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Academic Evaluation of Simodont® Haptic 3D Virtual Reality Dental Training Simulator

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Background: Visual, acuity and sensory motor skills are essential for performing different procedures in Dentistry. The importance of repetitive training and practice of fine manual skills in improving the performance and spatial perception of dental skills has been proven [34]. The use of a haptic device would allow the user to capture tactile sense with minimal intervention from the instructor [1]. Haptic technology, or Haptics, is tactile feedback technology which enhances advantage of a user's sense of touch by providing forces, tremors, and/or motions upon the user. The literal meaning of haptics is “I fasten onto, I touch” [2]. Haptics technology has been widely used in the fields of aviation, telecommunication and medicine [35].

1. In Dentistry, early studies investigated the use of virtual reality in different fields such as Orthodontics [5], Restorative Dentistry [5], Orthognathic Surgery [6], Implantology [7] and Endodontics [23]. In the past decade, attempts were made to develop a dental simulator by Luciano [8], Wang et al.[9], Kim et al.[10], Ranta et al. [11] and You et al.[12]. Most of these dental simulators are still in the early, or even experimental phase of development [16]. Haptic technology seems to have a bright future in dental education, hence our study aimed at evaluating of Simodont® haptic virtual reality dental training simulator.

Materials and methods: Eleven academic staff members from the School of Dentistry and Oral Health (Griffith University) volunteered to participate in this study to evaluate the fidelity of the new Simodont® haptic 3D VR dental trainer (Figure 1) and to assess its value as a new tool in preclinical dental training and early development of Psychomotor skills. The Simodont® is manufactured by Moog Industrial Group, Amsterdam. The Simodont® courseware was developed in cooperation with ACTA (Academic Centre for Dentistry in Amsterdam) and is currently being trailied in a variety of curricula. The courseware allows a variety of operative dental procedures to be practiced in a virtual oral and dental environment with force feedback. All academic staff members were asked to complete a pre-experimental questionnaire (Table 1). All tasks given to the participants during the evaluation session were identical and included manual dexterity exercises, clinical exercises on a single tooth as well as a simulated full arch experience with teeth present in contact (Figure 2).

Participants were then asked to complete a post-experimental questionnaire that contained a set of sixteen questions detailing their experience using the Simodont®. Following completion of the post-experimental questionnaire, participants were invited to comment about the advantages, limitations and missing elements in the Simodont dental simulator through open-ended questions.

Results: The results obtained from our pre-experimental questionnaire showed that the academic staff members of the School of Dentistry and Oral Health (Griffith University) were almost neutral in regards to the Simodont® Dental trainer (Table 1). Comparing the statistical results obtained from the post-experimental questionnaire to the ones obtained from the pre-experimental showed that there were some points of technical disadvantages of the Simodont® dental trainer, while in other educational aspects the academic staff members seemed positive about continuing using the Simodont® dental trainer in their students’ preclinical learning environment (Table 2).

In the open-ended questions, the participants commented about the advantages, missing elements and limitations of the Simodont® dental trainer. A total of 98 responses were obtained from our eleven participants. 80% of academic staff members commented about technical issues such as the simulated tissue of the different dental hard tissues, the positioning of finger rests, cutting efficiency of tools and the size and weight of the virtual hand piece. 70% of academic staff members liked the educational feedback and assessment methods provided by the Simodont®. 50% of academic staff members also liked the game-like situation the Simodont® provides and thought it would encourage students’ use as well as being a good tool for promoting dental education within schools. 40% of academic staff members felt the use of the Simodont® would increase the confidence of students before entering the clinical environment and provide opportunities for additional remodelling and practice for weaker preclinical and clinical students. 30% of academic staff members felt that the programme could remove caries with the available cutting utilities and currently programmed force feedback. 20% of the academic staff members did not feel the colour depictions of the caries detection dyes and of the restorative materials in the simulated traditional tooth cavity were appropriate and facilitated psychomotor development.

The most important missing features mentioned by the participants were a wider selection of rotary and hand instruments. Within the E-lessons loaded onto the simulator, customization of the clinical cases available and variable strategies for treatment planning were also considered a priority.

Discussion and significance: Interestingly, there were no significant differences between responses to paired questions in the pre and post-experimental questionnaires, which indicates that our evaluators largely experienced what they expected in the Simodont® trainer. We believe that a preclinical experience using manikins in a simulation lab is usually a richer educational experience that involves manual visual and tactile haptics. It also enhances communication with staff, clinical problem solving and decision making, which is more difficult to be provided by an automated system. This assumption is supported by our evaluators’ reports. We also agree that preclinical teaching methods could be fully replaced with the Simodont® and preferred the educational feedback provided by the Simodont® to be supplemented by feedback from a staff member they felt the human element is crucial in any educational process and should not be eliminated.

The comments that the tactile feedback provided by Simodont® is not realistic, is in agreement with other studies carried by Steinberg et al., [13] on PerioSim® the haptic 3-D virtual reality dental training simulator and Ben Gal et al., [14] who evaluated the PerioSim (Individual Dental Education Assistant) prototype and found out that the sensation it provided did not mimic reality in a convincing manner.

The reported limitations and missing elements in the Simodont® dental trainer were technical (e.g. the positioning of finger rests and selection of hand and rotary instruments), while the educational benefits of this dental trainer were appreciated by our evaluators. This indicates that a multidisciplinary cooperation between dental practitioners, psychologists, educational experts, engineers and software programmers is needed to achieve common language between all of them in order to address any issues or concerns before implementing the needs of dental education and put them into virtual reality.

Conclusions and recommendations:
1-The Simodont® dental trainer was accepted by academic staff members in our study as a new educational tool.
2-The Simodont® are seen to be educational while the reported limitations and missing element were technical.
3-The majority of academic staff members hold the view that dental simulation can replace traditional educational methods and cannot replace a human lecturer or tutor.
4-More studies are required to investigate the value of short and long term use of Simodont® in dentistry for early learners and senior students.
5-A detailed comparison between Simodont® and other available dental simulators using a universal valid ranking system is needed.
6-Comparing the effect of using Simodont® versus traditional training methods in development of new skills would be helpful for further evaluation of the new dental trainer.

References:

Table 1: Showing Means and Standard Deviations, and frequency distributions of answers of the pre-experimental questionnaire.

Table 2: Showing Means and Standard Deviations, and frequency distributions of answers of the post-experimental questionnaire.

Figure 1: Showing the Simodont® dental trainer which consists of a panel pc (Right side) and a graphics pc (The simulator) both connected together through the Simodont®courseware.

Figure 2: Showing the full mouth exercise used in the evaluation of the Simodont® dental trainer.