Development and Assessment of Mobile Device Instruction in STEM Education at K-21 level - Proof of Concept: Population Genetics

Introduction

This project builds on an ongoing NSF Cyber-Infrastructure project, which seeks to develop a cloud-deployed, scalable, virtual tool for the instruction of theory and practice of population genetics (NSF-OCI-CITEAM; Pop!World) in K-21 settings. This core goal has been achieved by successful launch of Pop!World on the Google App Engine (i.e "the cloud") as an open education resource, and implementation into UB's BIO 200 introductory unit (1, 2). The purpose of this project was to develop and deliver our already functional population genetics modules (Gateway, and Discovery) to mobile devices supported by Apple and Android operating systems (under CC licensing). We pursued two aims by expanding Pop!World: Aim 1) Technology Development, and Aim 2) Strategic Assessment.

Our overarching goal was to inform the design of technical tools and services intended to capitalize on pedagogical successes, and recognize and meet challenges of technology adoption and instruction inside and outside the classroom.

Outcomes on Aim 1.

A) We developed apps for the Discovery Module of Pop!World for two popular platforms: Google's Android and Apple IOS. This development took roughly 7 months core effort, and adjustments are still being made. For the Android platform we have developed usability for tablet, and phone versions. The Discovery version is being distributed free of charge through the App Store for i-pads, whereas the Android versions are distributed through the google play store. The app may be downloaded by directly open the following links on your device:

Android phone: https://play.google.com/store/apps/details?id=yunfei.UB.Popworld

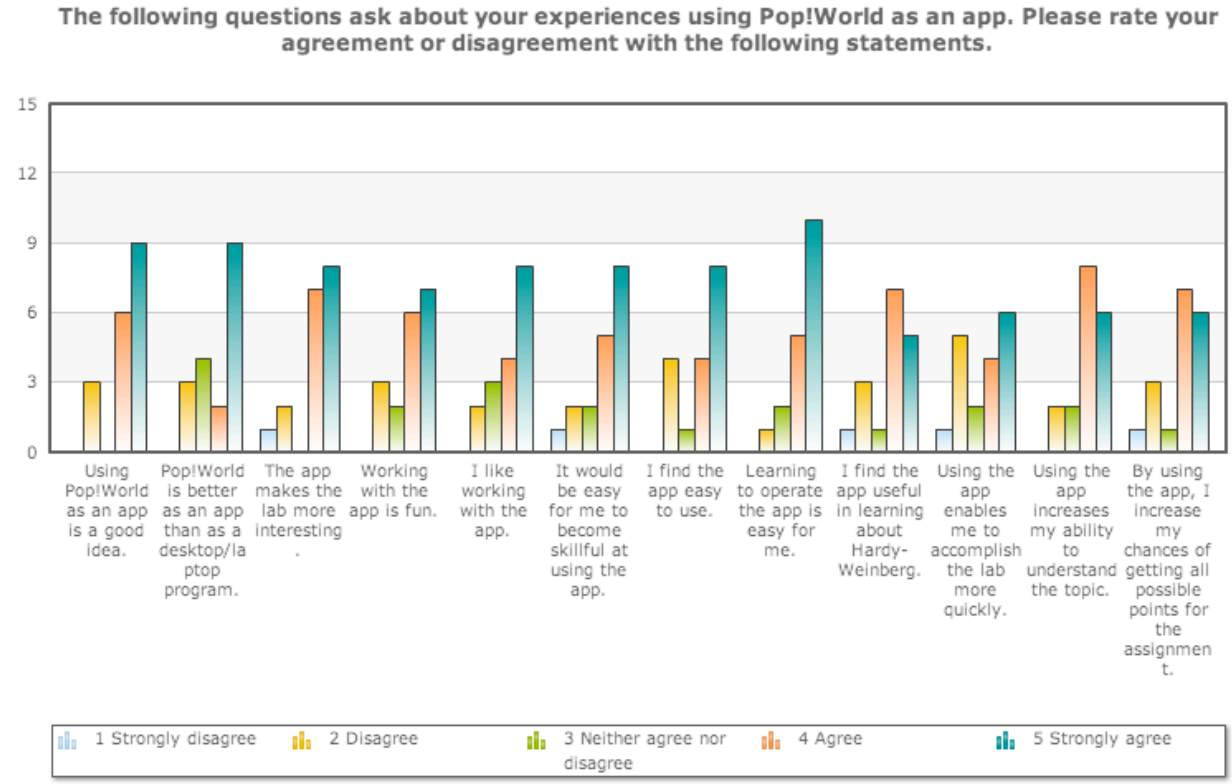
Android tablet: https://play.google.com/store/apps/details?id=yunfei.UB.popworldhd

iPad (2 and above, iOS 5 or later): http://itunes.apple.com/app/id649670263

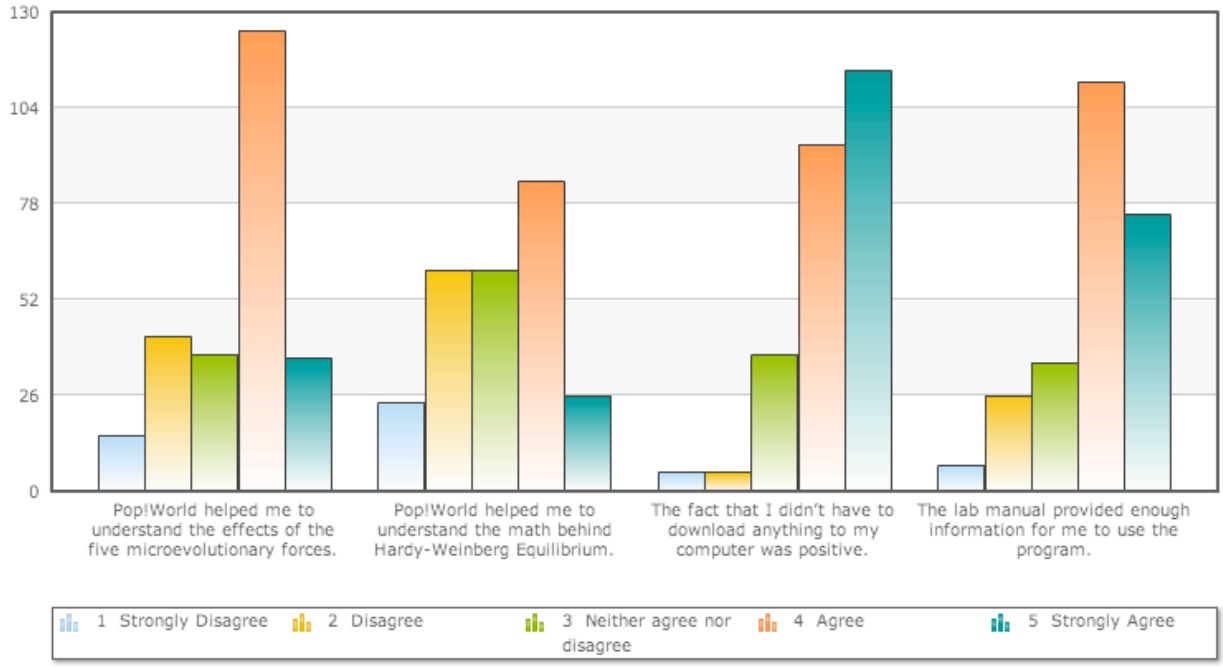
In the wake of app development we also redesigned the graphic implementation to make it more user-friendly. This included repositioning of the input and information windows, and a design that accommodates the haptic capabilities of mobile devices. Additionally, we completely re-envisioned the background graphics to each module of the Hardy-Weinberg assumptions. Background graphics were chosen be visually intuitive in their rendering of the evolutionary force to be studied (for instance, migration is rendered as two islands connected by a bridge – see below). Currently, the app is rated a 4+ in the App Store, and has been downloaded 220 times since its release in the fall of 2013.

B) The other goal of this project was a systematic assessment of the pedagogic/educational effectiveness of mobile device instruction in STEM education through controlled qualitative and quantitative research on a large scale. We set out to answer two questions: *A) How effective is mobile device instruction within the paradigm of STEM education?*, and *B) What factors influence the acceptance and use of mobile instruction and learning?* The idea was that results from this study will benefit learners and instructors in the public, as well as the private institutions (both traditional and online). Assessment results will also be interesting to the business sector, as it will inform about the potential profitability of mobile device instruction technology.
To begin answering both questions we implemented the use of the apps into our Fall 2013 BIO 200 course, which has a large enrollment (n > 1500, undergraduates). The cloud-deployed Pop!World is a regular part of our population genetics lab section on Hardy-Weinberg Equilibrium. Students were given the option to choose whatever device they want to use to complete the pertinent lab sections, and they had a choice between using their computer/laptop (traditional), a tablet (Android or i-pad app), as well a an Android based mobile phone. At the same time, students were asked to complete a survey with 40 questions (Likert Scale), not all of which related specifically to their use of mobile devices in the BIO 200 population genetic instruction. The survey was carried out with a professional survey software: esurveyspro (Premium Survey Services). Questions regarding mobile device use were randomly dispersed within the overall

questionnaire. In total, we got 288 responses (91.67% complete; 8.33% incomplete, 74.43% freshmen & sophomores). From all respondents 66.61% were female, and 39.39% were male, which constitutes a slight bias towards female respondents given the overall male/female student ratio in class. The majority of reporting students in this first round did their Pop!World lab work on a regular desktop computer or laptop. This is not surprising, as the student population in this survey have easy and unrestricted access to on-campus computer resources. Nevertheless, a significant proportion of students (7.42%) used a tablet to complete this assignment, although this is low compared to a 77.3% of users that report using mobile devices very often/often for things other than lab assignments. The figure below reports on the overall user experience with the Pop!World App.



Importantly, the majority of respondents ranked their experience in the 4 to 5 range (high, positive) in all questions. This means that users are generally positive about the idea of using a mobile device in instruction, and that they had little problem in learning how to operate the application. Additionally, users that used the app and the computer application felt that Pop!World as an app is better than the desktop/computer program. In terms of perceived learning gain, Pop!World (as app or computer application) was ranked as useful to understand population genetics, and Hardy-Weinberg equilibrium (below, questions 1 and 2). This is in concordance with previous research (see Poulin et al. 2013 – cited in grant application).



Interestingly, all students that reported using some mobile tablet version reported using the app either at home or in the library. Twenty percent of these users also reported using it in non-traditional learning spaces, such as coffee shops, while traveling, or while spending time with friends. This is somewhat surprising and shows that while mobile device use is on the rise in instruction, students still seem to prefer traditional learning environments (at home, or library) while engaging in the learning process. In other words: ***Mobile device use doesn't translate into mobile learning!*** This is preliminary data, but may have some important implications for both marketing, and educational innovations. Also, although the Android phone version was available for use (and downloaded most – 130 times), none of the reporting students used this option. It is currently unclear why, but could be related to the small screen (graphics rendering restricted). Also, we are not sure how many of these downloads are from students other than those using it at UB. Further research needs to be conducted to assess this.

Other (collateral) outcomes:
The National Science Foundation has asked us to furnish an NSF highlight on the grant preceding this IITG grant (see Introduction). We plan on using some of the outcomes gathered in this IITG effort to further develop the project, and apply for continuing grant funding with NSF.
We will participate with this project in the UB-Westminster Elementary School visit, as part of a greater STEM engagement with this local school.

Future Goals
We will continue our survey in the upcoming 2 semesters, with the goal of gathering statistically significant data for a full analysis. We will also continue developing the technology and concept for the Gateway module, which was not fully completed yet.

As a further development of this project we have already engaged with representatives at two other major educational institutions in Buffalo, namely: Buffalo State College, and Erie County Community College. Our approach is to take a typical STEM subject – Population Genetics – and use a cyber-infrastructure, and mobile enabled virtual platform (see this grant) as a teaching and learning environment across different institutions. While each institution will retain full agency over course content and development, our virtual tool will provide the connecting conceptual fabric. This will give us the opportunity to assess transferability, quality, and adaptability of the tool, refine the tool for interdisciplinary use, as well as test how effective students learn with the tool in diverse academic situations. In parallel, we will initiate an administrative dialogue to discuss and improve articulation of STEM subjects across institutions. Immediately tangible outcomes will be a) a comprehensive instructional tool for population genetics, b) the development of didactic plans catered to the specific needs of each institution, (a, and b are transferable nationally), and c) the establishment of the infrastructure to facilitate conversation and implementation of STEM projects across institutions.