WEARABLE COMPUTERS: WHAT'S IN IT FOR SCHOOLS? OPPORTUNITIES AND RISKS

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Abstract

This paper presents and discusses the preliminary findings of an on-going experimental study on the use of wearable technologies (the FitBit Surge) at a secondary school in Norway. The purpose of this project is to gain a deeper understanding of the types of challenges and possibilities that wearable computing can have for schools. Taking a socio-technical-educational approach, a researcher-driven experimental study was designed wherein we tested the ability of wearable computers to support and strengthen mathematics learning activities. For a two-week period, pupils were equipped with a smart watch that they used during their time at school. The smart watch was also used during their physical education sessions, and their movement and heart rate as well as such localisation data (GPS coordinates) as longitude, latitude and altitude were tracked. These personal data were later used in the students' mathematics class in an effort to help them learn how to interpret tables, create charts and understand mathematical concepts such as average, median, etc. Data were collected by means of observation and documented via field notes and video recordings of the pupils' activities as well as through in-situ interviews with the pupils and teachers. The purpose of putting these learning prototypes into practice was to gain a deeper understanding of how such personal devices might be adopted in a concrete classroom context. Preliminary findings indicate that for teachers to incorporate and implement wearable technologies into the classroom, a considerable amount of time, effort and advanced competency is required.

Keywords: Smart Watch, Wearable computing, Learning design

1 INTRODUCTION

In *Understanding Media: The Extensions of Man* [1], Marshall McLuhan proposes that all media are essentially extensions of ourselves and serve to provide a new transforming vision and awareness. Without delving deeper into McLuhan's pioneering work from 1964, suffice it to say that he was foresighted, as evidenced by today's explosive development of wearable technologies.

Over the last decade, there has been an outpouring of mobile computers available to the consumer market. Admittedly, what we now refer to as smartphones have existed since the early 2000s; however, it was not until the launch of the iPhone in 2007 that the development of such technologies had a true impetus to become widespread. A few years later in 2010, the tablet was introduced to consumers. Recently, an explosion of wearable computers have become available to consumers. As of September 2016, Vandrico's wearable device database (http://vandrico.com/wearables/) lists 447 available devices across a range of sectors, including those that may be used for entertainment, fitness, gaming, industrial purposes, lifestyle maintenance and medical tracking—there are even wearables for pets and animals. All of these devices offer wireless connectivity to other devices and applications and open up new opportunities for educators.

The Horizon report describes wearable computers as a technology that will find its place in education in four to five years. The relevance of wearable technologies to education is still somewhat vague, and while there is a range of research literature concerning the development and use of wearables across a wide range of fields and disciplines, educational applications are not examined in the main bulk of this literature [2]. It is not an exaggeration to claim that wearable technologies are still at an early stage of their development, and therefore no one yet knows how wearable technologies will be used or what applications they may have to education in the future. The limited amount of literature on the subject may also indicate that the possible applications of wearable technology are not seen as suitable for teaching and learning.

From a technological perspective, we observe a trend wherein mobile media such as smartphones and tablets are becoming increasingly personal. Mobile media are typically designed as individual devices rather than as multiuser systems, as is the case for most desktop computers. These issues pose several challenges for schools. First, schools face technical challenges when attempting to de-personalise mobile and wearable technologies so that they might fit into a classroom context. Second, and perhaps more challenging, is the issue of protecting students' privacy. Setting up and configuring a wearable computer—a smart watch, for example—implies filling the device with all manner of personal data, such as the students' height, weight, age, gender and other forms of sensitive personal information. While new digital media have been characterised as personal media (as opposed to traditional mass media) [3], wearable technologies take this concept a step further and can be understood to be *hyper personal media*.

The use of wearable technologies requires, in most cases, the support of various sensors used for the measurement of information. Such sensors might include those necessary for the measurement of positioning, pace, acceleration and other mechanical data. Various sensors may also measure biological information such as one's heart rate and body temperature as well as environmental information such as temperature and humidity. The past few years have witnessed an evolution in this area; wearables, which were once individual devices used in isolation, have now shifted and are becoming more social-oriented. With modern wearable technologies, users can share and exchange fitness data, play games and communicate with one another.

2 WEARABLES IN EDUCATION

There are few empirical studies that examine the use of wearable technologies in education [2]. Yamauchi and Nakasugi [4] conducted an early experiment wherein they utilised displays attached to the heads of students during history education courses. Students were presented with scenes from both the past and the present in an attempt to enable them to acquire a more visual impression of history by allowing them to view the actual places where important events had taken place. In a more recent study, Wu, Dameff and Tully [5] tested the use of Google Glass in medical training. The research team concluded that wearable devices have the potential to offer unique possibilities in roleplay-based learning contexts. Another study examined the use of Google Glass [6] in educational psychology, and the researchers concluded that this technology fits seamlessly into the lessons, allowing students to take photographs and video recordings of learning activities. One of the pedagogical benefits of using wearable technology in education is that it provides students with the opportunity to record their lessons, search online for clarifying information during class or take notes during group-work that can then be shared with all other group members [6]. Certainly, there are many possibilities and issues associated with the use of wearable technologies. However, in order for teachers to integrate wearable technologies into their learning designs and to effectively use them in the classroom, teachers must first understand their use potentials [2, 7]

3 FRAMEWORK FOR ICT IN NORWEGIAN SCHOOLS

In order to understand the role information and communication technologies (ICT) in Norwegian primary and secondary schools, we must examine the 2006 curriculum reform [8], which defined digital literacy as the possession of one of five basic skills (the ability to read, write, engage in numeracy and demonstrate oral and digital skills). According to the current national curriculum, ICT is meant to support all learning activities. This is challenging, as while four of the skills are directly connected to specific subjects, ICT is not [9]. Teachers are meant to integrate ICT into every subject area in order to enhance students' learning. Consequently, schoolteachers' skills in the use of computers as pedagogical tools are obvious prerequisites for the adequate implementation of ICT [10]. Teachers are faced with a situation wherein they must know how to teach students the practical use of ICT; furthermore, they must also possess a pedagogical strategy that defines how ICT should support and enhance learning in all subject areas. Integrating ICT in all subject areas is also challenging from the point of view of school management [11]. The need to encourage practical ICT skills amongst teachers and pupils is therefore evident: these skills are required for the support of other learning activities. Additionally, digital literacy is seen as an important knowledge area in its own right, as it will allow students to participate effectively in a modernised society.

4 THE CASE STUDY

The idea for this case study materialised from experience that several colleagues and I had with a project that researched the use of tablets in schools [12–14]. One of the challenges that schools were faced with when implementing tablets as a replacement for desktop computers and laptops involved the fact that the tablet was designed as a personal medium. Rather than being designed as a multiuser system, as is the case with most desktop computers, the tablet was conceived as an individual device.

As previously mentioned, ICT should, as a basic skill, be integrated into every subject at every level in Norwegian schools. This argument also applies to other basic skills; along with ICT, the practice of numeracy should also take place within such subjects as language learning, home economics and physical education. In a situation where mobile technology is becoming increasingly connected to the individual user, and where guidelines in the curriculum stress the importance of integrating basic skills into every subject, the idea was born to test the use of smart watches in a secondary school.

The aim of our research was therefore twofold. First, we wished to more closely examine how a wearable device could, technologically, fit into an upper primary classroom context. Second, we sought to look deeper into the question of whether a smart watch could be used to strengthen mathematics learning.

Given the fact that wearable devices are still under heavy development, we were well aware of the fact that we would be studying an immature technology, at least in terms of its use in an educational context. Unlike traditional computers and handheld devices such as tablets, wearable computers are rarely found (if they exist at all) in schools. I believe that we are still some years away from a world where schools invest in wearable devices and where teachers bring them into their lessons of their own initiative. In order to test the pedagogical use of wearable computers in education, we were obliged to pursue a more researcher-driven design where we, as researchers, brought the technology to the school.

4.1 The experiment

Regarding the available selection of wearable technologies, smart watches aimed at fitness and health improvement are among the most widespread. These devices often contain sensors used to measure heart rate, pace and location (longitude, latitude and altitude). They also (often) have predefined settings that are suitable for different workout situations. Additionally, the data produced during workouts and exercises can be shared with friends over the Internet in order to facilitate competition or to encourage users to motivate one another to be more active.

Within these technological frameworks, the pedagogical idea was born to gather the data produced during exercise and incorporate it into mathematics lessons. We designed an experiment wherein pupils were instructed to use a smart watch during their physical education classes and thereafter bring their own physical data into their mathematics classes. The objective of this approach involved an assumption that performing calculations and creating estimates of numbers (data) that the pupils had produced themselves during previous physical education classes would, potentially, serve to make abstract numbers and figures seem more contextualised and concrete. Furthermore, we also believed that performing calculations that concerned their own bodily movements would be a motivating factor.

Assessing the relatively large selection of smart watches that are available on the market (during the summer of 2015), we made the decision to use the FitBit Surge in our experiment. At that time, the FitBit Surge model had an inbuilt GPS for tracking location as well as sensors used to measure pulsations. Additionally, the FitBit Surge model allowed for the wireless syncing of data to either smartphones or computers via the Bluetooth protocol.

Figure 1: The FitBit Surge

The data synchronised from the watches following each physical exercise session were then posted to a personal repository web page at fitbit.com. Logging in to one's personal web site at fitbit.com would provide detailed information about recent activity as well as statistics regarding activities carried out during the previous months. Utilising the watch's GPS-tracking capabilities, information regarding runs and mobile exercises was presented in detail on a map; such data included information about longitude, latitude and altitude, recorded with an update frequency of 500 milliseconds. Next, those data were then exported and downloaded to a computer as an xml format file (Training Center XML—TCX). Via converter software installed on the computer, the xml file was once more converted into a comma separated values file (CVS). Presented as a CVS-file, the data was then imported into a spreadsheet application like Microsoft Excel, where the data was presented as numbers in cells and columns.

	A	B	C	D	E	F	G	H	I	J	K
1	UNIX TIME	TIME	LAT	LONG	ALT	DIST	HR	CAD	TEMP	POWER	
2	1461573781	2016-04-25T	59,884923	10,825906	108,6	0	99	0	No Data	No Data	
3	1461573786	2016-04-25T	59,884923	10,825906	108,6	0	99	0	No Data	No Data	
4	1461573791	2016-04-25T	59,884923	10,825906	108,6	0	100	0	No Data	No Data	
5	1461573796	2016-04-25T	59,884923	10,825906	108,6	0,002	102	0	No Data	No Data	
6	1461573801	2016-04-25T	59,884923	10,825906	108,6	0,012	103	0	No Data	No Data	
7	1461573806	2016-04-25T	59,884923	10,825906	108,6	0,024	107	0	No Data	No Data	
8	1461573811	2016-04-25T	59,884923	10,825906	108,6	0,035	111	0	No Data	No Data	
9	1461573816	2016-04-25T	59,884923	10,825906	108,6	0,046	118	0	No Data	No Data	
10	1461573821	2016-04-25T	59,884923	10,825906	108,6	0,057	122	0	No Data	No Data	
11	1461573826	2016-04-25T	59,884923	10,825906	108,6	0,067	126	0	No Data	No Data	
12	1461573831	2016-04-25T	59,884923	10,825906	108,6	0,074	129	0	No Data	No Data	
13	1461573836	2016-04-25T	59,884923	10,825906	108,6	0,08	129	0	No Data	No Data	
14	1461573841	2016-04-25T	59,884923	10,825906	108,6	0,087	136	0	No Data	No Data	
15	1461573846	2016-04-25T	59,884923	10,825906	108,6	0,092	135	0	No Data	No Data	
16	1461573851	2016-04-25T	59,884923	10,825906	108,6	0,092	134	0	No Data	No Data	
17	1461573856	2016-04-25T	59,884923	10,825906	108,6	0,092	133	0	No Data	No Data	
18	1461573861	2016-04-25T	59,884923	10,825906	108,6	0,093	134	0	No Data	No Data	
19	1461573866	2016-04-25T	59,884923	10,825906	108,6	0,098	134	0	No Data	No Data	
20	1461573871	2016-04-25T	59,884923	10,825906	108,6	0,105	132	0	No Data	No Data	
21	1461573876	2016-04-25T	59,884923	10,825906	108,6	0,11	129	0	No Data	No Data	
22	1461573881	2016-04-25T	59,884923	10,825906	108,6	0,119	130	0	No Data	No Data	
23	1461573886	2016-04-25T	59,884923	10,825906	108,6	0,127	132	0	No Data	No Data	
24	1461573891	2016-04-25T	59,884923	10,825906	108,6	0,135	130	0	No Data	No Data	

Figure 2: TCX output

The above illustration demonstrates how exercise data taken from the smart watch was presented when it finally reached the conclusion of the export and conversion process. Columns A and B display the time stamp, and Columns C and D indicate location data. Column F shows distance, and Column G displays the user's heart rate.

4.1.1 Applying the research design at the school

In preparing the collected data, it became clear to us that the process of accessing each individual's web portal at fitbit.com, exporting the data into a tcx file and then converting the tcx file into a file format that would be readable by spreadsheet applications was far too complicated for the average pupil in secondary school. Moreover, it would have been impossible for one single teacher to complete such a task n the time between the physical education class and the mathematics lesson. We therefore decided to concentrate our data collection within a time frame of two intensive weeks; during this time, two members of the research team would be present at the school to conduct all necessary conversions.

Another issue that emerged during the planning of this experiment involved considerations of the pupils' privacy and vulnerability. Setting up and configuring a smart watch (such as the Fitbit Surge) requires that the user fill the device with personal data involving one's height, weight, age, gender and other forms of sensitive information. Such hyper-personal data have the potential to stigmatise those pupils who feel themselves too short or too tall, or who are either more or less physically mature than their average classmates. A pragmatic solution to this problem was to preconfigure all the watches used in the experiment with a fixed height and weight.

Eight girls and thirteen boys participated in our experiment. Accordingly, we configured the 'girl' clock with data based on the average height and weight of a thirteen-year-old girl in Norway; we did the same for the 'boy' clock using that population's average data. Using such an approach, we felt secure that the students' personal data would not be compromised and that our research would not contribute to any potential ongoing discussions of height and weight among the pupils.

4.1.2 Activities at the school

In preparing for data collection, the school's headmaster put us in contact with a teacher who had the same class for both mathematics and physical training. He rescheduled his thematic plan in mathematics so that issues such as reading tables, calculating averages, making and understanding charts and diagrams and learning how to use computer spreadsheets (Microsoft Excel) fit into our time frame.

Figure 3: Introduction to the pupils

As previously mentioned, two weeks were set aside for the experiment. The pupils were first given an introduction to the project and then were presented with a time table that listed when the various activities should take place. At the conclusion of the first lesson, the pupils were given the preconfigured smart watches. After the break, the pupils gathered at the computer lab for an introduction to spreadsheets. For the remainder of the day, the pupils were engaged in other subjects and activities.

Figure 4: Physical training

Two days later, the pupils engaged in a physical training lesson. They were instructed to initiate the activity tracker on their smart watches, after which point the teacher proceeded with his lesson as usual, giving them different physical tasks and exercises to complete. The various assigned tasks were crafted to ensure that there was a mix of moderate and high physical strain. Between the assorted activities, the pupils sat on the floor and were given instructions.

During their lesson in mathematics the following day, the pupils began to perform calculations using the data they had themselves produced during their physical training session. It is important to add that the pupils did not have any previous experience or training in the use of spreadsheets prior to their introductory lesson just a few days earlier. In addition to analysing and interpreting the data, the pupils also had to familiarise themselves with a relatively complex user interface full of advanced mathematical symbols they never before seen.

Figure 5: Performing calculations on bodily data

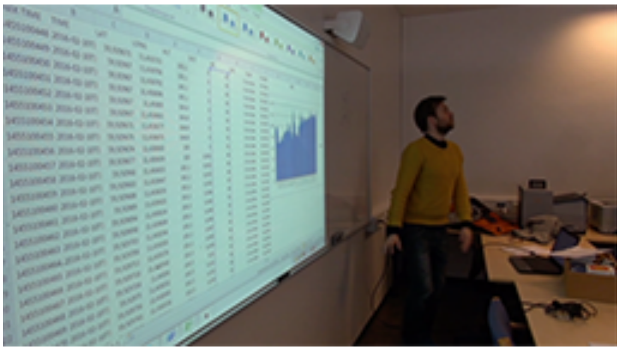

Figure 6: Performing calculations on bodily data

A good deal of the teacher's time in class was spent explaining the user interface and the functions of the spreadsheet application. The pupils were introduced to the relationship between cells and columns and were taught how cell addressing works. Following this introduction, the pupils were instructed how to calculate an average of the values of a column. The column representing the user's heart rate was chosen for this particular exercise. First, the pupils calculated their average heart rate during their previous physical training session. Then, they were instructed to create a diagram using data from the column representing their heart rate and the column representing time. Other calculations and diagram compositions were also attempted; for example, a plotted diagram with data from the columns representing latitude and longitude was created.

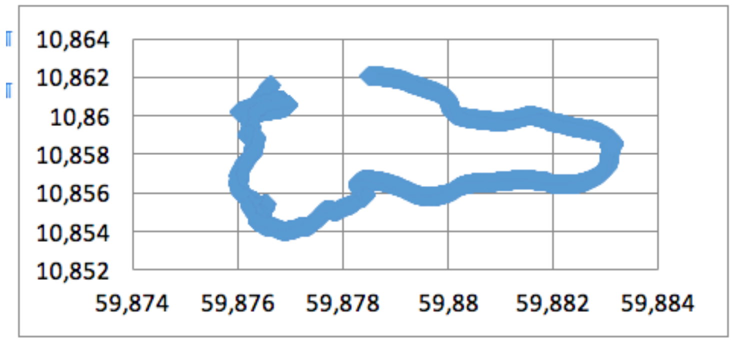

Figure 7: A chart showing movement based on longitude and latitude

It would be pure speculation to question whether the situation would have been different if the pupils had obtained a higher competence in the use of spreadsheets before entering the project. On the one hand, one might argue that if they had a greater competence, they would have spent less time interpreting and understanding the spreadsheet's user interface. On the other hand, there are reasons to believe that the data content functioned as a motivating factor, thereby contributing to an increased sense of joy and strengthened learning.

5 SUMMARY, CONCLUSION AND DIRECTIONS FOR FURTHER WORK

This paper reports on a two-week experimental study on the use of wearables in a secondary school in Norway. The pedagogical rationale behind this case study was based on an assumption that performing calculations and estimates of figures that had been created by the pupils themselves would increase the relevancy of abstract numbers and figures and make them seem more concrete. Additionally, we sought to gain a deeper understanding of the conditions and frameworks necessary for the implementation of wearable devices, such as smart watches, in education.

In planning and preparing this project, we were fully aware that we, in an educational context, were introducing a new and immature technology that is associated with various shortcomings. The transmission of data from the smartwatches via an online service to computers was complex and time consuming. This obstacle could have been solved if the pupils had enjoyed access to a smartphone or tablet that they could have used to carry out the process themselves. However, such a practice would have demanded considerably more pupil instruction time and may have increased the risk of data loss. Another crucial issue in this experiment was the necessity of protecting the pupils' privacy. Our pragmatic solution to this challenge was to de-personalise the parameters when configuring and preparing the devices. Average weight and height figures for girls and boys were used in combination with fictive names and e-mail addresses. Allowing the pupils to configure and set up the devices on their own would have increased the risk of compromising their privacy.

Technological shortcomings and other practical issues regarding the use of computers in education can be solved. Especially in this case, the further technological development of wearable computers will likely lead to improved and additional features, making wearable computers more appropriate for an educational context. In terms of privacy issues, there is unfortunately less cause for optimism. Mobile devices such as smartphones and tablets are largely designed as personal devices. Bringing them into schools implies a special set up and configuration process that tweaks the intended design; however, such tweaks are necessary in order to compel them to fit within a classroom context. The wearable devices used in this experimental case take this issue a step further. Despite our precautions to de-personalise the bodily data sent to each watch (with the exception of gender), the pupils bodies were indeed tracked, and their physical movement was recorded. Bringing such devices into schools and allowing minors to use them requires extensive knowledge and oversight on the part of teachers and/or facilitators; such parties must, in particular, be able to protect their pupils' privacy. As computing has become more and more cloud-based in recent years, challenges related to privacy have increased for those in the field of education.

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