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ABSTRACT

Background

Curriculum reforms are being driven by globalisation and international standardisation. Although new information technologies such as dental haptic virtual reality (VR) simulation systems have provided potential new possibilities for clinical learning in dental curricula, infusion into curricula requires careful planning.

Methods

This study aimed to identify current patterns in the role and integration of simulation in dental degree curricula internationally. An original internet survey was distributed by invitation to clinical curriculum leaders in dental schools in Asia, Europe, North America, and Oceania (Australia and New Zealand).

Results

The results (n = 62) showed Asia, Europe and Oceania tended towards integrated curriculum designs with North America having a higher proportion of traditional curricula. North America had limited implementation of haptic VR simulation technology but reported the highest number of scheduled simulation hours. Australia and New Zealand were the most likely regions to incorporate haptic VR simulation technology.

Conclusion

This survey indicated considerable variation in curriculum structure with regionally -- specific preferences being evident in terms of curriculum structure, teaching philosophies and motivation for incorporation of VR haptic simulation into curricula. This study illustrates the need for an improved evidence---base on dental simulations to inform curriculum designs and psychomotor skill learning in dentistry.

Key words: Dental, haptic, simulation, curriculum, survey

INTRODUCTION

Current dental curricula often differ in style, employing traditional, integrated or a mix of philosophies as the basis for their design. Following the Bologna recommendations, European dental schools have the authority to develop their unique curricula by incorporating core requirements whilst allowing flexibility to reflect regional needs.[1] This trend towards flexibility has also occurred in many other parts of the world as dental curriculum designs have evolved. Traditional curricula often involve a pre---clinical basic science foundation with hands---on clinical experience delayed to the later years. They also tend to focus on lectures and are organised into defined, discrete discipline---based subjects that may make subject integration difficult to achieve.

Integrated curricula, on the other hand, combine various disciplines according to curriculum domains or themes.[2] Often there is a combination of lecture---based teaching, self---directed learning and tutorials, with many incorporating some element of problem---based learning (PBL) or case---based learning. Typically, PBL curricula have no or few lectures, instead encouraging student---directed small group learning centred on problems or scenarios grounded in real---life contexts.[3] One example of innovative curriculum design involves that of the Adelaide Dental School, which in addition to incorporating PBL, focuses heavily on integration within the curriculum, using integrated learning activities (ILA's) to enhance learning, all occurring within an effective learning environment.[4---6] Several recommendations in dental education have now been published emphasising the importance of student---centred learning, encouraging a move away from traditional curriculum formats to a more integrated, outcomes and competency---based designs.[1, 2, 7---9]

In modern dental schools, the rapidly increasing scientific and clinical knowledge base[10, 11] and the continuing expansion of many complex and time---consuming dental procedures are adding pressure to already time---constrained curricula. These competing demands have been blamed for overcrowding curricula and preventing students from developing skills in critical thinking due to a lack of time for reflection and analysis.[12, 13] In the pre---clinical, psychomotor skill components of dental curricula explorations into the use of virtual reality (VR) simulation have been encouraging[14, 15] especially with regards to its potential to create opportunities for independent, self---paced, repeated practice of standardized tasks and cases.[16, 17]

Haptic virtual reality (VR) simulation

Simulation training in dentistry is a core curriculum component, providing the opportunity for a student to safely practice and develop procedural skills according to defined standards/competencies and learning outcomes before performing them on patients. Traditionally, phantom heads with either natural or synthetic teeth have provided the necessary simulation for learning the various techniques needed for clinical practice. Virtual reality (VR) simulation is increasingly being incorporated into dental curricula, with the advantage of being able to standardise and replicate procedures, in addition to reducing both direct supervision and consumables usage.[18]

Pioneered initially in aviation, the addition of haptic technology to VR simulation gives the user an element of sensory feedback that can potentially improve realism. In dentistry, for example, the user can sense the difference in tooth hardness when cutting enamel compared with dentine. In the surgical field, increasing patient demands for less invasive and radical surgery are increasing demands for laparoscopic surgery. Such procedures require extensive training utilising simulation, with particular emphasis on sensory perception due to the restriction of direct vision. The addition of haptic technology to laparoscopic VR simulators has been shown to improve performance[19, 20], precision, and speed of task completion with fewer technical errors.[21] In addition, one study suggested that the use of haptic simulation appeared to bring the student further up the motor skill learning curve when brought into reality, aiding the transition to the clinical setting.[22]

If such evidence is transferred to dentistry, it would suggest a positive outlook for dental haptic VR simulation, implying even greater incorporation into dental curricula. As it is, little research has been carried out in dentistry, and what has been completed appears to be, as yet, inconclusive. Studies have shown training on haptic VR simulators is at least as effective as training on traditional phantom head simulators[23], and, in general, perceptions from both staff and students appear good[24], but the advantages of haptic VR simulation over traditional phantom head learning have yet to be proven.[25]

Despite the lack of current evidence for dental haptic VR simulation, its integration within clinical curricula internationally is still being positively embraced.[26---28] The current small---scale studies are so far inadequate for substantial evidence---based recommendations, and as such, larger, well---designed trials are required to replicate the positive results established in the surgical field.[29, 30] An additional barrier may be the influence of regional teaching traditions and philosophies, either encouraging the introduction of new technologies or taking a more cautious approach until substantial unequivocal evidence proving the effectiveness of haptics is apparent. It appears though; there is increasing interest in the use of VR simulation as a potential tool for training within dental curricula. Dental VR simulation systems are now able to provide training scenarios in the fields of periodontology[31, 32] and oral and maxillofacial surgery[33---35] in addition to operative dentistry[24, 36, 37], the field most likely to utilise VR

dental simulation in the future. This survey, therefore, aims to explore the global situation at this early stage of VR use in dentistry, to identify current patterns in curriculum design and preclinical teaching, with particular focus on operative dentistry and caries management. The findings from this convenient sample of dental schools internationally may help provide some direction regarding current prevalence of use and reasoning as to why VR simulation integration may be more commonplace in some regions.

MATERIALS AND METHODS

An online survey was carried out using the Internet survey engine, Survey Monkey™ with the aim to more clearly understand the relationship between student cohort composition, curriculum and integration of haptic simulation when considering geographic region. The study obtained ethical approval from the Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster (HKU/HA HKW IRB; *IRB ref number: UW---13 320).*

<u>Questionnaire</u>

The original survey consisted of 18 questions, combining multiple choice and open---ended formats (Table 1). Content and construct validity were established through feedback from a panel of expert dental education peers who reviewed items and pilot tested the online format and logic. Opening questions (Q1---3) addressed curriculum length, class size and educational achievement required for admission. Further questioning (Q4---7) focused on curriculum content and teaching styles in relation to operative or conservative dentistry, the number and use of phantom heads in the curriculum, and the current and planned future use of haptic simulators within each responding dental school.

(Insert Table 1 here)

Question skip logic was applied for the section regarding haptic simulation use (Q8 to 14, Fig.1). Skip logic is a feature that changes what question or page a respondent sees next, based on how they answer the current question. Also known as "conditional branching" or "branch logic," skip logic creates a custom path through the survey that varies based on a respondent's answers. Participants were asked if they had haptic simulators in their dental schools and if answering yes, a further four questions relating to the use of the haptic simulators regarding implementation, timing, distribution and quality of learning time were given. If the school did not use haptics, they were asked about their possible future intention to use haptics.

(Insert Fig.1 here)

Response rates for Q15---18 were too low to be considered representative, and so were excluded from data analysis.[38] The excluded questions were as follows:

- *Question 15: At what point in the curriculum are the haptic simulators first used? (response rate: 30%)*
- *Question 16: Has the time devoted to use of phantom heads (traditional dental simulators) been proportionally reduced since the introduction of the haptic units? (response rate:30%)*
- *Q17: Indicate the approximate change in distribution of learning time that has occurred since haptics have been installed by choosing the appropriate description of pull down menu. (response rate:5%)*
- *Q18: How much learning time is spent on haptic simulators in the entire dental school curriculum? (response rate:26%)*

Participants

One hundred and forty---two universities with dental schools were identified internationally and invited to participate based on regional groupings from Oceania (Australia and New Zealand), Asia, Europe and North America. Invitations were sent based on a combination of online searching and professional networks via dental education associations and two major dental education journals. E---mail addresses for a staff contact actively associated with curriculum leadership in clinical learning and teaching in courses relevant to 'operative' or 'conservative' dentistry were sought from each institution. A formal invitation to participate in the study was sent to these Faculty members, and a reminder was sent 2 and 4 weeks after the initial email if a response had not been elicited. Of the 142, 62 dental schools responded, giving a response rate of 44%.

Analysis

Statistical analysis was carried out on the retained items with SPSS software (Version 23.0; SPSS, Chicago, IL, USA) using One---way ANOVA for the continuous data and Chi---squared analysis for categorical data. Two multinomial logistic regression analyses were carried out to determine factors which may explain the variance in: a) geographic region and b) degree curriculum length.

RESULTS

Results were firstly grouped into geographic region to ensure a fair regional response was obtained. (Table 2)

(Insert Table 2 here)

Student cohort composition

Results in Table 3 indicated a significant difference in degree curriculum length (Q1, χ^2, $p<0.05$). The North American Schools had shorter dental curricula compared to all other regions, with 100% having a 4---year graduate entry programme. In Europe, most dental schools (90%) had a 5---year undergraduate degree curriculum, with 5 or 6---year programmes being the norm in Asia. Asia, Europe and Oceania all had a similar mean intake of students per year (n~ = 66), but North America differed again by having substantially larger classes (Q2, ANOVA, p=0.096). North America also has the fewest direct entry students, that is students entering directly from secondary education,) (Q3, ANOVA, $p<0.001$) with Oceania having the least amount of local students (68.6%), (Q3, ANOVA, $p<0.05$).

(Insert Table 3 here)

Curriculum design and learning approaches

As indicated in Table 4, for all four regions, a mixed curriculum design appeared to be standard. Little difference was apparent in relation to the percentage of traditional learning being undertaken; however, then trend in North America was slightly higher (41.7%). Dental schools in North America and Oceania did not appear to be using an integrated structure (Q4, χ^2, p<0.001).

Regarding cariology teaching, Asia, Europe and Oceania appeared to adopt either a minimal intervention or a mix of minimal intervention[39] and traditional[40] philosophies. North America had the highest amount of traditional cariology teaching at 25% (Q5, $\chi2$, $p<0.05$). Oceania had the highest number of mean hours devoted to cariology/operative dentistry learning in their curriculum (175.8 hours), with Asia having the least (95.7 hours), (Q6, ANOVA, p=0.063).

Regarding use and implementation of the International Caries Detection and Assessment System (ICDAS II)[41] into the learning, around two thirds of dental schools in Europe and Oceania reported adopting the system with only one third in North America and Asia (Q7, $\chi 2$, $p<0.05$).

(Insert Table 4 here)

Simulation and Haptics

Table 5 indicates that regional differences were apparent between curriculum length and the number of phantom head units, with North America indicating substantially more units on site than the other regions (Q8, ANOVA $p<0.05$). Regional analysis also showed significant differences in relation to the time when phantom heads were first used (Q9, χ^2, $p<0.001$). The majority of courses in North America and Oceania introduced phantom heads for skill development in their first year (83.3%) while most European courses reported beginning phantom head simulation practice in the second year (45%) and the majority of Asian schools delay until the 3rd year (50%).

Notably, all the North American dental schools allowed student access to VR simulators in their non---contact time for self---directed, unsupervised practice compared with 50% for Asia, 55% for Europe and only 33% for the respondents from Oceania (Q10, χ^2, $p<0.05$).

Significant differences were also apparent in relation to supervised contact hours with the highest levels being found in North America. Asia appeared to have the lowest levels of supervised clinical skill contact hours with one third of dental schools reporting less than 150 hours (Q12, $\chi 2$, $P<0.05$).

Regarding uptake and innovation of haptic simulation, a significant difference was apparent between the four groups, with Asia and Oceania having the highest rates of uptake of haptic VR simulators (75% and 66% respectively) while North America and Europe were less accepting (16% and 25% respectively) (Q13, χ^2, P<0.001).

(Insert Table 5 here)

Regression analyses

Two multinomial logistic regression analyses were carried out to determine if

1) Geographic location (Asia, Europe, North America or Oceania) was associated with factors relating to dental curricula and
2) Degree curriculum length (4 years, 5 years or 6 years) was associated with factors relating to the curricula.

Results regarding geographic location identified three significant factors that were able to explain 73.7 % of the variation (Nagelkerke R^2 = 0.78, p < 0.001). It was found that the percentage of local students, the year students first used phantom heads and installation of haptic simulators were significantly associated with geographic region. Stronger associations were apparent for Asia (82.6 %) and Oceania (80.0 %) than for North America (66.7 %) and Europe (65.0 %). When compared to Asia, Europe and North America were less likely to possess haptic simulators, whereas Asia was more likely to use phantom head learning later in a course. (Table 6)

(Insert Table 6 here)

Results concerning curriculum length indicated four factors explaining 82.5% of the variance (Nagelkerke R^2 = 0.79, p < 0.001). It was found that the percentage of direct entry students, dental schools using the ICDAS II system, the year students first practice on phantom heads, and supervised contact hours in student skill development were significantly associated with the length of dental training. This association was stronger for the 4---year (87.5 %) and 6---year courses (84.6 %) than for the 5---year courses (78.6 %).

(Insert Table 7 here)

DISCUSSION

One of the prime objectives of this paper was to garner information from various institutions with regard to VR simulation and haptic technology usage, as well as gage whether academics understand the potential uses of recent innovations in virtual reality and dental training.

Although the outcomes of the online survey must be viewed with some caution due to the modest response rate (44%), it still provides an indication of international trends with regards to: curriculum philosophies and structures; the timing and placement of clinical simulation in dental curricula; and the incorporation of virtual simulation through the use of haptic VR simulators. In addition, the interpretation of terminology can inevitably be problematic in the use of surveys, and of note is the definition of the term 'haptic'. The definition of haptic within this survey was open to interpretation, but It would be is presumed that when asking about haptic simulation, incorporation of haptic technology providing sensory feedback is involved, and not simply a traditional manikin with tracking such as the DentSim for example.

(For this manuscript, the terms 'dental degree curricula', 'programme' and 'curricula/curriculum' represent the acquisition of a degree required to practice dentistry and are used interchangeably. The term 'course' represents a credit---bearing block or unit within a curriculum/ programme.)

Effect of curriculum length

Indications from the survey responses suggested that dental degree curricula remain quite variable globally in relation to length, with North America having shorter graduate entry dental curricula in general compared with undergraduate entry in most other countries. Australia has some variation reflecting both graduate and direct entry pathways, as does Asia with programmes running from 4 up to 6 years in length. These variations in length seem to flow through to the time when students are exposed to simulation procedures. The shorter, graduate entry curricula generally have students commencing simulation learning in the first year whereas the longer curricula tend to delay until the second year. This is logical given that the basic sciences have been usually covered in the prior degree and that students must complete the required number of clinical hours to complete their clinical experience and competencies, especially in those cases where clinical requirements or case completions are mandated prior to graduation. Interestingly, some fully integrated designs are introducing simulation practice in the first year to expose younger learners to dental skills. The goals of such early exposure include vertical and horizontal integration of content[2] drawing on situated, authentic learning principles.[42] This is reflected in the results of the regression analysis related to course length which indicated that the percentage direct entry, dental schools using the ICDAS II system, the year dental students first use phantom heads and less supervised contact hours were significantly related to curriculum length ($p<0.001$).

Of note may be the difficulty in correlating commencement of patient care with that of simulation training. Even though dental schools with shorter curriculum lengths may potentially begin preclinical simulation training earlier, this may not be correlated with early exposure to patient care. This factor seems to be quite unique to individual dental schools. In relation to North America with its 4---year curricula, studies have indicated patient care beginning in the second[43] or third year[44], whereas in the UK, for example, with typically 5---year curricula, patient contact may occur as early as the first year.[45]

Effect of the extent of simulation training hours

One surprising outcome was that the responding North American Schools also reported the largest number of simulation hours, even though they have the shortest course length (Table 5, Q12, Table 3 Q1). This may be a reflection of the philosophical view of North American schools that place a strong emphasis on surgical management of hard tissue diseases. One detailed survey (2001) of North American dental schools discovered that 40% of teaching hospitals had not fully adopted a non---surgical/antibacterial approach to the management of dental caries. In addition there appeared to be resistance to the movement towards a less invasive 'medical model' of caries management.[46] A later survey (2007) reflected this possible limited emphasis on the non---surgical and monitoring aspects of caries with only 67% of north American dental schools teaching re---evaluation of preventative outcomes and only 25% teaching specific re---evaluation of remineralization.[47] A current survey (2017) was suggestive of continued disharmony regarding the teaching of cariology in North American Dental schools with 'a wide range of teaching practices related to caries removal.[48]

All North American students in the survey were able to access simulation learning outside of formal contact hours, a feature quite different from the responses received from Australia, even though several Australian Schools also have adult learners in graduate entry 4---year curricula. Why the latter does not permit independent, after hours learning is unclear, but it may relate more to regulatory policies and provisions than indicate less support for independent, self---regulated learning. Graduate and employer surveys in Asia have indicated general positivity related to independent learning in the form of PBL, suggesting that providing methods of flexible learning appear to be beneficial.[49, 50]

Effect of haptic VR simulation

Results from this survey suggest variation in the implementation of haptic simulation in dental curricula. Reasoning behind this may be due to the initial investment needed, which is substantial if large numbers of units are desired. North American dental leaders have indicated that minimal US state financial support has left many state---supported schools struggling for funding and that many schools now have to generate 70% or more of the operating budget from tuition, grants and revenue from clinical services or donations.[51, 52] Also, in addition to initial outlay costs, ongoing funding allocations for VR simulators must be available for maintenance and software updates as well as for training supervisory staff.[53] Besides budget considerations, there is limited evidence in dentistry that the training provided by haptics is superior to that of phantom head simulators. Early studies suggest that haptics may improve the speed of skill acquisition[54] but the need for studies with larger numbers of subjects and a more robust trial methodology has been indicated. Many dental schools may be delaying the acquisition of haptics until a more definitive evidence base is available.

Early adopters of haptic VR simulations

One of the interesting aspects of the study was the large proportion of responding institutions in Oceania indicating they had or were planning to introduce haptic learning. One aspect for this wide early adoption in Australia may relate to the 2006 Health Workforce Reform package from the Council of Australian Governments[28], which provided substantial funding to incorporate or enhance use of simulation in learning environments. Of the 9 Australian dental schools that responded to the survey, 3 schools had been asked to lead the project working group of the Australian Council of Dental Schools that published guidelines, in 2010, for use of simulated learning environments in dentistry and oral health curricula.[28] Hence this may have prompted more Australian Schools to incorporate haptic simulation learning.

A similar trend was noted for Asia. This may be related to curriculum developments of many schools in the region[55, 56], in particular China, where movement away from the traditional stomatology pathway involving a medical degree prior to dental specialisation is occurring[55]. In addition, countries such as Japan and Taiwan appeared to have embraced dental technological advancements and seem keen to utilise simulation technology in dental training.[57, 58] Paradoxically, while Asia and Oceania are generally more accepting of haptic simulations, the majority of educational research as to their efficacy is coming from Europe and North America.

The Future

As with other virtual technologies to support student learning in dentistry[59], haptic simulation is still in its early stages of development and has yet to expand into all areas of clinical simulation learning. As the range and type of simulations and tasks expand and the knowledge of how best these units can be used for psychomotor skill development is more clearly resolved, it is possible more schools will incorporate haptic simulation. Initially, there would seem to be a range of positive advantages for the incorporation of haptic simulation. It allows learners to be exposed to a variety of simulated dental carious lesions and tooth shapes, something, which can be increasingly harder to find in many countries. The simulation can be easily dovetailed into broader computer---aided learning packages that students can access and complete during non---committed learning time. This may be able to reduce the burden in a shrinking pool of dental academics as well as reduce some of the recurrent costs faced by schools and students in traditional simulation. However, more development work will be required to expand and quality assure the suite of learning packages.

Limitations

As always, caution must be taken with interpretation of survey results, especially where response rates are modest as is often the case with online surveys. It is possible respondents have a interest in the recent developments of VR dental learning which has introduced some bias, hence care must be taken when applying the results across all geographic lcoations. In addition, in this survey, one dental curriculum leader/clinician responded on behalf of each dental school and so may not be representative of the whole faculty's opinions or the overall structure of a curriculum.

CONCLUSION

The results of this survey have provided an overview of the current status of dental simulation training and curriculum design across the globe. Technological innovations such as haptic VR simulations are unlikely to undergo complete acceptance throughout the world in the first instance. In addition to factors at a local level, the adoption of new techniques and technologies may be influenced by cultural and historical aspects that will result in regional variations.[12, 60]

While this survey has been able to pinpoint a number of individual features, there is little evidence in the dental literature to suggest the overall competency of dental students on graduation is superior in one particular region, with one particular teaching philosophy, length of degree curriculum or if the training has involved haptic simulation. Therefore, each dental community has a responsibility to ensure appropriate standards of dental graduates are achieving appropriate levels of knowledge, skill development and professional attitudes.[1]

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Table 1. Survey Questions

	Question
	Student cohort composition
1.	What length is the primary degree at your dental school?
2.	What is the average student intake per year in your school? (i.e. class size)
3.	What is the approximate proportion of admission profiles of your students?
	Curriculum Design and Teaching
4.	Describe the learning and curriculum structure.
5.	What is the current philosophy of cariology teaching in your dental curriculum?
6.	Approximately how many hours is devoted to cariology/operative dentistry in your curriculum?
7.	Has the ICDAS system been incorporated into learning and teaching in cariology at your dental school?
	Simulation
8.	How many phantom heads (traditional simulators) do you have in your dental school?
9.	At what stage in your curriculum do students first use phantom heads? (traditional dental simulators)
10.	Can students access the phantom heads (traditional simulators) in their non---contact (free---study) time?
11.	What is the staff/student ratio for phantom head teaching?
12.	How many supervised (contact) hours in the curriculum are spent in student skill development for dental caries management? (hours spent on phantom heads or any other type of simulator)
	Haptics
13.	Does your institution have haptic simulators? *Question logic; if answer to 13 is YES, then respondent answers Q 15, 16, 17, and 18. If NO then respondent answers Q 14 only. (Fig.1)*
14	Are there plans to introduce the use of haptic simulation?
15	At what point in the curriculum are the haptic simulators first used?
16	Has time devoted to the use of phantom heads (traditional dental simulators) been proportionally reduced since the introduction of the haptic units?
17	Indicate the approximate change in distribution of learning time that has occurred since haptics have been installed by choosing the appropriate description of pull down menu
18	How much learning time is spent on haptic simulators for the entire dental school curriculum?

Table 2. Breakdown of regions into country for survey respondents

Region (total N of dental schools)	Number of participating dental schools/total asked	Regional response rate	Individual countries involved. (number in brackets)
ASIA † *(total n=169)*	24/62	39%	Hong Kong(1), India (2) ,Thailand(4), Japan(6), Malaysia(4), Cambodia (2), China(3), Taiwan(2)
EUROPE† *(total n=230)*	20/45	45%	UK(8), Ireland(2), Norway(1), Austria(1), Netherlands(1), Germany(2), Belgium(1), Finland(1), Italy(1), Denmark(1), Spain(1)
NORTH AMERICA † *(total n=66)*	12/27	44%	USA(10), Canada(2)
OCEANIA† *(total n=10)*	6/7	86%	Australia(5), New Zealand(1)

†reported number of dental schools as of Jan 2017 (Information from online databases: EOS Europe.org, ADEA.org, dentaljuce.com)

Table 3. Cohort composition in relation to region of dental training (Q1---3)

Question	Asia		Europe		North America		Oceania		Test	p---value
Q1. What length is the primary degree at your dental school?	n	(%)	n	(%)	n	(%)	n	(%)	χ2	P=0.006
4 years	2	(8.3)	1	5.0	12	(100)	2	(33.3)		
5 years	8	(33.3)	18	90.0	0	(0)	4	(66.7)		
6 years	14	(58.3)	1	5.0	0	(0)	0	(0)		
Q2. What is the average your school? (i.e. class size)	n	Mean size	n	Mean size	n	Mean size	n	Mean size	ANOVA	P=0.096
	24	74.8	20	77.5	12	121.7	6	77.6		

Q3. What is the approximate proportion of admission profiles of your students?	n	(%)	n	(%)	n	(%)	n	(%)	ANOVA
% Direct entry	20	(80.7)	19	(81.2)	12	(26.5)	6	(60.0)	P<0.001
% Local	23	(93.0)	20	(90.3)	9	(78.7)	5	(68.6)	P<0.05

Table 4. Curriculum design in relation to region of dental training (Q4---7)

Question		Asia		Europe		North America		Oceania	Test	p---value
Q4. Describe the learning and curriculum structure										
Curriculum structure Integrated	5	(20.8)	3	(15.0)	0	(0%)	0	(0%)		
MIxed	13	(54.2)	13	(65.0)	7	(58.3)	4	(66.7)		
Traditional	6	(25.0)	20	(20.0)	5	(41.7)	2	(33.3)		
Q5. What is the current philosophy of cariology teaching in your dental curriculum?		(%)		(%)		(%)		(%)	[illegible]	[illegible]
Minimal	9	(37.5)	8	(40.0)	3	(25.0)	3	(50.0)		
Traditional	5	(20.8)	2	(10.0)	3	(25.0)	0	(0.0)		
Mixed	10	(41.7)	10	(50.0)	6	(50.0)	3	(50.0)		
Q6. Approximately how many hours is devoted to cariology/operative dentistry in your curriculum?	n	Mean number of hours	n	Mean number of hours	n	Mean number of hours	n	Mean number of hours	ANOVA	P=0.063
	22	95.7	13	194.6	6	164.2	5	175.8		
Q7. Has the ICDAS system been incorporated into learning and teaching in cariology at your dental school?	n	(%)	n	(%)	n	(%)	n	(%)	χ2	< 0.05
Yes	9	(37.5)	12	(60.0)	4	(33.3)	4	(66.7)		
No	12	(50.0)	5	(25.0)	5	(41.7)	1	(16.7)		
Don't know	3	(12.5)	3	(15.0)	3	(25.0)	1	(16.7)		

Table 5. Simulation and haptics in relation to region of dental training (Q8---14)

Question	Asia		Europe		North America		Oceania		Test	p---value
Q8. Average number of (mean ± SD)	79.13	± 53.24	61.15	± 31.98	122.25	± 80.19	56.33	± 32.67	ANOVA	< 0.050
Q9. Year dental students first use phantom heads	n	(%)	n	(%)	n	(%)	n	(%)	χ2	< 0.001
1 = 1st year	3	(12.5)	7	(35.0)	10	(83.3)	5	(83.3)		
2 = 2nd year	4	(16.7)	9	(45.0)	2	(16.7)	1	(16.7)		
3 = 3rd year	12	(50.0)	4	(20.0)	0	(0.0)	0	(0.0)		
4 = 4th year	5	(20.8)	0	(0.0)	0	(0.0)	0	(0.0)		
Q10. Free time use of simulation lab	n	(%)	n	(%)	n	(%)	n	(%)	χ2	< 0.05
1= Yes	12	(50.0)	11	(55.0)	12	(100.0)	2	(33.3)		
2= No	12	(50.0)	9	(45.0)	0	(0.0)	4	(66.7)		
Q12. Supervised contact hours spent in student skill development	n	(%)	n	(%)	n	(%)	n	(%)	χ2	< 0.050
1 ≤ 50 hours	8	(33.3)	4	(20.0)	0	(0.0)	0	(0.0)		
2 = 50---100 hours	12	(50.0)	7	(35.0)	0	(0.0)	1	(16.7)		
3 = 101---150 hours	2	(8.3)	4	(20.0)	5	(41.7)	3	(50.0)		
4 ≥ 150 hours	2	(8.3)	5	(25.0)	7	(58.3)	2	(33.3)		
Q13. Dental schools with										
1= Yes	18	(75.0)	5	(25.0)	2	(16.7)	4	(66.7)		
2= No	6	(25.0)	15	(75.0)	10	(83.3)	2	(33.3)		

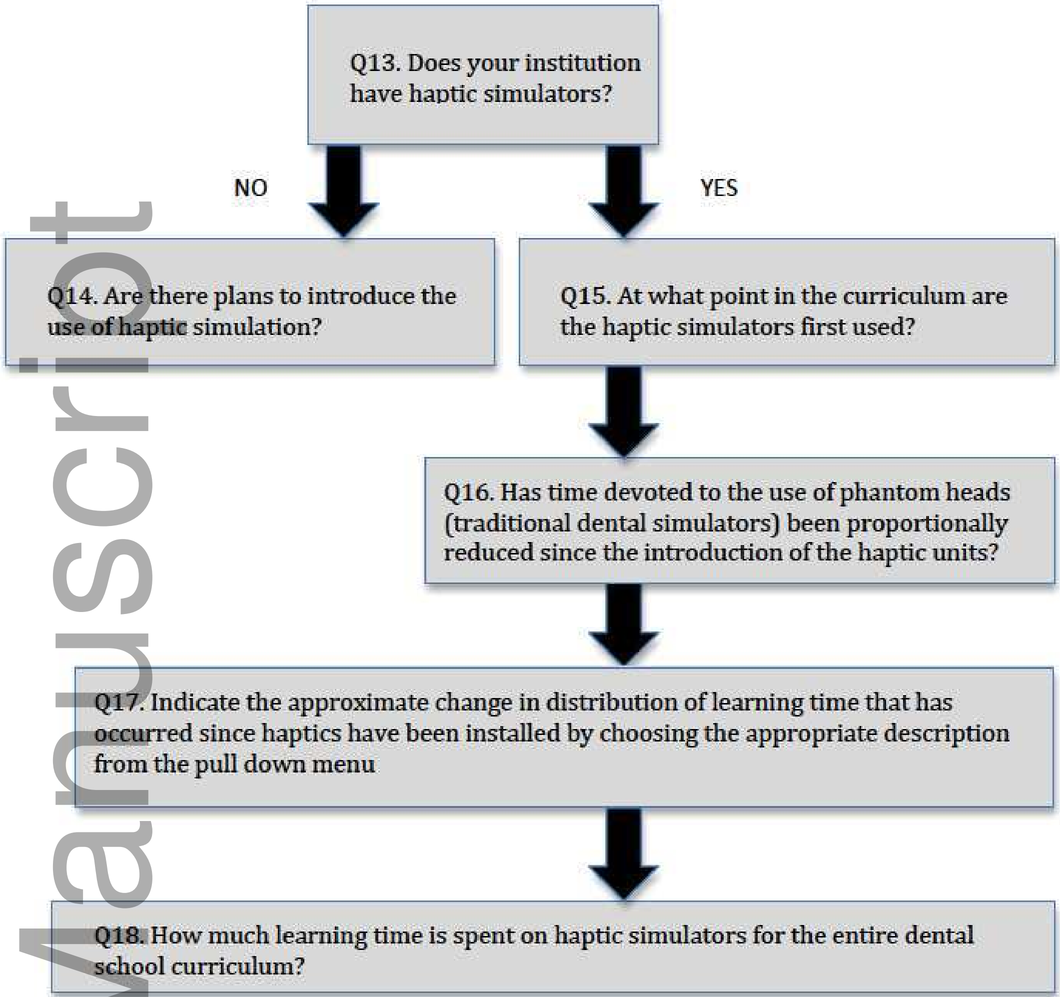
Table 6. Results of regression analysis concerning region

		95% CI for Odds Ratio		
	B(SE)	Lower	Odds Ratio	Upper
Asia vs. Oceania				
Intercept	---4.24(3.72)			
Percentage of local students	---.25(0.10)			
When phantom head first used	5.20(1.90)	4.35	180.88	7522.93
Dental school has haptic simulators	1.95(3.25)	.01	7.05	4104.63
Europe vs. Oceania				
Intercept	---5.02(3.52)			
Percentage of local students	---.22(0.10)	.66	.80	.97
When phantom head first used	3.43(1.91)	.73	30.82	1295.72
Dental school has haptic simulators	4.98(3.15)	.30	145.20	69547.21
North America vs. Oceania				
Intercept	---5.78(3.67)			
Percentage of local students	---.15(0.10)	.72	.86	1.04
When phantom head first used	.55(1.99)	.04	1.73	85.66
Dental school has haptic simulators	6.60(3.18)	1.43	731.74	374104.83

Table 7. Results of regression analysis concerning length of dental degree curriculum

		95% CI for Odds Ratio		
	B(SE)	Lower	Odds Ratio	Upper
4 years vs. 6 years				
Intercept				
Graduate entry	.07(0.03)	1.01	1.1	1.14
Using ICDAS	1.98(1.18)	.72	7.29	73.99
When phantom head first used	---5.23(1.79)	.00	.00	.18
Hours on simulator	2.35(0.93)	1.70	10.52	65.07
5 years vs. 6 years				
Graduate entry	.03(.03)	.98	1.03	1.08
Using ICDAS	---.53(.67)	.16	.59	2.19
When phantom head first used	---1.80(.65)	.05	.17	.60
Hours on simulator	.46(.51)	.58	1.58	4.29

Figure 1. Question skip logic


Q13. Does your institution have haptic simulators?
NO
YES
Q14. Are there plans to introduce the use of haptic simulation?
Q15. At what point in the curriculum are the haptic simulators first used?
Q16. Has time devoted to the use of phantom heads (traditional dental simulators) been proportionally reduced since the introduction of the haptic units?
Q17. Indicate the approximate change in distribution of learning time that has occurred since haptics have been installed by choosing the appropriate description from the pull down menu
Q18. How much learning time is spent on haptic simulators for the entire dental school curriculum?