App Development for the Social Good: Teaching a Socially Conscious Mobile App Development in an Upper-Level Computer Science Course

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Abstract: Mobile application development is an emerging technology that affects users, developers and almost every sector of our lives. Along with the widespread adoption of mobile devices, there has also been a surge in mobile application development. To meet the demands for next-generation workforce equipped with mobile development skills, there has been an increase in post-secondary courses that teach mobile development. While some courses use it as an application area to teach relevant topics, majority focus primarily on mobile application development itself. These students, the makers of the future mobile technology, who are involved in app creation – from defining the concept to requirements gathering, to final implementation – takes into consideration how the app will work successfully and effectively. However, their design decisions are not always made thinking about how the application will influence the user, the community, and the society at large. To address this critical issue, in this paper, we report our experience with weaving the notion of social and ethical computing while designing and developing an upper-level computer science course on mobile questionnaire development. Our primary course goals were twofold: 1) Teach students the basics of mobile app development with a team project that exposes them to industry level software development practices, and 2) Introduce students to the notion of socially conscious computing from the perspective of how mobile applications and their design decisions can influence human lives and society. By appealing to students' interest in helping others, in this course, socially conscious mobile development aimed to give students life-changing experiential learning not typically achieved in the classroom, while providing a portable software that benefits society at large. We also focused on teaching students to appreciate how computing influence society and how they can play a role in it as future generation technology makers.

1. Introduction

The phenomenal rise of the mobile devices and the rapid diffusion of mobile computing are amongst the most notable developments of recent times. To meet the demands for a next-generation workforce equipped with mobile development skills, there has been an increase in post-secondary courses that teach mobile development. While some courses use it as an application area to teach relevant topics [1], the majority focus primarily on mobile application development itself. Mobile development is a multidisciplinary topic that requires practical application of knowledge from various domains of computer science (CS) (e.g., networking, operating systems, data communication, programming, data structure, security, and privacy are to name a few).

The developers of mobile applications are usually CS graduates, who are considered to be the makers of the future mobile technology. These makers are involved in app creation – from defining the concept to requirements gathering, to final implementation – takes into consideration how the app will work successfully and effectively. However, their design decisions are not always made thinking about how the application will influence the user, the community, and the society at large. Regardless of the benefits that this new technology offers to its users, there are some ethical concerns to the user of mobile applications and services. Mobile apps, for instance, can have secret access to device features like the camera or voice recorder,

photos, contacts, messages, calendar, location, and browsing history, which can be used against the users for various ill intended activities. Hence, helping students understand the importance of behaving ethically and with social responsibility, while developing mobile applications, is a very crucial goal for CS educators. It is essential to introduce students to the notion of socially conscious computing from the perspective of how mobile applications and their design decisions can influence human lives and society [2, 3]. By appealing to students' interest in helping others, socially conscious mobile development can aim to give students life-changing experiential learning not typically achieved in the classroom, while providing a portable software that benefits society at large.

In this paper, we present our experience in designing and delivering a mobile development course that focuses on developing mobile apps for social good by integrating socially conscious computing in the design and development process. We provide an overview of our course structure, course modules, learning objectives, and few case studies which stress ethical thinking throughout the process of app design and development. Our goal was to expand the current repertoire of in situ learning activities that require ethical judgment and to integrate those practices into their development process. Even though we have not taken any feedback, mainly, if students perceived the notion of socially conscious computing from the perspective of mobile app development, we found that students were excited by having to apply what they learned to complex ethical situations during their project.

The rest of the paper is organized as follows: Section 2 defines what we mean by socially conscious computing. Design of the course including learning objectives, learning model, outline and the structure of the course are presented in Section 3. Section 4 explains what ethical considerations are necessary to integrate socially conscious computing in the mobile application development process. In Section 5, we highlight few mobile applications, as case studies, that were developed as part of the course deliverable. Finally, Section 6 presents the conclusion and few future ideas related to this course.

2. What is Socially Conscious Computing?

The future CS majors, technology makers, need to realize that the context in which technology is used must be reflected in the technology's design - because of the ethical implications of its use and because understanding the consequences of such use helps improve the design. This insight was included in Computing Curricula 1991 [4] and has been a part of CS Accreditation Board curriculum standards since 1987 [5, 6]. Thus, the social, ethical, and professional context of the technology was added to the core undergraduate curriculum as part of the natural evolution of the maturing CS discipline. However, in addition to the traditional computer ethics curriculum, which CS major students usually get exposed to during their coursework, in our institution we wanted our students to gain further knowledge on how their decision on the design and implementation of cutting-edge technology can have an impact on society and how they can become a more honest and mindful citizen.

In this section, therefore, we provide a general definition of what we mean by *Socially Conscious Computing*. The large number of various sensing devices, such as sensors (e.g., RFID, motion sensors, microphone, camera, etc.) and mobile phones (recording the logs of GPS, calls, and messages), combined with e-mail and Web (e.g., DBLP, BBS, social network sites, blogs, Wiki), offer the in-situ data for analyzing human behavior and interaction, which in turn gets used in

innovative technologies that provide various service to users these days. As makers of technology, the future generation needs to ensure that all these technological innovations are positively impacting society. For example, data collection and analysis need to be done, so it does not violate the privacy of the user in any sense, does no harm to the user for using those services or applications, and does not prohibit the use of service due to implicit bias during the development process, and so on. Thus, socially conscious computing can be thought of as computing for social good, and it can be considered an umbrella term meant to incorporate any educational activity, from small to large, that endeavors to convey and reinforce computing's social relevance and potential for positive societal impact. In addition to the obvious benefit to society, socially conscious computing endeavors to exploit the finding that students' desire to have a positive societal impact is a strong determinant regarding their choice of career they choose [40]. It is worth noting that this positive societal impact is considered an inclusive term, and therefore, it includes sustainability [7], ICT4D [8], ICT4Peace [9], value sensitive design [10] and so on. We wanted our students to learn to make positive social change through the mobile application development course where design and development for socially conscious computing were weaved into the curriculum using various strategies. Through our course, we wanted to teach the following two primary knowledge areas to the upper-level CS majors –

- 1) teach the fundamentals and principles of mobile application development and
- 2) teach the process of analyzing the design, development, and use of the mobile application for social good by

- being truthful in working with the client
- being respectful and not misusing the client's time and other resources
- understanding the moral dimensions of the information age
- applying the basic concepts of responsibility, accountability, and liability
- being aware of licenses, and attributing borrowed work that is otherwise not licensed.
- safeguarding the privacy and confidentiality of app users
- designing controls for users that allow them to maintain appropriate privacy and confidentiality of themselves
- contributing to the social good where markets would not otherwise serve

3. Details of the Course

The course organization was motivated by presenting concepts from the bottom-up to facilitate learning, performance, and retention. In particular, the sequence of topics started with an introduction; then we presented example cases and their design considerations, the implication of design choices, and finally implementation techniques. For each concept, we started by presenting a bird's eye view of the concept before delving systematically into the details. We further attempted to teach students, not only how a particular application (like Pedometer application provided by Android developers) works, but also how the collection of users' physiological data is a private data and how these types of data should be transmitted securely to the cloud and stored in the cloud securely.

3.1 Learning Outcomes of the Course

The official learning outcomes of this course are as follows,

- be able to understand the fundamentals and principles of mobile application development
- be able to learn how to ask important questions, design and conduct investigations, collect, analyze, and interpret content, and apply what they have learned to new problems or situations
- be able to understand how mobile applications and their design decisions can influence human lives and society
- be able to critically analyze research literature at the intersection of computer science, philosophy, and the law
- be able to understand the effect of, and the source of, bias or discrimination in a software development design process
- be able to design and develop mobile applications which can be useful for society

In short, our unofficially desired outcomes were for students to be more critical about their mobile application design and development activities during their careers. We also wanted them to be aware of strategies that are available to them for understanding and deciding on which project they might work based on their desire to become an active, honest and mindful citizen.

3.2 Course Outline

We have offered a mobile app development course open to all computer science and integrated science and technology majors. The course was offered as an upper-level 3-credit elective course aimed at juniors and seniors of both of the program. We divided the entire course into 5 modules, where every module covered fundamental aspects of mobile development with Android OS [11]. Each module of the course was dedicated 2-3 weeks. The completion of each module also enabled the students to complete a critical component of the project, which they developed in a team. The 5 modules of the course cover basic and few advanced concepts of mobile development using Android. These 5 modules are: 1) *Module 1*: mobile user interface (e.g., activity, intents, layouts, views, fragments, dialogue fragments, etc.), 2) *Module 2*: mobile storage (e.g., shared preferences, SQLite database, content providers, data files), 3) *Module 3*: Location-based services, 4) *Module 4*: Sensing with integrated mobile sensors (e.g. accelerometers, Gyroscope, GPS, Camera, Bluetooth, etc.), and 5) *Module 5*: Google App Engine.

Different Android programming concepts are reinforced through a set of thematic programming labs that introduce these topics and incrementally allow the student to build a complex application. For our course, we designed programming labs on each module (totaling 5 programming labs) of the course, each forming a basic component of their project. These labs were designed to help students learn the key components of the Android programming environment. Students were allowed to add on more functionality to each lab, eventually developing a set of components that collectively formed a mobile sensing application. Since each module comprised of 2-3 weeks (close to 4-5 classes), labs were completed individually during the first class, so each student's progress could be assessed. In the following 3-4 class periods, students worked in their team (4 to 5 students in each team) to work further on the lab component and add additional functionalities to complete the development of the corresponding component of their project.

A significant part of this course is a team project where students worked in small teams (4-5 people) for joint problem-solving. During the first week of the course, students had to come up with a mobile sensing application idea that would solve a particular problem. To narrow down the domain of application areas, so it is easier to make fair and consistent assessments, we encouraged students to develop mobile sensing application that can be divided into 5 modules that are taught in the course and that can be used for social good, for example mobile sensing applications that provide mental or physical wellness of human beings. With these criteria in place, we had 7 different projects in the course. For example, one project was to suggest healthy food recipes based on the user's food consumption pattern, exercise frequency, and current hankerings selection. Another application was to allow a group of users to play a game where they need to walk/run to reach the moon, to eventually encourage them to do more physical activity. Another critical application was to detect lapping or pacing motion in dementia patients' walking pattern. We provide the details of the projects as case studies in Section 5.

3.3 Learning Model

In this course, we choose to engage students in a blended learning model, which utilizes the power of modern online teaching and traditional in-person interaction during class. The course seamlessly makes use of the best of both worlds in two ways – 1) incorporating *flipped classroom* by providing online video lectures on course modules, and 2) allowing students to do more interaction, critical thinking, and hands-on-practice during class through labs and project development. Mainly, students accessed the course contents (video lectures) through the LMS (Canvas) [12], conducted technical discussions in Piazza [13], collaborated using Gitlab [14], and attended weekly classes for labs.

3.4 Integrating Project Based Learning (PBL)

With the fast growth of mobile platforms and our dependency on mobile technology, it is very likely that computer science graduates will find themselves developing mobile applications once they are in the job market. Hence, our major goal was to design a course to help our graduating students obtain skills and knowledge, which would help them toward acquiring jobs in the mobile development area. Additionally, we wanted the students not only to learn mobile application development for social good but also to deepen their understanding of fundamentals of mobile platforms, design challenges, and underlying implementation challenges, so they are better equipped to tackle real-world problems, and social implication of their design choices and implantation practices. To achieve this goal, we decided to move away from the traditional setup of such applied courses and use Project Based Learning (PBL) as the main teaching model that engages students in learning knowledge and skills through an extended inquiry process structured around complex, authentic questions and carefully designed projects.

PBL is simply defined as “an instructional approach that contextualizes learning by presenting learners with problems to solve or products to develop” [15]. PBL is different from traditional instruction because it emphasizes learning through student-centered, interdisciplinary, and integrated activities in real-world situations. In PBL environments, students learn primarily by constructing knowledge and making meaning through iterative processes of questioning, active learning, sharing, and reflection [16]. Students work together in groups to conduct discussion, apply logic and reasoning, and devise solutions to complex problems. The teacher's primary role in PBL is to structure activities to stimulate motivation and encourage reflection and to facilitate learning through scaffolding, feedback, guidance and prompts for thinking. To do this

effectively, it is clear that students in the PBL environment must be motivated to learn and be able to focus their efforts and attention appropriately, monitor and evaluate their progress, and seek help as needed. We tried to implement all these aspects of PBL in our course through flipped classroom (video lectures), active learning strategies, peer instruction using online discussion boards, hands-on application of learned content during labs, reflection on project phases, teamwork on project development, peer evaluation on project phase presentations and developing a project that solves a real problem as well as serves a real purpose.

3.5 Class Discussion on Socially Conscious Computing

The study and analysis of the ethical and social implication of mobile computing practices are interdisciplinary in nature. Hence, on certain days during the semester, students were asked to analyze the design and features of few specific mobile applications (for example: GoogleFit App). The students were asked to conduct discussion on (1) understanding the user goals and the ethical issues to address such goals in an app like GoogleFit; (2) examining if the design choices were ethical; (3) exploring how the designs implemented by the developers are impacting users (for example anyone using GoogleFit app would need to use the same google account profile, even though the user might want to use to a different profile); and (4) analyzing use cases to uncover and examine ethical and social issues due to developer's choices of design principles and implementation techniques. Students conducted this discussion in a fish-bowl discussion manner [39], where a group of students (inner group) would serve as the fish and conduct the discussion and rest of the students (outer group) would observe, critic and finally share their thoughts with the inner group.

In addition to occasional fish-bowl discussions, during every module, we dedicated one class for discussion on their own project's social and ethical implications. The students discussed were first asked to reflect on 1) analyzing scenarios/use cases in their projects to uncover and examine ethical and social issues. 2) what are the use cases in their project that can impact users negatively, 3) how users can be provided with options for better decision making, 4) what design changes are needed so users can take informed decision, and 5) what sort of design decisions and implementation techniques are required so users' data cannot be used for profiling. Students were provided with resources [17, 18] before the discussion, which was used by students, so they can conduct a meaningful discussion based on the frameworks identified for ethical computing and computing for social good.

4. Ethical Considerations in Mobile App Design and Implementation

Below we summarize some key topics which were identified as being useful to practice mobile application development for social good-

- *Individual and professional responsibility:* It is very crucial for students to examine their ideas regarding individual and professional responsibility, especially in the context of the development of a technology that can have a direct impact on user lives. Individual responsibilities include the moral imperatives in the ACM Code of Ethics [19], such as 1) avoid harm to others; 2) being honest; 3) being fair, and 4) not discriminate against users when providing services.
- *Being thoughtful about risks:* The primary risks associated with the mobile application is to do with the collection and management of data. It is a moral and ethical duty to stay well-informed of the current industry standards for privacy and security and to initiate appropriate

procedures with regards to handling user data. The potential of risks can further escalate due to the use of various third-party platforms and libraries. Therefore, the developers' understanding of the risks is also contingent on the knowledge and understanding of such implementation details.

- *Ensuring reliability:* Because error-free design is impossible to achieve, mobile technology developers must know the dangers associated with incomplete or unreliable technology. For example, designers of critical safety systems must make choices and tradeoffs in design and implementation to make sure the system is providing accurate service. Anticipating the ethical dimensions of these choices yields more thoughtful and informed design decisions which in turn ensures the development of reliable mobile applications.
- *User autonomy:* It is very important to respect and support people's ability to make free and informed choices about whether the user wants to use certain services while using the mobile application. The standard process to achieve is allowing users to opt out of certain services or allowing the user to enable device resources to be used by the service. Developers should never automatically assume that user will enable all device resources or should never automatically opt-in user for all services. They should provide users with meaningful controls like opt-outs where feasible, particularly when the data is sensitive or used in a non-obvious way.
- *Integration of user consent:* One standard process of building in user autonomy in the mobile application is through the development of user consent. Especially in mobile applications that are developed solely for research purpose should have a standard user consent as the first screen of the application. Due to the limited opportunities to describe the research in the App Store and the potentially misleading information, developers should not rely on the user's choice to install the app as evidence of consent to participate in a research study done through mobile applications. Rather, the app needs to present information about the study within the app and ask explicitly for consent before it can begin collecting data. However, Morrison et al. have discussed the potential unsuitability of presenting these screens as the first action following installation of an app, when a user will likely not yet understand exactly what the app does and might be especially keen to skip such screens to find out [20]. To address this issue, when the user installs such application for the first time, they should be presented with several swipes through pages describing the functionality of the app. At the end of these, the user can be invited to "contribute to research" and then can be led to participant information about the research. The idea of embedding the participant information screens at the end a set of instructions is that users will have a clearer idea of what the app is that they are consenting to use.
- *Being aware of user privacy preferences:* Ensuring user privacy is one of the most important requirements when developing mobile applications which can be used in numerous scenarios by users. To ensure user privacy, it is critical that data collected from the user are not used for profiling. Developers should build privacy into their mobile apps from the start in order to foster trust and confidence in the mobile app ecosystem. If the app is ad-supported, the app should include access to preference management tools that indicate advertising preferences. Unless required for core functionality of the app, it should not access sensitive data.
- *Practice privacy by design:* Privacy should be a central consideration in any app design process and considered at all stages of app development. Responsible app developers will go

above and beyond compliance with regulatory requirements and law; strive to make privacy assurance a default mode of operation.

- *Security of users:* The success of the mobile application highly depends on how much security does the app provide. Users want safe app environments where they can interact with each other. Therefore, developers need to deliver digital solutions with app security in mind. For new generation developers, there are various strategies (HTTPS, clearing the cache, obfuscating code, protecting local storage, and keeping sensitive data inside the app) which can be integrated to ensure the security of users.
- *An option of user feedback:* It is important to provide users with a way to contact developers and respond to questions and concerns. This can be accomplished through a simple form accessible from within the mobile app, a feedback forum, or by providing an email address where users can contact the developers or responsible party.
- *Collect minimal data:* Developers should strive to provide users with choice and control around the unexpected collection and use of personal information. Mobile app developers should only collect the minimum amount of data required to provide a service, with a goal towards ways to achieve the functionality while anonymizing personal information. When this data is used outside the scope of what users would reasonably expect, the developer needs to make sure users can easily opt-out. This is a trade-off that the developer community needs to understand and practice while implementing mobile apps that solely run based on user data.
- *Aligning mobile apps with user goals:* Some mobile app designs are built for productivity, but many others are not. For example, Waze wants to help users find faster ways of driving places (by avoiding traffic or construction), while Candy Crush is just trying to help users squeeze in some mindless entertainment in spare time. Hence, it is reasonable to argue that in order to introduce ethics into mobile app designs, the developer needs to align their goals with those of the users.

5. Case Studies: Developed Mobile Applications

In this section, we present a few mobile applications that were developed by the students in our course. Through these case studies, we would also like to provide a compelling example of how tightly bound the ethical choices are to the design and implementation decisions of a mobile application that is developed for social good.

5.1 Combating obesity in young adolescents

Obesity has become a major public health issue in most countries around the world. In addition, adolescent obesity is increasing at an alarming rate all over the world. Many attempts have been made to address this issue that ranges from doing exercise to following a diet plan to playing games. While the existence of the above works indicates the past and ongoing efforts to combat adolescent obesity, they are clearly not enough since it is still rising. Researchers have found that adolescent obesity controlling has a lot to do with combating unhealthy cravings that need strong will power and motivation at such an age. Often, young people and their caregiver struggle to find healthy and nutritious recipes that would fulfill the craving of young people. In order to motivate unfit adolescents towards healthy eating, our research tries to provide them with alternative tasty yet healthier food options using a mobile application. The students in this particular project worked on the design and development of a mobile application, which has the

potential to help deal with adolescent obesity by motivating its users to choose a healthier food option when they have a craving for unhealthy or junk food. To find a healthy recipe, the application uses a recognition algorithm, a decision tree-based learning algorithm that considers user's meal intake history and current cravings. Fig 1 and Fig 2 shows the screenshot of the prototype application.

Figure 1. [Left to right] Select taste, spice, and cuisine to find recipes for craving

Figure 2. [Left to right] display recipe, social connection page and scoreboard

Ethical design and implementation considerations: In this application, to minimize privacy risks, we have adopted an approach where the data is anonymous by default. That is, we try not to collect any identifying information such as an IP address, real name, location, etc. Storage and management of the data after collection is potentially where most of the risks lie. Therefore, the students went beyond anonymous data collection and integrated more procedural approaches to handling the data. For example, how we separate data for potential identifiers, how we create datasets, and how we transfer data to the cloud. We also provided notice about geo-tagging since our app also takes pictures of users. Geo-tags and related metadata may reveal the location coordinates where the photo was taken. Since users are not always aware this is happening; we decided to provide a notice explaining that geo-tagging may occur.

5.2 Detecting wandering behavior in patients with dementia

Wandering is among the most frequent problematic, and dangerous behaviors for elders with dementia. Frequent wanderers likely suffer falls and fractures, which affect the safety and quality of their lives. Due to its complexity and diversity, there is still no unanimously agreed definition on wandering behavior. Among the approaches of wandering monitoring, the movement pattern-based methods become dominant in practice as well as in academic studies. In order to monitor outdoor wandering of elderly people with dementia, students in this project designed and developed an application that collects GPS trace of users and detects wandering behavior. In general, the pacing and lapping movements are considered two of the most common wandering patterns in dementia patients. Pacing is a repetitive back- and-forth movement within a limited area, and lapping is a repetitive travel characterized by circling a large area.

There are numerous challenges in detecting wandering behavior: a) sensor data collected from a mobile phone has a lot of noises which may not reflect the real route or motion of the dementia patients, b) wandering behavior itself varies a lot, caused by not only the diversity of wandering patterns but also the individual difference. So, it is not easy to construct a uniform model that detects wandering behavior, and c) since human's regular travel pattern sometimes also includes wandering like a pattern, it is hard for machines to distinguish between the two. Hence in our application, for analysis, we have applied the following two techniques: a) one idea is representing wandering traces as loops, the problem of wandering detection is transformed into detecting loops in elders' mobility trajectories. b) The movement patterns of pacing and lapping that are key factors of wandering behavior are detected by analyzing the sequence of changes of direction in a trace. The rationale for doing so is rooted in the fact that both pacing and lapping behaviors are characterized by taking loop-like locomotion in nature. Changes in moving directions are thus frequent throughout the process of each movement. The more distinguished directions a patient has in a little perimeter, the more likely he is following a wandering behavior. The rotations and turns can be detected using the Gyroscope data. The developed application can

- Identify and model a new outdoor wandering detection problem using GPS traces for dementia patients.
- Use machine learning based detection technique by finding loops in GPS traces of the dementia patients using the collected GPS data and gyroscope data.
- Utilize a power optimization approach, so the continuous collection and monitoring of sensor data do not drain the mobile device battery.

The screenshot of prototype application is shown in Fig 3. We evaluate the proposed method on a set of real-world datasets, collected using the prototype application. The experimental results (Fig 4 and Fig 5) show that our method performs well in terms of detection performance.

Figure 3. Screenshot of prototype application

Figure 4. GPS trace points and paths of lapping

Figure 5. GPS trace points and paths of and pacing

Ethical design and implementation considerations: Walking is usually considered a low risk (such as miscount step or incorrect walk trace) form of physical activity, and therefore the health risks associated with using a walk detection apps are low. However, since the target audience of our application is elderly and vulnerable population, walking is actually considered a high-risk activity and we had to make sure there are very low false positives. Due to the nature of our user base, we had to make sure user's personal information we collect, store, and transfer is as accurate, complete, and up-to-date as is needed so there is no chance of error in alerting the user about a potential threat regarding pacing and lapping motion. We also obtained user permission before accessing location data. Precise geo-location information is increasingly considered

sensitive information and we decided to only collect and transmit such information when we have users' clear, opt-in permission.

5.3 Increasing physical activity in young people

Regular physical activity is essential to maintain or even improve an individual's health. Physical inactivity has been described as a global pandemic in recent days. Recent estimates suggest that approximately 80% of young people internationally are not meeting the physical activity guidelines of 60 min of moderate-to-vigorous physical activity each day. It is of additional concern that children and adolescents are spending a large proportion of their day engaged in screen-based recreation. To address this issue, students in this project developed a location-based, goal-setting and reward based mobile application for encouraging school children or college students to participate in physical activities in a social friendly manner. This application has the potential to help deal with adolescent obesity by motivating its users to stay active physically by participating in a game with peers. Walk to the Moon is an enhanced, interactive pedometer application that is meant to motivate the user to be more active. The user's daily step count is used in a game with the goal of walking all the way to the moon. To help the user reach the moon, the application has unlockable achievements, called power-ups, that increase the user's step count and boost them closer to reaching their goal. Our application includes several features: (a) exercise routes generated based on which friend is closer to user's location, (b) group-based game where updates of group members' achievements can be shown on each player's screen, and (c) social network interface that allows participating users to invite friends to participate in self- organized group competitions.

Figure 6. Screenshot of the prototype application

Ethical design and implementation considerations: Unlike the last application, we considered walking as a low risk (such as miscount step) form of physical activity in this one. Minor risks are that the app may set inappropriate goals, or make people feel negatively about their levels of physical activity. Our app requires express permission for the user to access location information. In our app's privacy policy, we also specify how we collect, use and share location data. We also provided disclosure for: (1) the level of location data collection such as precise or fine, zip level, zip+4, or coarse; (2) whether the data is being used with a unique mobile identifier; and (3) the period of time that the user's location data is linked with the user's identifier. We also provided notice about geo-tagging since our app also takes picture of users. Geo-tags and related metadata may reveal the location coordinates where the photo was taken. Since users are not always aware this is happening, we decided to provide notice explaining that geo-tagging may occur.

5.4 Study Space: A place for students to study around campus

Amongst college campuses nation-wide, students rush to the library to complete their homework, study for tests or meet with teachers and other students. When students desire a guarantee that they will have the ability to reserve a room where they can complete their work, they utilize a service which the university (e.g., James Madison University (JMU)) has generated to arrange their booking. The idea of this app is to make the reservation of any room across campus for students as easy as a click! Study Space has been designed by and for JMU students in efforts to improve JMU's facilities and how they provide their students the means for which to achieve their goals. The mobile app allows a user to reserve a room which they have in mind by submitting the date and time for which they would like to be accommodated. If they are unsure or have no particular room preference, they can filter the number of apartments to peruse by selecting room features for which they would like to use.

Figure 7. Screenshot of the prototype application in iOS Platform

Figure 8. Screenshot of the prototype application in Android platform

Ethical design and implementation considerations: The idea of using an app such as Study Space by encourage the students to reserve more rooms just for the fun of it. A constraint was added that if the same user is trying to reserve another room at the same time, a warning email will be sent to an administrator. More constraints must be done such as 1) check of the location of the user, users far away from the campus by more than an hour drive shouldn't be allowed to reserve a room; 2) users privacy should be reserved, so any information about who reserved which room should be removed from the database after a certain date (may be at midnight every day).

5.5 Secure Monitoring Cloud System for Energy Consumption

Consumers have become increasingly cognizant of the negative effects of energy consumption as well as the importance of footprint reduction. Despite the increased interest in energy reduction and consumption, the average consumer still feels intimidated and unsure of how to begin. We propose an energy monitoring application to be used per room within a house that is efficient, intuitive, and economic. A cloud-based service that allows end-users to monitor, store, and display energy usage data in an intuitive graphical user interface. User-friendly Android and iOS applications allows the user to look at real-time energy usage data for the entire house or building to best pinpoint where excess energy is being expended to understand better how to reduce consumption.

Figure 9. Screenshot of the prototype application in iOS Platform

Figure 10. Screenshot of the prototype application in Android platform

Ethical design and implementation considerations: Several ethical consideration should be taken in account while using a mobile app such as energy monitoring: 1) Security and privacy are very essential in these types of application. Users should be informed of any privacy or security concerns while using these systems. 2) Multiple users living together as roommate, may have to agree of the idea of sharing how much energy they consume.

6. Related Works

In recent years, there are number of institutions that offer courses on mobile technology, which can be classified into three categories [21]. First, mobile application development classes, in which students learn about building applications [22]. Second, mobile computing classes [24], in which students study mobile computing related issues and algorithms. Third, mobile computing client classes [23], in which students learn traditional CS concepts using mobile development as a context for examples. However, there is hardly any course that teach the ethical practices from the context of mobile application development integrating socially conscious computing.

One of the very few relevant research work reported in [25] their experiences in implementing support for autonomy (consent and withdrawal) and minimizing privacy risks in a research app deployed via the Apple App Store. The authors argued that while it is possible and desirable to implement a research app according to ethical guidelines and frameworks, the uncertainties require ongoing attention to ethical issues during development as well as post deployment. Another relevant work is presented in [26], where Wart et al. developed a twelve-week “Apps for Social Justice course” that was taught at an after-school program and students were exposed to classic social justice literature, identified local community needs, and went through a design process to create fully functional mobile applications to address those needs.

As an example of standalone courses, Sung et al. [21] offered two upper-year mobile computing electives, with one focused on the implementation of a mobile application and the other on the design of mobile applications. Many other institutions have applied or used mobile technologies to enhance their teaching and students’ learning experiences [27, 28, 29, 30]. Cobcroft et al. [28] studied mobile learning outcomes, challenges and proposed guidelines for future mobile learning experience. Fenwick et al. [29] describe upper-level courses that center on Android development. There are a variety of courses that teach mobile development as the context, including CS1 courses [31, 32, 33], CS2 [34] and courses on topics ranging from HCI [35], software engineering [36] to games [37] to security [38]. Iskandarova et al. [41, 42, 43] used mobile development as a learning tools for kids in a children museum. Other researchers [44, 45] use project-based classes to teach mobile development or part of a senior capstone project [46].

While some of the above-mentioned courses cover almost similar mobile technology related technical contents that we have covered in our course, our focus was also to inform our students how they can continue to do socially conscious computing through various design and development practices and ethical reflections.

7. Conclusion

In this paper, we reported our experience of offering a course on mobile development that introduce students to the notion of socially conscious computing from the perspective of how mobile applications and their design decisions can influence human lives and society. Even though we have not taken any specific feedback on if the students really perceived the notion of socially conscious computing from the perspective mobile development, we found that students were very excited by having to apply what they learned to complex ethical situations during their project. Each team focused on developing a mobile application that can be used with a purpose of “social good”. The instructors’ experiences, students’ grades, course evaluations, anecdotal evidence and students’ feedback indicate that the integration of socially conscious computing in a mobile development course helped to provide (mostly) positive learning experience to students. In future we plan to offer this course in two formats– traditional (in class) and online. We would

like to compare if the delivery format of the course has any influence on students' learning experiences and if one is better over the other.

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