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GREENING OF E-LEARNING CHECK OUT (GECKO)

Gilly Salmon
Beyond Distance Research Alliance
Email: gks13@le.ac.uk

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GECKO, an exploratory pilot project, found there was no significant difference between total carbon emissions created by students during a blended learning module, i-Science, and those emissions created by students during a face-to-face Physics module and that establishing individual carbon emissions by a particular student is very challenging. However, GECKO developed a Learning Carbon Footprint based on four key parameters (ICT, paper, energy and travel) to inform the University's policy on environmentally sustainable learning and teaching. To promote discussion of this policy, the report includes hypothetical examples of Learning Carbon Footprints from each of the University's four Colleges.

1. BACKGROUND

In 2002 the UN launched the Decade of Education for Sustainable Development to integrate the principles, values, and practices of sustainable development into all aspects of education and learning. The UK government moved to address environmental challenges through the Climate Change Act of 2008. Within the education sector, the Higher Education Funding Council for England and the Learning and Skills Council published strategies aimed at environmentally sustainable education. Higher Education Institutions (HEIs) adopted operational measures such as estate management, energy efficiency, space management and the purchasing of environmentally friendly technologies.

The Times Higher Education (THE) published in 2008 a Green league table ranking universities by their environmental performance: the University of Leicester was ranked 96th, the lowest of all HEIs in the East Midlands. GECKO, funded by the Teaching Enhancement Fund (TEF), was an exploratory six-month pilot project to address environmental challenges faced by the University. It compared total carbon emissions created by students during a blended learning course, i-Science, with those emissions created during a face-to-face Physics course. GECKO also developed a Learning Carbon Footprint based on four key parameters (ICT, paper, energy and travel) to inform the University's

policy on environmentally sustainable learning and teaching. To promote discussion of this policy, the report includes hypothetical examples of Learning Carbon Footprints from each of the University's four Colleges.

2. PROJECT AIMS AND OBJECTIVES

The project had three aims:

2.1 To compare Carbon Dioxide emissions of blended and face-to-face modes of delivery

In this context, GECKO defined Carbon Dioxide emissions as those created by students during their studies through use of ICT, paper and energy, and through travel. These parameters were selected for their relative impact on the environment and their relevance to Higher Education; as well as the ease with which data could be gathered from the students. Emissions created by staff in teaching were excluded.

Within each parameter there are further variables not taken into account; Table 1 lists some of these:

Parameter	Potential variables
ICT	Additional peripherals plugged into a PC which are not reported as being used The infrastructure running servers that power the Internet The environmental impact of production and distribution
Paper	Whether the paper was previously recycled What type of ink/bleach was used in the paper production The type of printer/photocopier used
Energy	Available space within the lecture hall that was wasted The type and size of the light bulbs being used in individuals' accommodation
Travel	Whether the vehicle has been correctly serviced to maintain efficiency How the vehicle was being driven The traffic situation on specific journeys to campus

Table 1 Example of variables not taken into account within each parameter

Modes of delivery at the university range from on-campus to 100% distance learning. On-campus learning includes learning at home or in a student residence, as well as face-to-face in a lecture hall, library, laboratory or workshop; it includes learning from books, online from the VLE and through practicals and field trips. Distance learning includes learning at home or at a workplace, from correspondence materials or online from the VLE. Blended learning is a mixture: it may include any of the kinds of learning in on-campus or distance learning. Different modules deploy different

blended mixtures. GECKO looked at carbon emissions for a particular blend used in i-Science and for face-to-face learning in Physics.

2.2 To test the hypothesis that blended learning is more environmentally sustainable than face-to-face

Does blended learning, of the kind used in i-Science, create less Carbon Dioxide than a face-to-face module like Physics? GECKO's objective here was to compare emissions, based on data collected from students for key elements of the four parameters:

Parameters	Elements
ICT use	Use of PC, laptops, photocopiers and scanners
Paper use	Printing and photocopying
Energy use	Electricity and gas consumed
Mode of travel	By car, bus, bicycle, motor bicycle, taxi or walking

Table 2 Key elements of the four parameters selected for GECKO

2.3 To develop the Learning Carbon Footprint for various modes of delivery

These two modules, i-Science and Physics represented only two modes of delivery, but GECKO aimed to use these case studies to develop a model, the Learning Carbon Footprint, based on the four parameters, that could then be applied, hypothetically, to other modules using different modes.

3. RESEARCH METHODS

3.1 Comparing Carbon Dioxide emissions of blended and face-to-face modes of delivery

GECKO surveyed online 10 student volunteers from each of two courses: BSc i-Science (L34) uses blended delivery and BSc Physics (F300) uses face-to-face delivery. These students were recruited with the help of the program director. As an incentive each student participating received a £20 food voucher; 16 completed all the research components.

All 20 students attended an induction at which the researchers explained the research objectives and sought individual informed consent from the participants. During the induction, for calculating later their learning-related Carbon Dioxide emissions, students provided information on themselves about:

-- Address at which they currently lived

-- Type of accommodation they lived in

-- Their access to ICT different equipment

-- Learning locations they used most frequently

-- Their mode of travel

-- Other forms of energy use.

Students contributed data during three one-week periods in November-December, 2008. They were given booklets to keep a log of how long they spent on their PCs or laptops, photocopiers and scanners, how much paper they used for printing and photocopying, how much energy they consumed in the form of electricity and gas for heating and lighting, and how far they travelled by public or private transport to or from the University during the 15-credit module. Data from the logs were used to calculate each individual's learning carbon footprint, based on the four key parameters.

Case study: i-Science (blended learning)

BSc i-Science (L34) uses blended learning with courses delivered both face-to-face and online through Blackboard. Students are issued with laptops at the beginning of their programme. The i-Science programme has similar learning objectives to those of the BSc Physics programme although the latter is delivered through a different mode. Table 3 shows the intended learning outcomes, teaching and learning methods and assessment methods for i-Science.

Case study: Physics (face-to-face learning)

The BSc Physics (F300) programme is delivered solely through traditional face-to-face on-campus methods. Table 4 shows the intended learning outcomes and teaching and learning and assessment methods for the programme.

3.2 Testing the hypothesis that blended learning is more environmentally sustainable than face-to-face

Testing the hypothesis for each of the four parameters required conversion of the data to a common base, kilogrammes of Carbon Dioxide, and guidance was sought from established authorities as to the best approach. Emissions from ICT use and paper consumption were based on conversion factors supplied by Toshiba. Those for energy consumption used the Carbon Trust's conversion factors, and those for travel the conversion formulae supplied by the Department for Transport. Each student's average weekly Carbon emission was calculated. Total average weekly Carbon emissions were calculated for each module and for the two modules combined.

Developing the Learning Carbon Footprint for various modes of delivery

The Learning Carbon Footprint is a readily-grasped graphical representation of the CO2 emission for each delivery mode covering the four key parameters (ICT, paper, energy and travel). The footprint made up of:

Toes: The length of the toes represents ICT usage
Ball: The diameter of the ball of the foot represents the paper usage
Arch: The width of the arch of the foot represents energy usage
Heel: The diameter of the heel of the foot represents travel.

Intended learning outcomes	Teaching and learning methods	Assessment methods
A general understanding of the scientific method and its limits Advanced knowledge of one or more sciences, including physics, chemistry, biological sciences, geology Knowledge of applications in one or more of the above areas and archaeology, geography and engineering Experience of current research in interdisciplinary areas of science Basic knowledge of IT and computing Competence in basic mathematics e.g. numeracy, algebra, graphical analysis. Professional and personal skills e.g. presentation, written and oral communication Experience in the public understanding of science Independent learning skills	Problem-based learning Lectures Seminars Tutorials Group projects, discussion and problem solving Laboratory and workshop activities Extended research project Laboratory and project supervision Peer review Coursework Specified reading	Written examinations Presentations Project reports Notebook assessment Problem solutions Laboratory notebooks Assessed tasks and problems Oral assessment Group assessment (outcomes and oral questioning) Portfolio

Table 3 i-Science teaching and assessment methods

In order to develop a simple benchmark for comparison purposes, GECKO added together the data from the two student groups and applied the data to create a base carbon footprint. Each parameter has a base size represented by the average Carbon Dioxide emissions of the two groups combined. The size of each parameter for each group can then be compared visually with the base size (Figure 1). Environmentally sustainable modules are likely to have smaller toes, ball, arch and heel in the footprint than the base size for each, and modules that are not sustainable are likely to have larger ones.

To produce the Learning Carbon Footprints for GECKO the average Carbon Dioxide emission per student for each module was calculated for each parameter, and compared with the base figures (the average for both groups together) as shown in Table 5.

Intended learning outcomes	Teaching and learning methods	Assessment methods
Working knowledge of general physics Exposure in some areas of physics {astrophysics/space science}. Understanding of the scope of physics {astrophysics/space science/e-science /nanoscience} Interests in and aptitudes for a range of areas of physics and technology Develop independent learning skills Knowledge and generic skills for employment in R&D Experience of applications of physics and professional skills in Industry. Experience of study of Physics in a Continental European University.	Problem-based learning Lectures Projects Problem solving classes Marked assignments Laboratory and project supervision Tutorials, Workshops, Practice throughout course Group problem solving Resource based learning European experience Industrial experience Specified reading	Written examinations Reports (projects and laboratory) Laboratory notebooks/ assessment Presentations (group and project) Notebook assessment Assessed problems and tasks Project summaries Assessed tasks Group assessment (outcomes and oral questioning)

Table 4 Physics teaching and assessment methods

To promote discussion of university policy on environmentally sustainable learning and reducing carbon emissions, GECKO then created hypothetical footprints along the same lines, using the four parameters, for two modules from each of the four Colleges (see Figures 2-5 below).

4. PROJECT OUTCOMES AND ACHIEVEMENTS

4.1 Comparison of Carbon Dioxide emissions of blended and face-to-face modes of learning

To assess the average Carbon Dioxide emission associated with each mode of study, the four key parameters (ICT, paper, energy and travel during the project) were aggregated for each mode. Table 5 shows the differences in Carbon Dioxide emissions between the two groups, with i-Science students scoring lower on ICT and paper use, whilst Physics students scored lower on energy and travel.

Parameters	i-Science (blended learning)	Physics (face-to-face learning)	Both groups combined (base)
	Average per student (kg)	Average per student (kg)	Average per student (kg)
ICT	0.89	2.91	2.25
Paper	0.06	0.28	0.20
Energy	7.22	4.99	5.73
Travel	0.09	0.05	0.06
Total average emissions per student	8.26	8.23	8.24

Table 5 Comparison of Carbon Dioxide emissions

4.2 Is blended learning more environmentally sustainable than face-to-face learning?

Table 5 shows that the average Carbon Dioxide emission per student was 8.26kg for i-Science (blended learning) and 8.23kg for Physics (face-to-face learning) students. The difference was very small, therefore within the limits of this exploratory pilot study blended learning was not shown to be more environmentally sustainable than face-to-face learning.

4.3 The Learning Carbon Footprints

GECKO produced the Learning Carbon Footprints by calculating the average Carbon Dioxide emission per student (in kgs) for each module and for each parameter, and compared these with the average for both groups together. Figure 1 shows the I-Science and Physics module footprints compared with the base footprint.

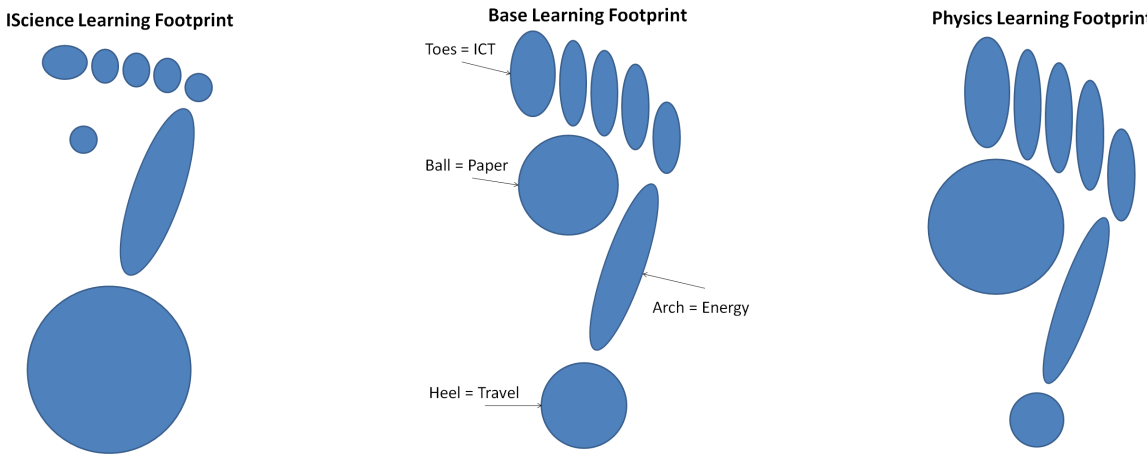


Figure 1 The i-Science and Physics Learning Carbon Footprints compared with the base Learning Carbon Footprint

Note that these only show differences between the parameters: the base footprint is not an idealised model of low carbon emissions. The university might aim to lower emissions, making each parameter smaller.

4.4 The hypothetical Learning Carbon Footprints

GECKO created hypothetical Learning Carbon Footprints for two programmes from each of the four colleges at the university. These are not based on statistics gathered from students, but on rough, debatable characterising of each programme, to stimulate discussion about how to help the university to become more environmentally conscious in its teaching and learning.

In Figures 2-5, GECKO has applied a simple scale of 1 to 5 to each of the four parameters. 1 = small amounts of Carbon Dioxide and 5 = large amounts of Carbon Dioxide, compared to the base footprint discussed previously.

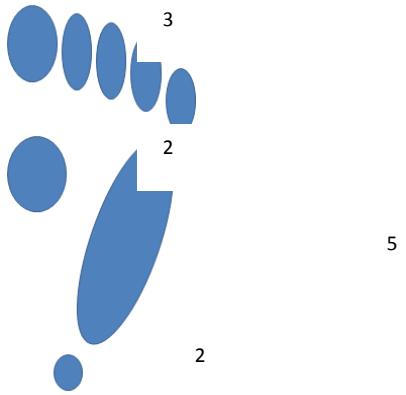
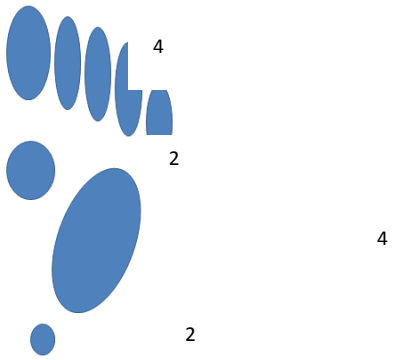
On-Campus BSc Chemistry	On-Campus BEng Communications and Electronic Engineering
	
A programme of this nature would have an average use of ICT, supplemented by handouts and note-taking, which use less than average amounts of paper. Time spent in laboratory, and seminars, yields a higher than average figure for energy. Travel is minimal as most students live local to campus.	A programme of this nature would require more ICT use than the Chemistry example but not as high as other programmes. The paper consumption would be similar as would the travel. However, less time would be spent in workshop or laboratory with more individual learning taking place in students' own accommodation.

Figure 2 Learning Carbon Footprints for College of Science and Engineering

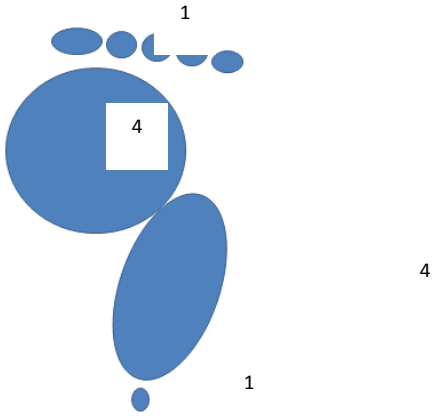
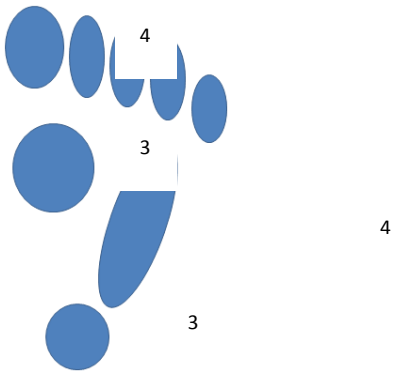
Distance Learning MBA	On-Campus BA Human Geography
	
In this programme there is minimal use of ICT for the distance learning MBA, with most learning materials being paper-based. All distance learners will be studying in their own accommodation or workplace so individual heating and lighting use will be high. Travel will be negligible, unless students travel to a summer school on-campus in which case these emissions will be high.	ICT use will be quite high for geography-based programmes because of data recording and analysis. Paper use will be less than in distance learning programmes but still around the base average. Energy use is based on a mix of lectures and seminars, plus personal study in private accommodation and travel is required for field-trips.

Figure 3 Learning Carbon Footprints for College of Social Science

On-Campus LLB Law	Distance Learning MA in Archaeology and Heritage
 4	1 5 1 4
The hypothesis behind Law students being high users of ICT, Paper and Energy stems from the fact that this programme is content- heavy requiring long hours of contact time, personal study and time spent in the Library. Travel is below the average for on-campus students.	The distance learning Archaeology programme uses very little ICT, but instead relies on distributing learning materials and text books (high paper use). Energy consumption is likely to be above average as individual accommodation will need heating and lighting. Travel is negligible as students rarely visit the campus.

Figure 4 Learning Carbon Footprints for College of Arts, Humanities and Law

On-Campus MBCHb (Medicine)	Distance Learning MSc Occupational Psychology
	
Studying medicine requires some use of ICT but perhaps not to the level of other programmes. In medical school, students rely on study-books (high paper use), which they complete through the lectures and workshops. Energy use is high because of higher amounts of contact time and personal study. Travel is similar to other on-campus students.	The distance learning psychology programme uses much ICT with innovative blackboard adoption. There is an above average use of paper. Energy is high because of the individual study when at a distance. Travel is negligible.

Figure 5 Learning Carbon Footprint for College of Medicine, Biological and Psychological Science

Figures 2-5 do not show how much Carbon Dioxide is emitted by each programme. GECKO has no data on which to base such comparisons.

5. Evaluation

GECKO showed how different modes of learning can impact in different ways on the environment. In the two case studies:

-- Carbon emission associated with ICT use is higher for face-to-face than for the blended learning. Students on the latter use laptops which may be more environmentally friendly than PCs despite their use over longer periods of time.

-- Paper use is higher for face-to-face learning than for blended learning. Face-to-face students, more than blended learning students, are likely to have access to printing and photocopy facilities on campus. Also, face-to-face students may be given handouts.

-- More energy is used for heating rooms for individual blended learners (i-Science) than for lecture halls for face-to-face students, although the difference depends on the class size in the face-to-face mode.

-- Carbon emissions associated with travel are higher for blended learning than for face-to-face students because i-Science students are mostly mature students who do not live locally and tend to use their own cars to come to campus.

The following lessons emerged from this exploratory pilot study:

-- Environmentally sustainable learning design: The findings from this study show there is no significant difference in carbon emissions between blended and face-to-face modes of delivery. Thus, instead of opting for one mode of delivery over another, i.e., face-to-face over blended learning, staff will need to consider how to balance specific elements of the learning design and delivery in a manner that will improve a module's eco-friendly impact.

-- Greening "travel": GECKO's findings for travel were rather surprising. It was originally expected that students on the blended learning programme would make only an occasional journey to the university and hence produce lower carbon emissions associated with travel. On the contrary, GECKO found that slightly higher carbon emissions were associated with travel by students taking the i-Science blended learning. This finding was a result of one participant travelling by car to the university in the first week of the research. Whilst occasional face-to-face meetings with tutors on campus may indeed be valuable for students on blended learning programmes, their needs might be met through promoting synchronous interaction, using web-conferencing tools. The "Green Meter" produced by iLinc Communication (Hickley, 2008), is one example of how to assess positive environmental gains through substituting synchronous interaction for learning-related travel. The meter is designed to estimate the amount of carbon that might have been emitted had users opted to travel to meeting sites.

-- Promoting "green" behaviour: This pilot study has shown that energy use by i-Science students is higher compared with their Physics counterparts. One student on the i-Science programme reported in Week 1 that he forgot his laptop and left it on for 24 hours and then did so again in Week 3. Undoubtedly individuals' behaviour has to be taken into account. Students need to be made aware of the environmental implications of their learning-related behaviour and the efficient use of ICT equipment both at home and when attending the university. One possible way of achieving this would be to incorporate environmentally sustainable programmes into the Higher Education curriculum whilst integrating good behaviour in use of energy. Student awards should go a long way towards encouraging environmentally responsible behaviour amongst students.

-- Use of hypothetical Learning Carbon Footprints: If departments within the Colleges could examine hypothetical Learning Carbon Footprints for their own programmes and modules within them, they might well be able to generate numerous varied proposals for reducing the size of one or other of the parameters, with the general aim of 'greening' the university's teaching and learning.

6. CONTINUATION OF THE PROJECT

This study was exploratory: its findings are not representative, even of the wider i-Science and Physics programmes in the University of Leicester. At this stage the Learning Carbon Footprint provides a provisional basis for comparing different modes of learning design and delivery and their impact on the environment. To this end, the pilot footprint can be used to estimate the

environmental impact associated with entire student cohorts of a taught programme or it can be used for assessing individual students' environmental behaviour.

A large-scale project in a wider context might refine and eventually validate the GECKO Learning Carbon Footprint. As in many costing studies, it would include a process for arriving at agreed assumptions and formulae that would underlie the Footprint. It would also be important to reach agreement about how to collect the data from students and possibly from staff concerned. Possibly useful URLs appear in the appendices below. Finally, the university would need to consider what weight it would be prepared to give to findings from such a project, in debates about cutting down Carbon Dioxide emissions from teaching and learning.

7. DISSEMINATION

The findings of GECKO may be disseminated through the following channels:

Internal	External
Websites – Gecko Website updated & Green Website report Appropriate committees – E-Learning Sub-Committee, Estates, ESD Course representatives – Prof. D. Raine Student Participants Students Union Representatives University Departments/Services – IT Services, Academic Office, Estates Inform the new E-Learning Strategy (currently in revision)	Press Release (Associated Press) Target Conferences – EDEN & Online EDUCA Target Publications – ALT Newsletter, ALT-J, BJET

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[last accessed 23rd April 2009]

Background questionnaire

A: Contact Information

Name: (Surname)---------- (First Names)----------

Address----------

----------Post Code----------

Email----------Tel----------Mobile----------

B: What type of accommodation do you live in? (Tick as many as are applicable)

Single bed-sit ☐ Shared room ☐ Studio ☐

☐ ☐ ☐

Catered Self-catered *Shared House *(List No. of people :-------)

Other ---------- ---------- ----------

C: Which of the following programmes are you enrolment on? (Tick the applicable option)

☐ ☐

I-Science Physics

Course code----------(please write down your course code)

D: Which of the following ICT equipments do you access to on regular use? (Tick as many as are applicable)

Desktop PC-Home ☐ Desktop PC-Uni ☐ Laptop-Uni ☐ Laptop-Home ☐

☐ ☐

Printer- Univ. Printer-Home ☐ Scanner-Univ. Scanner-Ho ☐

Others (Please list as many as are relevant to your learning) ---------- ----------

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E: Where does your learning take place?

Univ-Lectures ☐ Univ-Seminar ☐ Univ-Librar ☐ Bedroom ☐

Other (Please list as many locations relevant to your learning) ---------- ----------

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F: What mode of travel do you use to or from the university regularly?

Drive ☐ Bus ☐ Shared car ☐

Walk ☐ Bike ☐ Taxi ☐

Other (Please list as many relevant to your travel to univ) ---------- ----------
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G: Please indicate the sources / amount of energy you use in connection with your learning?

Electricity: ☐ No of bulbs (per bedroom) ☐ Wattage

Heating: ☐ Type (Electric) ☐ Type (Gas)

Others (Please list as many relevant to your learning) ---------- ----------
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***Data Protection Statement**: Any data gathered as part of this research will be kept confidential by the research team and in accordance with University of Leicester Ethical policies. The findings of this research project will be shared with other members of the project and will be published in relevant academic journals and/or presented at relevant conferences, seminars or workshops. All references to participants will be anonymised.*