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ORIGINAL ARTICLE

A Preliminary Study in Using Computerized Dental Simulators to Train Students at Faculty of Dentistry, King Abdulaziz University

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Abstract. To assess the ability of computerized dental simulators to improve students cavity preparation skills on manikins at Faculty of Dentistry, King Abdulaziz University. Also to determine their capabilities to relate or indicate the level of profession in cavity preparation. Sixty participants formed of students and interns were divided, based on their level of training, into three groups and were assigned randomly to test and control groups. All groups received a baseline assessment of lower second molar class I cavity preparation. The test groups received training on the computerized dental simulators until they reached a target score. The number of attempts and durations were recorded. After completion of training, all groups were assessed again on lower second molar class I cavity preparation by two supervisors based on a detailed rubric given to the students before their baseline and final cavity preparation. The group assignments, level of training, pre- and post- training cavity preparations were masked from the supervisors. There was statistically insignificant improvement in all of the three test groups after computerized dental simulators training, and within the limitations of the study. The computerized dental simulators failed to indicate the level of experience based on reaching the target score.

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Introduction

Training the manual skills in dentistry is important for improving clinical performance. In the preclinical labs, students develop their cavity preparation skills by practicing on plastic teeth in manikins. This way of training has the advantages of low cost, being readily available, ease of use and long-term validity[1]. On the other hand, one of its main disadvantages is the lack of objectivity in assessment. As it relies on instructors for evaluation and feedback, which can lead to the confusion and annoyance of students[2,3].

Computerized Dental Simulator (CDS) is a new technology that can offer training on multiple dental procedures in a virtual simulating environment. It allows the learner to visualize, feel and perform dental procedures with unlimited practice and on-site feedback and assessment. It could be a useful assistant to human instructors at times of limited availability or high demand[4]. Also it will eliminate assessment subjectivity due to inter- and intra-evaluator scoring variability.

DentSim was the first dental reality simulator developed in the late 1990's[5]. Several investigators in dental education showed that CDS is an effective tool in teaching restorative dentistry, in helping to reduce training hours[6-8], in early identification of students who may perform poorly in the operative course[9] and in recognizing differing degrees of performance[10].

A study by LeBlanc *et al.*[2] in 2004 evaluated the impact of CDS training on the development of dental manual dexterity. The study compared CDS training with laboratory-only practice and revealed that the use of CDS can improve the students' manual dexterity. Another study by Urbankova[4] in 2010 compared CDS training at two different time points to traditional training alone. The study found that the early use of CDS training in conjunction with the traditional way results in better performance compared to only traditional training.

Gottlieb *et al.*[11] in 2011 compared the faculty members' perceptions and expectations of dental students manual dexterity, whether trained with CDS or not. They reported that CDS training could enhance the students' manual dexterity as it can immediately instruct the students to do the needed adjustment. They also found that CDS students showed greater manual dexterity that might be due to developing strategies that circumvent the computer to obtain higher scores. In addition, they stated that using CDS alone does not allow the students to discuss their mistakes with their supervisors, as they rely solely on the simulator's instructions. As such, the students may fail to understand the nature of their mistakes and overcome them.

Therefore, the aim of this study is to assess the ability of computerized dental simulators to improve the cavity preparation skills on manikins for King Abdulaziz University Faculty of Dentistry (KAUFD) students, and to determine the capability of the computerized dental simulators to relate to or discriminate between the levels of profession in cavity preparation.

Methodology

The research ethical form was filled and submitted to the Research Ethics Committee of the Faculty of Dentistry (REC-FD) before conducting the research project with filing number 043-14. Sixty participants (thirty males and thirty females) from KAUFD were selected according to their willingness to participate in the study. They were divided based on their level of training into three groups of twenty participants each (ten males and ten females): a 3rd-year group, a 4th-year group, and an internship year group. Participants in each group were further assigned randomly to test and control groups with five males and five females in each group. The study was introduced to each participant individually, and those willing to participate were informed that they have the right to withdraw from the study at any time they wish.

Simodont® Dental Trainer (Fig. 1) was used for the participant's training. Simodont® Dental Trainer is a CDS developed by Moog BV. (Moog BV, Pesetaweg 53 2153 PJ Nieuw-Vennep, Nederland)

along with haptic experts and Academic Centre for Dentistry in Amsterdam experiences in dental education[12]. It is a dental simulator that allows the learner to practice a vast number of dental procedures in a realistic virtual environment with instant evaluation and guidance[12-14]. In addition, the Simodont® Dental Trainer provides the trainer with hypothetical case scenarios to give a comprehensive clinical experience[13]. With these capabilities, Simodont® Dental Trainer could enhance the manual dexterity and dental ergonomics of the trainee[13,14].

Fig. 1. Moog Simodont® Dental Trainer.

At the beginning of the study, each participant was assigned a number and given a detailed rubric on which their evaluation would be based. They then performed a baseline class I cavity preparation on a lower second molar plastic tooth. The rubric was created by the evaluators and approved by an operative supervisor at KAUFD (Table 1). Lower second molar class I cavity preparation was selected to resemble the cross shape cavity preparation on the CDS flat surfaces (Fig. 2). The bur used was unified to FG109 bur to match the one that will be used in the CDS training. Following the baseline cavity preparation, participants in the test group received training on the CDS until they reached a target score of 100% caries removal and no

Table 1. Class I amalgam preparation rubric.

Criteria/Grading	**2**	**1**	**0**	**Comment**
Depth	1.5 - 2 mm	<1.5 or >2 mm (no more than 0.5 mm difference)	< 1 mm or > 2.5 mm	
Criteria/Grading	**2**	**1**	**0**	**Comment**
Width	- Includes all main & deep supplemental grooves. - Not extending >1/3 of the cuspal incline.	- Includes all main & deep supplemental grooves. - Extending >1/3 but < ½ of the cuspal incline.	- Does not include all main & deep supplemental grooves. &/or - Extending > ½ of the cuspal incline.	
Criteria/Grading	**2**	**1**	**0**	**Comment**
Walls Direction	Walls are 80° (slightly converge occlusal)	Walls are 90°	Walls are diverging occlusal	
Criteria/Grading	**1**		**0**	**Comment**
Cavosurface Angle	90-110°	———	<90 or >110°	
Criteria/Grading	**1**	**0.5**	**0**	**Comment**
Floor	- Flat pulpal floor. - No incline.	- Flat pulpal floor with a slight incline.	- Pulpal floor is not flat.	
Criteria/Grading	**1**	**0.5**	**0**	**Comment**
Line Angles	All line angles are rounded	Some line angles are not rounded	Most of the line angles are sharp	
Criteria/Grading	**1**	**0.5**	**0**	**Comment**
Finishing	Smooth surface all over	Some rough surfaces present	Most of the surfaces are rough	
Total out of 10				

more than 10% of the sound tooth structure removal from the sides and the bottom of the cavity. Due to difficulties in reaching the target, a new target was set; 99.5% caries removal and sound tooth structure removal not more than 10% from the bottom and 15% from the sides. The numbers of attempts and durations to reach the target were recorded for each participant. After completion of the assigned training, participants in both groups performed class I cavity preparation on lower second molar plastic tooth again.

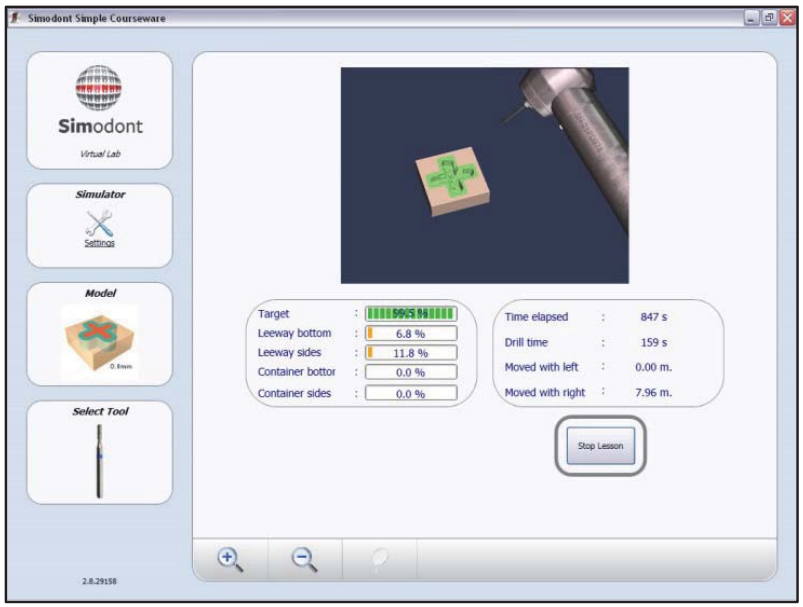

Fig. 2. The flat surface used on the Simodont® dental trainer.

The duration of the study lasted two months. Throughout the two months of the study period, 19 of the 60 participants dropped out of the study with a response rate of 68.3%. Lack of interest and difficulty to arrange their time with the training sessions were the main reasons given by the 19 drop-out participants to discontinue the study. Two supervisors evaluated the cavity preparations scoring the results according to the same detailed rubric that was given to each participant at the beginning of the study. The group assignments, level of training, pre-and post- training cavity preparations were masked from the supervisors who were given the number and color-coded plastic teeth. The correlation between the scores of the two supervisors was calculated using Pearson's r correlation.

Results

Forty-one (41) out of 60 participants completed the study with a response rate of 68.3%. Table 2 shows the demographics of the participants who completed the study. Statistical analysis was conducted using Analysis of Variance (ANOVA) (Table 3 and Fig. 3).

Table 2. Demographics of the study.

No. of Participants	Interns (20)	4th Year (11)	3rd Year (10)
Male	10	1	0
Female	10	10	10

Table 3. Mean scores of the two evaluators for each group with standard deviations and ANOVA results.

	Groups	Subjects Number	Mean Score	Standard Deviation	ANOVA
Pre-test	Interns	10	5.4	2.2	p=0.8
	4th year	6	5.3	1.0	
	3rd year	5	4.8	1.9	
Post-test	Interns	10	6.4	1.0	p=0.2
	4th year	6	5.5	0.6	
	3rd year	5	5.4	1.4	
Pre-control	Interns	10	5.3	1.9	p=0.3
	4th year	5	6.4	1.0	
	3rd year	5	6.6	1.7	
Post-control	Interns	10	6.2	1.0	p=0.8
	4th year	5	5.9	1.0	
	3rd year	5	6.3	0.5	

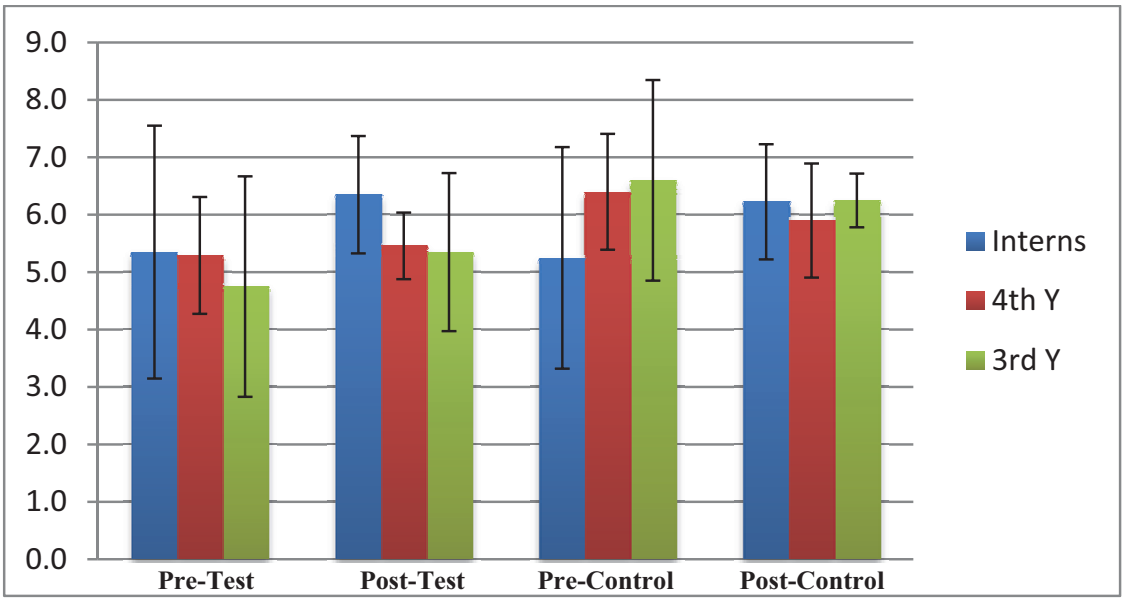

Fig. 3. Chart of pre- and post- CDS training scores.

Results showed the mean scores of the class I cavity preparation given by the two evaluators for the pre- and post- test and control groups with the standard deviations. The scores of the two evaluators had a correlation coefficient of 0.51 (Table 4). The mean duration and duration per attempt are presented in Table 5 and Fig. 4. Number of attempts for each test group is presented in Table 5 and Fig. 5.

Table 4. Correlation coefficient of the scores of the two evaluators.

	Correlation Coefficient r	r^2
	Supervisor 1	
Supervisor 2	0.51	0.26

Table 5. The mean duration, duration per attempt and number of attempts for each test group.

	Duration in Minutes	Duration per Attempt	Number of Attempts
Interns	29.8	8.1	3.9
4th Y	55.5	12.5	5.0
3rd Y	38.2	11.2	3.6

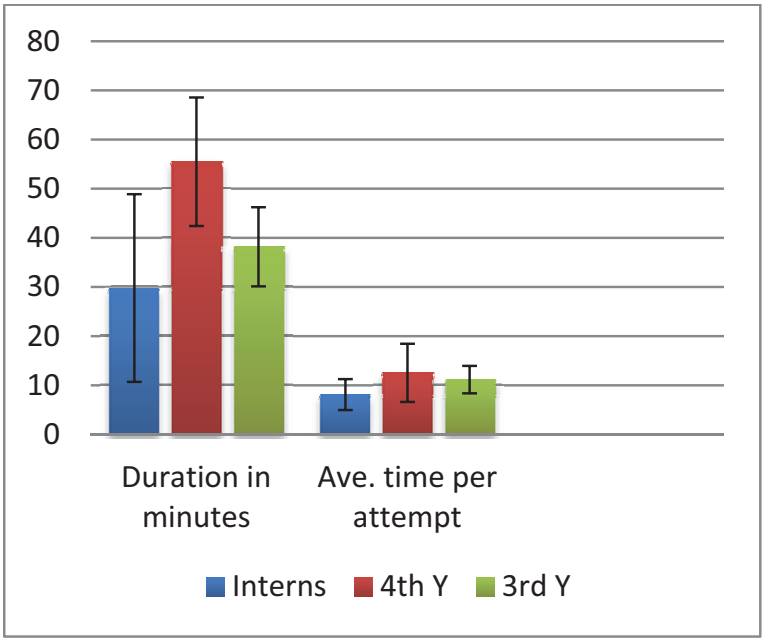

Fig. 4. Chart is representing mean duration and duration per attempt for each test group.

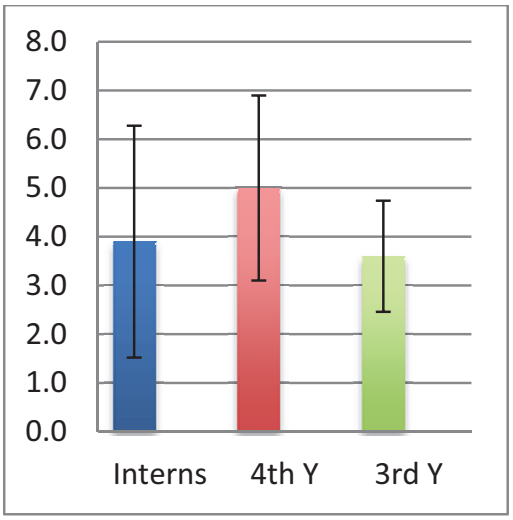

Fig. 5. Chart illustrates the mean number of attempts for each test group.

Overall, there was no significant difference between the pre- and post-test groups of interns, 4th year or 3rd year (Pre-test p = 0.8, Post-test p = 0.2). Also, there was no significant difference between the pre- and post-control groups of interns, 4th year or 3rd year (Pre-control p = 0.3, Post-control p = 0.8) (Table 3).

Table 6. The mean scores and standard deviations with the *t*-test results.

Groups	Sub-Groups	Mean Baseline	SD	Mean Final	SD	Comparison	t-Test
Interns N = 20	Test n = 10	5.4	2.2	6.4	1.0	Pre-test & Pre-control	p = 0.4
						Post-test & Post-control	p = 0.5
	Control n = 10	5.3	1.9	6.2	1.0	Pre-test & Post-test	p = 0.1
						Pre-control & Post-control	p = 0.1
4thYear N = 11	Test n = 6	5.3	1.0	5.5	0.6	Pre-test & Pre-control	p = 0.1
						Post-test & Post-control	p = 0.2
	Control n = 5	6.4	1.0	5.9	1.0	Pre-test & Post-test	p = 0.4
						Pre-control & Post-control	p = 0.2
3rdYear N = 10	Test n = 5	4.8	1.9	5.4	1.4	Pre-test & Pre-control	p = 0.1
						Post-test & Post-control	p = 0.1
	Control n = 5	6.6	1.7	6.3	0.5	Pre-test & Post-test	p = 0.3
						Pre-control & Post-control	p = 0.3

In addition, the "student's" *t*-test (Table 6) did not find a significant difference between the pre- and post-test grades; for all three groups (Interns p = 0.1; 4th year p = 0.4; 3rd year p = 0.3) for a critical value of 0.05. Also, there was no statistically significant difference between the pre- and post-control grades for all three groups (Interns p = 0.1; 4th year p = 0.2; 3rdyear p = 0.3) for a critical value of 0.05.

Discussion

Results using ANOVA indicated that there was some improvement in all of the three test groups after CDS training; however, it was not statistically significant (Table 3 and Fig. 3). Comparing the results with the control groups, the post-control grades improved for the interns' group and were lower for the 4th and 3rd-year groups. Again these differences were not statistically significant.

The results for the duration and number of attempts (Table 5; Fig. 4 and 5) showed that the interns took the least time and almost the same number of attempts as the 3rd year. Surprisingly, the 4th year took the highest amount of time and number of attempts. This can be interpreted as that the participants in the intern year group were experienced and could get along with any new clinical or training situation. While the participants in 3rd-year group were more keen and fresh, which made it more appropriate to introduce them to a new method of training. On the other hand, the participants of the 4th-year group were in a transitional situation between preclinical lab and actual clinical environment. Thus, taking them back to the preclinical situation and introducing them to a new training method might cause some confusion.

Due to unavailability of the full version of the software at the time of the project CDS evaluation of cavity preparations was not tested, which could have given the study more validity. However, two professional dental supervisors in the operative dentistry graded the plastic teeth based on a detailed rubric, the inter-rater correlation was 0.51, which means that only 51% of the grades between the two supervisors were correlated. This might raise the concern on the

subjectivity of grading cavity preparations by supervisors, and it could be one of the main advantages of using CDS as a method for evaluation. To overcome that problem, a third evaluator could be added to increase inter-rater correlation that would give more valid and credible results.

In testing the ability of CDS to discriminate between the different levels of participants, we were unable to detect any significant difference between the test group scores after training. Accordingly, there was no difference in the trainers' level of experience on the scoring, whether they were trained on the simulator or not. This could be attributed to the simplicity of the procedure, which was a class I cavity preparation in lower second molar on plastic teeth rather than to the inability of CDS itself to detect the skills of participants. However, raising the level of difficulty of the procedure to be class II, or class I with buccal or lingual extension, may result in detecting significant differences between participants.

Limitations of the study

1. CDS evaluation of cavity preparations was not tested.
2. Simplicity of the procedure that was class I cavity preparation in lower second molar on plastic teeth.
3. Not tracking the exact amount of practice time students spent during their regular operative course, which may especially impact the performance of the third-year students.

Conclusion

CDS is an effective tool for the preclinical training of cavity preparation for the third-year students.

It is an effective tool to eliminate subjectivity in grading.

Recommendation for Future Research

In future studies, the authors recommend adding a third evaluator and consider only the two similar or close scores and exclusion of the third. To investigate the effectiveness of CDS in training and its ability to detect skills differences, evaluation of the skills of students

performing more advanced procedures like compound cavities as Class I with extension or Class II must be considered.

Acknowledgment

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دراسة أولية لإستخدام أجهزة المحاكاة الحاسوبية لتدريب الطلاب في كلية طب الأسنان بجامعة الملك عبدالعزيز

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جدة – المملكة العربية السعودية

المستخلص. الهدف من هذا البحث هو تقييم قدرة أجهزة المحاكاة المحوسبة للأسنان لتحسين مهارات إعداد تجاويف الأسنان لطلبة كلية طب الأسنان جامعة الملك عبدالعزيز وتحديد قدرة المحاكاة المحوسبة على ربط أو تقييم مستوى المهنة لإعداد تجويف الأسنان. تم تكليف ستون مشترك من طلبة وأطباء امتياز الإشتراك في هذا البحث. وقد قسموا إلى ثلاث مجموعات بناءاً على مستوى التدريب وتم توزيع المجموعات عشوائياً إلى مختبر ومراقب. كل المجموعات تلقت تقييم أولي على تحضير تجويف الفئة الاولى للحشوات على الضرس الثاني السفلي. المجموعة المختبرة حصلت على تمرين على أجهزة المحاكاة المحوسبة إلى أن وصلت للهدف المحدد. تم تسجيل عدد مرات التمرين ومدته. بعد إتمام التمرين تم تقييم كل المجموعات مرة أخرى على تحضير تجويف الفئة الأولى للحشوات من قبل أثنين من المشرفين على أساس خطوات مفصلة أعطت للطلبة قبل بداية تحديد المستوى والإعداد الاخير لتجاويف الأسنان. كانت مهام المجموعات ومستوى التدريب قبل وبعد إعداد التجاويف السنية مخفية على

المشرفين. وقد أظهرت النتائج وجود بعض التقدم في كل المجموعات المختبرة بعد التدريب على أجهزة المحاكاة المحوسبة إلا أنها لم تكن ذات دلالة إحصائية. ولذلك فإنه في الحدود المتاحة لهذا البحث لم تسطع أجهزة المحاكاة المحوسبة الاشارة إلى مستوى الخبرة على أساس الوصول إلى الهدف المحدد.