Inspiring and Cultivating Female Innovators through Mobile App Development

Completed Research Paper

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Abstract
Globally there is an increasing focus on science, technology, and innovation (STI) throughout all industries and government sectors leading to demands for a larger, more diverse workforce. However, such demand is hardly filled by the supply. The overall goal of this study is to present a strategy to attract incoming freshmen, especially female students, to the STI fields and to increase the retention rate of current female students by offering a mobile app development class. The paper first provides a brief overview of different factors hindering women from participating or staying in the STI fields. The role of gender in innovation and its implications in education is next discussed. Three guiding course design principles used to inspire and cultivate student innovations are summarized. We compare three mobile app projects proposed by boys and three projects by girls and discuss findings to determine differences in learning styles. Finally, future research directions are presented.

Keywords
Mobile app development, innovation, gender, course design, broadening participation, STI, STEMs.

Background Introduction
The participation gap by women, as well as underrepresented minorities, and persons with disabilities in science, technology, engineering, and mathematics (STEM) is well documented (National Science Foundation 2011). In particular, the issue of women being underrepresented in the science, technology and innovation (STI) fields has been recognized worldwide for a long time. According to the 2011 United Nations report, average participation rates of women throughout the world in the scientific fields are 30 percent, with even lower percentage in information technology. (The United Nations 2011). The 2012 Taulbee report shows that, in spite of the steadily increasing enrollments in undergraduate computer science (CS) programs in the United States, women are remaining underrepresented as bachelor's degree recipients in the computing fields, with 12.9 percent in 2011-2012 (Frieze and Quesenberry 2013; Zweben and Bizot 2013). The fact that the number of women recipients of CS degrees has steadily declined since 1984 (Zweben 2012) further corroborates that women's progress in the technology field cannot be taken for granted (Hill et al. 2010).

The intensified demand for qualified STI talent and skills have been observed in diverse sectors such as finance, manufacturing, retail, education, health care, and media, and is not limited to the traditional STEM fields any more (Hewlett et al. 2014). Employers are seeking new hires with big data, social media, and robotics expertise among others (Hewlett et al. 2014). Therefore, broadening participation in computing is considered important as an international issue with a call for an ACM Special Interest Group (Dahlberg 2012).

As Information Systems/Information Technology (IS/IT) educators, the ensuing question for us is what we can do individually and collectively, at the course, curriculum, or program level, to address such challenges. The overall goal of this study is to present a strategy to attract incoming freshmen, especially female students, to the STI field and to increase the retention rate of current female IT/IS students by offering a mobile app development class. Instead of focusing on the traditional computing fields, we approach the challenge from a different perspective: cultivating student innovations in diverse fields using technology as the medium. By introducing a gender lens to innovation, this work aims at investigating the

experiences and inspirations of both male and female students in mobile app development, comparing innovative mobile app prototypes generated by both genders, and providing insights and lessons regarding introducing the innovation component into the IT/IS curriculum design and implementation.

Where are the Women? – The "Leaky Pipeline" Issue

"Leaky pipeline" is a phenomenon haunting STI-related fields worldwide (Blickenstaff 2005; Camp 1997). It refers to the fact that the interest of girls in STI in elementary education is high (look at their participation in science fairs), falls as they complete high school and enter college, and drops further along the career path. There has been a continuing gender gap as women and men entering into and advancing in the field, as seen in "high-tech" industry and innovative activities in particular (Womenable 2010).

Many influences have been noted over the years for females not viewing computing as a career path. Some of these factors include the different ways in which boys and girls are raised (Spertus 1991), different confidence levels in using computers between men and woman (Beyer et al. 2003), and cultural attitudes about maternity, childcare, parental care and working outside the home (Trauth et al. 2008). Females tend to leave STEM subjects in primary and secondary education due to lack of preparation for advanced studies, and stereotypes embedded in culture that STEM careers are male-dominated fields (Blickenstaff 2005; The United Nations 2011). Furthermore, many women working in the STEM fields walk away from their professions at different stages of their careers. According to one of the Harvard Business Review (HBR) research reports, 52 percent of highly qualified women working for science, technology, and engineering companies dropped out of the field over time due to a hostile, geek workplace culture, gender imbalance in teams, isolation from the rest of the team, extreme work pressure, and a lack of clarity surrounding career path (Hewlett et al. 2008). However, once women leave the workforce in any profession (the "off-ramp") it is extremely difficult to get back (the "on-ramp") (Hewlett 2007). This is particularly pronounced in technology where the fast pace of change in the computing field makes women feel "not current" to rejoin the workforce in technology.

According to the report from the Center for Talent Innovation, in 2010, there were seven job openings in computer occupations for every qualified graduate in the U. S. (Hewlett et al. 2014). The U.S. Department of Labor predicts that by 2018 there will be 1.4 million technology job openings in the U.S. Only 61% of those openings will be filled without increasing the number of graduates with qualified skills and expertise, and just 29% of applicants will be women (Johnson-Stempson 2014). Leading tech companies such as Google, Facebook, Amazon, and Apple will have more than 490,000 new jobs for science, technology and engineering (Craig et al. 2012). With such critical need for talent, "companies simply cannot afford a drain, much less a hemorrhage, of capable women" (Hewlett et al. 2014, p.2). However, unless this "leaky pipeline" issue can be solved soon, the U.S. is facing a larger and larger gender gap in STI, progressing from elementary school to college to professional occupation, and from entry level to managerial positions. We need to plug these holes as well as increase the number of entrants in the pipeline. One of the major objectives of this study is to address pre-occupation gaps by designing and implementing a mobile app development course to attract and train a diverse pool of potential participants.

Is Innovation just "Blue"? – Towards An Inclusive Perspective

Despite an increasing interest in innovation and its impacts on economic growth and development from industry practitioners and policy makers, there is little research focusing on the role of gender and gendered practices in innovation and innovative firms (Alsos et al. 2012). Innovation has long been linked to men and masculinities, mainly resulting from the perception that that the traditional women's workplace, tasks, and activities are not seen as central to innovation (Blake and Hanson 2005; Kvidal and Ljunggren 2010). In addition, innovation was historically associated with large, private corporations and primarily limited to technology and products from research and development (R&D) departments, thus, rarely linked to "feminine" sectors such as service, healthcare, and public sectors. (Womenable 2010). Due to such a narrow definition of innovation and limited scope when examining and studying innovation, women are almost invisible and their perspectives are marginalized in innovation processes.

The lack of women as innovators in science and technologies may lead to women end-users and consumers' needs being neglected. Previous studies reveal that women use technologies for different purposes and therefore, have different demands than their male counterparts (e.g., Ca and Göransson

2010). For example, women are more likely than men to use information technology for family-related matter such as health and education (Gurumurthy 2004). As the number of women as customers of technologies is increasing, no one can afford to lose the opportunity of exploring the innovation potential represented by women professionals including scientists and engineers, and the market potential represented by women consumers and users. Surprisingly, there are quite a few women behind varied successful innovations that make this world better. The non-exhaustive instances include Helen Grener for the Roomba robotic vacuum cleaner, Patsy O'Connell Sherman for the spray-on fabric protector, Dr. Virginia Apgar for the Apgar test evaluating a newborn's health, and Meg Horihan for the pioneering Web application Blogger, the antecedent of blogs (Hewlett et al. 2014). In spite of these inspiring innovations by women, there is still dearth of "innovation by women for women's needs" (Murenzi et al. 2010).

A multitude of initiatives and actions have been taken to broaden and retain women's participation in STI fields within the context of firms, industries, and policy making. It has been recognized that workforce diversity such as gender balance and inclusive leadership will boost innovation (Hewlett et al. 2013). According to Deloitte Touche Tohmatsu Limited's (DTTL) survey on 720 business leaders from 42 countries across Asia, Europe, and the Americas, innovation and idea generation are the most significant advantages to organizations that embrace inclusive leadership to improve gender diversity (49 percent of respondents) (Deloitte 2013, March 08).

Along with this stream of discussions, an emerging view of innovation proposed by OECD (The Organization for Economic Co-operation and Development) expanded the definition and focus of innovation, as listed below, which provides a broader and more comprehensive perspective for a better understanding of gender and innovation (OECD 2005):

- Placing greater emphasis on the role of networking and linkages among players in the innovation process;
- Recognizing the importance of innovation in less R&D-intensive sectors such as services and low-technology manufacturing; and
- Expanding the definition of innovation to include additional types of innovations in organizational behavior and marketing.

Based on the above discussion and findings from industry, we believe we can make a contribution as students enter college, not necessarily committed to a computing major. As a result, we have designed and implemented a mobile app development class to incorporate innovation concepts that are equally attractive to boys as well as girls. More details are given in the next section.

Innovation Can Be "Pink": Reimaging of IT/IS Classes

Project Rationales

Despite many attempts to broaden participation through a number of government-funded and other programs, not enough progress has been made. Women are entering college in increasing numbers. However, research shows that women enroll in majors they feel will lead to a career which will have a positive social impact and will involve collaboration with others, fields such as education, nursing, and psychology (Tulshyan 2010). Unfortunately, subjects like information technology (IT) or computer science (CS) are perceived as the realm of "geeks" and one of the popular misconceptions is that programming is a difficult as well as tedious task, requires high levels of mathematics proficiency, and has the least level of interactions and communications with co-workers. As faculty members teaching IT, we believe that we need to do more and that the first step is for female students to be attracted to the discipline as early as possible. This initiative aligns with the United Nations' recent report demanding that policy makers take the situations and abilities of women as well as men into account and do more to leverage female talent in STI education, careers and leadership (The United Nations 2011).

"We carry powerful computers in our pockets, our social networks and interactions are increasingly computer-mediated and online and offline lives are increasingly fused. That's the world that young people need to understand, and that's the technology with which they should be empowered" (Abelson 2011). The underlying objective of the mobile app development class is to develop strategies to convert incoming college students from their traditional role as technology consumers to technology creators and to

cultivate female innovations through creating mobile apps. Why mobile apps as the anchor? As we look around today's students, we see female students equally tied to technology, particularly their mobile devices as male counterparts. In introducing them to a new role as technology innovators, we believe that girls will find mobile technology less intimidating, more fun, a medium for collaboration and communication, and a tool that can be applied to their career of choice (e.g., fashion or healthcare).

Guiding Principles

We designed the course by adapting the framework from the CS Principles project funded by National Science Foundation (NSF) and the College Board (http://csprinciples.org). The core tenet of the principles permeates all of the activities to inspire and cultivate student (especially females) innovations, summarized as below.

Increasing the level of confidence in students. Previous studies found that women's computer confidence was much lower than men's, which is a major barrier to women's advancement in STI fields (Beyer et al. 2003). Lower levels of self-confidence and efficacy in turn impede women's motivation to participate in or stay in the fields, let alone engaging in creation and innovation activities. Some studies attributed women's low confidence to their less playful and relaxed attitude towards computers (Rasmussen and Hapnes 1991). In addition, the fact that women's interest in programming develops at a later age than men's may, to some extent, explain why women in average had less programming experiences than men (Margolis et al. 2000; Zubrow 1987). Lack of programming experience may negatively impact women's confidence, too. To counter such trends, we provide students with hands-on technology activities and opportunities to solve real-world problems. Students learn how to create their own mobile apps using MIT App Inventor, a visual, web-based programming environment widely used at the college level. Previous programming experience is not a prerequisite. By teaching students how to design and implement mobile apps, the aim is to transform their role, or at least perspective, to one of technology creators rather than just technology consumers. The hands-on laboratory work and inquiry-based individual and group projects are designed to improve each students' problem-solving skills, impart up-to-date knowledge of technology, and promote critical and creative thinking. Early exposure to these fundamental elements of computational thinking should lead students, especially girls, to a better sense of their own interests in the technology field or beyond (Grover 2009).

Fostering students' communication skills and social interactions in a team setting. Girls tend to equate computing, technology, and innovation with "programming", "boring", "geek", or "lonely". Girls may be discouraged from entering the field that they perceive as being solely technology- oriented, although many "feminine" skills such as better interpersonal skills and an ability with language are exactly what is needed in innovation processes (Vowler 2003, May 27). We aim to break the stereotypes and create a female-friendly, gender-neutral classroom environment and culture. Working in small teams, students will use an Android platform device and the MIT App Inventor tool to build any app they want to imagine such as a game, a personal convenience app, an app to help people communicate, or an app that talks to web services like Twitter. Students (both girls and boys) can have intellectual interactions and develop social bonds by creating a computing artifact together.

Cultivating innovations by promoting student diversity across different academic programs. Research has found marked differences in what interests boys and girls in computing. Generally, girls care more about the creativity and potential to make an impact on the world (Brown 2014, February 18). The mobile apps development courses are offered to incoming freshmen and transfer students. These courses are designed to expose students with different academic backgrounds and interests to some of the foundational elements of computing as part of the university's Discover program. The students use the same tool they have learned in the classroom to create an innovative mobile app of interest to them. They not only need to come up with mobile app ideas and develop prototypes, but also need to prepare an "elevator pitch" speech to have an organization fund their proposal. Both technical skills and communication skills are emphasized with respect to the innovation process.

Case Study: Comparisons of "Man-Made" and "Woman-Made" Mobile Apps

The course has been taught 5 times over the last two years and a number of interesting apps have been proposed. We have received many positive feedback and comments from the students, especially females. In this paper, we will showcase three mobile app prototypes proposed by male students and three apps proposed by their female counterparts. They are representative of the population of applications created

by the respective genders. By comparing the differences between mobile apps developed by both genders, we aim to investigate different approaches to attract and engage woman in the STI fields.

Case 1: WeatherStyle.

WeatherStyle is a weather app proposed by a female student from the Graphical Design program. The app integrates and enhances different elements of the existing weather apps such as Cloth and Swackett. When opening the app, users will enter their zip code and then will be prompted to choose their gender – male or female. Depending on their selection, a man or woman dressed for the current weather will be shown. Above the photo will be the current date, weather icon and the high and low temperature of that day for the location. Below the picture will be the current days forecast such as partly sunny. Sliding to the right will show outfits for the next four days. Instead of using drawings, the outfits will be photos of models wearing current trends of popular brands. This makes a perfect marketing opportunity for clothing stores wanting to showcase their current clothing. Users viewing the photos will want to find out where to purchase the clothing, which can be done by links on the app.

Case 2: Dog caL.

The app idea was proposed by a female student from the Nursing program. She has three dogs and needs an app that can store multiple pets' information in one place and multiple calendars for different pets. Dog caL is a calendar app for owners of single and multiple pets that, unlike iCal or Google calendar, allows the user to have separate calendars specifically for each pet and their individual needs. . For instance, if the user had three dogs, they would be able to have three different calendars. The calendar would be equipped with alerts so as to let the owner know when their pet has an appointment with their vet or when they need to apply medication. Another great feature would be the availability of the information of the vet, groomer, daycare etc. all in one place. This would be most useful for pet owners because while having pets is a joy, they need to be taken care of on a schedule and it can be difficult to keep track of this.

Case 3: Mobile Receipt (MR) Tracker.

Mobile Receipt (MR) Tracker was proposed by one female student majoring in Information Systems. Her goal is to help consumers save the receipts, organize them after shopping, and retrieve them whenever they want. The MR Tracker app converts the receipts into a PDF form so that the customers can send the receipts through emails, Bluetooth and SMS. MR Tracker will also assist consumers to organize the elements into various categories such as grocery, school supplies, etc. The app will also consist of the currency set up which is vital in the conversion of the currency in accordance to the nation in which the customer is located. It can generate monthly or even annually expenditure reports for customers. In summary, this app will help the consumers avoid problems such as losing important receipts, enable them to have a better-organized personal (or household) financial report, and add efficiency and convenience to their daily lives. In addition, it will help reduce the paperwork, hence, boost the existence of a green world.

Case 4: Fantasy Sports.

This app was proposed by a male student majoring in Economics. The app targets sports fan such as himself. There are many different websites running fantasy sports leagues and many fantasy sports to participate in but no central place to access all of them together. Users need an app that allows them to check all of their fantasy sports teams from a central place. The app he designed allows users to check and edit each of their different types of fantasy sports teams. There are a variety of fantasy sports people can play. On yahoo.com they include football, baseball, basketball, hockey, soccer, golf, and auto racing. Espn.com hosts all of those same fantasy sports minus golf. The app users will be able to check all of these types of fantasy sports teams listed above if they choose to participate in that many. Only the sports that each person chooses to play will be listed when they log onto the app.

Case 5: Message Aggregator.

The app is called "Message Aggregator", proposed by a male student majoring in IT. The student created this app to tackle the disconnection between all of our various communications services. Currently, mobile phone users must keep track of their e-mails, text messages, Facebook messages, Twitter "tweets," push notifications from other applications and more. Worse than this is that their friends or colleagues

may use one or more of these services, requiring users to keep in touch with all of these services or risk losing contact with a portion of their acquaintances. Rather than having to continuously check various applications and services for messages from contacts, it would be much easier to have all of one's incoming messages in one place.

Case 6: Find Your car.

The app is called "Find Your Car", proposed by a male student majoring in business. The student created this app to tackle the problem of finding your car when you have completely forgotten where they parked it. The application would function by maintaining the most recent parked location of the person's car. It would determine when and where the car is parked. The app would tap into the phone's GPS system, and would automatically store the location of your car.

We categorize the above six mobile apps based on each student's gender, major, topics of the games as shown in Table 1.

Mobile Apps	Gender of designer	Major	App Genre
WeatherStyle	Female	Graphic Design	Lifestyle (fashion)
Dog caL	Female	Nursing	Lifestyle (pet care)
MR Tracker	Female	IT	Lifestyle (shopping)
Fantasy Sports	Male	Economic	Sports
Message Aggregator	Male	IT	Social Networking
Find Your Car	Male	Business	Map/Navigation

Table 1. Mobile Apps Developed by the Students

We do not intend to generalize or draw any conclusion from the six cases given the limited size of the sample. However, comparisons of the six cases, to some extent, suggest that women tend to apply technology in the broader context and employ it to serve the needs of other disciplines and make a social impact; while men are more likely to focus on programming and consider technology as a "self-sustaining" discipline (Pivkina et al. 2009; Rosser 1990; Tobias 1990). Fisher (2005)'s work provides another angle to examine how men and women innovate differently. She refers to the way women think as "web thinking" and the male pattern of thinking as "step thinking". Women tend to think in a more contextual and holistic way. As women make decisions, they weigh more variables, see a wider range of possible solutions to a problem, and use imaginative judgment. Men are more likely to focus their attention on one thing at a time, discard what they regard as irrelevant data, and seek the straightforward path to the goal.

We believe that women do not innovate less or have inferior capability in terms of innovation than men. Due to different needs, focus, and interest, women just innovate differently from men in most cases and their applications are more oriented to their lifestyle (fashion, caring for pets, and shopping in our sample).

Conclusion

Technology is used everywhere today and the needs for mobile apps is increasing every day. In addition, tools to generate mobile apps are well developed, allowing innovative ideas to be implemented, at least in a prototype version, without the need for advanced programming or mathematical skills. We believe that our small number of classes have demonstrated mobile apps are excellent vehicles for entry-level college students to innovate and easily see the results of their innovation, Lifestyle applications were clearly of interest to female students and we will modify our course materials to ensure such lifestyle apps are used as examples. This study adds to the body of knowledge on gender differences with respect to innovation activities in classroom settings. It also provides three guiding principles that other schools can follow and adapt to their IT/IS curricula to attract more potential women participants.

For future activities, we will explore taking the course down the pipeline, to the high school level through a summer camp program in Summer 2014. We will also invite computing teachers from our local high school to all or part of the week-long summer camp, and will provide them with all the materials to introduce such programs in their schools. We will work with them to track the apps created by males and females and their focus.

Our final plan is to introduce a joint college/high school innovation environment in concert with the local high schools system. The purpose of this endeavor will be service learning with the opportunity to "innovate" applications (mobile and others) for the local non-profit community.

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