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| <b>Institution:</b> University of Northumbria at Newcastle                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                           |                                              |
| <b>Unit of Assessment:</b> 11 (Computer Science and Informatics)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                           |                                              |
| <b>Title of case study:</b> Transforming STEM and digital literacy education for under-represented groups: improving user behaviour, skills, and aspirations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                           |                                              |
| <b>Period when the underpinning research was undertaken:</b> 2001 - 2020                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                           |                                              |
| <b>Details of staff conducting the underpinning research from the submitting unit:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                           |                                              |
| <b>Name(s):</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Role(s) (e.g. job title):</b>                          | <b>Period(s) employed by submitting HEI:</b> |
| Rebecca Strachan                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Professor of Digital Technology and Education             | 01/09/2008 - present                         |
| Alison Pickard                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Associate Professor                                       | 08/10/1996 - present                         |
| Linda Banwell                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Director of the Information Management Research Institute | 1999 - 2005                                  |
| Biddy Casselden                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Senior Lecturer                                           | 01/09/2001 - present                         |
| Jonathan Sanderson                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Senior Lecturer                                           | 01/09/2014 - present                         |
| Opeyemi Dele-Ajayi                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Senior Research Fellow/Lecturer                           | 01/09/2014 - present                         |
| <b>Period when the claimed impact occurred:</b> 2014 - 2020                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                           |                                              |
| <b>Is this case study continued from a case study submitted in 2014?</b> N                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                           |                                              |
| <b>1. Summary of the impact</b> (indicative maximum 100 words) <p>The North East of England has a significant digital skills challenge, and young people in the region show poor progression into Science, Technology, Engineering and Mathematics (STEM) careers. Northumbria University research into user behaviour in information and digital environments has generated impact in two ways. Firstly, a project with Your Homes Newcastle, Newcastle City Council, and the city's libraries introduced a scheme of digital support for excluded groups that improved access and skills and enhanced digital citizenship for 1,700 people. Secondly, research findings on appropriate digital tools have also been adopted as part of a suite of initiatives delivered by Northumbria University (through NUSTEM) and partners. Interactive workshops were delivered to ~95,000 children and ~18,000 families, carers, and teachers in 34 primary schools and 16 secondary schools from less-affluent areas in the North East. This led to improved knowledge of STEM subjects and broadened children's educational aspirations, and also generated improvements to primary curricula. Research tracked the specific effect of NUSTEM initiatives on a sample of 372 students, by comparing 2017 data with a 2015 baseline. Data showed that children became more willing to pursue STEM careers, with the biggest effect being seen in young girls. The success of Northumbria's public engagement approach has led to it being adopted by a number of partner organisations, including Gateshead and Derby Colleges. This has led to improved gender diversity in vocational STEM courses and enabled the North Tyneside Combined Authority to develop new Adult Education initiatives.</p> |                                                           |                                              |
| <b>2. Underpinning research</b> (indicative maximum 500 words) <p>Since 2000, Northumbria University's Digital Learning Laboratory (DLL) research group has conducted research into user behaviour in information and digital environments. This research has focused on the design, evaluation, and effectiveness of digital interactions and the educational practices necessary to develop digital citizenship and digital literacy in both children and adults.</p> <p>The recent government report 'No longer optional: employer demand for digital skills' (2019), outlined the importance of all citizens having the digital skills they need to fully participate in society. DLL's research focuses on addressing this challenge; the main themes are user needs and behaviours, trust, and engaging and effective digital learning solutions. Their impact stems from work originating in the JUBILEE (JISC User Behaviour in Information Seeking: Longitudinal Evaluation of Electronic information services) project, run by Dr Pickard and others. Funded by JISC, this project ran national surveys and in-depth case studies over five cycles. It revealed that user behaviour was unstructured, and that many people lack a systematic approach to both training and search patterns. DLL researchers applied these findings to the production of a</p>                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                           |                                              |

toolkit which enabled information practitioners across the UK, USA, and Europe to provide the support their users needed in order to develop more efficient searching behaviours [R1].

Through the JISC funded i-Trust project, DLL staff explored how trust is created for users accessing digital resources, and how this trust guides user behaviour and fosters greater confidence and digital literacy. Building on online studies with stable cohorts over time, an innovative 'trust model' was developed. This model incorporated external factors, internal factors, and users' cognitive states, such as disposition to trust and attitude to risk [R2]. The research showed that users found access to information through commercial search engines was favoured, but sources identified through mediated portals such as educational software and digital libraries were associated with greater levels of trust [R2].

Dr Pickard and Professor Strachan employed digital games to illustrate the importance of considering user needs and their behaviours to provide active and engaging solutions that enabled and supported individuals on their learning journey [R3]. This created an opportunity to further develop understanding of the impact of interventions on digital citizenship. Research highlighted that digital literacy courses to prepare children for safe and effective online access are more effective if they apply operationalised techniques for critical reading, inculcating a 'cognitive questioning state,' rather than simply teaching from a list of criteria [R3-R4]. Work-based learning (WBL) methods benefit from similar critical digital skills development techniques and offer greater flexibility. Adjusting teaching content to suit the specific WBL environment enriches the user experience through enhancing the capacity for targeted applied operationalisation most suited to the learners' job role and development needs [R4-R5].

Taken together, this body of research on (1) user behaviour and user needs, and (2) approaches to provide an engaging, effective, and inspirational education experience for different groups, was used to develop a holistic and sustained approach to STEM outreach and widening participation (and its evaluation strategy), and the NUSTEM Theory of Change (ToC) for STEM perception, aspiration, and uptake [R6]. NUSTEM (formerly Think Physics), grew from a HEFCE GBP1,176,716 project (led by Professor Strachan) to re-imagine STEM outreach and engagement for under-represented groups. The NUSTEM ToC describes a methodology for planning, participation, and evaluation for organisations aiming for social change. The NUSTEM ToC looks at the change required to rapidly improve numbers and diversity of young people choosing careers and further education in STEM, and particularly technology, engineering, and physical sciences [R6]. The project integrated good practice developed by DLL members with the latest advances in technology (emerging social media, online gaming, mobile devices, and open educational resources) to create a blended support system designed to keep children (and particularly girls) involved and excited about STEM subjects throughout their education.

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

**R1. Linda Banwell, et.al. inc. Alison Pickard (2004)** JISC User Behaviour in Information Seeking: Longitudinal Evaluation of EIS (JUBILEE): Fifth Annual Report; Final Report. JISC <http://nrl.northumbria.ac.uk/14659/>

**R2. Alison Pickard, Gannon-Leary, P., and \*Coventry, L. (2011)** 'The onus on us? Stage one in developing an i-Trust model for our users' *Library and Information Research* **35**(111) <https://doi.org/10.29173/lirg473>

**R3. Rebecca Strachan, Kongmee, I., and Alison Pickard (2016)** 'Using massively multiplayer role playing games (MMORPGs) to support second language learning: A case study of the student journey' in *Utilizing virtual and personal learning environments for optimal learning* (IGI Global) ISBN13: 9781466688476 pp87-109. Available on request

**R4. Liyanage, L., Rebecca Strachan, Biddy Casselden, et. al. (2013)** Design of educational systems for work based learning (WBL): the learner experience, *Higher Education, Skills and Work-Based Learning* **3**(1): 51-61

<https://www.emerald.com/insight/content/doi/10.1108/20423891311294984/full/pdf?title=design-of-educational-systems-for-work-based-learning-wbl-the-learner-experience>

**R5.** Walton, G., **Alison Pickard.**, and Dodd, L. (2018) 'Information discernment, mis-information and pro-active scepticism' *Journal of Librarianship and Information Science* **50**(3): 269-309  
<https://doi.org/10.1177/0961000618769980>

**R6.** \*Davenport, C., **Opeyemi Dele-Ajayi**, \*Emembolu, I., \*Morton, R., \*Padwick, A., \*Portas, A., **Jonathan Sanderson**, Shimwell, J., \*Stonehouse, J., **Rebecca Strachan**, \*Wake, L., \*Wells, G., and \*Woodward, J. (2020) 'Theory of Change for Improving Children's Perceptions, Aspirations and Uptake of STEM Careers' *Research in Science Education*, pp1-15  
<https://doi.org/10.1007/s11165-019-09909-6>

#### **\*Internal Northumbria collaborators**

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Emembolu, I., Padwick, A., Portas, A., Shimwell, J. - members of the NUSTEM project team

#### **Research funding**

G1. JISC, 2010, GBP24,000 'User trust in information resources on the web'

G2. HEFCE, 2014 - 2017, GBP1,176,716, (PD006) 'Think Physics Catalyst Fund'

G3. HEFCE, 2017- 2019, (L03) GBP316,868, BRIDGE Project

#### **4. Details of the impact** (indicative maximum 750 words)

There are two main strands of impact arising from this body of research. Firstly, research on how people engage with digital learning provided the basis for digital citizenship community programmes. These supported those unfamiliar with online services, in order to improve access and skills (and, hence, digital citizenship). Secondly, using the ToC, NUSTEM provided a vehicle to engage children and young people in STEM careers and opportunities. Activities delivered through a sustained programme of engagement were created to inspire children's interest in STEM careers. Their success led to increased interest in STEM careers among primary school children, updated teacher-training, revised curricula in schools with some of the least-affluent children in the region, and the adoption of these methods by organisations across North East England.

##### **4.1 Improved adult digital citizenship through skills development**

In 2014, Newcastle City Council set itself the goal of becoming 'digital by default' by 2017, requiring its residents to access council services online. However, estimates suggested that 20% of adults lacked the basic skills to use online services. These 'digitally excluded' groups were also likely to be heavy users of both council and government services. Northumbria University co-created Digital Champions to support this transition, a project run with the organisation responsible for managing council homes on behalf of Newcastle City Council, Your Homes Newcastle (YHN), and funded by the Chartered Institute of Library and Information Professionals [E1].

This programme involved community engagement activities with local public bodies, including Newcastle City Libraries and Newcastle City Council. In total, 90 organisations collaborated with the programme to train digital champions to deliver services to the public; this has run every year since the 2014 pilot [E1]. By 2018, 1,700 people had been supported, and at least 60 people were able to move into work as a result [E2]. The programme also led to increased capacity for customers to access online job opportunities, manage their finances, and secure vital benefits [E3]. An initial YHN report on the project pilot reported that free Wi-Fi had been installed in all YHN sheltered, tower, and community venues, enhancing access to council digital content. 773 people engaged with 22 active Digital Champions [E3, p6]. The project quickly expanded beyond the pilot to focus on delivering skills in the community. This was free to all Newcastle residents,

helping them to access online support through new digital literacy workshops held at public libraries. These included twice-monthly 'Techy Tea' parties for people to learn skills such as how to install relevant apps on their personal devices [E4, p3]. Benefits were reported by users who had been identified as previously excluded from accessing and using key resources for social support. Representative quotes from users sum up the impact on them:

- *'I also learned some things that I never knew before and I will use them when I leave the course I am doing. And the tablet will help me when I finish the course and I will do more online and feel safe doing it.'*
- *'This course was great; I have learnt about how to be secure online and make sure websites are secure. I now have access to free magazines and eBooks.'*
- *'I learned about the supermarket money and online accounts such as rent account and council tax online.'* [E4, p6]

## 4.2 Improving aspirations, teaching, and learning in STEM subjects

### 4.2.1 Increased STEM awareness in primary school children from less affluent areas in the North East of England

A range of groups are disadvantaged in terms of access to STEM opportunities; in particular, young women, people of all ages from less-affluent regions, and especially children with protected characteristics or from primary schools in less-affluent areas. Many see no route to STEM-based careers, and consequently have little incentive to study STEM subjects. Between 2014 and 2020, the NUSTEM ToC model was used to address these challenges for girls and those from less privileged socio-economic backgrounds. The ToC requires sustained engagement with children and schools through a multi-faceted approach including workshops built on digitally enhanced learning techniques. These were delivered to 94,821 children in 34 partner primary schools and 16 secondary schools from groups under-represented in STEM education and careers [E5, p7]. These workshops included participation from a total of 17,947 family members, carers, and teachers in the partner primary schools [E5, p4].

NUSTEM research-led workshops used specific digital tools and techniques informed by wider research on digital engagement, including a 'STEM Knowledge and Aspiration Tool', and a 'STEM Person of the Week' feature to both influence thinking and gather data. These interventions changed the way students talked about STEM subjects and careers and improved the ability of parents to talk about the subjects with children; *'It has really encouraged us to do more things at home as a family'* [E5, p18]. The 'STEM Person of the Week' activities proved so successful they have now been adopted nationally into 'British Science Week 2021' – jointly run by the British Science Association and UKRI – for all age groups, from early years, through primary and secondary education [E6, p9, p23, p36]. NUSTEM tracked the specific effect on a sample size of 372 students by comparing 2017 data with a 2015 baseline [E7, p6]. The sustained interventions had a particularly positive effect on girls. In 2015, prior to the interventions, girls were significantly less likely than boys to know about STEM jobs (e.g., games tester, surveyor, and technician). In 2017, following the sustained intervention, there was no significant difference between boys and girls. Furthermore, one of the STEM jobs, Engineer, showed the greatest increase in the percentage of boys and girls that wanted to do that job in 2017 compared to 2015 (70.6% expressed an aversion to pursuing engineering before the interventions, and only 47.1% afterwards [E7]).

### 4.2.2 Enhanced design/delivery of curriculum and teaching practice in NE England schools

Digital education tools were developed for teachers to use in the classroom, enabling children to critically engage with online resources, to learn more about STEM subjects and explore their enhanced awareness and aspirations in STEM fields. These tools were used in schools through NUSTEM outreach activities. Curriculum changes focused on linking STEM subjects to career opportunities through the NUSTEM Primary Careers Tool [E5, p20]. Three primary schools have rewritten their curriculum vision for science, incorporating STEM links and more practical-based teaching [E5, p20]: *'The Primary Careers Tool has been instrumental in helping us to implement a careers drive through the curriculum'* (Headteacher, Cowell Primary School) [E5, p21].

Similarly, The Ogden Trust, a charity promoting STEM education to disadvantaged children in 796 schools across England, adopted the tool: *'The Primary Careers Tool is an excellent addition to the primary teacher training that we offer at the Ogden Trust ... [I]t's taken real expertise to develop a tool that allows large numbers of classroom teachers to broaden the careers language and ambition of their students'* (Jackie Flaherty, National Teaching and Learning Lead, Ogden Trust) [E5, p21].

#### 4.2.3 Improved design and delivery of adult education and community engagement in educational institutions in NE England

NUSTEM's ToC approach has also been deployed beyond children's education by the North of Tyne Combined Authority's (NTCA), and shaped NTCA's engagement practices for Adult Education initiatives, while also providing a framework for the external evaluation of their STEM and Digital Skills programme. NTCA's Strategy Manager said: *'The Theory of Change shaped the engagement practice of our outreach work which is part of our approach in tackling the economic challenges in the North of Tyne region'* [E8].

The model has also been used in a project to improve diversity in enrolment on construction degree courses, in a HEFCE-funded collaboration between Northumbria University, Gateshead College, and Derby College. The BRIDGE project adapted the NUSTEM ToC to build on an understanding that the high-tech, computer-based, digital imaging and design elements of construction are particularly appealing to many young people, leading to an emphasis on the 'digital' in construction training. As a result, Gateshead College's apprenticeship programme saw an increase in applications from women from 8% to 23% [E9, p23]. At Derby College, with 2,000 apprentices, 32% of students live in deprived wards. There are also above-average BAME student populations, and no women were in the college's construction apprentice cohort in 2016. However, after the NUSTEM ToC engagement model was applied, the 2018 female student cohort for construction apprenticeships increased to 39% [E9, p43].

#### 5. Sources to corroborate the impact (indicative maximum of 10 references)

| Ref. | Source of corroboration                                                                                                                                                                                                                          | Link to claimed impact                                                                                                         |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| E1   | 'Go Digital Newcastle: connecting our city' 2015 pp 91-96                                                                                                                                                                                        | Acknowledges contribution of Northumbria University                                                                            |
| E2   | Profile of Newcastle City Library Digital Champions project                                                                                                                                                                                      | Confirms 1,700 participants and at least 60 people in work                                                                     |
| E3   | YHN Digital Champions Pilot Project Evaluation Report December 2015                                                                                                                                                                              | Analysis of effects of pilot project reporting on infrastructure and skills progress                                           |
| E4   | Newcastle Futures Digital Inclusion Report Evaluation Report, November 2018                                                                                                                                                                      | Evaluation report showing participants increase in confidence and ability to access services. Feedback comments                |
| E5   | NUSTEM impact report 2014-2020                                                                                                                                                                                                                   | Evidence for work with children and interactions with key influencers. Testimonials from teachers and schools                  |
| E6   | British Science Week Early Years Activity Pack                                                                                                                                                                                                   | National adoption of STEM Person of the Week initiative at early years, primary, and secondary levels                          |
| E7   | NUSTEM project evaluation data (2020) 'Using action research to design and evaluate sustained and inclusive engagement to improve children's knowledge and perception of STEM careers' International Journal of Science Education 42(5): 764-782 | Peer reviewed output corroborates impact of the NUSTEM project engaging primary school children between 2015 baseline and 2017 |
| E8   | Testimonial - Maria Antonio, North of Tyne Combined Authority                                                                                                                                                                                    | Evidence of impact on adult education and engagement policy                                                                    |
| E9   | BRIDGE Project – Final Report                                                                                                                                                                                                                    | Impact on diversity of construction programmes                                                                                 |