Enhancing Ethical Awareness though Practical Engagement with Mobile Media

Meriel Huggard*[1], and Ciarán Mc Goldrick*[1]

[1]Trinity College Dublin, Dublin 2, Ireland.

Corresponding authors: Meriel.Huggard@tcd.ie, Ciaran.McGoldrick@tcd.ie

***Abstract*—Ubiquitous computing technologies play a critical role in the monitoring and assessment of a patient's physical health and medical well-being. They can provide medical practitioners with a way to bridge the gap between intermittent consultations, by providing them with insight into a patient's day-to-day activity and physiological condition. Such applications of technology give rise to many challenging ethical questions, from the end-to-end confidentiality and security of the data collected to the privacy of each individual patient. In this paper we detail a practical laboratory task where final year undergraduate students design, implement and validate a mobile media system to gather data on patient behavior and well-being that can be reported back to a medical practitioner for review prior to a meeting with the patient. We evaluate the students' experience of working with a range of mobile, wireless technologies and devices such as Android smart phones, tablets and wireless sensing platforms. We explore how their perception of the technologies they use evolves and how their engagement with the project enhances their ethical awareness of the use of such technologies.**

Keywords— Engineering Ethics, Mobile Media, Practical Laboratory, Wireless Communications;

I. INTRODUCTION

ABET [1] and other accrediting institutions place responsible, ethical innovation at the heart of the educational and personal development of current and future engineers. The development of these skills, within a formal educational setting, can prove challenging: many students perceive ethics as a rather narrow set of rules and principles that are learnt about, and considered, in isolation; rather than as an integral part of their future professional practice.

The object of the assignment detailed in this paper is to provide students with practical experiences where ethical principles form a key element of the conceptualisation, design and realisation of a real world engineering task. This assignment formed a core element of a final year undergraduate Wireless Communications module.

One of the key aims of the assignment was to bring about a change in students' perspectives of ethics through engagement in developmental tasks that involve a clear, non-negotiable ethical dimension. The sub-tasks within the assignment were specifically chosen so as to encourage the students to engage in collaborative, interdisciplinary ethics research as part of a broader laboratory-based assignment in the ubiquitous computing domain.

II. MOBILE MEDIA AND ETHICS

The emergence and rapidly accelerating growth in the availability of standardized wireless technologies such as Bluetooth, Wifi, and Zigbee has led to research interest in their future deployment in the Internet of Things. This has fuelled the expansion in capabilities of devices such as wireless sensors, smart phones and tablets; together with their associated media technologies. Many of these devices can make intelligent decisions or take action based on the information they have acquired about their surroundings and location e.g. from sensors, accelerometers, GPS. They can also interact on a global scale through social media, such as Twitter and Facebook, apps, email and even common SMS messages.

The ethical issues surrounding "emerging technologies", such as the mobile devices mentioned above, pose many challenges for those involved in their creation, deployment and exploitation [2,3,4]. These issues can range from the way in which they are embedded in everyday life to the protection of the sensitive, personal information they capture and relay. This makes them an ideal tool for the exploration of ethical issues in a practical environment with final year undergraduate students who have already begun to explore the broader impacts of technology on society and the world around them.

III. THE WIRELESS COMMUNICATIONS MODULE

The Wireless Communications module described herein is an optional element of the undergraduate Integrated Computer Science program at Trinity College Dublin. This is a full-time accredited degree program that offers students the opportunity to exit after four years with a Batchelor's degree in Computer Science or after five years with a Master's level qualification, subject to the attainment of an acceptable standard.

The Wireless Communications module runs over a twelve week semester, from September to December, with one laboratory and two timetabled lecture hours per week. The class also have access to any necessary laboratory infrastructure for at least six hours per week. Class size has varied from 18 to 35 students in the seven years that this module has been delivered. Assessment on the Wireless Communications module is carried out through a combination of assigned coursework and a written examination.

Topics covered include the fundamental principles of wireless transmission and how these support and underpin the development of wireless communication networks. This forms the foundation for the subsequent consideration of a wide

variety of wireless communication systems from WiFi and cellular networks, through to wireless sensor networks and the apps that run on mobile devices.

Students taking this module have over three years of experience in computer programming, primarily in Java, and have also taken courses in computer hardware, networking and telecommunications. They have also engaged with ethical issues in a number of modules, such as a freshman module on computers and society.

IV. The Assignment

Prior to the commencement of their work on the assignment, students are given a one-hour preliminary class where they are introduced to the assignment's objectives and goals, as well as the philosophical underpinnings of its design. This enables the faculty member to enter into a simple didactic contract with the students, agreeing the anticipated level of commitment, the expectations of both faculty and students and the modalities for engagement with the assignment. In particular, the assessment criteria and anticipated outputs are discussed in detail and agreed upon by all.

The students work in small, mainly self-selected groups of three or four. Each group is encouraged to draw on their pre-existing skillset when deciding on their intended approach to the assignment. A minimal problem domain task specification, such as that used for this assignment, has been found to encourage creativity and novelty in both application area and technical implementation [5,6].

The Wireless Communications module is taken by final year undergraduate students, thus the technical environment in which they work is deliberately chosen to reflect that of an engineer in the real world: The students are provided with a range of wireless technologies with which they can realise their prototype and there is no single, mandated device or platform that they must use.

Those taking the module were given access to the wide range of mobile and wireless devices available for use within the host institution. Where appropriate a rota was established to ensure that each group has access to the necessary equipment. Groups were encouraged to make strategic decisions on the wireless technologies they chose to work with based on their collective skillset, proficiency and interests.

The task description provided to the students was as follows:

A. Background

Medical practitioners often find themselves restricted in terms of the information available to them on a patient's well-being and behaviour. The data they gather is usually obtained through verbal reports from the patient or those who live with them and from journals or diaries kept by the patient. These reports can often be unreliable or skewed in favour of recent symptoms; for example, a patient may concentrate on reporting on the pain they feel today, rather than on the pain they have experienced over the previous week. The ultimate goal of this project is to use mobile technologies to gather data on patient behaviour and well-being that can be reported back to a clinician e.g. a hospital consultant or specialist nurse, for review prior to a meeting with the patient.

B. The Laboratory Assignment

Using the available mobile technologies (Arduino, Wireless sensors and sensor boards, Android smartphones, tablets etc.) design and, where possible, prototype a mobile device suitable for use in the health care setting detailed above.

Behaviours one could consider monitoring include that of adults in an ambulatory setting e.g. in their own home, or multiple individuals in a specialised care facility. One could look to monitor behaviour such as repetitive unfocused behaviours e.g. repetition of the same task, or provide a system to monitor well-being e.g. for fall detection. One could prototype a system to gather information from patients throughout the day; for example, through the completion of surveys on a smart phone or tablet. One could also look to provide a method for aggregating data from multiple mobile devices for analysis and summary in a suitable form for presentation to a clinician.

As the end users of this project are patients you should consider any ethical issues that may arise throughout the life cycle of your project from prototyping to deployment and the gathering of personal medical data.

It may also be appropriate to consider and document any necessary security aspects to the project, even if time limitations mean you are unable to addresses these fully in your final solution.

As well as producing a prototype of your system, you are required to produce a report that includes technical detail on the mobile technology you have used, a discussion of the design philosophy behind your system and the implementation work carried out. Your report should also address any ethical issues that arose during the assignment. The role and workload of each person in the group should be clearly stated in the report. Finally your report should include a one-page description of your system, including the arguments for its adoption, suitable for presentation to a medical professional with a non-technical background.

V. Outcomes

The student groups taking the module in 2013/14 developed a wide range of solutions that spanned the broad scope of the problem scenario. Some of the more innovative student projects are described below to illustrate this, together with the ethical issues that arose during the course of their work.

A. Fall Detection System

The team working on this project looked at existing fall detection systems, noting that the literature indicates that amongst the elderly unattended falls are a major cause of severe injury and even fatalities [7].

The solution proposed was a distributed one involving both decision trees and local thresholds to determine whether an individual has fallen or come close to falling. The system was built using the Arduino (www.arduino.cc) compatible

Xadow (www.xadow.cc) platform. The team connected several coin-sized sensing components using a flexible connector, thus creating a device that is unobtrusive and easily integrated into clothing such as a sweater or t-shirt. The sensors monitored acceleration and reported values exceeding pre-determined thresholds using a Bluetooth Low Energy connection to an Android device. The device then implements a decision tree for each sensor to determine if a fall has occurred and to classify the nature and type of the fall. Where necessary, alerts are then generated for transmission to care givers.

While the prototype was being developed the initial focus was on the security of the data generated and the prevention of malicious attacks e.g. through the generation of false alerts. However, as the team moved into the calibration and testing phase of the work they begun to focus more on the issues associated with the testing of such a system. One of the topics considered was about the ethics surrounding testing of the system and in particular about asking people to simulate falling. The team looked at way of testing their system without the need for a human subject; for example, by placing the t-shirt containing the sensors on a mannequin and then pushing this over to simulate falling forwards, backwards or to one side. The team also explored how they would move beyond laboratory testing to the use of human subjects and the ethical approval they would need to obtain for usability testing.

B. System for Detecting Activity within the home

This project attached wireless sensors to doors and used the on-board accelerometer to determine when a door was opened. It was assumed that doors had self-closing mechanisms and therefore individuals needed to open doors in order to move from room to room. The wireless sensors formed a network that was able to monitor an individual's movements about their home. The collected information was time stamped and relayed to a database running on a remote server via a gateway node. This node was equipped with a sensor board that enabled it to make a connection via a cellular network.

Security aspects of the system included the encryption of data for transmission between nodes in the wireless sensor network and across the cellular network. The students also noted issues relating to the security of the data within the data base.

Future plans included the use of an additional sensor to be carried by the person so that their movements could not be confused with those of other family members, care workers etc. Another proposal was the generation of alerts if the individual appeared to remain stationary for too long. The nature of these alerts was considered e.g. an initial alarm that rang in the house to which the person could respond or the generation of an alert to a neighbor, care worker etc.

The team initially focused on ethical issues surrounding the security and integrity of the data collected; they did not envisage the need for ethical approval for the testing of their system as it was "attached to doors, not people". However, as the project evolved issues such as the intrusiveness of monitoring individuals in their own home were considered. The team also developed their sensitivity to the issues surrounding the testing of systems with human volunteers, appreciating that their proposed systems needed to be looked at from a number of ethical vantage points e.g. making sure their wearable sensors were as unobtrusive as possible and that testers were fully briefed on all aspects of the study.

C. Symptom Logger

This team of students focussed on tracking an individual's well-being over a number of days or weeks, allowing for the reporting of symptoms e.g. headache, nausea. The system was a mobile application which allowed individuals to log their symptoms as they occurred and also generated alerts to encourage people to log information on their well-being.

It was felt that this system would be suitable for those who experience difficulties remembering information that occurred in the close past i.e. those experiencing difficulties with their recent long-term memory. These individuals may have no difficulties functioning from day-to-day but may not be able to recall what they had for breakfast two days ago or if they were feeling poorly last week. It was also felt that such a system might be suitable for those unwilling to share intimate details in face-to-face consultations with medical practitioners.

The interface was designed to be as uncluttered and simple as possible. The individual was able to record their well-being on a Likert scale [8] and were then encouraged to record their symptoms in a text box. It was noted that the questions asked could be tailored to suit any known medical problems the user was having or to use existing medical questionnaires such as those for the assessment and management of pain.

The system allowed the individual to view the history of the data they had entered, and to make changes to it. However the original information and the amendments made were logged and reported to the clinician. The system allowed the clinician to view information relating to individual patients or to all patients under their care. The application was implemented on the Android platform and it was envisaged that it could be used on either a smart phone or tablet.

The initial ethical issues considered were the loss or theft of the Android device on which the logger was running, along with the secure transmission of the data from the device to the medical practitioner. However, as the project evolved the focus shifted to the recording of data and allowing an individual to edit or delete historic entries. The team engaged in strong debates on whether it was ethical to allow the clinician to view entries that had been deleted by the patient. Concerns were raised about use of the application by family members or care givers rather than by the individual themselves, possibly leading to data that was difficult to interpret. One suggestion was that those involved with the care of the individual could be given their own mobile applications to record their views of the patient's well-being. The team reached the conclusion that they would have to work closely with those with a good knowledge of medical ethics in order to solve these issues.

VI. Evaluation

Quantitative data was gathered on the students' opinion of the assignment, its impact on their ethical awareness and their familiarity with wireless devices. This is illustrated in Figure 1 below. The survey also assessed the relationships between the assignment objectives, learning outcomes and technical environment. Students were asked to provide qualitative feedback along with the final report on their work.

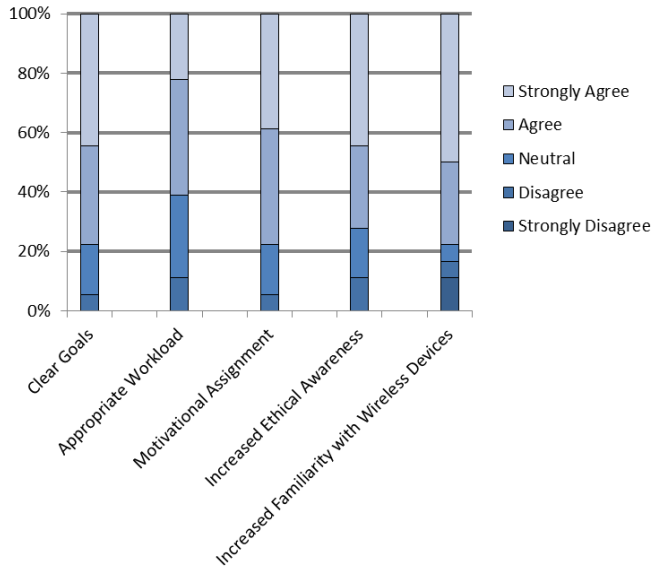

Fig. 1. Summary of Quantitative Evaluation.

A questionnaire relating to the assignment objectives was completed by the students. This showed that 84% of students agreed that 'Creating a novel healthcare application that makes maximal use of the available wireless technologies' was a feature of both the assignment and its assessment criterion. Over 81% of the students also agreed with the statement that the assignment 'Encouraged them to think more deeply about the ethical nature of their work'; while 76% of the students felt that 'Building a working prototype was a key component of the assignment'.

Analysis of the qualitative data confirmed that the students enjoyed working on a real-world problem. They commented that this made the project more meaningful and relevant. They were also very enthusiastic about being given a wide range of wireless technologies with which to work. Some commented that this freedom of choice meant they were truly in charge of the design of their system, in marked contrast to other coursework assignment and projects they had worked on during their undergraduate career. Many mentioned that they experimented with all of technologies available before making their final design choices.

Many students commented on the nature of the ethical challenges they had to consider and how this made them think about ethics in a different light; as one student commented: "Ethics are everywhere".

Some expressed frustration with the operational structure of their groups, for example one student felt that another took control of all of the implementation work and this led to feelings of exclusion. Another common frustration was with the challenges of working with new technologies where not everything works as anticipated or documented; this led some to feel the level of support and guidance given was not as high as they would like it to be.

VII. Conclusion

Wireless devices have become ubiquitous and are weaving their way into all aspects of human life and endeavor. They are having an increasing impact on the way individuals live, work, learn and play. The novel laboratory assignment seeks to provide senior undergraduate students with hands-on experience with a wide range of wireless devices, whilst also increasing awareness of the ethical issues surrounding their use in the development of real-world technologies.

References

[1] ABET, "Criteria for Accrediting Engineering Programs, Effective for Reviews During the 2014-2015 Accreditation Cycle", available at: http://www.abet.org/uploadedFiles/Accreditation/Accreditation_Step_by_Step/Accreditation_Documents/Current/2014_-_2015/E001 2014-15 20EAC 20Criteria 203-13-14(2).pdf (accessed 15 June 2014).

[2] James H. Moor, "Why We Need Better Ethics for Emerging Technologies," *Ethics and Information Technology*, Vol. 7, No. 3, pp111-119, 2005.

[3] Brock E. Barry and J. R Herkert, "Engineering Ethics," in A. Johri and B M. Olds (Eds.) *Cambridge Handbook of Engineering Education Research*, Cambridge, pp.673-692, 2014.

[4] Hamad, J.A.; Hasanain, M.; Abdulwahed, M.; Al-ammari, R., "Ethics in Engineering Education: A Literature Review," in Proc *43rd Annucal Conference Frontiers in Education Conference*, IEEE, pp.1554,1560, 23-26 Oct. 2013.

[5] M. Huggard and C. Mc Goldrick, "Unlocking the Laboratory: autonomous wireless sensor authentication in practice," *Campus-Wide Information Systems*, vol. 30, issue 4, pp.308-316, 2013.

[6] M. Huggard and C. Mc Goldrick, "Practical Positioning Projects: Location Based Services in the Laboratory", in Proc. *35th Annucal Conference Frontiers in Education Conference*, IEEE, pp.S3F-1, 19-22 Oct. 2005

[7] M. Huggard and C. Mc Goldrick, "Computer Experience - Enhancing Engineering Education", in Proc. *International Conference on Engineering Education*, pp.T4C-21 - T4C-25, August 2006.

[8] Muhammad Mubashir, Ling Shao and Luke Seed, "A survey on fall detection: Principles and approaches," Neurocomputing, vol. 100, pp. 144-152, 2013.

[9] R. Likert, (1932) "A Technique for the Measurement of Attitudes", *Archives of Psychology*, vol. 140, pp.1–55, 1932.