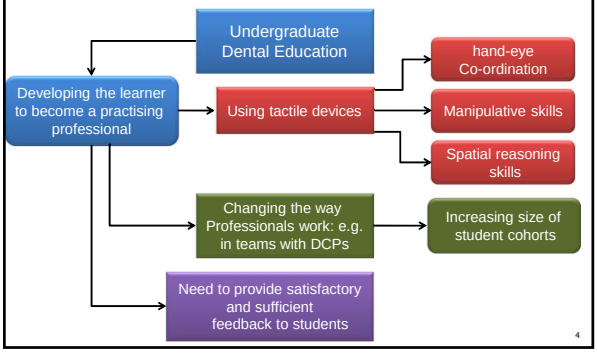
# Results of Students' learning Clinical Skills using a Haptic Dental Simulator 2009 - 2016

**Presenters: Margaret J. Cox and Barry F. Quinn**

**The Dental Institute and the**
**Department of Education and Professional Studies**
**King's College London**

**ADEE - Barcelona– August 2016**

## Goals and issues for Dental Education




4

## hapTEL Interdisciplinary team and partners

Prof. Margaret Cox (Director, KCL)
Prof. Nairn Wilson (User-Group Coordinator, KCL)
Prof. Mark Woolford (Dean of Dental Education, KCL)
Dr. Jonathan P. San Diego (Project Manager, KCL)
Dr. Barry Quinn ((Lead Clinician, KCL)
Dr. Arash Shahriar-rad (Doctoral/Post-Doctoral Researcher)

**King's College Staff and Post-graduate students**
Dental, Medical and Nursing clinicians; psychologists; sociologists; robotics specialists and educational researchers

**University of Reading - Cybernetics team**
**Birmingham City University Engineering**

### In collaboration with

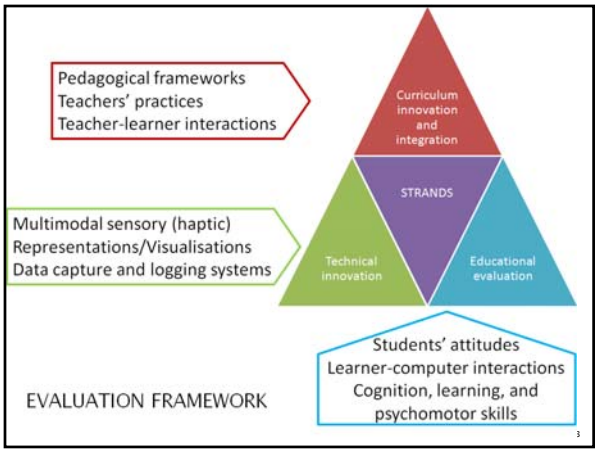
**Generic Robotics – Dr. Alistair Barrow and colleagues**

2

## Clinical concepts and skills for undergraduate dental students

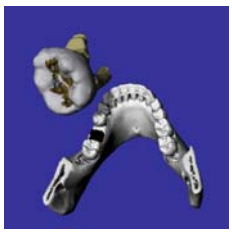
- Caries removal
- Depth of the cavity
- Angle of entry into the tooth
- Speed of the bur
- Different tactile sensations in cutting between different tissues
- Cavity design
- Time available for the task and the actual time taken

5



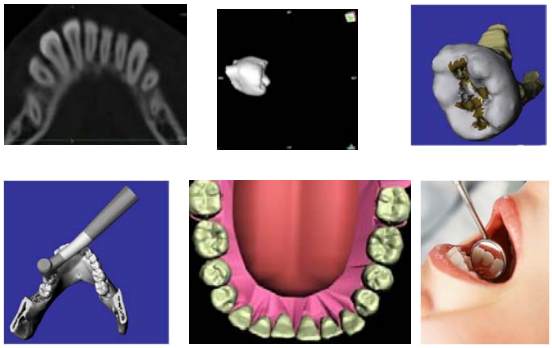

3

## Graphic models



6

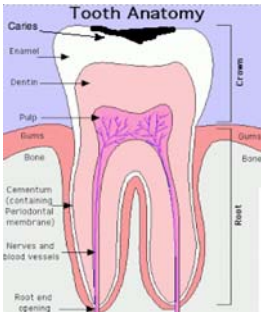
## Teeth and mouth model



7

## Specific goals for caries removal

- Remove as much caries as possible.
- Retain the enamel and dentine.
- Avoid drilling into the pulp.
- Complete the task in a reasonable time



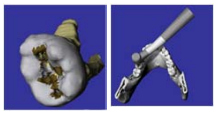

10

## Traditional

- Removal of artificial decayed material on a plastic tooth
  - Three sessions: Two attempts per session

## hapTEL

- Removal of virtual decayed material on a virtual tooth located in a jaw
  - Three sessions: as many attempts as they wish within a given time per session



8

## Learning activities and objectives for BDS Year 1 - students

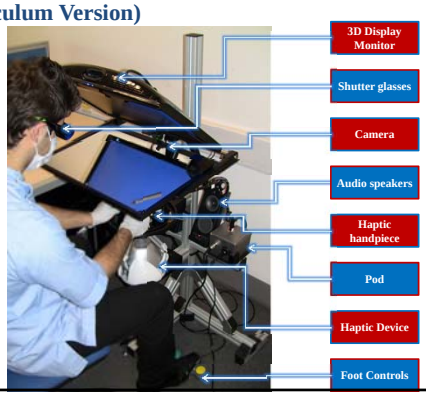
hapTEL virtual dental work-stations were used to teach BDS-Year-1 dental students basic clinical skills:

- Operating on a virtual tooth shown on the horizontal screen – simulating the patient in a dental chair;
- Adopting the correct posture;
- Holding the hand-piece correctly;
- Using the hand-piece with the correct angle;
- Applying the right amount of pressure;
- Completing the task in the allotted time.

11

## hapTEL Workstation

**(Curriculum Version)**




9

## Student cohorts (2008 – 2016) N = 897

| | 2008/ 2009 | 2009/ 2010 | 2010/ 2011 | 2011/ 2012 | 2012/ 2013 | 2014/ 2015 | 2015/ 2016 |
|---|---|---|---|---|---|---|---|
| Total Student numbers | 48<br>96 | 144 | 132 | 126 | 130 | 101 | 120 |
| Number of Sessions<br>Total hours | 3<br>6 | 3/3<br>6/4 | 3/3<br>6/4 | 4<br>8 | 2<br>2 | 2<br>2 | 2<br>2.5 |
| Assessment | Pre-post tests | Pre-post tests | Pre-post tests | Log files | Log files | Log files | Log files |

12

## Cavity Preparation Tasks

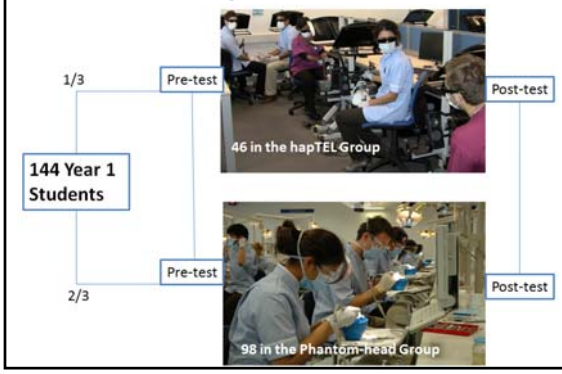
- Task 1 – Floating virtual tooth to orientate with the equipment and learn how to use the components.
- Task 2 – Floating virtual tooth with small occlusal carious lesion in outer third of dentine.
- Task 3 – Lower left 6 situated in the mouth, similar lesion to Task 2
- Task 4 - Lower left 6 situated in the mouth, with larger carious lesion more than half-way through the dentine.
- Task 5 - Lower left 6 situated in the mouth, with larger carious lesion within 0.5mm of the virtual pulp chamber

13

## Dr. Quinn demonstrating to the students how to use the hapTEL work station

16

## 2008 – 2011 Study Design (Large scale trials)




14

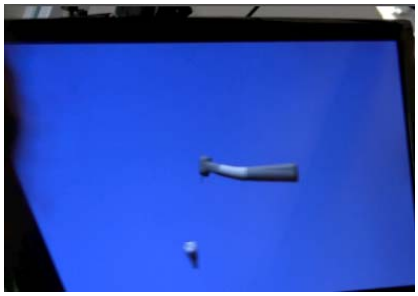
## All Cavity Preparation Tasks

The students should learn how to:

- wear the correct PP equipment;
- sit in the appropriate position;
- collaborate with the 'dental nurse' (work in pairs);
- select the appropriate speed of the drill;
- hold the hand-piece correctly;
- feel the different virtual tissue densities;
- respond to feedback when cutting virtual healthy dental tissues: enamel and dentine;
- control the pressure to avoid going into the pulp;
- complete the operation in a reasonable time.

17

## Screen view of the hand-piece and Tasks 1 and 2 single floating tooth



15

## Students in the hapTEL lab in their PPE equipment

18

## Students working in partnership as the dentist and the dental nurse

19

## A student log file of performance on Task 4

Data from HapTEL logs
Task/Cavity=4
User Name: H031
Material Logs
Enamel: Remaining 98.13%
Dentine: Remaining 98.69%
Caries Removed 80.12%
Pulp exposed: Yes
Pulp: Removed 0.203%
Timing Logs
Total Duration: 149.69 seconds
Time at first contact: 8.79seconds
Time spent Drilling: 126.80 seconds

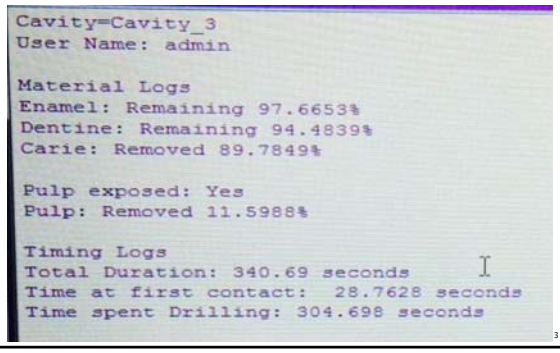
22

## Feedback to the student

- Tactile feedback from the device
- Visual feedback from the amount of decayed material removed from the tooth
- Log files recording:
  - Amount of Enamel Remaining (%)
  - Amount of Dentine Remaining (%)
  - Amount of Caries Removed (%)
  - Pulp Exposure (%)

20

## Student's photo of the caries removal results for Cavity 3 – lower 6th in a jaw




3

## Evaluation methods

The students' learning evaluated by:

• A set of psychometric instruments used by the original hapTEL team

•Discipline specific measures to determine the students' knowledge of impact of haptic use on the enhancement of manual dexterity skills, clinical procedures

•Attitudinal - feedback questionnaires to canvas perceptions and learner experience.

Also:

•Staff experience and technical support issues.

•Feedback on: system design, operational issues and realism of the simulator

21

| | All tasks | Task 2 | Task 3 | Task 4 | Task 5 |
|---|---|---|---|---|---|
| Median delay to first contact - seconds | 25.4 | 20.7 | 35.1 | 23.4 | 20.7 |
| Median time spent drilling - seconds | 130.8 | 94.2 | 103.6 | 193.9 | 158.8 |
| Median caries removed - % | 83.7 | 66.6 | 89.7 | 88.1 | 86.9 |
| Median enamel remaining - % | 96.8 | 98.4 | 96.8 | 96.5 | 95.4 |
| Median dentine remaining - % | 97.6 | 98.5 | 99.0 | 96.5 | 94.9 |
| Attempts exposing pulp - *n* (%) | 86 (67.7) | 25 (58.1) | 16 (44.4) | 24 (92.3) | 21 (95.5) |

## Table showing sample of 10 students' Cavity 3 results

| | | Cavity 3 | | | | | |
|---|---|---|---|---|---|---|---|
| % of healthy enamel remaining | % of healthy dentine remaining | % of caries removed | Pulpal exposure | % of pulp removed | Time at first contact - secs. | Time spent drilling - Secs. | Total duration - Secs. |
| 93.00% | 99.00% | 98.00% | yes | 0.50% | 17.50 | 277.96 | 313.02 |
| 91.88% | 97.77% | 94.30% | yes | 0.02% | 14.11 | 99.03 | 117.71 |
| 97.03% | 96.99% | 91.58% | yes | 0.30% | 17.81 | 131.81 | 159.76 |
| 98.34% | 96.79% | 82.44% | yes | 0.72% | 218.11 | 430.44 | 671.30 |
| 96.56% | 99.57% | 96.77% | no | 0.00% | 91.48 | 485.24 | 581.60 |
| 97.91% | 98.92% | 83.69% | yes | 0.61% | 146.53 | 52.19 | 270.52 |
| 96.53% | 97.30% | 89.61% | yes | 0.87% | 9.03 | 203.28 | 218.39 |
| 97.87% | 99.75% | 94.09% | no | 0.00% | 11.48 | 170.26 | 198.90 |
| 96.24% | 96.71% | 94.44% | yes | 0.39% | 26.88 | 102.86 | 137.29 |
| 96.29% | 99.81% | 96.42% | no | 0.00% | 31.73 | 163.89 | 202.88 |

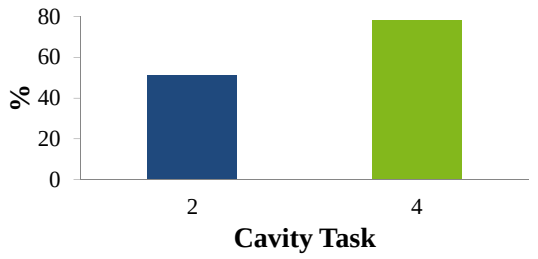
25

## Example of results for 2015

- 66.6% of caries was removed on average in Session 1 compared with 86.9% for the most difficult Task 5 (Session 2).
- 58.1% of students exposed the pulp while working on a simple caries lesion (Task 2), compared with a more complex cavity (Task 3) in which the pulp was minimally exposed by a minority of students (44.4%).

28

## Study 2 - Mean % of Caries Removed




26

## HapTEL Results over 7 Years

### Students' learning

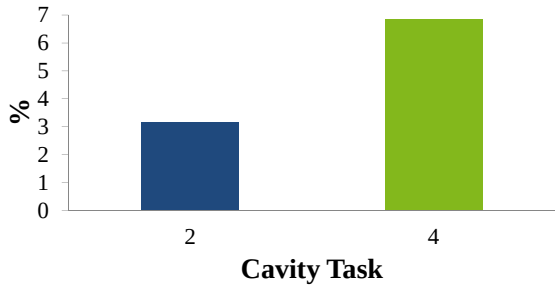
- Consistent improvement in students' caries removal skills
- Comparable improvement in skills compared with the traditional phantom head impact
- High level of commitment to learn with the hapTEL work-stations (100% turn out).

### Curriculum integration

- Trials with clinical tutors provided enhancements to the system
- Medical, Nursing, DCPS and Dental tutors aim to use the systems with more students
- Comparisons between the dental and injection system with 3rd year Dental students provided positive feedback on both systems

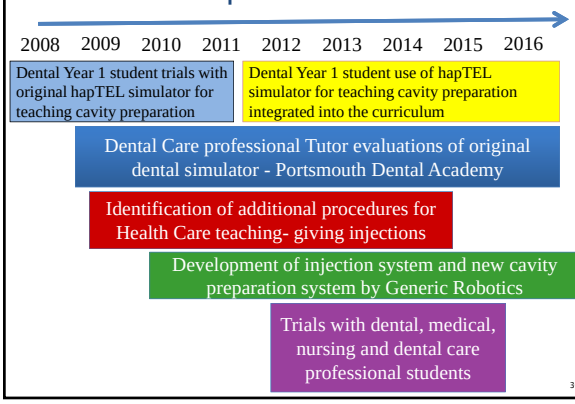
29

## Mean % of Pulp Removed




27

## Phases in hapTEL - evaluations



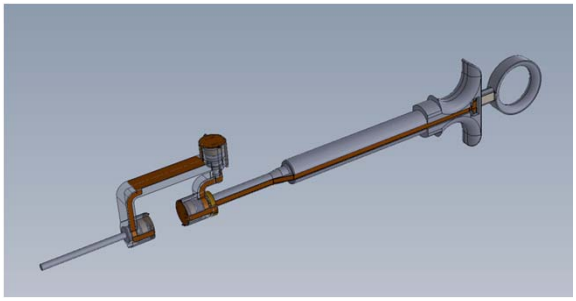

30

## Tutor trials with Dental Care professionals (Portsmouth Academy) – Original dental system

- Concept excellent (all).
- 3D image excellent(all).
- User operation of software could be a little more intuitive (all).
- Left hander had trouble with handpiece orientation.
- Mirror extremely hard to use/orientate (would be good for a second person to the mirror; i.e. Dental nurse) (those that tried).
- Force feedback from handpiece felt very good.
- Using loops on anything lower than level 7 extremely hard to see. Viewing tooth progress icon great idea.
- Results file could be easier to access.
- Could do with hand rest on top of ring as having to stabilise handpiece (dentists)
- Handpiece felt slightly restrictive/heavy (dentist)
- Massive scope for development

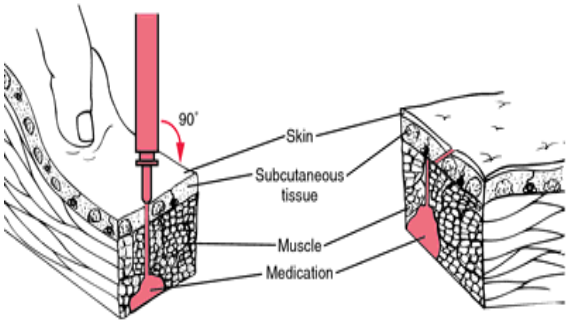
31

## Technology Strategy Board project injections – July 2013 – June 2014



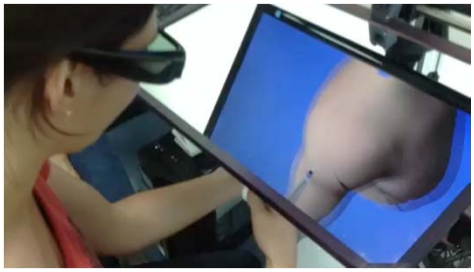
34

## Injection procedure




32

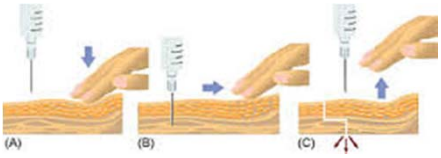
## Nursing students using the Injection system



35

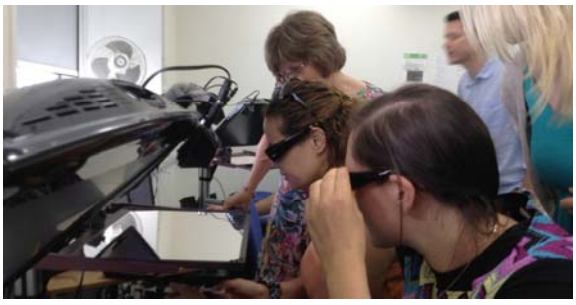
## Processes and concepts associated with administering injections

- Determining any allergies of the patient
- locating landmarks (on the skin) and associated anatomy
- technique for safe IM injection
- safe medicine management / administration
- recognition of poor practice / technique



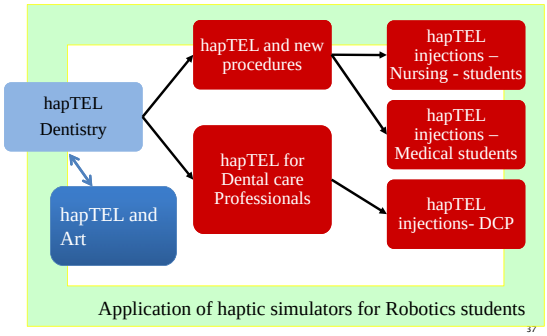

33

## Nursing students using the injection system



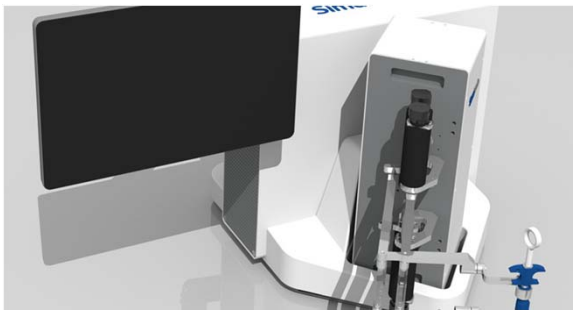
36

## Expansion into other functions across Health – Care departments




37

## New dental-injection/cavity system



**e:** info@simuteam.com **I t:** 01189 357 087 **I www.simuteam.com**

40

## Conclusions from these studies

The results show that a haptic system simulating simple dental procedures can enhance dental-undergraduate students' cavity preparation skills with only 2-3 hours practice by improving

- Students' hand-eye coordination
- Students' fine and gross motor skills and through formative assessment provided by the dynamic feedback on students' performance of cavity preparation and log-files of their performanc

38

hapTEL

KING'S College LONDON

THANK YOU for your interest

mj.cox@kcl.ac.uk
http://www.haptel.kcl.ac.uk

Follow us on Twitter @hapTEL

TLRP Technology Enhanced Learning

EPSRC

University of Reading

## Conclusions: Implications for haptics in Health Care Education

In order for haptic TEL or other TEL resources to be absorbed into the curriculum and make a positive contribution to students' learning:

1. University teachers need to be involved in the innovation from the beginning.
2. TEL needs to complement the traditional teaching practices
3. TEL needs to be seen to enhance the evolving curriculum.
4. Extensive ongoing support for teachers is needed to maximise its potential.

39