Institution: University of Huddersfield

Unit of Assessment: 11 (Computer Science and Informatics)

Title of case study: Enabling Better Mobile Learning for Digital Skills Development

Period when the underpinning research was undertaken: 2005–2020

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Rupert Ward	Professor Head of Department (2009–2015) Project Lead (iDEA) (2015–2017)	2005 to present
Joan Lu	Professor	2000 to present

Period when the claimed impact occurred: 2014–2020

Is this case study continued from a case study submitted in 2014? No

1. Summary of the impact

Challenges in access to education, and the well-publicized digital skills gap, call for innovative methods and supporting technology to promote education. Research at the University of Huddersfield (UoH) has led to two innovations: WRS, a communication device to give rapid feedback to learners, and iDEA, a learning platform based on sound technology acceptance principles. Together, they have influenced changes in best practice for government and professional bodies, revolutionized professional standards and training, changed educational practice in primary, secondary and higher education, and encouraged continuing personal and professional development and lifelong learning. This impact has been felt by millions of users covering over 95% of the world's countries, delivering worldwide impact in educational attainment.

2. Underpinning research

The success of individuals and the societies in which they live, depends on education. This is particularly true in the field of IT, where there is a well-publicized digital skills gap. This is exacerbated by the fact that at Key Stage 4 only 4% of girls rank IT first in terms of an enjoyable subject, compared to 17% of boys. This has resulted in women being only 20% of the STEM workforce, even though, in the UK, digital skills are required for 82% of online job vacancies [S1].

Digital skills gaps are often discussed in terms of a set of 21st-Century skills that describe the knowledge, skills and behaviours required for success in today's multi-cultural society. A better link is required between 21st century skills development and employment needs, especially in Computer Science [S2] and, globally, millions lose out on learning because they cannot access formal education.

Mobile learning, whereby learners access the curriculum from their phone or tablet, can offer a potential solution to these challenges by mixing formal and informal teaching methods. However, the learning materials must be structured such that they provide the skills needed by industry, satisfy the requirements of exam boards and effectively engage students to learn and retain what they have learned. This requires learning tools that are multilingual and culturally sensitive.

In 2020, more than 1.3bn children globally had their education impacted by Covid-19, due to school closures. A mature mobile learning infrastructure would have reduced this impact.

Research at the University of Huddersfield (UoH) has focused on identifying and testing ways to solve the challenges of developing such systems for mobile learning and increasing their adoption.

The research in this case study was performed by the Technology Acceptance and Mobile Learning (TAML) research group at UoH. It was led by Prof. Rupert Ward (at UoH since 2005), and Prof. Joan Lu (at UoH since 2000). TAML's research is pitched at two levels:

Work Surrounding the Underlying Mobile Learning Platform
Professor Lu started her research over 15 years ago, creating a Wireless Response System (WRS) which provided rapid feedback to schoolroom pupils, communicating answers during lessons. WRS are affordable, efficient and accessible and can be adapted to diverse learning contexts. However, they suffered from performance and user acceptance issues and in 2015, Lu undertook research to improve the operational efficiency of wi-fi using fast data streaming technology. The initial application was in smart homes [R1], where they demonstrated its use anytime and anywhere across multi-session and multi-user configurations. This was applied to speed up the data-acquisition element of WRS.

To maximize access to mobile learning globally, language translation needed to be optimized. In 2016, the researchers in TAML investigated the key multilingual WRS access issues, which were found to be character sets, operating systems, user interfaces, formatting, and culturally appropriate content [R2]. The WRS was applied within English primary education [R3] (2018). Two schools in West Yorkshire, were provided with WRS technology (small tablet computers) and teachers were trained to use them. Feedback from heads, teachers and pupils was used to analyse the level of pupil interest, engagement and understanding.

Work Surrounding the Technology Acceptance Model
Professor Ward's work on mobile learning adoption began in 2011, when he investigated how to make mobile learning easier for the student, making reflective learning tasks undertaken by university students more effective and engaging, as they built their personal development portfolios. He developed a mobile application (app) that organized student learning activities within an e-portfolio and could be accessed at any time.

Ahmed and Ward (2015) explored a range of technology acceptance models, to identify ways that the app could be improved. The research highlighted that the current models were too generic and inadequate when applied to e-learning. In 2016, their investigations focused on improving the adoption of e-learning. A meta-analysis of the existing technology acceptance models identified over 150 possible acceptance factors. From these, five key factors were synthesized and codified in the General Extended Technology Acceptance Model for E-Learning (GETAMEL) [R4]. The factors were: self-efficacy (confidence), subjective norm (socially conforming), enjoyment, computer anxiety and experience. The model was then tested with students using the e-portfolio solution [R5].

The individual factors in GETAMEL enabled mobile-learning solutions to be customized so that technology acceptance barriers to learning were lowered and intention to use mobile-learning solutions increased. An initial e-portfolio test showed that the five factors identified in this model accounted for 58% of behavioural intention to use [R5]. The factors therefore have become key determinants of effectiveness and adoption online when there is a lack of direct human engagement.

Between 2015 and 2017, Ward was seconded to the Royal Household, where he applied the GETAMEL factors to the development of a mobile learning platform for a charitable foundation (iDEA idea.org.uk/). The platform hosted the learning materials needed to develop a 21st century skills e-portfolio. Interactive digital badges (validated indicators of accomplishment or skill) and an associated awards structure were developed. iDEA was designed to promote confidence, social learning, enjoyment and experiential learning, and to reduce anxiety [R6].

3. References to the research (indicative maximum of six references)

Case for quality of supporting publications: [R1], [R4] & [R5] are published in Scimago-ranked Q1 journals, and two ([R1,R4]) are being submitted as REF outputs. MOBILITY is a peer reviewed, international conference for mobile learning [R2]. IJEEE is an open access international journal [R3]. Ward's book was commissioned by Emerald Publishing [R6].
[NB Joan Lu is the anglicised name of Zhongyu Lu]

[R1] Meng, Z., and Lu, J. (2015). A Rule-based Service Customization Strategy for Smart Home Context-Aware Automation, 28 Apr 2015, In : IEEE Transactions on Mobile Computing. 15, 3, p. 558–571 14 p., 7097069. https://doi.org/10.1109/TMC.2015.2424427
[R2] Ali, A. and Lu, Z., Internationalization Testing for a Multilingual Based Wireless Response System: A Case Study. MOBILITY 2016 The Sixth International Conference on Mobile Services, Resources and Users (pp. 7–12). International Academy, Research, and Industry Association (IARIA), (MOBILITY Conference on Mobile Services, Resources, and Users). https://www.thinkmind.org/index.php?view=article&articleid=mobility_2016_1_20_70014
[R3] Joan Lu, Mike Joy, Gail Newton, James Robert, Mohammed Yousef, Simon McKenna, Use of a Student Response System in Primary Schools — An Empirical Study, International Journal of e-Education, e-Business, e-Management and e-Learning, IJEEEE 2019 Vol.9(4): 324–330 ISSN: 2010-3654, http://www.ijeeee.org/show-77-915-1.html#
[**R4**] Abdullah, F., and Ward, R. (2016). Developing a General Extended Technology Acceptance Model for E-Learning (GETAMEL) by analysing commonly used external factors. Computers in Human Behavior, 56, 238–256. https://doi.org/10.1016/j.chb.2015.11.036
[R5] Abdullah, F., Ward, R., and Ahmed, E. (2016). Investigating the influence of the most commonly used external variables of TAM on students' Perceived Ease of Use (PEOU) and Perceived Usefulness (PU) of e-portfolios. Computers in Human Behavior, 63, 75–90. https://doi.org/10.1016/j.chb.2016.05.014
[R6] Ward, R. (8th June, 2020). Personalised Learning for the Learning Person. Emerald Publishing Limited. ISBN 978-1-789731507 (available on request)

4. Details of the impact

The research findings in section 2 were translated into the two technologies:

(i) The Wireless Response System (WRS), developed by Professor Lu, is a mobile learning tool to measure learning behaviour and quantify understanding. It improves on the state of the art, in that it does not use specialist equipment (it can use a wide range of existing devices), it is multi-lingual and multi-discipline, and its online implementation uses a range of web services to ensure secure local or remote connection between tutor and learner.
(ii) Professor Ward led the iDEA.org.uk project, a digital skills portfolio learning portal whose design is based on the five GETAMEL factors [R4], with the objective of optimizing adoption and engagement through self-directed mobile learning. Ward carried out most of the development during his Royal Household secondment (2015–17), creating an online environment where learners could gain digital badges and awards through bite-sized personalized learning. The initial focus of iDEA, was to enable the development of skills necessary for employment, especially in the digital and computer science sectors.
To summarise the impact, these technologies have benefited educational institutions, learners (Key Stage 2 to adult), local and national governments, employers and employees, via practitioners, professional services delivery and performance enhancement. The detailed impacts are grouped under four headings:

Encouraging Continuing Personal and Professional Development and Lifelong Learning

The use of WRS [R2] has increased intercultural awareness through its 300,000 users worldwide, from more than 100 countries. It supports five languages (Russian, Polish, Arabic, Chinese and English) and six disciplines (engineering, languages, law, maths, cyber-security and database design). The system means students are prepared to learn by making mistakes. A lecturer in Shanghai said: "The students can freely express their individual opinion because the system is designed anonymously [..] they do not worry in case they have made mistakes" [S6].

iDEA has been widely adopted by the personal and professional development programmes for UK job centres, prisons, local councils, schools and universities. Since its launch in 2017, over 7 million iDEA digital badges have been completed in over 190 countries [S7]. Talking about the

breadth of the iDEA user base, the Special Adviser to the City & Guilds Group stated: "in coordination with the Armed Forces, the Department for Work and Pensions (DWP) and Jobcentre Plus (JCP) Youth Obligation programme, iDEA training is [enabling] learners to move from the benefit system into employment, [..] with the job centre initiative alone providing free and highly accessible training for 1.6M learners across the UK". He continued: "iDEA's uptake has been phenomenal, with more than six million badges completed to date. This success, and iDEA's impact more generally across the world, have been because it [..] is so fit for purpose" [S7]. The philosophy of iDEA is discussed in detail in a book by Ward, which has a foreword by the OECD's Director for Education and Skills: "Learning systems need to better recognise that individuals learn differently, and in different ways at different stages of their lives. They need to create new ways of providing education that take learning to the learner and that are most conducive to students' progress. Learning is not a place, but an activity. [..] Future learning systems need to use the potential of technologies to [..] connect learners in new and powerful ways, with sources of knowledge, with innovative applications and with one another" [R6].

Changing Educational Practice in Primary, Secondary and Higher Education

Testing of the WRS [R2] demonstrated improved learning progress and subsequent academic achievement. The immediate feedback on student understanding provided by the WRS enabled teachers to monitor progress in real-time and more easily analyse learning barriers, especially in bilingual contexts. Using the information, they adjusted what they taught and how they optimized the overall learning experience. For instance, in Wuhan, China, its use has improved student performance and maintained their employability during the 2020 pandemic. The Course Leader, School of Computer Science and Engineering, Wuhan Institute of Technology said: "The use of WRS improves student performance and the grade average of our courses. This year, despite the Covid-19 period, through the use of the WRS system, students still maintain a high degree of enthusiasm for learning. Compared with previous years, we have performed well, and the employment rate of graduates still reached 85%. WRS has made a good contribution to our success and achievements" [S8].

iDEA has improved education in UK primary and secondary schools, by influencing and enabling changes to the curriculum. It was used by Computing at Schools, a charity supported by the professional body for computing, known as BCS the Chartered Institute for IT, that works to improve the quality of computing education. iDEA has also enabled gender equality; the scheme Code: First Girls has supported 25,000 female coders since 2017. Internationally it was adopted by the Council of British International Schools, iamtheCODE (an African-led scheme to encourage marginalized girls to study STEM subjects) and the British Council (2017 onwards) [S9]. A Programme Manager at iDEA wrote: "iDEA has changed learning. In formal education, it is used both to teach the curriculum in Key Stage 2 and 3, as well as to inspire and motivate digital skills development outside of the classroom.[..] iDEA's overall audience is 52% female this year, reflecting its cross-gender appeal and helping to break down gender barriers in the tech sector. Internationally, it is used in more than 95% of all countries". Commenting on the unusual circumstances of 2020, she added: "at the start of the UK lockdown, more than 1M additional iDEA badges were completed in less than five weeks as schools transitioned rapidly to mobile learning" [S9].

Defining Best Practice for Government and Professional Bodies

iDEA was cited as best practice by the UK Government in a DCMS report (2016), which stated: "Third sector organisations have particular roles to play at various levels: for example, support for digital skills development in young people is being provided through iDEA" [S3]. The Royal Society, in a 2017 report on Computing Education in UK Schools, commented: "iDEA is an innovative Badge Store concept that helps people develop skills for free [..] Badges have been mapped against the National Curriculum and the Skills Framework for the Information Age. This helps support teachers across a range of curriculum subjects including the three core areas of formal computing education: digital literacy, computer science and IT" [S4].

The Greater Manchester (GM) Digital Strategy (2018) identified iDEA as a means of increasing digital inclusion. It decided to "Roll out the iDEA digital enterprise award across GM so that we

have an easily accessible free way for any young person or adult across GM to develop digital skills for life and work". [S5] This factor was underlined by the description of iDEA as "the digital and enterprise equivalent of the Duke of Edinburgh Award" by the Royal Society in 2017 [S4].

Revolutionizing Professional Standards and Training

The application of iDEA within the Computing at Schools scheme and the Key Stage 3 National Curriculum in the UK, demonstrated how digital badging can underpin existing qualifications by providing a granular skills profile to an employer, rather than an opaque traditional qualification syllabus. The work was applied to higher education through the development of a 21st Century digital skills taxonomy and framework for the mini-qualifications (microcredentials) that constitute a full, traditional qualification. The framework informed the review of the new BCS computing accreditation standard for universities. It was also used in developing a global microcredentialing standard for the cross-professional body, International Council on Badges and Credentials (ICoBC). Its impact on the BCS standard is in increasing transparency within university degrees by better communicating digital skills acquisition to employers, lecturers and learners. It has also been adopted by Manchester Metropolitan University for their international computing degrees. Wider international adoption has increased skills transferability globally, making it easier to communicate capabilities across subjects, sectors and economies. This has enabled governments, the OECD and other inter-governmental organizations to better analyse and address global digital skills gaps [S10]. The President of the BCS (2017–2018), stated: "Rupert's research, [..] has highlighted to the BCS review group an additional important strand for consideration within its accreditation review. Rupert is representing the BCS in discussions with the ICoBC, in parallel with the accreditation review, to develop an international recognised standard through a digital skills taxonomy (an agreed categorisation of skills) and a microcredentialing framework (a way of linking acquired skills to qualifications) [..] Rupert's work is significant input to the inclusion of informal learning, something which has profound implications for skills development both within the BCS and within other professional bodies" [S10]. Without the novelty demonstrated in identifying and testing the five factors in the GETAMEL model and applying these to iDEA.org.uk, the technology would not have been accepted, the intention to use would not have been as high as it has been, and the global ongoing reach and significance both in numbers and breadth would not have occurred.

5. Sources to corroborate the impact

[S1] DCMS (2019). No longer optional: employer demand for digital skills. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/807830/No_Longer_Optional_Employer_Demand_for_Digital_Skills.pdf (See p.7)
[S2] Shadbolt, N. (2016). Computer science degree accreditation: Shadbolt review. https://www.gov.uk/government/publications/computer-science-degree-accreditation-and-graduate-employability-shadbolt-review
[S3] ECORYS (Firm). (2016). Digital skills for the UK economy. (DCMS/DBIS joint commissioned report) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/492889/DCMSDigitalSkillsReportJan2016.pdf (See p.63)
[S4] Royal Society. (2017). After the reboot: Computing education in UK schools. Policy Report. https://royalsociety.org/~/media/policy/projects/computing-education/computing-education-report.pdf (See p.81)
[**S5]** Greater Manchester Digital Strategy https://www.greatermanchester-ca.gov.uk/media/1090/digital-strategy-2018-2020.pdf (See p.13)
[S6] Testimonial – Using a mobile learning system (SJTU)
[S7] Testimonial – Special Adviser to the City & Guilds Group (iDEA – Digital Skills)
[S8] Testimonial – Use mobile learning system (Wuhan Institute of Technology)
[S9] Testimonial – Global educational impact (iDEA – International Education)
[S10] Testimonial – Chair BCS Registration and Standards Committee, President BCS The Chartered institute for IT 2017 2018 (Accreditation Standards)