An Investigation into the Teaching of Injection Procedures in Dental Education and Other Clinical Skills Programmes Using a Virtual Haptic Simulator

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King’s College London

40th Annual Conference of the Association for Dental Education in Europe
Original hapTEL machine
hapTEL Workstation (Curriculum Version)
Teaching and Learning of clinical skills in dentistry

Clinical skills

Undergraduate Dental Education

Using tactile devices

Manipulative skills

Spatial reasoning skills

Changing the way Professionals work: e.g. in teams with DCPs

Increasing size of student cohorts

Need to provide satisfactory and sufficient feedback to students

hand-eye Co-ordination
Anatomy of the tooth

- Caries
- Enamel
- Dentin
- Pulp
- Gums
- Bone
- Cementum (containing Periodontal membrane)
- Nerves and blood vessels
- Root end opening
Study Design (Large scale trials) per year for three years (2009-2012: 430 students)

1/3

Pre-test

144 Year 1 Students

2/3

Pre-test

46 in the hapTEL Group

Post-test

Post-test

98 in the Phantom-head Group
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 (%)
Examples of assessment techniques

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<th>Total Pulp(2):</th>
<th>Total Carie(3):</th>
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<td>Total Pulp Removed:</td>
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<tr>
<td>Total Carie Removed:</td>
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Educational impact hapTEL results

- hapTEL ‘dental chair’ provided individual feedback including log-files to each student who didn’t have to wait for the tutor to provide feedback.

- TEL activity enabled the students to have multiple attempts to improve their practice compared with the traditional activity which was limited to two plastic teeth per student per session.
  - 1 plastic tooth costs £16. £13,800 per term for 144 students

- hapTEL tooth could be enlarged 6-times by the students so they could see the result of their caries removal, and learn about accurate self assessment

- hapTEL ‘dental chair’ enables the students to replay the video of their procedure to observe their strengths and weaknesses

- Year 1 students who were only taught using the hapTEL virtual system and had never treated a real or plastic tooth, performed as well as the traditionally taught students when preparing a plastic tooth cavity at the end of the term.
Kings College Dental students exploring and recording ceramic object
Data from HapTEL unit (2012)
Cavity = 4
User Name: H031
Material Logs
Enamel: Remaining 98.13%
Dentine: Remaining 98.69%
Carie: Removed 80.12%
Pulp exposed: Yes
Pulp: Removed 0.203%
Timing Logs
Total Duration: 149.69 seconds
Time at first contact: 8.79 seconds
Time spent Drilling: 126.80 seconds
Computer i
Cavity=4
User Name: H120 DO 1

Material Logs
Enamel: Remaining 94.8204%
Dentine: Remaining 98.1405%
Carie: Removed 90.8138%
Pulp exposed: No
Pulp: Removed 0%

Timing Logs
Total Duration: 216.435 seconds
hapTEL for Dentistry

- Simulating the dental chair

hapTEL related to art

- Links between drawing and clinical surgery skills

hapTEL applied to other healthcare subjects

- Developing the system for injections
The hapTELX – project (2012-14)

hapTELX – Funded by King’s College Teaching Fund
In partnership with Generic Robotics
1. to expand the hapTEL systems for teaching medical, nursing and DCPs manual dexterity skills:
2. to enhance the current functionality of the system for teaching a wider range of clinical skills in dentistry; and
3. to expose robotics students to the main concepts of haptics and its integration with robotic systems and include haptics in the robotics curriculum

Overall aim to identify the most appropriate and achievable haptic related learning tasks, involving feel, for students learning clinical skills, oral surgery, nursing, medicine and dental hygiene therapy.
The hapTELX & G project team

- Dental Institute – King’s College London (KCL)
- Department for Educational and Professional Studies
- School of Medicine – The Chantler Simulation and Interactive Learning (SaIL))
- School of Nursing
- Centre for Robotics Research
- Centre for Technology Enhanced Learning (CTEL)

- Portsmouth University – The Dental Academy

- In partnership with Generic Robotics – haptics company
Expansion into other functions across Health – Care departments

hapTEL and new procedures

hapTEL for Dental care Professionals

hapTEL injections – Nursing - students

hapTEL injections – Medical students

hapTEL injections- DCP

Application of haptic simulators for Robotics students
The hapTELG project (2013-2014)

Advanced haptics for high dexterity computer interactions

Aim 1 - to design a new application of advanced haptic interface technology by developing and expanding the original dental clinical procedures and validating and analysing the resource in an educational context.

Aim 2 - to investigate how advanced haptic technologies might be applied to teaching and learning in clinical settings in order to inform future researchers and developers

In partnership with Generic Robotics
Sponsored by the UK Technology Strategy Board
Evolution of hapTEL

Original hapTEL simulator for teaching cavity preparation

Comparison with drawing skills

hapTELEX

hapTELG
Phases in hapTELX-G evaluations

2012

Dental Year 1 student trials with original hapTEL simulator for teaching cavity preparation

2013

Dental Care professional Tutor evaluations of original dental simulator - Portsmouth Dental Academy
Identification of additional procedures for Health Care teaching - giving injections

2014

Development of injection system by Generic Robotics
Trials with dental, medical, nursing and dental care professional students
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
Goals and issues for Healthcare Clinical Assessment

Developing the learner to become a practising professional

Undergraduate Education

- hand-eye Co-ordination
- Manipulative skills
- Spatial reasoning skills

Using Traditional & hapTEL systems

Assessment

Enhancing the formative assessment by providing real time feedback to students (on the process rather than the product)

Enhancing the summative assessment of clinical skills by measuring psychomotor skills in pre-course selection and pre-clinical phase
Goals and issues for Medical Education

- Undergraduate Medical Education
  - Developing the learner to become a practising professional
  - Using tactile devices
    - Limited ward based opportunities
      - Need to provide satisfactory and sufficient feedback to students
      - Simulated situation to help with procedural competency & clinical awareness
      - Good for independent or supervised practice
        - New method in clinical skills teaching
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
Injection procedure

- Skin
- Subcutaneous tissue
- Muscle
- Medication

90°
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
Clinical skills checklist – on control screen

- Cleanse hands with alcohol gel
- Introduce yourself and check patient’s identity
- Discuss procedure with patient and gain consent
- Check identity with drug chart
- Check correct drug
- Check correct dose
- Check correct route
- Check drug allergies

- Stretch skin with thumb and forefinger
- Inject at 90 degree angle
- Aspirate/pull black plunger
Trials with Nursing students - 20 students in two groups
Nursing students using the Injection system
hapTELG-X student trials to date

Likert scale (strongly agree to strongly disagree) questionnaire
1. Ease of using the injection system (6 items)
2. Importance of injection performance (5 items)
3. Using haptic devices improve my injection skills (5 items)
4. Advantages and disadvantages (free comments)

Selection of 21 students’ results
• The responses ranged markedly between different students:
  • the system was easy to use (41%) and others reporting the opposite; difficult to use (59%).
  • Worthwhile activity (81%) and only 9% thought it was a waste of time.
  • Holding needle at the correct angle was very important (95%)
  • Being able to feel the skin resistance was very important (100%)
hapTELG-X Advantages and disadvantages

Advantages
• To be able to look at different layers of tissue was very useful
• Feedback was useful
• Picture was perfect
• Nice experience to be able to practise doing injections using advanced technology.
• Found the tool a very good resource for learning

Disadvantages
• Syringe was sometimes difficult to manoeuvre
• Need to be able to use the other hand
• The device didn’t always feel realistic
• The procedure was a little rushed
• Would benefit from a staff demonstration first
• Would prefer to landmark the site accurately as you weren’t able to touch the arm
Conclusions: hapTELG-X development and Preliminary evaluation results to date

Issues and limitations to the projects

• Longer time required to develop the injection system.
• Building on the existing work-stations meant additional technical modifications but enabled more machines to be used.
• Extensive procedures to obtain ethical approval

Achievements to date – Further data being analysed

• Trials with clinical tutors provided enhancements to the system
• Nursing tutors and 40 Year 1 students who used the system found it was a good device to improve injection techniques.
• Comparisons between the dental and injection system with 3rd year Dental students provided positive feedback on both systems.
• Further student trials planned for the 2014 autumn term.
Curriculum Technology Future trends

Dentistry Medicine Nursing Art

Configuration Components Functionality Level of immersion

Drilling Injecting Cleaning Drawing Shaping

Technology

Educational Activity
THANK YOU for your interest

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