Perceived Utility and Feasibility of Wearable Technologies in Higher Education

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Abstract. With the capacity to provide hands-free access to contextually relevant information, wearable technologies have the potential to transform many aspects of learning and teaching. Yet to date the uptake of wearable technologies in higher education has not been fully realised. This study examined the perceptions of educators (n=202) regarding the utility and feasibility of applying wearable technologies in tertiary education contexts, in an attempt to understand their under-utilisation. Results indicated significant differences between the perceived utility and feasibility in most of the use-cases examined, with the utility significantly exceeding the feasibility in the four wearable technology use cases deemed of greatest potential benefit. The impediments to achievability included cost, technological issues, distraction, privacy, and resistance to change. Implications for educators and higher education institutions are discussed.

Keywords: *wearable technologies, utility, feasibility, higher education.*

1 Wearable Technologies and Their Under-Utilisation

Wearable technologies can be defined as wearable digital devices that often incorporate wireless connectivity for the purposes of seamlessly accessing and exchanging contextually relevant information (Bower and Sturman 2015). As at 21st of June 2016 there were 436 devices in the Vandrico Wearable Technologies database (Vandrico 2016) across a range of industries including fitness, medical, entertainment, industrial, gaming and lifestyle sectors. Examples of already popular wearable devices include: Fitbit, Nike+, Misfit and Jawbone wristbands, Apple and Garmin watches, Oculus Rift, Google Glasses and Google Cardboard headsets, and “newcomers” such as Xiaomi bands, Samsung Gear, Epson Moverio, Microsoft HoloLens, Magic Leap’s lightweight AR, AMD Sulon and Meta One (Wareable 2015). It is predicted that in a few years the wearable technology market will be several times larger than it is currently (Page 2015).

Early examples of wearable technology usage in education include rendering 3D objects for mathematics and geometry education (Kaufmann et al. 2000), supporting situated learning in authentic contexts, e.g. field trips to natural environments (Rogers et al. 2002), learning history in the actual places that it occurred (Yamauchi and Nakasugi, 2003), and students as agents in participatory simulations (Colella 2000). More recently, universities have commenced investigating how wearable technologies could be integrated into the curriculum through introductory workshops (Macquarie University Learning Technology Research Cluster 2015; University of Canberra 2014). However, there are generally few examples of uptake in actual courses (exceptions are discussed below). One of the reasons that wearable technologies may be under-utilised is because educators do not deem their use to be of sufficient pedagogical value. Another reason that they may be under-utilised is that educators feel that it is not feasible for them to implement wearable technologies in their classes.

This study examined university educators’ (n=202) perceptions of the utility and feasibility of deploying wearable technologies in specific contexts. Qualitative data was also used to explore why wearable technologies might be under-utilised in tertiary education.

2 The Potentials and Limitations of Wearable Technologies

Wearable technologies can incorporate a wide range of sensors for measuring mechanics (position, displacement, acceleration, force), acoustics (volume, pitch, frequency), biologics (heart rate, temperature, neural activity, respiration rate), optics (refraction, light wave frequency, brightness, luminance) and atmospherics (temperature, humidity) (Barfield & Caudell, 2001). Using captured data enables wearable devices to be ‘aware’ in so far that they can recognise, adapt and react to their owner, their location and the activity being performed (Viseu, 2003). This constitutes a paradigmatic shift from digital simulation (replication and separation) to digital augmentation (connectivity and responsiveness) (Viseu, 2003).

Outside education wearable devices have been used in health care to support medical diagnosis, movement disorder therapy, and drug administration (Son, et al., 2014), for care of the elderly by tracking people with Alzheimer’s disease (Mahoney & Mahoney, 2010), and to enable face recognition and subsequent overlay of personal information using augmented reality (Kim, 2003). However, there is a scarcity of recent research into the use of wearable technologies in education (exceptions include Coffman & Klinger, 2015; Wu, Dameff, & Tully, 2014, as discussed later in this paper).

Yet, wearable technologies offer a wide variety of potentials (or ‘affordances’) to educators. Pedagogical affordances of wearable technologies include the ability to offer in-situ contextual information, recording, simulation, communication, first-person view, in-situ guidance, feedback, distribution and gamification (Bower and Sturman 2015). Wearable technologies offer other affordances in terms of educational quality (engagement, efficiency, and presence) and logistical implications (hands-free access, and freeing up spaces) (Bower and Sturman 2015).

The use of wearable technologies in higher education has been claimed as a high interest research field by the advisory board of the 2014 NMC Horizon Report Australia Edition (Johnson et al. 2014). There are a few instances where universities are already using wearable technologies in their curriculum. Google Glass has been used during medical training role-play activities to provide a first-person viewpoint and the ability to record activity (Wu, Dameff and Tully. 2014). In another recent trial teachers and students were provided with access to Google Glass during educational psychology and organisational behaviour classes in order to take pictures of student work, video record class activities, access the Internet and poll students for responses to questions (Coffman and Klinger 2015).

Universities in Australia are starting to integrate wearable technologies into their curriculum. The University of NSW has started using virtual reality (VR) head-mounted displays in engineering (UNSW Engineering 2014), and the University of Western Australia has used Fitbits in their Self eHealth Challenge (Glance et al. 2016). Other Higher Education examples include using virtual reality headsets to create a serious game that promotes wildlife conservation awareness, using the Emotiv EPOC EEG system to learn cognitive and brain sciences, and using Oculus Rift to provide pre-service teachers with a virtual practical experience (Alvarez et al. in press). These examples demonstrate the potential to help students learn in new and more effective ways.

However, these examples notwithstanding, wearable technologies are far from entering the mainstream of learning and teaching. To that end we investigate the extent to which low perceived utility or perceived difficulties in implementing wearable technologies may exist amongst tertiary educators.

3 Methodology

In order to ascertain the perceived usefulness and feasibility for various educational affordances of wearable technologies, an online survey was designed to elicit the insights of Higher Education experts in the learning technology field. The first part of the survey included demographic items relating to the respondents' institution, country, teaching areas, age, years of teaching experience, and gender. This section also asked respondents to rate their ability to use computers and the Internet for learning and teaching, as well as to rate their knowledge of wearable technologies. Both of these were answered on a 5-point Likert scale ranging from ‘very poor’ to ‘very good’.

Respondents were then asked to rate the usefulness of eight specific use cases as well as the ease with which the use cases would be achieved. Specific use cases were provided so that participants could clearly imagine and rate the utility and feasibility of wearable technology usage. The selection of cases was based on the discussions between members of the research team, based on their knowledge and experiences with wearable technologies in order to represent a wide range of generally applicable learning and teaching possibilities. Google Glass and Oculus Rift were used as examples in order to provide respondents with concrete examples of what is meant by ‘wearable technologies’. The following use cases were presented:

- Demonstrations from the first-person perspective from locations that are difficult for students to access.
- Simulated experiments or situations that would otherwise be potentially hazardous for students.
- Students being able to text questions during classes, which then appear in teachers' field of vision.
- Being able to control lecture slides during a lecture via voice command or other unobtrusive means.
- Having students wear Google Glasses or similar during practicum placement so that they can be advised discreetly in real-time.
- Quickly accessing references, stored data and information from the Internet during classes.
- Providing remote students with wearable technologies so that they can participate and be more involved in live classroom situations.
- Offering wearable technologies to students with sight or hearing difficulties so that they can receive live audio or text translation of resources or conversations.

For each use case, respondents indicated their agreement to two direct statements; "this would be useful" (utility) and "this would be easily achieved" (feasibility). Level of agreement was measured on a 6-point Likert scale ranging from 0 'strongly disagree' to 5 'strongly agree', with an alternative 'unsure' option also available. Respondents were also given the option to clarify any of their ratings with a written response.

Calls to participate in the survey were distributed to the members of the following scholarly organisations via their respective websites and/or electronic mailing lists: Australasian Society for Computers in Learning in Tertiary Education, Open and Distance Learning Association of Australia, Higher Education Research and Development Society of Australasia, European Distance and E-learning Network, Asia-Pacific Society for Computers in Education, International Forum of Educational Technology and Society, Professional and Organization Development Network in Higher Education, Society for Teaching and Learning in Higher Education (Canada), and Association for Learning Technology (UK). The Call was also posted to several other online learning and educational technology networks and communities such as ITFORUM, MirandaNet, WWWEDU, and DEOS (Distance Education Online Symposium), as well as shared with various special interest groups of the American Educational Research Association, EDUCAUSE, and the Joint Information Systems Committee (UK). Additionally, a number of smaller professional societies focused on specific areas relevant to or associated with the topic of the present study (e.g., mobile learning, virtual/augmented reality in education) were targeted. In all, over 30 national and international channels were used to disseminate the call.

The survey was opened from the 29th of September 2014 to the 24th of November 2014. It resulted in 322 responses from 16 different countries. Participants that did not provide complete demographic data were removed from the sample, as were those that did not complete at least a pair of utility-feasibility ratings for one of the eight cases. This resulted in a sample of 202 participants. This included 110 females and 92 males with a mean age of approximately 45 years old. On average the respondents had been teaching in Higher Education for approximately 11 years and had been using the Internet for learning and teaching for 14 years.

Quantitative data were analysed using Microsoft Excel. Descriptive statistics were examined and paired-samples t-tests were carried out. In order to facilitate comparison of ratings responses were removed if they did not form part of a utility-feasibility pair, as were responses of 'unsure'. A Bonferroni adjusted significance level of $0.05/8 = 0.00625$ was used to account for the fact that eight tests were being conducted. Qualitative data analysis techniques were applied to analyse any clarifications or explanations provided by respondents.

Qualititative analysis was performed using the NVivo 10 Computer Assisted Qualitative Data Analysis Software (CAQDAS) system using thematic analysis techniques in accordance with Neuman (2006). An initial open coding phase focused on classifying any key themes. This was followed by an axial coding phase, which incorporated a refinement of categories through repeated revision of the data, and also provided the opportunity to consolidate consistency of coding and category demarcation. Lastly, in a selective coding phase, the categories were once again revisited to select epitomic responses, as well as pertinent responses that may not have been representative but held insight with relation to the category or theme in question. The selective coding phase provided a further opportunity to revisit the categorisations to uphold consistency of classification. Both the quantitative results and the results of the coding process are presented. Quotes are used when describing key themes in order to promote accuracy of reporting.

4 Results

The quantitative results from the survey are shown in Table 1, in descending order of average perceived utility. The results are also shown below in graphical form to visually represent the differences between average ratings (see Figure 1). It can be seen from the graph that educators on average ‘agree’ to ‘strongly agree’ that wearable technologies would be useful to provide support to those with sight or hearing difficulties, to perform demonstrations from the first person perspective, to simulate hazardous experiments, and to promote greater participation in live classroom situations. However for each of these use cases, participants provided a significantly lower rating of the feasibility (between ‘mildly agree’ and ‘agree’). Having students use wearable technology to receive advice was perceived as less useful (between ‘mildly agree’ and ‘agree’) but was still considered significantly more useful than it was feasible. Educators felt that having students text questions that appeared in the teacher’s field of vision was the least useful use case, but also one they felt was significantly more achievable than it was useful. Using wearable technology to quickly access web-based information or controlling lecture slides via unobtrusive means were considered relatively less useful, with no significant difference between their perceived utility and feasibility.

Across the use cases anywhere between 13 and 29 people out of the 202 respondents (between 7% and 15%) were unsure of the utility or feasibility, or did not provide a response to the use case. The qualitative feedback is helpful in understanding why people expressed different preferences or may not have been sure about the utility and feasibility of using wearable technologies for education.

Table 1. **Tertiary Educator Perceptions of the Utility and Feasibility of Wearable Technology Use Cases**

Use case	**Utility**		**Feasibility**		**n**	**Paired t-test p-value**
	$\bar{x}$	*s*	$\bar{x}$	*s*		
Offering wearable technologies to students with sight or hearing difficulties so that they can receive live audio or text translation of resources or conversations	4.55	0.73	3.46	1.34	175	0.000**
Demonstrations from the first-person perspective from locations that are difficult for students to access	4.36	1.06	3.63	1.05	188	0.000**
Simulated experiments or situations that would otherwise be potentially hazardous for students	4.30	1.13	3.38	1.20	185	0.000**
Providing remote students with wearable technologies so that they can participate and be more involved in live classroom situations	4.10	1.11	3.24	1.34	181	0.000**
Quickly accessing references, stored data and information from the Internet during classes	3.87	1.28	3.82	1.14	187	0.627
Having students wear Google Glasses or similar during practicum placement so that they can be advised discreetly in real-time	3.70	1.34	3.17	1.30	173	0.000**
Being able to control lecture slides during a lecture via voice command or other unobtrusive means	3.48	1.40	3.76	1.15	182	0.008
Students being able to text questions during classes, which then appear in teachers’ field of vision	3.30	1.48	3.66	1.23	189	0.001**

** Denotes significant result using a significance level of 0.05/8 = 0.00625

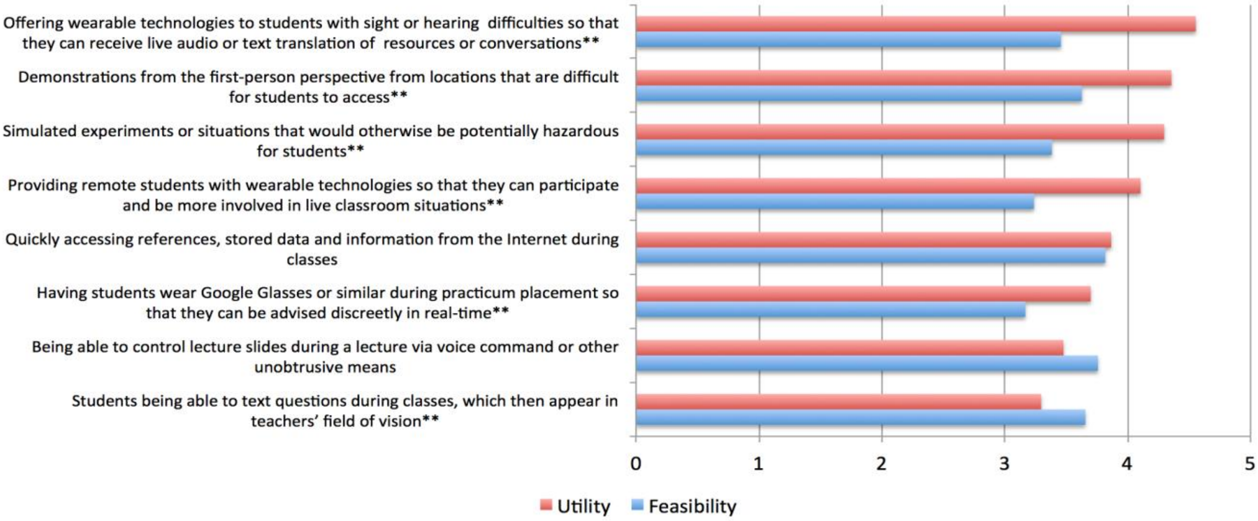

Figure 1. **Graph of Tertiary Educator Ratings of Perceived Utility and Feasibility of Wearable Technology Use Cases**

The most frequently raised issue with relation to the use of wearable technologies for learning and teaching amongst the use cases was **cost** (n = 19 respondents). Several respondents indicated that they felt cost presented the largest hindrance in terms of feasibility ("my biggest concern with the achievability issue across the board is cost"). Respondents also indicated that cost was an equity issue in so far as it would "make ubiquitous access difficult", and particular use cases might be particularly labour intensive ("translation or transcription is labour intensive and too costly for us to achieve in live events").

Technological issues were also a frequently cited impediment to implementation (n = 17). In general terms the approaches were seen to push the boundaries of what was currently achievable, for instance as one participant expressed "I feel that current technology would be challenged in terms of 'realistically' providing an immersive, seamless virtual presence". Interfacing old systems with new was also seen as an issue, for example "it becomes complicated when systems such as proxy servers come into play, do the existing technologies play well with these new technologies?". Streaming of information represented a specific challenge, as one person articulated "I know how difficult it could be to then stream back to the wearer the classroom as we do this just with streaming back to computers and we run into obstacles".

The potential **lack of pedagogical benefit** of wearable technologies within the use cases was also raised by some (n=12). Often this related to particular use cases. For instance in response to controlling presentation slides through audio directives on wearable devices, "why replace the click of a remote with a voice command". In terms of providing remote students with wearable technologies, another participant noted "I don't see why they can not continue using their desktops, worst case, tablets". The quality of information representation on wearable devices was also challenged, for instance when quickly accessing stored data "we can do this with phones and even then this is sometimes very difficult to read/view on a small mobile device - this would be harder on a watch or glass device".

Some respondents thought that the wearable technologies could be **distracting or disruptive** in some of the use cases (n=10). For instance, one participant indicated that "it may be distracting to students if they attempt to access too much info in a lecture/tutorial". On the other hand one respondent expressed that "I think it would be distracting for me as a teacher to see text questions from the class popping up while I'm teaching". One concern was that the wearable devices themselves "may hinder student engagement as the novel technology and not the content becomes more of the student focus".

For a few respondents part of the reluctance to utilise wearable technologies seemed to stem from a **resistance to change** (n=7). As one participant put it "there will be some mild to moderate tech aversion (resistance) from both students and tech-averse staff". Part of the resistance from staff was seen to be due to workload as reflected in the comment that "many university employees, particularly lecturers, are often unwilling to make the time to learn about new technologies".

Privacy and legal issues were also raised by some respondents (n=5), particularly with relation to collaboration during field-work and recording. For instance, in the discipline of education, one participant expressed "wearing technology in the field will be difficult because of privacy concerns… each school district hosting one of our education students would need to form policies about this… it is already difficult and in some districts impossible to take pictures or video". Similarly in health one respondent felt "it would be helpful, but is very unlikely to work due to the confidentiality of health situations - e.g. hospitals". Audio recording was also seen to constitute problems: "there may be legal issues as there is with recording voice conversations".

5 Discussion

Generally speaking the 202 tertiary educators who participated in this study felt that there is utility in using wearable technologies for learning and teaching. Average ratings of utility for four of the use cases lay between 'agree' and 'strongly agree', and for the other four use cases lay between 'agree' and 'mildly agree'. Participants generally had a lower rating of the feasibility of the use cases, with the average achievability rating lying between 'mildly agree' and 'agree'. Importantly, participants on average provided a significantly lower feasibility rating as compared to utility for the four use cases that were deemed to be of most value: offering wearable technologies to students with sight or hearing difficulties, providing a first-person view of demonstrations, simulating hazardous experiments, and promoting greater participation in live classroom situations. Thus it appears support may be required in order for educators to implement many of the most useful applications of wearable technologies.

Based on qualitative feedback respondents provided several reasons that might inhibit the use of wearable technologies for learning and teaching amongst the use cases. Cost, technological issues, lack of perceived pedagogical benefit for some cases, distraction, resistance to change, and privacy concerns were all seen to propose obstacles to implementation. We note that some of these issues were only raised by a small proportion of the overall sample, but that the concerns generally concur with the broad limitations of wearable technologies found in other research (Bower and Sturman 2015).

Given educators clearly perceive benefit in many wearable technology uses but have concerns regarding achieving these uses in the classroom, we propose the following institutional and systemic strategies for supporting the use of wearable technologies in education:

1. Provide funding to support the use of wearable technologies in education based on cost-benefit analysis
2. Offer technical support that enables educators to offer high quality student experiences
3. Conduct professional development that allows educators to understand the potential benefits and limitations of utilising wearable technologies within courses, including how to address issues of student distraction
4. Reflect upon issues relating to privacy and confidentiality and be proactive in forming policy around these matters.

There were limitations to this study. The survey instrument used Google Glass and Oculus Rift as examples of wearable technologies, and this may have biased people in their responses. To temper this concern, we do note the existence of references to other wearable technologies within participant responses, for instance smart watches. Also, comparing Likert scale responses to ordinal utility and feasibility ratings using t-tests could potentially be challenged by researchers. However, we note that this is a common practice within the field, and see this approach as a mathematical (objective) way to provide a measure of difference rather than as a means to absolutely determine whether or not a course of action should be accepted or rejected. We also note that the survey was conducted in late 2014 and the wearable technologies field has changed markedly in that time. The questions were designed to be technologically agnostic so as to be resistant to developments in the fields, however we acknowledge that people's perceptions of wearable technology utility and feasibility may have shifted since the survey was conducted.

6 Conclusion

In this paper we show that tertiary educators generally recognise the value of utilising wearable technologies for learning and teaching in many instances, but factors such as cost, technological issues, distraction, privacy and resistance to change impact on the extent to which implementation is seen to be achievable. The significant gap between utility and feasibility is most evident in the use-cases that are perceived to be most useful, which highlights the importance of support for implementation. We suggest that in order to harness the promise of wearable technologies institutions and systems should provide funding, technical support, professional development, and constructive policy to create an environment where innovation and development can flourish.

In order to fully harness the potential of wearable technologies we also propose that a collaborative approach needs to be adopted. To that extent we call on any people interested in forming part of a community of practice relating to the use of wearable technologies to make contact with the authorial team. In this way we will be able to pursue the goal of enhanced learning and teaching through the use of wearable technologies in a coordinated and constructive fashion.

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