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SUSQI PROJECT REPORT

Incorporating the use of haptic simulators in dental education and engaging students in sustainable practice

The Envirodent team at the Sustainability Student Engagement Event

Start/End date of Project: October 22-present
Date of Report: 23rd June 2023

Team Members:
Project lead - Zahra Shehabi (Consultant in Special Care Dentistry), Alessandra Booth (Dental Core Trainee and Academic Clinical Fellow)

Giulia Pintaritsch (4th Year Dental Student).

With thanks to:

- Rachel McLean and Rosie Hillson from Centre of Sustainable Health for their mentoring throughout this process
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Background:

The acquisition of manual dexterity and tactile sensory surgical skills are essential in Dentistry. The development of these skills should be incorporated into the five-year dental undergraduate teaching programme as early as possible to give students the confidence to deliver dental procedures chairside. The teaching of these preclinical skills is traditionally addressed through dental schools using the conventional method outlined below. However, a newer method has been introduced for Barts NHS Trust dental trainees, (Haptics simulators) which can bring a range of benefits.

1. *The conventional method*

Conventionally, students learn the pre-clinical skills through practicing to drill plastic teeth on phantom (dummy) heads (Fig. 1). This practical learning takes place from year two of the dental undergraduate curriculum in either the dental clinical skills laboratory or on dental chairs in the clinic. This method is non-patient facing, however replicates the full surgery set up utilising drills, single use cutting burs, filling materials, instruments and single use consumables (e.g. suction, barrier coverings, filling materials). Compressed air is required for the drills, with water used for cooling the handpieces and the filling process. The students are required to wear full personal protective equipment (PPE) due to the aerosols generated and handling of clinical materials. This teaching requires a clinical tutor to be present.

SusQI

This template forms part of the SusQI Toolkit available at susqi.org developed by the Centre for Sustainable Healthcare (CSH). CSH is registered as a company limited by guarantee in England & Wales No. 7450026 and as a charity No 1143189. Registered address 8 King Edward Street, Oxford OX1 4HL.

Figure 1: Students cutting plastic teeth on a phantom head

2. Haptic simulators

The Dental Institute (Queen Mary University of London & Barts Health NHS Trust) have invested 1.7million of a Barts Charity award on 42 Simodont Haptic simulators (at a cost of £41,000 each). The initial driver of this switch to haptic simulators was the COVID-19 pandemic which resulted in a cessation of all clinical practice in dentistry. Only a small proportion of UK Dental Schools use virtual simulators (McGleenon & Morison , 2021). Haptic simulators utilise an immersive 3D virtual environment combined with motor and tactile perceptions to replicate sensations such as drilling teeth. Students begin cutting shapes into virtual blocks from year one of the dental programme (compared to year two using conventional method) to improve manual dexterity and familiarise themselves with drilling teeth using the reflection in a virtual dental mirror. They then progress to cutting cavities and are exposed to more advanced clinical scenarios such as crown preparations. Feedback is given continuously and instantaneously via the simulator and so the need for a dental tutor is not essential. Furthermore, the pressures of needing a dental chair are also negated, making it a more efficient way to manage resources.

Figure 2: The Haptic Simulator & Haptic Suite

The simulators were purchased and first used in October 2022 and have been used intermittently since. A full roll out from September 2023 is planned. However, the environmental and financial savings, along with social impacts of this change to skills teaching, are yet to be established. It is hoped that the SusQI approach taken with this project will demonstrate triple bottom line benefits and further consolidate the need to utilise this resource regularly and more frequently.

The Envirodent Project

The Envirodent project within the Dental Hospital has been led by one of the dental consultants, with the aim of looking at a system wide approach to sustainability within the Dental Network at Barts Health. Student feedback from the Haptics project (highlighted later in this report) revealed the need for greater student involvement and awareness in sustainability activities. This feedback initiated a student engagement project as a means of meeting this need and has therefore been included as a side arm of this project.

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Specific Aims:

- To assess the impact of the newly purchased Haptic Dental Simulators across the triple bottom line (social, environmental and financial) using a SusQI approach
- To utilise a student delivered initiative to deliver preventative care advice to a local community to reduce their need for dental treatment

Methods:

Studying the system:

Process mapping was undertaken (Fig. 3) to identify areas where savings could be achieved using the Haptic simulators

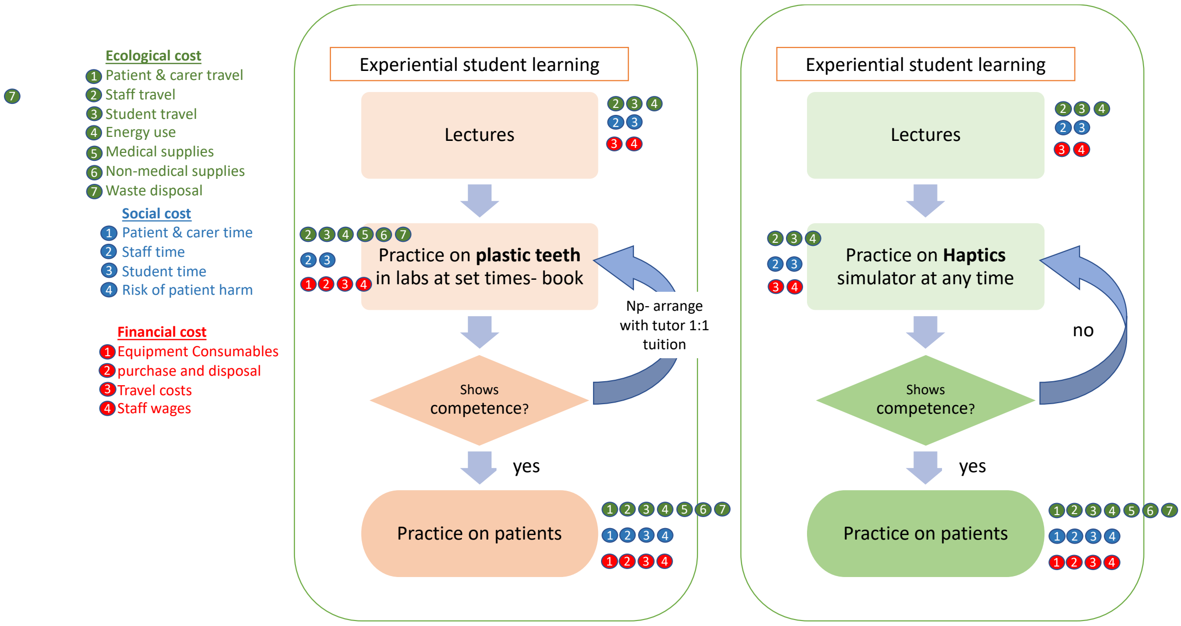

Figure 3: A process map comparing the conventional method of drilling plastic teeth to the Haptic simulator

Data items saved on the haptics server showed (Table 1) that undergraduates in Year one and Year three are the main users of the haptic simulators, though this might be underestimated as it relies on students saving their work.

Usage			
Group	Saved simulated items	Comments	
BDS 1	1281	manual dexterity training	
BDS 2	48	cariology	
BDS 3	252	cariology	
BDS 3 mod 2	558	cavity crown/ onlay/ inlay prep	
Dclin Dent Pros	59	all	
MID	31	all	
DSCP PG	92	all	
Total	**2321**		

Table 1: Simulated items saved, reflecting work students have undertaken using the simulator.

BDS= Bachelor of Dental Science; MID: minimally invasive dentistry, DSCP PG= Dental Science for Clinical Practice MSc programme.

To ensure a like-for-like comparison between the conventional method using plastic teeth and the haptic simulator, BDS year one items saved were removed from the data totals of the Haptic simulator as students

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do not start practicing pre-clinical skills using the conventional method until their second year. This resulted in a total of 1040 items saved over a six-month period.

The student engagement programme was then initiated by

1. Supporting a student volunteering oral health promotion and prevention programme
2. Organising a sustainability workshop focussed on idea sharing and generation for a new dental clinic aimed at improving dental access to the local community in Homerton

Measurement:

Patient outcomes:

- Datix and iatrogenic damage relating to treatment by students
- Questionnaire to students regarding iatrogenic damage to patients and improving technical skills

Population outcomes:

Given that the Haptic Suite has only recently been opened, any population outcomes would be difficult to ascertain. The prevention project that focused on a community prevention approach was aimed at improving the oral health of the local population. No literature exists that quantifies the impact of preventative advice in relation to a reduction in treatment need which makes the long-term impact of this project challenging to measure.

Environmental sustainability:

- All plastic teeth, gums, packaging and screws used in the conventional method were weighed in the Dental Lab
- Distributors of the above were contacted to ascertain material compositions to calculate carbon emissions
- Energy usage of the Haptic simulator was established

CO_2 emissions saved from using the Haptic Simulator in comparison to the conventional lab based was calculated using the following carbon emissions data:

- Stainless steel: 6.145 $kgCO_2e/kg$
  Taken from: **(Small World Consulting, 2023)**
- LDPE (for the plastic packaging): 2,586.72 kgCO2e/tonne
  Taken from: **(Department for Energy Security and Net Zero, 2023)**
- Average hard plastic (use this for the Melamine): 3,263.9 kgCO2e/tonne
  Taken from: **(Department for Energy Security and Net Zero, 2023)**
- PET (use this for the gums/thermoplastic elastomer): 4,018.48 kgCO2e/tonne
  Taken from: **(Department for Energy Security and Net Zero, 2023)**
- Transport emissions: **(Department for Energy Security and Net Zero, 2023)**

A questionnaire was disseminated to students to capture their perceptions on the environmental impact of using phantom heads and plastic teeth to develop their preclinical skills. A comments section was included to capture any qualitative feedback from the students.

Economic sustainability:

- Procurement data was obtained regarding orders and costs of consumables and plastic teeth purchased in the traditional method, which would be saved
- There is an investment cost for the Haptics simulators - £1.7 million for 42 Simodont Haptic simulators (at a cost of £41,000 each).

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Social sustainability:

- Questionnaire to measure confidence, anxiety and stress amongst students using the Haptic simulators. Access to the simulators was also assessed
- Feedback forms were disseminated to students

Results:

Patient outcomes:

Measuring whether the simulators have improved health outcomes for patients under the care of the service would be difficult to directly establish and attribute solely to the haptic simulators. However, the student feedback questionnaire suggested that just under half the students who responded felt more confident about treating patients and over two-thirds thought their skills had improved (Fig. 4). Liaising with the governance lead, we know that there are approximately five-six incidents per year resulting from iatrogenic damage to patients from student treatment and these include soft tissue damage, though this is likely to be under reported. There have been no increases in patient incidents related to student treatment since the procurement of the Haptic simulators and any reductions in incidents would need to be studied over time, with results likely to be confounded by increasing in number of patient treatment sessions conducted under undergraduate students.

Figure 4: Student feedback regarding confidence and technical skills using the Haptic simulators

Environmental sustainability:

1. **Carbon calculations for the conventional method**

The number of teeth and gums ordered for academic year 22/23 were obtained from the lab manager (Table 2).

Item	Quantity
Plastic teeth	38,472
Gum adult upper	200
Gum adult lower	200
Gum child upper	200
Gum child lower	200

Table 2: No. of teeth ordered for academic year 22/23, all of which was utilised in a single academic year

The frequency of gum replacements per tooth was calculated to allow incorporation into the final carbon calculations. On average one full arch gum is replaced every 48 teeth (38,472 teeth/800 gum arches = 48) The composition of plastic teeth and gums was ascertained from the supplier as melamine and elastomer respectively. -The average weight of a tooth was established by weighing each individual tooth. Only one quadrant of the mouth for the upper and lower arch was weighed (Table 3, appendix).as the weights of the opposite site would be the same (16 teeth in total instead of 32). The average weights of the gingivae (gum) were also measured (Table 4, appendix).

Each pack of plastic teeth contains

1. 100 teeth
2. 100 stainless steel screws

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3. A clear plastic bag

Carbon calculations of each tooth and gum, along with all the component parts above were established by weighing each component, using the carbon emissions in the methodology section above and standardising weight conversions from grams to kilograms to tonnes (Table 7, appendix). The items are shipped from Germany, so to calculate transportation emissions, the weight of the plastic teeth, component parts and packaging was converted to tonnes (Table 5, appendix). Emissions factors were derived from the resources stated in the measurements section above and the total transport emissions were calculated (Table 6, appendix). A summary of these is demonstrated in Table 12.

Item	Number per tooth	Carbon emissions (kgCO2e)			
		Raw materials	Transport	Waste	Total
Tooth	1	0.003	0.00003	0.00096	0.004
Gum (1 gum for every 48 teeth)	0.021	0.001	0.00000	0.00015	0.001
Screw	1	0.001	0.00001	0.00020	0.001
Packaging	0.01	0.000	0.00000	0.00006	0.0002
Total per tooth					*0.00618*

Table 12: Summary of carbon calculations for a plastic tooth and it's components

As the most frequent procedure was filling of a tooth, the calculations were converted back to Kilograms to add the carbon footprint of a composite filling using figures published in existing literature (PHE & CSH, 2018). We assumed that this would roughly average out the times where students used other materials such as wax for tooth morphology modules and the more consumable intensive procedures like crown and bridge preparation. It was difficult to establish frequency of different procedures in the lab as this information is not recorded, but it would have provided a more accurate estimation for carbon footprinting. Nevertheless, it was thought that the use of the carbon footprint of a 15 minute 'composite restoration' would suffice as an approximate estimation and may even be an underestimation when considering the length of time students take in the lab (using more energy, water, compressed air, changing of PPE etc). Furthermore, some students will have several attempts at drilling and restoring a tooth so there are times when the whole dental arch may need to be replaced (32 teeth). The figures therefore represent a minimum estimated carbon emissions figure. Patient travel was removed from pre-existing carbon emissions data as no patients are involved in the learning process. Carbon emissions associated with staff travel was also removed as this would have been similar in both methods used.

carbon footprint of a composite restoration KgCO2e	14.75
CO2e Patient travel KgCO2e	2.419
CO2e Staff travel kgCO2e	5.9
CO2e Comp restoration-patient - staff travel KgCO2e	6.431
Number of haptics items BDS year 2+	1040
CO2e plastic teeth + gum+ screws packaging + waste+transport KgCO2e	0.00618
CO2e comp restoration (without pt and staff travel)+plastic teeth KgCO2e	6.43718
Haptic items X restoration of a plastic tooth KgCO2e	6694.67
Add extra two teeth as at least 3 teeth replaced each time (+2 x 6.246) x1040 KgCO2e	12.8594
Total KgCO2e/Kg for 1040 plastic teeth drilled	**6707.529**

Table 8: Total carbon footprint calculations for practicing on 1040 plastic teeth

Therefore, the total carbon footprint of using the conventional method for 1040 practical learning procedures over a 6month period is a minimum of 6707.529 KgCO2e and an estimated **13,415.058 KgCO2e over an academic year**

2. Carbon calculations for the Haptic simulators

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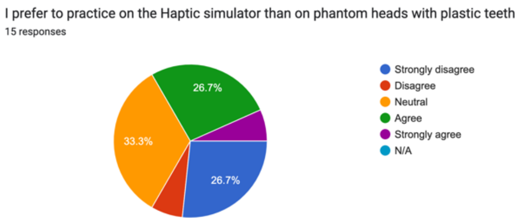
It was not possible to establish the carbon footprint of the production of a Simodont Haptic simulator but as the conventional method also uses a dummy head and drills, we focussed on the carbon calculations of things that were regarded as consumption items (e.g. energy, teeth, consumables) as opposed to static items of equipment. For the Haptic simulators, the only consumption item is energy. Energy use was calculated as follows:

- The number of watts the simulator requires for function is 400 Watts and used for an average of 2.5 hours per item saved. KWh were calculated as follows:
- (Watts x hours used)/1000= (400 x 2.5)/1000= 1KWh
- The emissions factor for electricity (KgCO_2/KWh)= 0.2749
- So for 1KWh, KgCO2e=0.2749 for a 2.5 hours sessions (each session used per item)
- For haptic items saved 1040x0.2749=285.896 for 6 months x 2 for 1 year=<u>571.792 KgCO2e</u>

Carbon savings
13,415.058 kgCO2e for plastic teeth drilled over 1 year - 571.792 kgCO2e Energy used for haptics =
12,834.266 kgCO2e savings over a 1 year period

3. Feedback from students & student engagement initiate



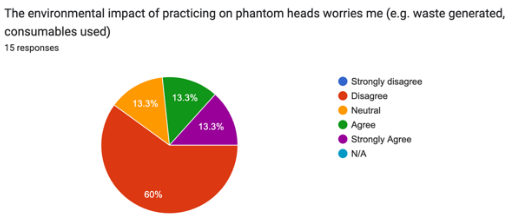


Figure 5: Feedback questionnaire from students regarding preference and environmental impact

As part of the feedback from students, they were asked about their preference between the simulators and the conventional method (phantom heads with plastic teeth) with only a third preferring the haptic simulator method. Students also shared their perceptions of the environmental impact on practicing using the conventional method. Comments were divided, and are collectively reflected in the following comments:

"The haptics have made me feel better about how my learning impacts the environment when compared to working in the lab where we are producing a lot of waste"
"When considering that dentistry is a huge contributor to wastes, the benefits of plastic teeth outweighs the waste part"

This, along with verbal feedback received from students revealed:
- Environmental awareness is varied amongst students, with many not understanding the implications of dentistry on population health
- A narrative of 'we can't do anything about it anyway'

As a result, an engagement initiative with students was launched via the 'Envirodent' project and consisted of:
1) Clinician input into the student prevention volunteering programme, *Barts Community Smiles*, to incorporate sustainability into the preventative advice given to members of the community. Feedback from community members was collected over two days:
    - Festival of communities held on the 9th June 2023 at Queen Mary University. Results showed that there was a good awareness of sustainability in relation to health and dental

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care after the festival (Table 9). The question was subsequently changed for the family hub event to ascertain degree of awareness.

- Family hub networking event held on the 16th June 2023 on the Isle of Dogs revealed a higher level of awareness of the impact of dental care on the environment (figure 7). This is likely due to the demographic of health-conscious parents who attend this type of event.

Most of the attendees at these events were residents of Tower Hamlets with approximately one fifth travelling by car and one third walking to the events.

2) A one-hour tutorial on sustainability delivered to three BDS year representatives on 6th July 2023 to facilitate a workshop

-

Figure 6: The student sustainability workshop with facilitators

- A practical sustainability workshop was organised on the 19th July with eight undergraduates (fig. 6). Students were given the opportunity to generate ideas for a new clinic in Homerton and pitch one idea to a panel of judges, with the help of facilitators. The judging panel included representatives from the sustainability transformation team, the Trust green group, Green at Barts co- chair and industry representatives. Given the success of the event, a further workshop with larger numbers will be planned in the new academic year, using the student pilot group as facilitators. Ideas included introducing intra-oral scanners to reduce waste with impression taking, managing patient's treatment plan better to reducing appointment times and providing more secure cycling facilities to support alternative sustainable transport to work.

- Since the workshop, we have been able to engage with Community Health Partners who will be exploring the option of installing secure cycle racks for staff and students at the new clinic. Shower facilities have also been incorporated into the design. The next steps would be to carry out a fact finding exercise to gauge how many students/staff would cycle to the new clinic and build on an active travel campaign thereafter.

Question	Yes (%)	No (%)
Are you aware of the environmental impact of dental care?	67.7	32.3
Are you aware of how we can reduce the environmental impact of dental care?	55.4	44.6
Are you aware of the health effects of climate change?	81	19

Table 9: Community member feedback regarding sustainability awareness

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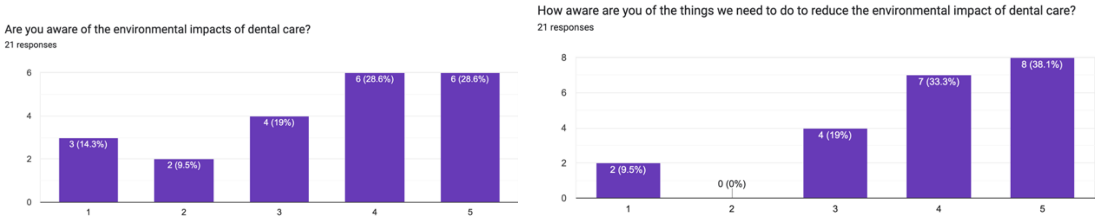

Figure 7: Awareness regarding environmental sustainability at the Family Hub event using a 5 point Likert scale. 1= not aware, 5= very aware

Population outcomes

From the feedback from community members (Table 10) regarding the student prevention and promotion initiative (Figure 8), the majority of patients agreed that the stalls provided enough information about looking after their teeth. More members from the Family Hub event were likely to seek dental care. This could be due to fewer responses gathered as the footfall was less at the family hub. Studies have shown that oral health promotion can improve oral health resulting in better oral hygiene and less decay, missing or filled teeth (Naidu & Nandlal, 2017), and UK studies have shown a 22% reduction in decay in patients who received toothbrushes, toothpastes and fluoride varnish (Milsom, et al., 2014)

Figure 8: Barts Community Smiles student volunteers at the Family Hub event (left) and at the Festival of Communities (right)

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
Has our stall activity provided more knowledge about how to look after your teeth?	0% (0)	0% (0)	13.8% (9)	35.4% (23)	50.8% (33)
	0% (0)	4.8% (1)	9.5% (2)	19 % (4)	66.7 % (14)
Are you more likely to seek dental care for a dental check-up after speaking to our team?	1.5% (1)	0% (0)	29.2% (19)	27.7% (18)	41.5% (27)
	0% (0)	0% (0)	19% (4)	14.3% (3)	66.7% (14)

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Table 10: Feedback from community members regarding dental care. Figures in blue represent responses collated from the Festival of Communities, whilst those in green represent the Family Hub event

Haptic Simulator Economic sustainability:

Consumables savings were calculated per tooth drilled to estimate savings using haptic. There are a minimum of 3 teeth replaced every time a tooth (tooth drilled + tooth either side) to avoid students being unfairly marked for iatrogenic damage of adjacent teeth.

Cost of consumables per tooth drilled						
Item	**Price (£)**	**Price (£) + V/**	**Quantity**	**£ Per item**	**Quantitiy/treatment**	**Price(£)/ trea**
Apron	4.21	5.052	200	0.02526	1	0.02526
Masks	16.43	19.716	50	0.39432	1	0.39432
Gloves	13.33	15.996	200	0.07998	6	0.47988
Burs 17/18	44.87	53.844	50	1.07688	1	1.07688
Burs 19/20	18.47	22.164	50	0.44328	2	0.88656
Burs 1-16	28.84	34.608	50	0.69216	1	0.69216
Disposable exam kits	2.75	3.3	1	3.3	1	3.3
disposa shield	29.72	35.664	250	0.142656	5	0.71328
Suction tip	2.34	2.808	100	0.02808	1	0.02808
Composite	1.9	2.28	1	2.28	2	4.56
Cotton wool	3.04	3.648	500	0.007296	4	0.029184
3 in 1 tips	21	25.2	250	0.1008	1	0.1008
Matrix band	1.78	2.136	1	2.136	1	2.136
wedges	28.51	34.212	500	0.068424	2	0.136848
Rubber dam	10.44	12.528	30	0.4176	1	0.4176
Optibon	145.32	174.384	80	2.1798	1	2.1798
Microbrush	37.78	45.336	400	0.11334	3	0.34002
Tooth	1.68	2.016	1	2.016	3	6.048
Gum	0.32	0.384	1	0.384	3	1.152
					Min total cost(£)/ sessio	**24.696672**

Table 11: Cost of consumables per patient treatments

- 1040 haptic items drilled (from saved data)
- To calculate savings on consumables multiply haptic item quantity by minimum cost of consumables using traditional method: 1040 x 24.697=£25,684.539 saved for 6 months, £51,369.078/yr.
- The cost of a phantom head (conventional method) is £15,222.71. 42 phantom heads would cost £639,353.82. However, this does not include the cost of handpieces, light fixtures or energy used for compressed air, lighting and water
- Based on these bare minimum estimates on current usage, it is estimated that the haptic simulators will be cost neutral in 21 years (£1,722,000-£639,353.821= £1082,646.18; £1082,646.18/£51,369.078=21)

Social sustainability:

In the feedback from students regarding Haptics, questions were asked regarding wellbeing and access to the simulators (Figure 9). Under half of the students (40%) felt less anxious/ stressed about patient treatments following use of the simulators, with 33.35 disagreeing with this statement, suggesting that the learning experience from the Haptic simulators by itself is not enough to prepare the students mentally for patient treatments. Ease of booking sessions the simulators was considered under social sustainability as it can impact on student administration. The conventional method would require liaison with the lab technician as there would need to be a member of staff present for health and safety reasons, whereas the Haptics Suite offers drop in sessions and do not require logistical planning.

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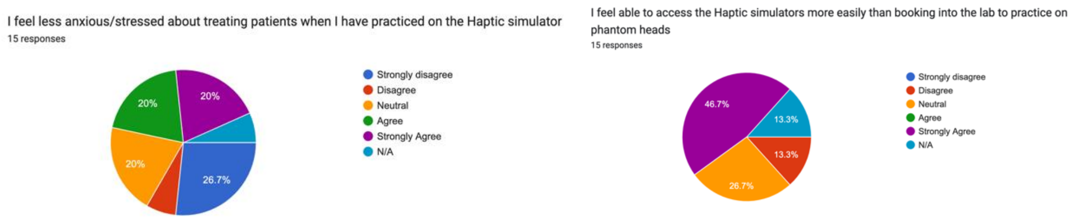

Figure 9: Questions regarding access to Haptic simulators and wellbeing

Feedback from staff supporting students regarding time and efficiency savings were not elicited due to time constraints of the project

Discussion:

The dental profession experienced a surge in plastic consumption and disposal during the COVID-19 pandemic (Ahmadifard, 2022) and a halt in student activity which has negatively impacted on student experience and learning. With this cessation of routine practice came innovation, lateral thinking and offered the opportunity to rebuild learning with the propelled use of technology in modernising digital dentistry.

The use of virtual reality has been shown to improve the technical skills of dental students (LeBlanc, et al., 2004). This is especially important as there is a general reduction in clinical experience amongst students graduating for several reasons such as; increasing numbers of student intakes; a reduction of suitable patients; and a lack of staff resources (McGleenon & Morison , 2021).

The use of over 39,412 plastic teeth and gums costing £78,602 per academic year is phenomenal. The price tag of over £1.5 million for the Simodont Haptic simulators may seem hefty, but the investment offers both financial savings and environment savings as demonstrated in this report. This makes the use of haptic simulators- a long-term cost-effective learning experience. As students can reset the simulator and carry out the same procedure continually, the data from the Haptics server is underrepresented as the analysis relating to the number of procedures completed relies on students saving their work. Furthermore, year one students also use the haptic simulators (removed from original calculations) and there are plans to expand usage within postgraduate specialties (e.g. endodontics) and courses for external general dental practitioners. The equivalent of this using the conventional method would be the drilling of multiple plastic teeth, and so the environmental savings in this report are likely to be underestimated. After discussion with the lab manager, it has been agreed that in some cases the drilled plastic teeth can be reused and this is now planned for:

1. Sessions with a prosthodontist for preparation of teeth for dentures
2. BDS year 1 sessions in the Fundamentals of Dentistry module for the hands on tooth polishing sessions
3. The additional dentistry summer school for filling

However, for the vast majority of procedures the plastic teeth cannot be reused.

The feedback from students' questionnaires revealed that many students did not prefer the Haptic simulators, this reflects feedback from national data which shows that Haptic simulators should be used to complement conventional methods rather than completely replace them (McGleenon & Morison , 2021). Clinical governance data for the dental hospital highlights the low risk of iatrogenic damage by students (estimated to be around five-six incidents per year) compared to staff groups so the hope is that with a blended approach to learning, the risk will be reduced further. However, one must bear in mind that incidents are likely to be under reported.

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What was striking, was the feedback received from students following the questionnaire on the Haptic simulators which suggested a lack of awareness amongst students on sustainability in clinical practice. The sustainability workshop that ensued was successful in generating positive feedback from both the students and the judging panel but only eight out of the 25 students who signed up attended. Unlike medicine, the Dental Undergraduate Curriculum as set by the General Dental Council is yet to incorporate sustainability into the learning outcomes but a consultation document highlighting the need for this looks promising. Nevertheless, we are hoping to take a pro-active approach by using the initial workshop pilot and affiliating volunteering hours to a second workshop which the students are required to acquire over the course of their degree. The three pitches of the sustainability workshop will also be taken forward to implement aspects of the students' proposals into action, although some of these proposed initiatives will be dependent on funding.

The link between oral health promotion, the delivery of preventive treatment on carbon footprint and health outcomes is more difficult to establish due to the influence of confounding factors and factors limiting access to dental care. The student-led volunteer initiative, Barts Community Smiles, focusses solely on oral health promotion as an aspect of preventive care and reducing health inequalities.

The oral health promotion activities at the Festival of Communities and the Family Hub Network event both appeared to increase participants' knowledge of oral health. The long-term retention of this oral health knowledge on oral health outcomes cannot be evaluated through this means or the translation of this knowledge to reduced treatment needs. We also observed that although event participants felt their knowledge on oral health improved, this trend did not fully correlate with motivation to seek a dental check-up to prevent disease. It is important to consider other barriers to accessing dental care. The NHS GP Patient survey showed that only 30% of respondents were successful in scheduling an appointment at a practice they had never visited before (NHS England, 2023). Studies have shown that adults living in neighbourhoods which have a high-ranking score on the Index of Multiple Deprivation are less likely to report using dental services (Lang, et al., 2008). The Tower Hamlets local authority is ranked as the 10th most-deprived local authority area across the UK (Tower Hamlets Council,, 2015**)**; as such, the participants of our questionnaire may already be less likely to seek dental care, despite an increased awareness of the importance of oral health acting as a facilitator to seeking care. This further stresses the importance of delivering preventative advice to the public in community settings.

The opening of a new undergraduate dental clinic in Homerton will be supported by the delivery of regular oral health promotion stalls. This is likely to provide mutual benefit to students and the local community. Reflective studies exploring students' perspectives on community engagement in dental undergraduate education show that students feel their awareness of social responsibility and confidence in patient interactions are increased after performing community engagement activities (Witton & Paisi, 2022). This form of community engagement further supports the Dental Schools' Council endorsement of education activities which place emphasis on the social determinants of oral health and may increase student awareness of the role of the dental team in promoting health equity (Watt, et al., 2014).

The influence of seeking preventive dental treatment and oral health messaging on the long-term reduction of clinical activity and its correlated triple bottom line impacts remains to be fully understood. The Dental Network is committed to working with local community partners to improve oral health outcomes, increasing access to dental care within the local community and the continued support of community engagement projects within the dental undergraduate curriculum.

Conclusions:

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As the focus in Dentistry turns to artificial intelligence and technology-based solutions, there should be an inevitable and substantial reduction the carbon footprint which we have demonstrated in this project. The benefits of this will not totally replace the opportunities to practice on phantom heads but will be a medium for enhancement of skills and using a blend between the two methods in dental education is necessary. What this SusQIP has shown is that there is a lack of understanding and awareness amongst dental undergraduate students regarding the relevance of sustainability to Dentistry which can be addressed by introducing workshops and practical based solutions. Collaborative working between clinical staff and students will enhance and expand the current community-based prevention program by offering guidance on how developments in dentistry such as sustainability can improve population health. Interest in sustainability within dentistry has increased but is yet to catch up with medicine, and the initiatives described in this project could encourage dental teams to engage in similar projects.

Appendix

Weights of plastic teeth			
Lower tooth in quadrant	Weight (g)	Upper tooth in quadrant	Weight (g)
LL1	0.461	UR1	0.838
LL2	0.46	UR2	0.527
LL3	0.668	UR3	0.815
LL4	0.726	UR4	0.773
LL5	0.82	UR5	0.836
LL6	1.561	UR6	1.527
LL7	1.299	UR7	1.149
LL8	0.962	UR8	0.875
Total/quad	6.957	Total/quad	7.34
Total/arch (Quadrant x 2)	13.914	Total/arch	14.68
Average weight of lower tooth	**0.869625**	**Average weight of upper tooth**	**0.9175**
Average weight of all teeth	**0.8935625**		

Table 3: calculations for the average weight of a tooth

Gingivae (gum)	Weight (g)
gingivae upper	7.949
gingivae lower	5.643
Average weight gingivae	**6.796**

Table 4: calculations for the average weight of the gingivae

total wieght weight of tooth including the gum, screw and packaging (g)	1.273
Coversion to Kg	0.001273
Conversion to tonnes	0.000001273

Table 5: Conversion of the total weight of a plastic tooth, components and packaging to tonnes

Distance from Bremerhaven port to London Gateway Port (km)	957
Emission factor for shipping (general container ship): kgCO2e per tonne.km	0.019773
weight of plastic tooth + components (tonnes) x km x emissions factor	2.40887E-05
Distance from London Gateway Port to RLH (km)	50.2
Emission factor for Average HGV: kgCO2e per tonne.km	0.21909
weight of plastic tooth + components (tonnes) x km x emissions factor	1.40009E-05
Total transport emissions per tooth + components	**3.80895E-05**

Table 6: Calculation of the transport emissions for each plastic tooth, screws and packaging

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KgCO2e per tooth + components+ packaging	
Item	Weight
steel screws x 100 (g)	18.27
screw x 1 (g)	0.1827
convert to kg	0.0001827
kg CO2e stainless steel/**kg**	6.145
Stainless steel screw kgCO2e	0.001122692
outer packaging x 1 (transparent plastic bag) (g)	5.46
out packaging per tooth (packaging/100) (g)	0.0546
convert to tonnes	5.46E-08
CO2e clear plastic LDPE kgCO2e/tonne	2,586.72
Packaging LDPE kgCO2e	0.000141235
Average weight of tooth (g)	0.8935625
convert to tonnes	8.93563E-07
CO2e melamine kgCO2e/tonne	3,263.90
CO2 emission of plastic tooth kgCO2e	0.002916499
Average weight of gum (g)	6.796
Average gum weight/tooth (g)	0.141583333
convert to tonnes	1.41583E-07
CO2e elastomer (for gingivae) kgCO2e/tonne	4,218.48
CO2e gingivae kgCO2e/tonne	0.000597266
Total waste disposal CO2e of plastic tooth + components	0.00136661
Transport kgCO2e per tonne.km	0.00003809
Total KgCO2e/tonne per tooth components/packaging/transport	**0.00618239**

Table 7: carbon emission calculations for a tooth including all the component parts

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