developed through analysis of data, hypothesis formation and group discussions.

The science content in the four UbiqBio units, which span the life science curriculum from genetics to evolution, is closely tied to Massachusetts and national standards, and derived from a core set of topics that are fundamental to an appreciation of modern biology and associated with powerful misconceptions that block a student's understanding of these critical ideas. The activities, supplementary materials, and assessments are classroom ready. Equipment set up and management is simple, and games can be played on devices that students have or will have in the near future. These range from cell phones to netbooks to desktop computers. Games are fun and easy to learn, yet require strategies that teach, explain, and reinforce challenging core biology concepts. Students participate willingly and teachers find it exciting to augment student learning with these highly motivating tools.

The research questions we are exploring in this project focus on student learning and engagement, as well as teacher adoption and usability. Six teachers in the Boston area are incorporating UbiqBio games into their curricula this year, lending smartphones to their students and having them play each game as they teach the corresponding topic. Data collection includes statistics logged during gameplay, teacher and student interviews and observations, and a biology content assessment administered to experimental and control groups. By examining all of these aspects, we hope to learn more about students' play patterns with mobile games and their effectiveness in solidifying content knowledge.

Beetle Breeders

One of the UbiqBio games we have developed is called Beetle Breeders (see Figure 1), which focuses on the concepts of Mendelian genetics and inheritance patterns. In this game, players are running a beetle pet shop. Customers want to buy beetles with certain traits and it's the players' job to breed them. They choose the contracts they want to work on, then mate the right beetles to produce the desired offspring. They must use their

knowledge of Mendelian genetics to work with increasingly difficult patterns of inheritance and maximize their profits. Within each class, students see who can earn the most money in the beetle business!

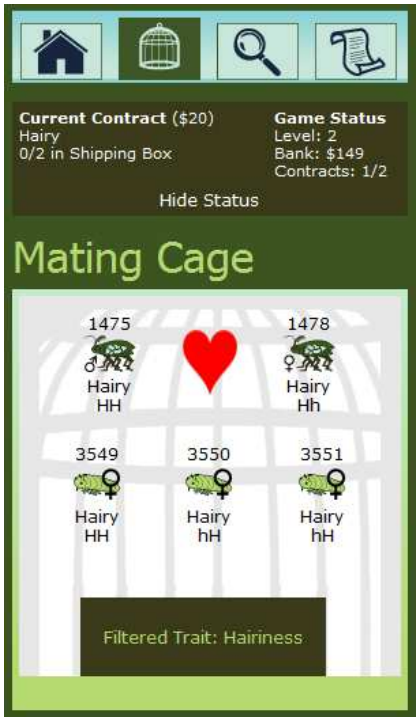

Figure 1. Beetle Breeders Screen Shot.

Preliminary data and anecdotal findings from student groups that have begun participation in the study have shown that students are motivated by the game's entrepreneurial goals. On their way to finding success in the game, they get significant practice with concepts involving genotype, phenotype, and Punnett squares, and they engage more often and more deeply with the biology topic.

CSCL Interactive Event

The interactive event we are planning for the conference has three main goals.

- We will showcase the UbiqBio games, making them accessible to practitioners and others interested in mobile learning.
- Through video footage, we will hear from biology teachers and students, who have participated in the study and used UbiqBio games in their class, about what they see as the successes and challenges of this type of learning tool.
- In addition, event participants will be part of a real-time research project that explores one of the core questions of mobile learning games: how should games fit into existing curriculum and content learning?

Schedule permitting, the event will take place over two separate sessions, one at the beginning of the conference, and one at the end, as well as during interstitial moments throughout the conference. At the introductory session, attendees will become familiar with the genre of UbiqGames, our UbiqBio project, and the Beetle Breeders game in particular. They will also have a chance to hear from some of the Boston-area teachers who have already used UbiqBio games in their classes. We will then split the participants into two groups, in preparation for the mini-research project in which everyone will be taking part. Half of the group will leave the session, not receiving the content lesson. The other half will stay for an explanation of genetics and inheritance patterns, the science content in Beetle Breeders, to ensure that they have prior knowledge when they begin to play. After the session, both groups will play Beetle Breeders on their own smartphones or laptops, advancing as far in the game as they wish. The group that didn't receive the lesson will be learning the concepts as they play, and the other group will be putting their existing knowledge into practice by achieving goals in the game.

At the wrap-up session, both groups will have had ample time to experience the game and think about ways to implement it in a classroom. We will hear some reflections from a few representatives of each group to get a sense of the similarities and differences between their experiences, and whether that was affected by their prior content knowledge, or lack thereof. We will then facilitate discussion on UbiqGames in general, and more specifically on the context in which they can be used in an educational setting. Learning games can be used by students in many ways – from gaining their first exposure to a topic, to demonstrating their mastery of it, and

every step in between – but the implementation and curriculum around the game should be designed to reflect that context. Attendees will have time to discuss the merits of various strategies, how best to design collaborative games to suit certain purposes, and the pros and cons of implementing each variety.

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