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| <b>Institution:</b> University of Liverpool  |                      |  |
| <b>Unit of Assessment:</b> 11 (Computer Science and Informatics)   |                      |  |
| <b>Title of case study:</b> LIFTUPP: a tool for ensuring consistent performance of clinical graduates  |                      |  |
| <b>Period when the underpinning research was undertaken:</b> 2005 – present  |                      |  |
| <b>Details of staff conducting the underpinning research from the submitting unit:</b>   |                      |  |
| <b>Name(s):</b>  | <b>Role(s):</b>      | <b>Period(s) employed by submitting HEI:</b> |
| Prof Luke Dawson   | Lecturer - Professor | 1996 – present                               |
| Dr Phil Jimmieson  | Lecturer             | 1984 – present                               |
| Dr Ben Mason   | Lecturer             | 2006 – 2015                                  |
| Prof Rahul Savani  | Lecturer - Professor | 2009 – present                               |
| <b>Period when the claimed impact occurred:</b> August 2013 – December 2020  |                      |  |
| <b>Is this case study continued from a case study submitted in 2014?</b> No  |                      |  |
| <p><b>1. Summary of the impact</b></p> <p>LIFTUPP is an information system that shifts the focus of clinical education from knowledge acquisition to consistency of competent practice – a long-standing unmet need within the field. Developed since 2009 by the University of Liverpool’s Department of Computer Science and Dental School, LIFTUPP has transformed the UK’s dental education and has seen uptake in other types of clinical education both nationally and in the US and Australia. LIFTUPP has made impacts on health, education, and the delivery of professional services:</p> <ul style="list-style-type: none"> <li>• As of 2020, 63% of UK dental schools use LIFTUPP, as well as four medical and three veterinary schools.</li> <li>• A further 38 US and Australian clinical institutions adopted LIFTUPP since its acquisition in March 2019 by US-based educational technology provider ExamSoft.</li> </ul> <p>A secondary area of impact is economic: LIFTUPP Ltd. spun out from the University in October 2015, creating tech-focused jobs, and generating an average revenue of £261,000 per annum between 2015 and its acquisition by ExamSoft in March 2019 for [text removed for publication].</p>   |                      |  |
| <p><b>2. Underpinning research</b></p> <p>The LIFTUPP (Longitudinal Integrated Foundation Training Undergraduate to Postgraduate Pathway) information system is the outcome of a collaboration between the Department of Computer Science and the School of Dentistry at the University of Liverpool. The research that underpins this impact case study is interdisciplinary, and spans Informatics and Pedagogy.</p> <p>Recognising a need for change, the General Dental Council (GDC) drove a discussion about standards for dental education in the UK that resulted in the publication of the 2012 GDC “Standards for Education” document. Luke Dawson of the Dental School made significant contributions to this reassessment of standards [3.1, 3.2, 3.3]. A key outcome of the discussion was that dental education needed to shift its focus from knowledge acquisition to consistency and quality of performance across a range of realistic contexts, and over extended periods of time [3.1].</p> <p>Dawson, Jimmieson (Computer Science), and Mason (Educational Development) recognised that this shift in focus would require a fundamental change in the delivery of teaching and assessment, with detailed and continual monitoring of student performance to allow personalised programmes and instant delivery of feedback. To this end, a step-change in the level of computing infrastructure was needed [3.4, 3.5]. In particular, computing research was needed to deliver novel solutions for in-clinic real-time data collection, data presentation and visualisation, and automated synthesis of assessments and verification of requirements.</p> <p>The key computing innovations were:</p> <ul style="list-style-type: none"> <li>• <b>Methods for the analysis, meaningful presentation, and visualisation of complex clinical performance data for both students and staff [3.4, 3.6].</b> For each student, more than 5,000 data points from hundreds of clinical sessions and covering more than 30 skills have to be presented in such a way that the quality and consistency of performance of the</li> </ul> |                      |  |

student over time can be easily analysed and understood. As part of the research, a novel “barcode” view of consistency of performance was developed and evaluated [3.6]. Each barcode represents a student’s performance over time in relation to a group of competencies. For any such group, the barcode gives an accessible representation of consistency by showing periods of repeated appropriate performance as dense black regions of the visualisation, and other periods as predominantly white. These barcodes aggregate data from clinical sessions of varying difficulty that occur at different points in time, and a key research challenge was how to contextualise and calibrate the data according to these factors.

- **Methods for in-clinic real-time data collection [3.4, 3.5].** Clinical students spend substantial periods of time interacting with real patients in hospital clinics. Dawson developed a workflow model and grading scheme for clinical sessions. To operationalise these, LIFTUPP pioneered the use of iPads for real-time data collection in clinical sessions. This involved Human-Computer Interaction research to develop a user interface for the workflow model and grading scheme that allows staff to input detailed data on many students during a clinic, while still being able to focus primarily on student activity and student-patient interaction. For instance, LIFTUPP’s interface allows for rapid switching between students and simultaneous display of many workflow items. Moreover, the LIFTUPP application is aware of details of the clinical session, which allows for automatic selection of the correct workflows and for the right staff and students to be assigned to the workflow. At the end of the session each student is provided with personalised feedback on the device.
- **Automated synthesis of assessments and verification of requirements [3.4, 3.5, 3.6].** All clinical sessions and exam questions are declaratively coupled to learning outcomes. Thus, it is possible to efficiently verify if the requirements of accreditation bodies are satisfied. Moreover, LIFTUPP can semi-automatically synthesize exam papers meeting those requirements.

The first two bullets relate to the DEVELOP module of LIFTUPP; the last bullet relates to the MAP and OSCE modules of LIFTUPP. These modules are discussed in more detail in Section 4. The computing research that underpins LIFTUPP is described in most detail in the long arXiv version of [3.6].

### 3. References to the research

- [3.1] Dawson, L. J., Mason, B. G., Bissell, V., Youngson, C. (2017). ‘Calling for a Re-Evaluation of the Data Required to Credibly Demonstrate a Dental Student is Safe and Ready to Practice’ (2017). *European Journal of Dental Education*, 21 (2): 130-135. DOI: 10.1111/eje.12191
- [3.2] Macluskey, M., Durham, J., Bell, A., Cowpe, J., Crean, S. J., Dargue, A., Dawson, L. J., Freeman, C., Jones, J., McDouagh, A., McHanwell, S., Marley, J., Myrddin, L., Millsopp, L., Oliver, R., Renton, T., Taylor, K., Thomson, P. (2012). ‘A National Survey of UK Final Year Students’ Opinion of Undergraduate Oral Surgery Teaching.’ *European Journal of Dental Education* 16 (1): 205-212. DOI: 10.1111/j.1600-0579.2011.00717.x.
- [3.3] Dawson, L. J., Fox, K. (2018). "Can Assessment be a Barrier to Successful Professional Development?" *Physical Therapy Reviews*, 23 (1): 11-16. DOI: 10.1080/10833196.2017.1336840.
- [3.4] Dawson, L. J., Mason, B. G., Balmer, C., Jimmieson, P. (2015). ‘Developing Professional Competence using Integrated Technology-Supported Approaches: A Case study in Dentistry.’ In *A Handbook for Teaching and Learning in Higher Education Enhancing Academic Practice* Fourth Edition: 1-7. London, New York: Routledge. ISBN-13: 978-0415709965.
- [3.5] Dawson, L. J., Mason, B. G. (2013). ‘Developing and Assessing Professional Competence: Using Technology in Learning Design.’ In T. Bilham (Ed.), *For the Love of Learning*: 312. Basingstoke: Palgrave Macmillan. ISBN-13: 978-1137334299.

[3.6] Oliehoek, F. A., Savani, R., Adderton, E., Cui, X., Jackson, D., Jimmieson, P., Jones, J., Kennedy, K., Mason, B. G., Plumbley, A., Dawson, L. (2017). 'LIFTUPP: Support to Develop Learner Performance.' In *Proceedings of the International Conference on Artificial Intelligence in Education*: 553-556. DOI: 10.1007/978-3-319-61425-0\_62. Long arXiv: <http://arxiv.org/abs/1704.06549v1>

#### 4. Details of the impact

The LIFTUPP information system for clinical education, developed at the University of Liverpool from 2009, has had significant impact on:

- Practitioners and the delivery of professional services; through LIFTUPP's support for educators to deliver better clinical education.
- Understanding, learning, and participation; through LIFTUPP's role in improving the quality of clinical education for students.
- The health and wellbeing of people; through LIFTUPP's role in producing better clinicians.

The impact in these areas arose through LIFTUPP's transformation of clinical education practices across the UK and beyond. In particular, the Royal College of Surgeons recognised the step change that LIFTUPP was delivering for dental education in the UK by awarding Luke Dawson a Fellowship of the Faculty of Dental Surgery (quote from ceremony in October 2013):

*"The impact of LIFTUPP in dentistry is unprecedented and is in the process of improving assessment strategies, behaviour, and attitudes for approximately 2,450 dental students annually, as well as for around 350 dental educators..."* [5.1]

A secondary area of impact is economic, through the successful spinout of LIFTUPP Ltd. in October 2015 and its subsequent acquisition by US-based company ExamSoft in March 2019.

#### 4.1 Transforming Clinical Education

LIFTUPP significantly impacted clinical education in the UK by remodelling how students are assessed and supported. Traditionally, schools employ tests and exams at a limited number of points during a course, but LIFTUPP ensures consistency in competent practice by allowing a constant monitoring and delivery of feedback throughout a student's education. This longitudinal monitoring and feedback is the responsibility of the DEVELOP module of LIFTUPP, one of its three main modules. The other two modules are: MAP, an automated curriculum mapping tool, and OSCE (Objective Structured Clinical Examination), which enables the delivery of an internationally standard type of clinical exam.

Following extensive trials which first began in 2009, by 2015 LIFTUPP had been adopted by eight dental schools in the UK and two medical schools. As of December 2020, ten dental schools have adopted it (63%), as well as four medical schools, and three veterinary schools. During the REF period and in the context of LIFTUPP's impact on dental education, approximately 3,500 dental students and 450 dental educators benefited from using improved, competency-focused assessment methods each year [5.2].

The challenge that LIFTUPP addresses is not unique to the UK, and it has been applied internationally within the US and Australia. The former Dean of the University of Portsmouth's Dental School confirmed LIFTUPP's ability to transform dental education from its traditional insistence on knowledge acquisition:

*"I am now Associate Dean for Education at the University of California San Francisco (UCSF), one of the largest and most respected medical-dental schools in the United States of America, and can honestly say that I have been unable to source a better/more advanced education software solution [than LIFTUPP] to this age-old problem"* [5.3].

Following ExamSoft's acquisition of LIFTUPP Ltd. in March 2019, LIFTUPP's reach extended well beyond the UK. As explained by ExamSoft, LIFTUPP's tools address a *"pressing need amongst [their] healthcare education clients."* Key components of LIFTUPP have been integrated into ExamSCORE, one of ExamSoft's main products. LIFTUPP tools were used by 38 of ExamSoft's clients in the US and Australia during the impact period and continue to be rolled out to their healthcare education clients in these countries [5.4].

#### 4.2 Improving Student Development

The impact of LIFTUPP on educational practices is best described in reference to the "Standards for Education" document [5.5] of the General Dental Council (GDC). This illustrates how LIFTUPP enabled the refocusing of dental education from knowledge acquisition to consistency of competent practice.

Continual feedback and assessment [GDC Requirement 13]: the longitudinal aggregation of data enabled by LIFTUPP facilitates assessment of the consistency and breadth of student performance and allows the provision of detailed and continual feedback to students. The Interim Associate Head of Education and Dental Nursing Course Lead at the University of Portsmouth recognised LIFTUPP's transformative nature: *"LIFTUPP enables students to see their clinical journey as a development process rather than a grading process. The system highlights to students and tutors those skills which are considered to be good enough for independent working and those which require further development"* [5.6].

Enabling reflective learning [GDC Requirement 18]: LIFTUPP improves students' personal and professional development, encouraging self-reflection skills by exhibiting qualitative and quantitative data on the quality and consistency of their performance over time. This includes the use of the barcode representation (see underpinning research, particularly [3.1]), which gives students a high-level view of their temporal performance. Additionally, students can drill down into their performance on individual aspects of the clinical session, from the quality of a tooth restoration to their communication skills and professionalism.

A Professor of Operative Dentistry and Dental Materials Science at the University of Dundee, also a Honorary Consultant in Restorative Dentistry, identified LIFTUPP's exceptional impact on student progress and in improving the ability of faculty to support learning: *"Using LIFTUPP to provide feedback to the students has greatly enhanced their learning experience, enabling them to reflect and effect immediate changes to their practice, as appropriate. The data collected is invaluable to staff and students for monitoring progress, increasing confidence of the school in decision making"* [5.7].

Fairer and more transparent assessment: LIFTUPP presents educators and students with detailed data on the amount, difficulty, and quality of students' clinical activity. As confirmed by Dundee faculty (above), this rich data enables a progression panel to make well-informed and defensible decisions. Moreover, as noted by the Interim Associate Head of Education and Dental Course Lead at the University of Portsmouth: *"we have been able to calibrate staff by analysing patterns of assessment. Where an educator appears to deviate from the average assessment pattern demonstrated by the wider team, it is possible to offer training and support to ensure consistency"* [5.6]. LIFTUPP's impact on dental education not only urges improvements in students' learning but ensures consistency in the delivery of teaching across the entire faculty.

Development of the full range of professional skills: [GDC Requirement 13] LIFTUPP facilitates the real-time collection and presentation of data on all aspects of clinical activity, including communication with the patient and hygiene. A Lecturer in Medical Education at the University of Leicester noted the importance of this: *"The feedback gathered longitudinally allows students to see how they are doing across the board, in developing not just the necessary knowledge but also the professional skills and attitudes expected of a doctor"* [5.8]. By using LIFTUPP, institutions ensure a comprehensive education for their students. Assessing and improving communication skills has subsequent benefits in terms of the reduction of error and a patients'

understanding of their own condition and treatment, which together directly improve clinical experiences overall.

The data collected and visualised in LIFTUPP also ensures that institutions meet all of the remaining GDC requirements for student assessment. In particular, this relates to requirements 14-17, which necessitate that students encounter a wide range of clinical situations and patients, and that there is substantial data for making thorough judgements on student ability [5.5].

Student satisfaction: LIFTUPP's significant impact on dental education has been recognised in numerous dental school inspection reports by the GDC. One report from 2014 for Queen Mary University of London applauded LIFTUPP's use in "*clinical recording, feedback and reflection.*" Its introduction "*meant significant changes for the programme*" which "*generated excellent feedback from students*" [5.9].

#### 4.3 Creating an Innovative and Profitable Spin-Out, with Benefits to the Economy

After LIFTUPP's successful rollout to numerous dental schools, LIFTUPP Ltd. was spun out from the University of Liverpool in October 2015. Until 2019, LIFTUPP Ltd. operated as a successful company. It employed on average more than ten individuals in high-skilled occupations. It had an average revenue of £261,000 per annum, with individual licences costing between £10,000-35,000 per annum [5.10a]. In 2019, ExamSoft bought LIFTUPP Ltd. for [text removed for publication]. [5.10b]. ExamSoft maintains a base in Liverpool and continues to serve all of their UK university clients. In addition, 38 clients of ExamSoft in the US and Australia are already using LIFTUPP's tools via ExamSoft's products. ExamSoft are currently further integrating LIFTUPP tools in all their products, making them available to a much larger number of educational institutions worldwide.

#### 5. Sources to corroborate the impact

[5.1] Fellowship Award Ceremony Citation from the Royal College of Surgeons of England (2013), supporting impact on education and assessment for students and educators.

[5.2] Spreadsheet evidencing dental, medical, and veterinary institutions using LIFTUPP.

[5.3] Testimonial from Associate Dean for Education, University of California, San Francisco (2020), supporting impact of LIFTUPP as the first major instance of software innovation in clinical education practices.

[5.4] Testimonial from Client Solutions & Education Manager, ExamSoft (2020), supporting LIFTUPP's ability to meet healthcare educators' needs and integration of LIFTUPP into a core ExamSoft product, use by 38 institutions, and continuing rollout.

[5.5] General Dental Council, "[Standards for Education](#)" (revised 2015), demonstrating how LiftUpp meets standards for education.

[5.6] LIFTUPP Case Study: "LIFTUPP - The University of Portsmouth", containing 1) testimonial from Dental Nursing Course Lead supporting impact on student development and 2) testimonial from Interim Associate Head of Education and Course Lead supporting impact on educators and assessment.

[5.7] – Testimonial from Professor of Operative Dentistry and Dental Materials Science and Honorary Consultant in Restorative Dentistry, University of Dundee, supporting impact on student learning and institutional decision making, and noting value of data collected by LiftUpp.

[5.8] LIFTUPP Case Study: "LIFTUPP – The University of Leicester", containing testimonial from Lecturer in Medical Education supporting impact on LIFTUPP's ability to ensure professional skills and attitudinal development, in addition to medical knowledge.

[5.9] General Dental Council, Education Quality Assurance Inspection Report (2014), supporting impact on course delivery and excellent student feedback.

[5.10] Attachment containing evidence of LIFTUPP's economic impact:

a) Accounts of LIFTUPP Ltd., evidencing average of ten employees, average revenue of £261,000 per annum, and individual license costs (2018).

b) Exit modelling document evidencing LIFTUPP Ltd.'s [text removed for publication] sale price to ExamSoft (2018).