

# Students' Perception of Using Dental e-Models in an Inquiry-Based Curriculum

Yanqi Yang, Chongshan Liao, Cheuk Hin Ho, Susan Bridges

**Abstract**—Aim: To investigate students' perceptions of using e-models in an inquiry-based curriculum. Approach: 52 second-year dental students completed a pre- and post-test questionnaire relating to their perceptions of e-models and their use in inquiry-based learning. The pre-test occurred prior to any learning with e-models. The follow-up survey was conducted after one year's experience of using e-models. Results: There was no significant difference between the two sets of questionnaires regarding students' perceptions of the usefulness of e-models and their willingness to use e-models in future inquiry-based learning. Most students preferred using both plaster models and e-models in tandem. Conclusion: Students did not change their attitude towards e-models and most of them agreed or were neutral that e-models are useful in inquiry-based learning. Whilst recognizing the utility of 3D models for learning, students' preference for combining these with solid models has implications for the development of haptic sensibility in an operative discipline.

**Keywords**—E-models, inquiry-based curriculum, education.

## I. INTRODUCTION

MODERN dentistry is moving towards “electronic patient records” for both clinical treatment and dental teaching. Besides radiographs and photos, study models have long been an essential part of dental records. Electronic models (e-models)/virtual models have the advantages over traditional plaster models such as (1) simpler storage; (2) reduced risk of damage, disappearance, or misplacement; (3) simpler and more effective measuring; (4) easy transferal to colleagues, other specialists, and even patients [1]. However, different from the 2-D records, the e-models/virtual models in a 3D format are among the last type of clinical records digitalized in the dental field [2]. Transforming the traditional plastic models to e-models is the key stage of resource development. Scanning technology has been available since the middle 1990s, and software development over the past 5-6 years has refined this approach dramatically. These advances have made the capture of scanned-in images commercially viable and it is this computer-aided design (CAD) technology that is now used to produce digital study casts [2]. The high level of agreement between plaster and virtual models was reported by Bootvong et al. [3] who provided important evidence to support the use of e-models in clinical orthodontic practice, concluding that the analysis performed on e-models is as valid as that on traditional plaster models for intra- and inter-arch relationships as well as

tooth dimension measurement.

Electronic 3-D technology is in extensive use in education of many disciplines, such as physics [4], medicine [5], and engineering design graphics [6]. 3-D MUVes was used in an online problem-based learning (PBL) context and was found to be beneficial to the learning [7]. The Faculty of Dentistry of the University of Hong Kong (HKU) has been developing 3D e-models as one of the innovative resources for PBL and case-based learning (CBL) [8]. The overarching vision for educational technologies is to adopt a blended approach to support interactive, small-group learning – both in PBL [9], [10]-[12] and clinical settings [13], [14]. PBL in the Faculty of Dentistry is based on a series of carefully structured, integrated problems that allow students to be exposed to the main elements of basic biological, behavioral and social sciences that underpin dental surgery [15], [16]. In parallel to PBL, CBL is adopted as a complementary, inquiry-based pedagogy in Dentistry. Similarly to PBL, students work in groups and meet with a tutor in CBL tutorials. In case-based discussions, students are expected to apply the knowledge and skills developed in PBL to the “real” clinical problem-solving context of a patient case. Both PBL and CBL are inquiry-based approaches which aim to facilitate students' active learning, i.e. raising questions, searching for answers and finally understanding and solving the problems [17].

In our previous study [8], a pilot evaluation collecting students' perceptions of virtual models was carried out to assess the effects of creating the new learning resources through the technology of transforming the solid materials into virtual ones and to investigate students' perceptions on e-models in dental e-learning with respect to cognition and functionality. Initial students' feedback indicated that the 3-D models have been generally well accepted which confirmed the functionality of the program and the positive perception of virtual models for enhancing students' learning motivation.

As students' perceptions of the innovative learning resources may change with their exposure experience, manipulating skills and achievement of learning outcomes, we were interested to know whether students' perceptions of e-models changed over time and with additional practice. Therefore, this paper examines pre-and post-test results of a survey conducted on initial introduction of virtual 3D models when students were in the 2nd year of the curriculum (at the point of entry to supervised, basic patient care) and the follow-up survey was conducted after the students had one year's experience of using e-models in PBL and CBL tutorials (with one year's additional experience of delivery of patient oral care). The aim of this study was to investigate the changes of students' perceptions of

Yanqi Yang and Chongshan Liao are with Faculty of Dentistry, University of Hong Kong, Hong Kong SAR, China.

Cheuk Hin Ho is with United Christian Hospital, Hong Kong SAR, China.

Susan Bridges is with Centre for the Enhancement of Teaching and Learning/Faculty of Education, University of Hong Kong, Hong Kong SAR, China (Corresponding author; Tel: +852-39174771; e-mail: sbridges@hku.hk).

e-models for dental e-learning before and after their one-year experience of using e-models in an undergraduate dental curriculum.

## II. METHODS

This study was approved by the Institutional Review Board (UW12-098). E-models were introduced into an inquiry-based Bachelor of Dental Surgery (BDS) curriculum by integration with PBL and CBL in the Faculty of Dentistry, HKU. The software O3DM<sup>®</sup> was uploaded to the learning management system for students to download freely with permission from the O3DM<sup>®</sup> Company.

Fifty-two second-year BDS students (BDS II) were invited to complete an original pre- and post-test questionnaire survey with 21 simple questions relating to the characteristics of virtual models, students' perceptions of the use of e-models in PBL and CBL tutorials as well as their willingness for and real manipulation of e-models in PBL and CBL tutorials. In addition, their general preference for the type of models was also asked. The surveyed items are listed in Table I.

The pre-test survey occurred prior to any learning with e-models. The follow-up survey was conducted after one year's experience of using e-models. The questions were modified slightly in the follow-up survey by changing the pre-test questions asking whether the students will use e-models in PBL and CBL tutorials in to the post-test questions asking whether the students did use e-models in PBL and CBL tutorial in the past year.

With the questionnaire, the students were instructed to rate the items (Table I, items 1~20) on a 5-score scale with 1 as strongly disagree and 5 as strongly agree. For the last item in Table I, i.e. the preference of the type of models, the students were instructed to give their choice among e-models, traditional plaster models and both.

Students' feedback and data of the two sets of questionnaires were collected, and means and standard deviations of the scores were calculated. Paired t-tests and McNemar's tests were used to analyze the changes in results with SPSS 19.0. Significant level was set to be 0.05.

TABLE I  
ITEMS IN THE QUESTIONNAIRE

|                                  | Question items  |
|----------------------------------|---|
| Characteristics of e-models      | 1. The e-models are interesting.  |
|                                  | 2. The e-models are user-friendly.  |
|                                  | 3. The e-models show teeth and adjacent structures clearly.   |
|                                  | 4. The e-models can be rotated and moved easily.  |
|                                  | 5. Measurement can be easily done on e-models.  |
|                                  | 6. Introduction of e-models into PBL will make/makes PBL more interactive and interesting.                            |
| Use of e-models in PBL and CBL   | 7. E-models will be/are useful in PBL tutorial 1.   |
|                                  | 8. E-models will be/are useful in PBL self-learning.  |
|                                  | 9. E-models will be/are useful in PBL tutorial 2.   |
|                                  | 10. I will use/used e-models in PBL.  |
|                                  | 11. I will use/used e-models in PBL tutorial 1.   |
|                                  | 12. I will use/used e-models in PBL self-learning.  |
|                                  | 13. I will use/used e-models in PBL tutorial 2.   |
|                                  | 14. Introduction of e-models into CBL will make/makes CBL more interactive and interesting.                           |
|                                  | 15. I will use/used e-models in CBL.  |
|                                  | 16. E-models will be/are useful for the group to share the models together during PBL and CBL group discussion.       |
| Preference of the type of models | 17. I will use/used e-models during PBL and CBL group discussion.   |
|                                  | 18. E-models will be/are useful for me to go over the PBL and CBL problems after tutorials.                           |
|                                  | 19. I will use/used e-models to go over the PBL and CBL problems after tutorials.                                     |
|                                  | 20. Introduction of e-models into BDS curriculum is useful for me to approach the era of 'electronic patient record'. |
|                                  | 21. Preference of study cast is traditional plaster models, e-models or both.   |

## III. RESULTS

### A. General Perceptions

All the 52 students completed and returned the questionnaires (response rate 100%). The mean scores for the two sets of questionnaires in BDS II and BDS III were  $3.86 \pm 0.38$  and  $3.20 \pm 0.39$  respectively, which indicated the positive feedback of the e-models from the students both before and after their one-year experience of using e-models.

Although there was a slight decrease in mean scores one year later, no significance could be found between the pre- and post-test average scores of the 21 questions ( $p > 0.05$ ), nor the scores of every individual question ( $p > 0.05$ ).

### B. Students' Perceptions of the Characteristics of e-Models

For the characteristics of e-models regarding to the

attractiveness and friendly use, all the ratings were higher than 3.4. BDS II students rated the item "e-models can be rotated and moved easily" with the highest score,  $4.25 \pm 0.44$ , while BDS III students rated the item "The e-models show teeth and adjacent structures clearly" with the highest score. Although the average scores from BDS III students were lower than that scored one year ago when they were BDS II students, there was no significant difference ( $p > 0.05$ ).

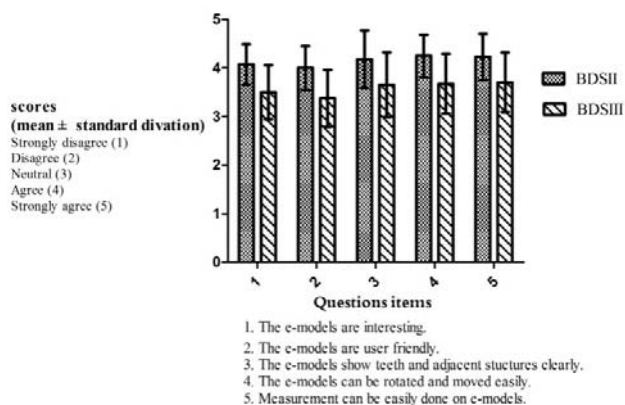


Fig. 1 Students' rating on the characteristics of e-models

### C. Students' Perceptions of the Use of e-Models in PBL

Although there was no significant difference ( $p > 0.05$ ), there existed slight changes in students' opinions on the usefulness of e-models and real manipulations with e-models during the one-year study (Fig. 2). The real manipulations with e-models showed lower scores than the students' opinions on the usefulness of e-models.

Two groups of questions were asked. Firstly (Fig. 2, Question group 1), the students were asked whether the e-models will be (BDS II) or are useful (BDS III) in the three phases of PBL tutorials, tutorial 1, self-learning and tutorial 2. The scores rated for the three phases, tutorial 1, self-learning and tutorial 2 were at similar level in both BDS II and BDS III surveys. Then (Fig. 2, Question group 2), students were asked whether they will use (BDS II) or used (BDS III) e-models in the three phases of PBL tutorials, tutorial 1, self-learning and tutorial 2. Similarly, the three phases shared almost the same weight in the two surveys.

### D. Students' Preference of the Type of Dental Models

For the item "my preference of study cast is traditional plaster model, e-model or both", 7.5% BDS II students liked to try e-models, 15.0% of them were willing to keep using the traditional plaster models, and 77.5% chose to use both e-models and plaster models, and those percentages changed to 7.5%, 20.0% and 72.5% respectively when the students were in BDS III (Fig. 3). However, confirmed by cross-tabulation, there was no significant difference in the change of preference between the 2 sets of questionnaires ( $p > 0.05$ ).

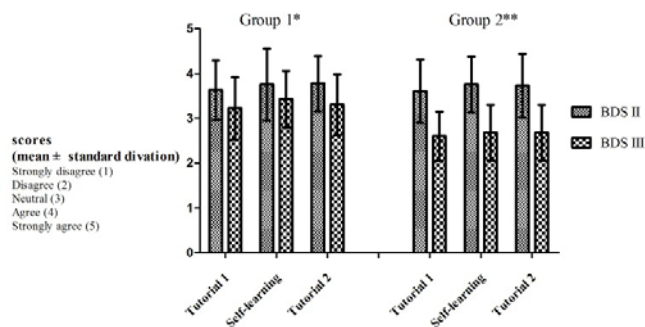


Fig. 2 The use of e-models in PBL

\*Question Group 1: the e-models will be / are useful in the three phases \*\*Question Group 2: I will use / used e-models in the three phases

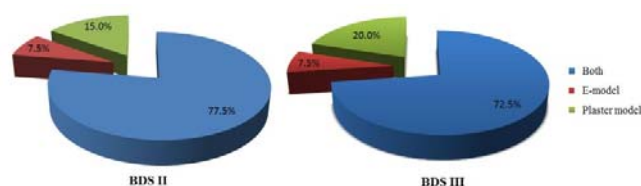


Fig. 3 Students' preference of the type of dental models

## IV. DISCUSSION

The imperative for supporting graduate's adaption to changing workplace demands in modern dentistry is a critical motivation for curriculum developers. Since virtual dental models are becoming more prevalent in general dental practice, undergraduate curricula need to prepare future graduates for this new clinical practice environment. This change in the profession, although meeting some opposition from conservative dentists who want to "feel" the plaster models in their hands, has considerable advantages, especially in the era of the electronic patient record when all patient information will be stored digitally. The advantages involve obviating the need for extensive storage facilities, reducing the risk of physical damage and/or the disappearance of the casts stored in the wrong location. In addition, there is the possibility of sharing the models with other colleagues. This latter point is especially important and beneficial for introducing virtual models into dental education. Additionally, the inclusion of virtual models and their analytic software holds important implications for student learning and curriculum design.

Siemen [18] highlighted the issue of "a growing disconnect" between "the tools and methods of classroom activity and those of youth culture and larger society" citing evidence that undergraduates are spending an average of 18 hours per week online (p.7). He also revisited debates regarding the optimum conditions for learning whether through minimal guidance or guided instruction [19], [20] and the role of technology in this debate. In an earlier study in clinical education considering the readiness of undergraduates to adapt to new technologies, Stokes et al [21] found that, of 191 students surveyed, there was, indeed, limited readiness for online learning using a distance education modality. Although most students (95.8%) were found to check their e-mail every few days or more, with

82.8% using the web frequently, fewer were engaged in technologies that were identified as supportive for future online learning such as Internet Relay Chat (37.7%), Message Forums (49.7%) and Video-conferencing (5.8%). If one is to consider these two issues at curriculum design level, i.e. student's readiness to engage with online e-learning and the tension between minimal guidance and guided instruction, there are some important lessons from this project's experience. With regard to guided instruction, the embedding into the curriculum of tutorials for explicit software familiarization and guided practice in the general operability and the use of analytic tools (e.g. orthodontic space measurement) was seen as critical to successful student engagement with e-models. Success with case-based analysis built on the principles of inquiry-based minimal guidance was contingent upon learner's abilities to apply the new tools. A possible false assumption by many modern educators in medical education highlighted by the Stokes et al. study [21] is students' readiness to proceed. Guided instruction is, indeed a necessary component of introducing new technologies and digital tools, even when working within a minimally guided, inquiry-based curriculum.

This survey study explored students' perceptions of e-models in view of the characteristics of virtual models, students' perceptions of the use of e-models in inquiry-based learning as well as students' willingness for and real manipulation of e-models in PBL and CBL tutorials. The mean scores for the two sets of questionnaires with both BDS II and BDS III were higher than 3, which indicated generally positive student feedback both before and after their one-year experience of using e-models. There was neither significant difference with the average scores for the 21 questions nor with the individual questions between the 2 sets of questionnaires. The positive feedback from the students indicates that e-models and accompanying analysis software are generally accepted by the students as useful learning resources.

The findings support the current curriculum approach of blended learning whereby face-to-face learning activities are enhanced by synchronous and asynchronous e-learning activities within an overarching inquiry-based curriculum design. Regarding e-models' functionality, on one hand, it depends on the software design as to whether they are really user-friendly. On the other hand, it is related to the users' manipulation skills with the computerized resources. The positive results indicate that the virtual models are easily manipulated, which confirmed the user-friendly design. At the same time, the background of the current young generation's familiarity with computer manipulation and information technology can also be considered as a contributing factor. As for the question items achieving the highest scores, students in BDS II agreed or strongly agreed that they were able to rotate the e-models easily, while most of students in BDS III agreed or strongly agreed that the e-models can show teeth and adjacent structures clearly. The difference revealed in those two surveys may be contributed by the increase of dental knowledge and practice with the BDS III students when they had got one year experience using e-models. Usually the beginners were firstly attracted by the easy rotating function of

e-models and gradually became familiarized with studying the detailed structures shown on the models during further exercises.

PBL and CBL enable students to maximize opportunities for learning by integrating face-to-face and virtual modalities, which encourage students' positive response to the incorporation of e-models in those learning ways. When it comes to the usefulness of e-models in different stages of PBL, both BDS II and BDS III questionnaires revealed that the students think the e-models are useful in all the three phases of PBL, tutorial 1, self-learning and tutorials 2. With the virtual models, since students have increased access through digital archiving on the learning management system, they do have more mobility and flexibility by studying the e-models on computers and do not need to borrow and carry cumbersome plaster casts. Due to easier duplication, students have individual access to a set of virtual models by themselves. In tutorials 1 and 2, the whole group of students can share the e-models on the screen and do not need to circulate the limited sets of plaster models. During self-learning, the students can access the models easily at home or library.

Interestingly, it is found that although the students think the e-models are useful in PBL tutorials, the scores revealing their real manipulation of the e-models during the tutorials were lower than the scores showing their willingness. It suggests that students' perception is an important factor for the use of learning resources but not the only factor. Teachers still need to do more promotion to encourage the students to explore the new innovative resources.

The findings also reveal a transition phase in the adaption of new technologies (enabling curriculum structure). Although more dentists are accepting the virtual record due to the advantages of digitalized models, some of them still prefer to touch the solid ones [2]. In both surveys, over 70% of the dental students preferred to use both hands-on haptic engagement with traditional plaster models and virtual manipulation of e-models in combination (Fig. 3). This result indicates a need for a transition period for moving from solid to virtual learning materials, especially in considering the psychomotor sensory development of a clinical learner. Certainly a distinct advantage of such analysis software is the real-time evaluation and feedback which has been recognized as critical to successful motor learning [22]. For dentistry, therefore, it may be necessary to maintain a blended approach to resources with solid materials being made available for development of requisite fine motor skills in getting a creative "feel" for the clinical dental problem at hand.

## V. CONCLUSION

Students did not change their attitude towards e-models over a two-year period. Most of them agreed or were neutral that e-models were useful in inquiry-based learning. This has implications for the role of guided instruction when introducing new educational technologies as learning tools within a minimal guidance, inquiry-based curriculum. Whilst recognizing the utility of e-models for learning, students responded positively to a blended approach introducing both

solid and virtual models simultaneously. Students' preference for combined use of virtual, e-models with solid plaster models for inquiry-based learning has additional implications for the development of haptic sensibility in an operative discipline.

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