Determining Competence in Prosthodontics in Undergraduate Dental School Programmes: An International Study

A thesis submitted to the National University of Ireland, Cork for the degree of
Doctor of Philosophy in Prosthodontics in the University Dental School and Hospital

December 2022

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LIST OF ABBREVIATIONS

ADEE	Association for Dental Education in Europe
CD	Complete Denture
DI	Dental Implant
FP	Fixed Prosthodontic
GDC	General Dental Council
RPD	Removable Partial Denture

LIST OF PhD CONFERENCE PRESENTATIONS

2022

Al Khalaf, K. I, da Mata, C., Lynch, C. D. Undergraduate Teaching and Assessment Methods in Dental Implants Curriculum: An International Delphi Survey. *International Association for Dental Research Meeting (PER-IADR Oral Health Research Congress), Marseille, France, September 2022.* [***Oral presentation***]

2021

Al Khalaf, K. I, da Mata, C., Lynch, C. D. Undergraduate Prosthodontics Curriculum: International Study of Current Teaching and Assessment Methods. *International Association for Dental Research Meeting (Irish Division), Belfast, United Kingdom, October 2021*. [***Oral presentation***]

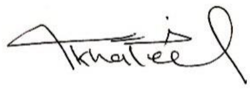
2019

Al Khalaf, K. I, da Mata, C., Lynch, C. D. Determining Competence in Prosthodontics in Undergraduate Dental School Programmes: A Literature Review. *International Association for Dental Research Meeting (Irish Division) Cork, Ireland October 2021*. [***Poster presentation***]

DECLARATION

This is to certify that the work I am submitting is my own and has not been submitted for another degree, either at University College Cork or elsewhere. All external references and sources are clearly acknowledged and identified within the contents. I have read and understood the regulations of University College Cork concerning plagiarism and intellectual property.

Signed	**Date**
Khaleel I. Al Khalaf	04/11/2022



ACKNOWLEDGMENTS

In the name of Allah, the most gracious and the most merciful. First and foremost, I am thankful to Almighty Allah for giving me the knowledge, ability and opportunity to undertake this study and complete it satisfactorily.

Secondly, this work would not have been possible without the support and help of my amazing supervisors, Professor Christopher D. Lynch and Dr. Cristiane da Mata, whose worthy guidance and professional attitude are appreciable in completing this dissertation.

I would like to express my sincere gratitude to Professor Lynch for his invaluable guidance throughout my PhD study. Professor Lynch's office door was always open whenever I encountered difficulty or had a question. Regardless of his busy schedule, he always had time to discuss my research project and steer me in the right direction.

I also thankfully acknowledge the help of Dr. da Mata throughout my PhD, from the first meeting when we discussed the PhD topic in her office, and for introducing me to Professor Lynch until I completed the last paper of my PhD project.

Finally, I am thankful to my parents, Ibrahim and Fatimah, for their constant prayers, support and love. I am also profoundly grateful to my wife Sukainah for her love, support, appreciation, encouragement and keen interest in my academic achievements.

THESIS ABSTRACT

Background and aims: In an era of increased attention on patient safety, as well as increased student mobility between many countries, it is of interest to investigate contemporary international trends in the teaching and assessment of prosthodontics. The aims of this PhD project were to investigate the teaching and assessment methods of the prosthodontics domains and to determine if it is possible to agree on competency standards in prosthodontics.

Structure and methods: This thesis includes an introductory chapter (Chapter 1), a narrative review of relevant educational and prosthodontic literature (Chapter 2), four original quantitative (questionnaire-base) studies to assess the contemporary teaching and assessment methods of prosthodontics on international basis (Chapters 3-6), and a mixed-method Delphi approach among prosthodontic/restorative dentistry experts to obtain a consensus on the most suitable undergraduate teaching and assessment methods (Chapter 7). Chapter 8 includes a qualitative study using one-to-one interview to explore the perspectives and opinions of senior dental academics that did not reach consensus using the Delphi method. Chapter 9 contains a systematic review synthesising the response rates in dental literature of questionnaire-base studies. Finally, a brief conclusion of the thesis was presented (Chapter 10).

Results: *Narrative review:* there was significant divergence among prosthodontic curricula in dental schools in terms of teaching methods, assessment criteria and how student competence is determined.

Quantitative studies: Our findings from the quantitative studies reinforced the findings of the narrative review; there was a significant international divergence of

undergraduate teaching and assessment trends among dental schools, including the preclinical and clinical course, of the prosthodontics divisions (complete denture, removable partial denture, fixed prosthodontics and dental implants). Divergence was evident in dental schools even within the same country.

Mixed-method Delphi and qualitative studies: A total of 23 senior academic experts from 11 countries participated in the Delphi study. There was a high level (92.6%, 175 statements out of 189) of consensus agreement over three iterative rounds, whereas 14 statements (7.4%) did not achieve a consensus. A total of 12 senior dental academics from seven countries participated in semi-structured interviews, it was agreed that academic professors, consultants, or specialists were the most suitable staff members to supervise students during preclinical hands-on sessions in removable and fixed prosthodontics. In addition, participants mentioned the availability of suitable patients for treatment, dental schools' curriculum and the level of students' skills as factors influencing the starting point of clinical sessions in fixed prosthodontics. We also found differences among the participating schools in regard to course contents and extent of teaching on dental implants. The experts suggested tailoring the curriculum according to what is expected from the graduating dentists and allowing students to observe dental implant cases before treating simple cases.

Systematic review of response rate: Overall, 133 studies with 149 response rates were included. The median response rate across the included studies was 77%, a significant negative correlation was observed between the response rate and the actual number of distributed questionnaires (sample size) ($r = -0.4127$; $P<0.001$). there was an association between the response rate and the area of distribution (e.g., national or international, $P= 0.0012$). Yet, it was unclear whether if there are correlations between the response rate and other variables (e.g., piloting, number of questions and the journal impact factor).

Conclusions: This thesis highlighted the current divergence in teaching and assessment methods of undergraduate prosthodontics. However, this divergence can be minimized, and the international harmonization of the dental curricula is highly possible by reassessing and tailoring the dental curricula. We presented a list of senior academics' consensus statements on the teaching and assessment methods of prosthodontics. In addition, multiple recommendations and challenge resolutions were suggested and introduced. Thus, our findings can be considered as guidelines and references to develop recommendations for stakeholders involved in undergraduate curricula among dental schools worldwide and in consistence with the local dental council recommendations, which will ensure dentists with the same level of competence at graduation.

CHAPTER 1: Introduction

1.1 Introduction

Dental education of undergraduate students has gone through many different stages since the last century. In 1925, Sir William Osler said *“give students good methods and a proper point of view, and all other things will be added, as their experience grows”* [1]. Teaching of undergraduate students in dental schools has three essential aspects, namely, theory teaching, preclinical and clinical practice. Integrity and quality of provided teaching of these three aspects will ensure graduating of students with high competence. The General Dental Council set out guidelines and requirements which are expected to be followed by the dental professionals, while the dental schools role is to design curricula that fulfil these requirements [2].

The importance of delivering quality teaching to the future dental practitioners will guarantee patients’ safety which is the golden practice principle *“do no harm”* [3]. In addition to providing up-to-date knowledge and clinical skills, dental schools are obligated to assess the students in these different aspects and ensure that the academic members involved in the teaching, training, supervision and students’ assessment are adequately trained to carry out the role. On graduation, students are required to understand the importance of providing high quality care that puts patients’ needs first, taking into account current and future oral health needs which is the main aim of dental professionals [2].

However, dental schools worldwide have different and divergent ways of teaching and training. This divergence in dental teaching could affect patients’ safety, especially with mobility of students and academic teachers internationally. In 1998, the ministers of education of Germany, France, Italy and the United Kingdom (UK) signed the Declaration of La Sorbonne which called for harmonization of the architecture of higher education qualification systems in Europe. One of their recommendations to harmonize dental curricula over the European Union is for it to be at least 300 credit-s course, considering both the learning outcomes and the professional competencies [4]. This harmonization of education should not be confined to the European Union countries and should be generalized worldwide.

Dentistry as a science consists of ten different specialities recognized by the American Dental Association (ADA), namely, dental public health, endodontics, oral and maxillofacial pathology, oral and maxillofacial radiology, oral and maxillofacial surgery, orthodontics and orofacial orthopaedics, dental anaesthesiology, paedodontics, periodontics and prosthodontics [5]. Dental undergraduate students have to learn these dentistry branches in general to be able to practice and deliver proper dental care. In addition, the learning outcome of basic dental sciences includes four core domains (Clinical, Communication, Professionalism, Management and leadership) which should be integrated and support each other [2].

1.2 Overall aims and objectives

The overall aim of this thesis was to determine the international current teaching and assessment methods in undergraduate prosthodontics curriculum. In addition, we aimed to set recommendations and potential guidelines for the dental schools stakeholders in order to harmonize the undergraduate prosthodontics curricula worldwide.

In particular, the objectives of the current thesis were as follows:

1. **Literature review:** to introduce the prosthodontics science in detail and explain the need for individuals to have dental prostheses through giving details about edentulism and tooth loss causes and consequences on patients'

wellbeing and health-related quality of life. Thereafter, the prosthodontics divisions, namely, complete dentures, removable partial dentures, fixed prosthodontics and dental implants will be identified with a focus on the traditional teaching methods commonly used in the undergraduate dental schools programmes. Furthermore, we aim to introduce the current innovative methods that are used in teaching at dental schools, various methods of students' assessments and competencies measurement.

2. **Quantitative questionnaire-based studies:** to describe the current teaching and competence assessment methods of CDs, RPDs, FPs and DIs amongst dental schools in several countries.
3. **Mixed-method Delphi survey study:** to survey and elicit the opinions of senior academics in prosthodontics/ restorative dentistry internationally, to achieve consensus on the most suitable undergraduate teaching and assessment methods to be employed in prosthodontics to ensure students' competence at graduation.
4. **Qualitative study (interviews):** To explore the perspectives held by senior dental academics worldwide regarding the current and best undergraduate prosthodontics teaching and assessment methods.
5. **Systematic review:** to investigate what is a reasonable response rate for dental questionnaire-based studies in recent literature and to assess the factors that affect the response rates.

The thesis aims and objectives are also presented in **Figure 1.1**.

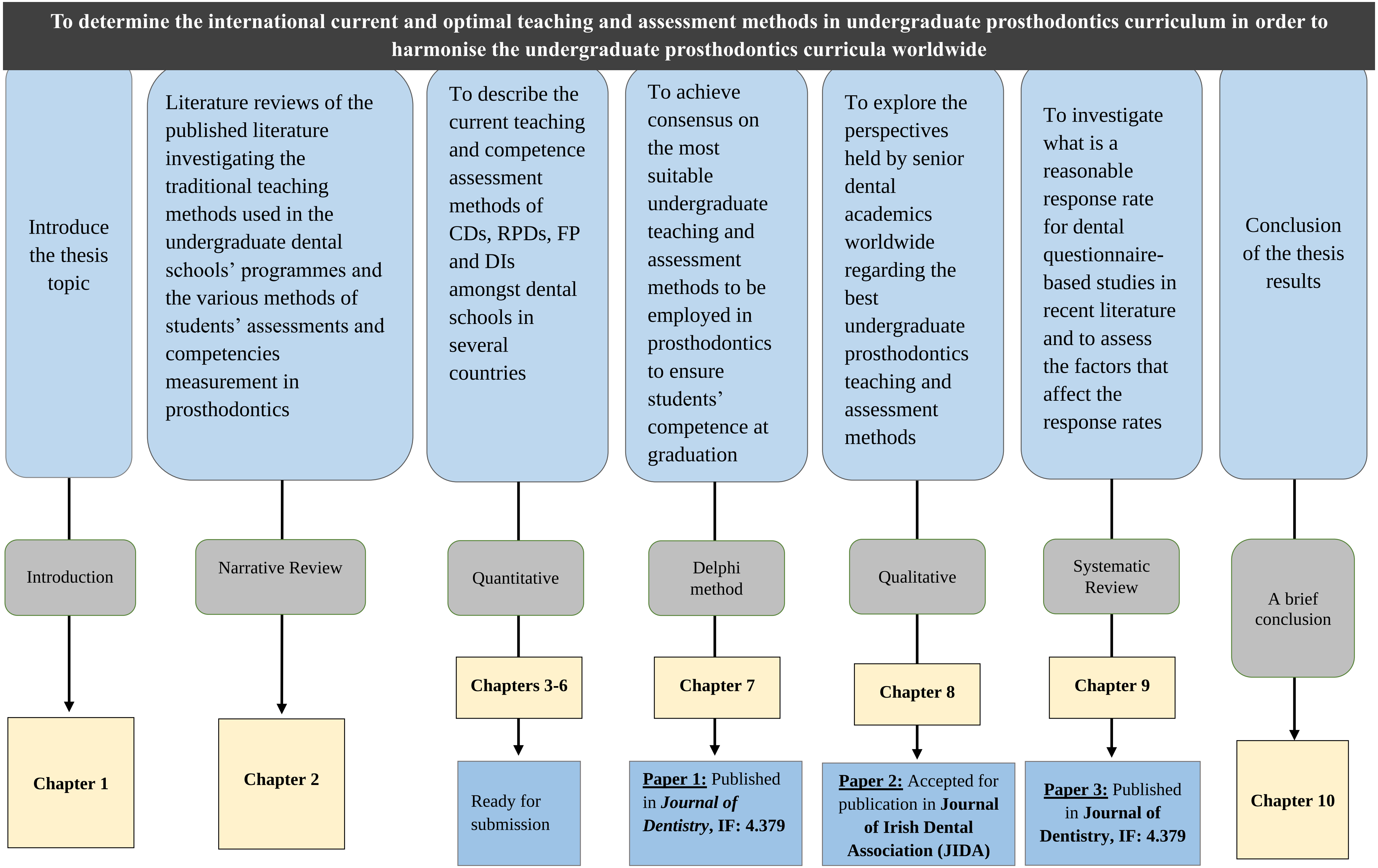


Figure 1.1 Thesis overview including overall aim, specific objectives, corresponding chapters, and papers

<u>CHAPTER 2: Literature review</u>

The main objectives of this narrative review were to consider assessment methods currently used in undergraduate dental school programmes for determining dental students' competence and progression in prosthodontics. It also aimed to review current teaching programmes for this subject. Therefore, an electronic database: PubMed/Medline and Google Scholar were searched in April 2019 using the following terms: [("dental" OR "dentistry" OR "dental school" OR "undergraduate" OR "prosthodontics" OR "restorative") AND [("Teaching "OR "teaching methods" OR "curriculum") OR ("assessment" OR "evaluation "OR "competence")]]. Variations of these terms were used to ensure exhaustive search results.

2.1 Prosthodontics overview

Prosthodontics is the branch of dentistry pertaining to restoration and maintenance of oral function, comfort, appearance and health of the patient by restoring and/or replacing missing teeth and craniofacial tissue with artificial substitutes [6]. It is a dental science concerning with the consequences of absence and/or loss (congenital or acquired) of oral tissues by inserting artificial devices made from biocompatible alloplastic materials, with the methods of assessment being whether more good than harm is done [7]. In simple words, it concerns the design, manufacture, and fitting of artificial replacements for teeth and other oral tissues. In addition, prosthodontics includes the rehabilitation of patients with complex orofacial defects to restore the appearance and the function consistent with the deficits encountered [8].

2.1.1 Edentulism

While it is important to understand the teeth and their supporting tissues development and formation process, it is essential to understand how the tooth loss process occurs. Edentulism or tooth loss can be defined as a debilitating and irreversible condition which described as the final marker of disease burden for the oral health. It is a medical status resulting when one or multiple teeth are missing, need to be extracted due to disease in the tooth itself (e.g., caries), disease of the tooth supporting tissues (e.g., gingivitis/periodontitis), orofacial pathology (e.g., cysts/tumour), or due to trauma. In a rare cases edentulism could be as a result of dental developmental defects, for example, anodotia and hypodotia [9].

Edentulism is found to have a significant effect on residual ridge resorption which consequently, leads to a reduction in the height of alveolar bone and the size of the denture bearing area [10]. This reduction affects face height and facial appearance, which are altered following total tooth loss. The loss of alveolar bone height and width also leads to substantial changes in the soft-tissue profile, such as protrusion of the mandibular lip and chin [11]. It also accompanied by functional and sensory deficiencies of the oral mucosa, oral musculature, and salivary glands. Additionally, it decreases tissue regeneration and tissue resistance which can impair the protective function of the oral mucosa [12].

Even though edentulism is more common in the elderly, it can occur among children and young adults as a consequence of tooth caries and periodontal diseases [9]. In 2010, 158 million people (2.3% of the global papulation) were affected by edentulism, and this is more common in females (2.7%) compared to males (1.9%) [13]. Dental caries and periodontal disease are the leading causes of tooth loss.

Among adults, periodontitis is the most common cause of the tooth loss while dental caries is the most prevalent chronic disease, and both diseases are preventable [14].

In 2009, a study found that the highest proportion of extractions due to caries occurred between 21-30 years of age, while that of periodontal disease was between 51-60 years and more than 80% of teeth lost occurred in those younger than 40 years. The mandibular first molar was by far the most frequently extracted tooth due to dental caries, followed by the maxillary first molar. Maxillary teeth were lost more than mandibular teeth due to periodontal disease [15]. However, many factors contribute to the decision to extract a tooth, including disease severity at individual tooth sites, the strategic value of a tooth, aesthetics and the cost-benefit ratio of available treatment options [16].

Tooth loss undoubtedly causes functional impairment, for example, with regard to chewing, food digestion, speech and aesthetics, depending on the location of tooth loss, which has a negative effect on patients' health-related quality of life [17]. The World Health Organization defined quality of life as *"individuals' perceptions of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns"* [18]. It has been stated that, to maintain a functional, aesthetic, and natural dentition throughout life as a goal for oral health, it is important to retain at least 20 natural teeth [19].

Hence, oral health status is one of several factors that have an impact on individuals' quality of life. Quality of life means maintaining the possibilities that people have been enjoying throughout their life [20]. Good oral health status should include the ability to chew properly, ease of ingestion and digestion of food and absence of facial pain. It should also contribute to communication, especially when speaking and smiling, which has the potential to increase peoples' confidence and self-esteem [21]. Tooth loss without replacement by removable or fixed prosthodontics can reduce quality of life to the same extent as cancer or renal diseases. However, general health is guided by functional status and by social and emotional factors [22].

In Australia and UK, people with 25 or more teeth had a significantly better quality of life than all other groups having fewer teeth [23]. In the UK, when this number increased, the quality of life was significantly improved. In addition, people who had less than 20 natural teeth but had no dentures were less than half as likely to enjoy enhanced oral health related quality of life compared to others in the population [23]. However, the number of teeth seems not to be a good marker for the quality of life, as dentition status may also be related to the position of remaining teeth and occluding pairs. For example, when anterior teeth are missing, aesthetics is seriously affected, therefore; quality of life may be significantly impaired [24].

Tooth loss and age have variable effects on different age groups affecting the quality of life. For example, in case of infants and small children, tooth loss hampers speech and sucking, while in teenagers and young adults aesthetics is a major concern, and amongst elderly people chewing is more of concern which affects individuals' quality of life while performing day to day tasks [25]. Oral health status has a greater impact on females' than males' quality of life in general. Females also more frequently perceive oral health as enhancing their appearance, mood, wellbeing and quality of life [26].

Furthermore, tooth loss (which is associated with increasing age) is associated with more negative impacts on oral health-related quality of life [27]. Tooth loss in elderly people causes disorders in the quality of life, especially when it affects their wellbeing, appearance and nutritional status [28]. For instance, plasma ascorbate and retinol were significantly lower in edentulous than dentate patients [29]. Consequently, poor nutrition, a decrease in the appetite and lower self-assessment are associated with depression [30]. Among adults 70 years or older, edentulousness was identified as an independent risk factor for weight loss [31].

2.1.2 Prosthodontics

Prosthodontics is divided to three main branches, namely, removable prosthodontics, fixed prosthodontics and dental implants. Removable prosthodontics concerns with replacement of lost dentition and the surrounding periodontium with removable artificial devices such as partial dentures or complete dentures. Partial dentures can be used when the individual has partially missing teeth, and they can be either teeth-supported, tissue-supported or can be both depending on the missing teeth position. In 1923, Kennedy proposed a classification for removable partial dentures according to the position of edentulous spaces. He classified removable partial dentures into class I: bilateral edentulous area situated posterior to the natural teeth, class II: unilateral edentulous area situated posterior to the natural teeth, class III: edentulous area bounded by natural teeth on both sides and class IV: a single, bilateral edentulous area located anterior to the natural teeth [32].

When the patient has lost all his/her teeth either in the maxilla or the mandible, complete denture is the treatment of choice. Complete dentures can be removable or can be retained to dental implant or remaining teeth and these are called overdentures. Fixed prosthodontics is concerned with restoring teeth using restorations that are attached/fixed to the patient's teeth, such as crowns and bridges. Crowns are used when a tooth needs to be covered to restore its function or appearance. Bridges or fixed partial dentures are fabricated to replace missing tooth/teeth by deriving their support from the teeth adjacent to the edentulous area. A dental implant is placed into the jawbone in order to hold single or multiple span prostheses to replace the missing tooth/teeth. It consists of a titanium screw which has special surface features that allow it to become accepted by the body and grow in union with the surrounding bone (osseointegration) while a fabricated prosthesis is retained to it coronally [33].

2.2 Teaching of prosthodontics in dental schools

Prosthodontics is concerned with the impact of tooth or tissue damage and partial or complete loss of teeth on oral function in its broadest sense. It deals with this defect mainly through prosthetic replacement. The discipline occupies a major portion of dental schools curricula, and dental practitioners usually devote much of their practice to prosthodontic services [34]. The curriculum of prosthodontics or any other dental speciality usually starts with teaching students the basic theoretical knowledge. Laboratory and preclinical practice to express the learnt knowledge and techniques are usually conducted simultaneously. Thereafter, clinical practice on patients under the supervision of qualified faculty member takes place. This practice occupies a significant portion of dental students' teaching and training [35].

Novice dental students are highly motivated to learn prosthodontic dentistry as it is an important step toward the fulfilment of professional goals. Poor course performance is discouraging for both students and faculty members which may reduce student motivation and increase stress during and following preclinical and clinical courses [36]. The preclinical teaching and practice are the students pass to develop the essential knowledge and gain psychomotor skills in the basic surgical procedures in general dentistry. During the preclinical sessions, students must also develop the ability of clinical decision-making to a point where they can meet the patients' need for diagnostic data gathering, interpretation, and treatment [36].

Traditionally, preclinical practice is frequently focused on procedures that are discipline-based, and faculty members from individual disciplines validate students once they have mastered the steps in each exercise. Eventually, students must develop skills and have sufficient preclinical practice to become comfortable with surgical procedures and have adequate feedback about the quality of their effort so that they can perform these procedures independently in the clinic [37]. Thus, students require specific instructions with immediate and accurate instructor feedback and much practice and repetition until they master each procedure with good psychomotor skills and confidence [38]. However, teaching methods nowadays must be evidence-based dentistry which may pose some particular challenges to some dental school curriculum and the profession [39].

It has been suggested that the clinic is the learning environment in which all students aspire to transfer the acquired knowledge from basic sciences by tuning and restructuring this knowledge [40]. The learning environment of the clinic is a challenging area for both educator and student. In this setting, the student is a trainee dentist responsible for patient care, and the clinic is both a patient care facility and a learning environment. However, clinical teaching in dental programs is supported by a range of educational modalities supporting patient care, such as lectures, tutorials, problem-based learning, clinical-based learning, interactive, simulation, computer- assisted modalities and clinical demonstration by a clinical supervisor [40]. The purpose of every curriculum is to provide the graduating dental students with a well-rounded, balanced educational experience and the preclinical and clinical exposures necessary for competence [41].

Dental students usually have their first exposure to the study of tooth cavity preparation through an operative dentistry laboratory course in which they are required to prepare teeth with rotary and hand instrumentation according to precise and exact criteria. Such preclinical practices need the students to have visual recognition skills and fine eye-hand coordination [42]. In prosthodontics, students start learning impression taking for partial or complete removable dentures, and then they learn how to cast this impression. However, the report of Institute of Medicine "*Dental Education at the Crossroads*" stated that inefficient use of faculty resources during the hours devoted to technical laboratory teaching in dental schools is preventing students to develop skills in a more time-efficient manner [43].

The General Dental Council in the UK published a framework for undergraduate dental education where the requirements for the content and delivery of the undergraduate dental degree programme were laid out. The purpose was to provide a framework to produce a caring, knowledgeable and competent dentist, able to accept professional responsibility for effective and safe care. The essential principles include; 1) dental students should have significant and appropriate opportunities to work and train together with those of professions complementary to dentistry, 2) students should understand the principles and techniques that allow them to act as the leader of the dental team, 3) they should communicate effectively with the dental technicians so that indirect restorations (fixed and removable prostheses) can be constructed and 4) students should have a sufficient understanding of clinical preparation and laboratory processes so that they can appropriately evaluate their own clinical work and the work provided to and received from the dental technicians [44].

2.2.1 Removable prosthodontics teaching

Removable complete denture:

Complete Dentures (CDs) or full dentures are removable prostheses which replace the entire dentition and related structure of the maxilla or mandible. Teaching of complete dentures in dental schools traditionally starts with:

1. Impression taking by using metal stock tray and impression compound material and then casting of this impression using dental plaster.
2. Learning how to fabricate custom tray which will be used to take a secondary impression using more accurate impression materials such as Zinc-oxide eugenol paste and cast it with dental stone.
3. The master or working cast will then be used to make record wax rims for the next clinical step (jaw registration).
4. During the jaw registration step, students need to master how to determine the rest vertical dimension, interocclusal space, occlusal vertical dimension, the orientation lines (incisal, canine and smile line) and shade/mould selection of the artificial teeth.

5. After mounting the registered wax rims on the articulator, artificial teeth are set to produce the wax denture which is used in the try-in stage.
6. In the lab, students learn how to do Flasking, de-flasking and packing of a heat cured acrylic resin to fabricate the final denture.
7. Finishing and polishing the denture is the last laboratory step before delivering it to the patient.

A simplified method for CDs fabrication is also used, which includes one impression followed by jaw registration, try-in and insertion of the finished denture. In 2004, a study was conducted to compare the patient satisfaction when using this traditional method for complete denture fabrication or to use a more simplified method. The study concluded that there were no significant differences between the two methods in the mean of patient satisfaction [45]. The author also conducted a 10 years follow-up of a randomized clinical trial, and he concluded that the simplified method remains more cost-efficient than the traditional method in the fabrication of the complete denture [46].

In consistence, a study was conducted among final-year dental students at the Federal University of Alfenas, Brazil to evaluate the effectiveness of CDs fabricated by the simplified method in comparison to the conventional method regarding patients' oral health-related quality of life (OHRQoL) and satisfaction, dentures' functional quality, and masticatory performance of patients who were rehabilitated by dental student. Results of the study also showed that there was no significant difference between the two methods regarding all investigated aspects. These findings indicate that the fabrication of complete dentures by using a simplified methods, even when made by dental students, was able to produce protheses with functional quality and patient satisfaction equivalent to those produced with the conventional method [47].

However, ideals should be taught and the undergraduate students should be encouraged to strive toward these ideals. They should be taught that there is a wide range of denture tolerance in the population and that the majority of patients can be provided with satisfactory dentures constructed by simple techniques. Nevertheless, the more exacting patient would require more complex forms of treatment and it should be within the novice dentist’s capabilities to provide all patient needs and care [48]. Three decades ago, dental undergraduate students on average treated eleven complete denture cases and two immediate replacement complete denture cases before qualifying [49].

Concern has been expressed that curriculum time for complete denture teaching has already been eroded to the point where students may not be adequately equipped when they qualify [50]. A recent study investigated the presence of geriatric dentistry in the curricula of worldwide dental schools. The study included 83 dental schools and found that geriatric dentistry teaching was a mandatory course in 56 dental schools (67.5%) with some clinical teaching. While it was taught as an independent subject in 14 schools (16.9%) and was taught as a series of lectures in 31 schools (37.4%) [51]. Another recent study also assessed the undergraduate geriatric dentistry teaching among geriatric dentistry teachers and senior students in five South American countries. The study reported insufficient hours for geriatric dentistry modules in the curricula and exclusively theoretical modules that do not allow students to learn typical specificities of older people. It also indicated some weaknesses regarding educational methods, professor training and the interaction between older people and students [52].

All the British dental schools still include complete denture teaching in their curricula but there is a large variation in the amount of experience that students gain. The majority of these schools taught CDs during the third, fourth and fifth year, with most taking place in the fourth and fifth years [48]. However, Schools fell into three groups; those in which students were required to treat 4-6 complete denture cases, those that required 2-3 cases and those that only required 1-2 cases to be treated prior to graduation. Staff: student ratios varied among these schools, ranging between 1:6, 1:8 and 1:10 or 12, while the higher ratios tended to be found in schools whose students treated fewer cases. In addition, there was wide variation in the number of registered specialists involved in teaching, ranging from 80% in one school to only one out of eight in another school but most had between a third and a half of their teachers on a specialist register [48].

Live clinical demonstrations to introduce students to the clinical stages of complete denture construction are still used in only three British dental schools while the rest used video programmes, though all the schools embraced e-learning in their clinical teaching methods. During the preclinical laboratory work course, there is a wide variation of content between these schools from a phantom head course covering all aspects to those that only cover such rudiments as pouring models and making custom impression trays. Clinically, impression compound is still used for primary impressions in three schools out of twelve while the rest are using irreversible hydrocolloid material either by itself or in combination with impression compound or silicone putty. The semi-adjustable articulators are used in the construction of the complete denture, however, the average value articulators are used in the majority of British schools [48].

Traditional method of complete denture construction is used in all British dental schools but some of them use the copy denture technique in addition to the traditional method. However, some techniques vary between these schools, for example, three schools use heat-cured bases for the jaw-registration stage. While only one out of the twelve schools regularly uses a facebow, and most of them occasionally do a check record, remount and occlusal adjustment using the articulator at the fit stage. Moreover, half of them require immediate CDs cases from their students, and most students have the opportunity to make immediate additions to existing dentures (repair). Though, all technical work for patients was completed by technicians in the majority of these schools. [48].

This wide variation in complete denture teaching is not confined to British dental schools; it also founds among the United States, Spanish and Portuguese dental schools. For instance, in the United States dental schools about 55% of schools reported incorporating new educational materials such as the use of dental implants and treatment of patients with implant retained overdentures at the undergraduate level. Sixteen percent are allowing students to graduate without a set number of required CDs as has traditionally been the case. A similar percent (16%) of schools were using newer techniques such as injection moulding and microwave processing technique in addition to the conventional processing techniques. However, a large percentage of United States dental schools agree on many topics of complete denture teaching [53].

This variation is not only in the technical teaching methods, but it also includes the teaching hours that devoted for teaching. In the UK, the number of lecture hours spent on CDs in one school was 42 hours, 28 hours in two schools while the remainder varied between 6-15 hours. Four dental schools devoted more time to laboratory work than clinical work, whereas three UK dental schools devoted more time to clinical work. Although, two schools did not devote any clinic time solely to CDs [54]. In the United States, the overall mean of laboratory hours in preclinical courses is 74 hours, ranging from 31.5-160 [55]. While in Spanish and Portuguese dental schools, the mean number of laboratory hours was 32.6 ± 25.6, ranging from 4-110 hours. The mean number of hours spent in clinical courses was 41.7 ± 44.1, ranging from 0-120 hours. However, the mean number of lecture hours reported for United States, Spanish and Portuguese dental schools was similar (28 hours, ranging from 12-80 hours) [56].

Clark *et al.* concluded that there is no mechanism in place to ensure that UK dental schools teach to the level expected by the General Dental Council [48]. Moreover, Dental schools reduced the complete denture curriculum in response to the reduction in the edentulous population until it considered to be one of the weakest areas for vocational trainers (a year of mandatory training for UK dental graduates). Thus, these trainers feel unconfident and unwilling to do this procedure which leads to a crisis in complete denture treatment in the UK [48]. In addition, lack of manpower planning and inadequate data relating to the predicted number of edentulous patients to be expected in the future, together with life style changes, may result in serious deficiencies in provision of CDs [57].

Removable partial dentures:

Removable Partial Dentures (RPDs) are the sum of a number of components that replace partially missing dentitions [58]. Thus, the fabrication of RPDs needs more clinical and laboratory steps as RPDs have more components than the CDs and consideration should be taken for the presenting dentation. RPDs can be an interim prosthesis (temporary) or definitive which needs more components and processing. The definitive RPD is usually made of a metal framework (cobalt-chromium or other metal alloys) and an acrylic base that is attached to the framework and holds the artificial teeth in position. RPD construction starts after evaluating the remaining dentition status followed by:

1. Taking the primary impressions using plastic stock trays and an irreversible hydrocolloid material.
2. The impressions are then casted with dental stone, and then the castes should be surveyed to determine the path of insertion, path of withdrawal and any undercut may need to be blocked.
3. Following the casts surveying, casts should be mounted on an articulator (bite registration might be needed) a design of the RPD is undertaken, planning its components for support, retention and stability. Depending on the agreed design, teeth modification (such as tooth contour) and preparation (such as rest seats and guide plane) must be done in the next clinical visit.
4. In this visit and after teeth have already been prepared and modified if needed, a secondary or master impression should be taken by using silicon, rubber base material or in some cases an irreversible hydrocolloid.
5. In the lab, the impressions are casted, surveyed and then the metal framework construction takes place.
6. In the clinic, the metal framework should be tried-in and a jaw-registration and teeth shade/mould selection may be taken in the same visit.

7. After that, the lab technician re-mounts the casts to the registration and sets the artificial teeth to be ready for another try-in.
8. Once the wax RPD is tried-in, it is returned to be processed and finished before it is sent to the clinic for insertion.
9. Follow up/maintenance visits could be needed to ensure the optimum fitting of the RPD and the health of the dentition.

The UK and Ireland dental schools have a dedicated preclinical course for teaching removable partial dentures. The majority of these schools (9 out of 11) start RPD teaching in the third year of the dental degree programme. In the remaining two schools, one of them has the preclinical teaching in the first year while the other as an introductory module during the first year. The mean of the total dedicated hours for the course is 67 hours (with a range from 24-200 hours) which divided between teaching and hands-on (practical). The dedicated teaching mean is 13 hours (ranged from 5-25 hours) consisting of tutorials (mean 9, ranged from 1-19 hours) and formal lectures for 10 schools out of 11 (mean: 4 hours, ranged from 1-10 hours). The staff: student median ratio for this course as follows; 1:10 for the course, 1:60 for the lectures, 1:12 for tutorials and 1:10 for the lab demonstration [59].

All these schools teach their students how to use the surveyor during this preclinical course through lectures, tutorials and practical (mean: 8 hours, ranged from 2-28 hours). In addition, all schools are teaching how to write a prescription for removable partial dentures by means of tutorials and seminars (mean duration: 2.5 hours, range 1-6 hours). Furthermore, seven schools dedicate a formal one-hour lecture in the course to teach this area. Using of semi-adjustable and average value articulators are taught in all these dental schools except one of them which only teaches average value. At the end of the preclinical course, seven of these schools have an examination that includes both written and practical assessments. Two schools have only practical assessments, while in one school it takes the form of a written examination and the final school does not set any examination at the end of the course. Additionally, this preclinical course is directed by a senior clinical academic either alone or in collaboration with a dental technician in ten schools, while it is directed by a dental technician alone in the remaining school [59].

Clinical teaching of RPDs and patient treatment is delivered in the third year of the course, in nine out of eleven dental schools investigated. In the other two schools, one began clinical teaching in the second year while the other in the fourth year. Clinical teaching staff: student ratio as follows; median in the clinical session is 1:8 (ranged from 1:6-1:10), median in the lectures is 1:60 (ranged from 1:35-1:160) and the median in the tutorials is 1:10 (ranged from 1:6-1:16). However, there was ‘paired teaching’ for clinical sessions in 7 of the 11 respondent schools and this ratio variation could cause pressures on teaching programmes. Furthermore, ten of these schools have further teaching of removable partial denture design and prescription writing. Four schools have further lectures on this topic while seven schools have further tutorials. Students using of surveyor when designing the removable partial dentures was reported in ten dental schools while it is never happen in one school [59].

In the stage of master impression-making techniques, nine schools teach the use of a special tray and polyvinylsiloxane and six schools teach the use of a special tray and irreversible hydrocolloid, however, some schools teach both techniques. The clinical requirements or number of items of treatment that the students must have completed prior to graduation, is two for acrylic and three for cobalt-chromium partial dentures (ranged from 0-3 for acrylic and 2-5 for the metal) and the number of completed cases in some schools is an area of concern. Multiple teaching challenges were reported by these dental schools such as lack of suitable patients (7 schools), lack of adequately trained staff (5 schools), pressures on teaching time from other sources (4 schools) and increase in student numbers (4 schools). This variations between dental schools in the curriculum and methods of teaching programmes could cause confusion in future dental graduates [59].

A more recent study by Clark *et al.* (2011), investigated the removable partial denture teaching course amongst eleven British dental schools. It found similar results to Lynch and Allen (2007), as the majority of the dental schools commence the removable partial denture teaching in the third year (7 out of 11 schools) while the remaining two schools start the teaching during the second year. In addition, most of these schools have clinical teaching of the course in the following years of their programme. A dedicated prosthetics clinic where the students treat patients under the supervision of specialist staff still available in some schools, however, some prosthodontics cases are treated in multidisciplinary restorative clinics in all schools. Regarding the required cases that students must completed before qualifying, most of the schools set a requirement number of minimum three cases to be completed. Although, three schools have no numerical requirements but each school has a different estimating number of cases that student ideally should complete by the end of the programme [60].

During the preclinical course, all schools have a laboratory based introductory course, which varies from 7 sessions to 22 full days (12 session for the majority). It either precedes clinical work (six schools) or runs in parallel (four schools), however, only two schools still give live clinical demonstrations while the remainder use videos together with phantom head and design sessions. In the preclinical sessions, all the schools teach students how to surveying the study casts, ten schools teach making custom trays, surveying and blocking out the master cast, nine schools teach pouring casts, setting up the teeth and processing acrylic resin, seven schools teach duplicating the master cast, laying down the wax pattern for Co-Cr casting, investing and casting a Co-Cr framework and only four schools teach denture designing [60].

In the clinic, students in all dental schools were expected to treat at least one case requiring a removable partial denture with a cobalt-chromium framework. The rest of cases could be acrylic resin removable partial dentures, which are soft tissue supported with a wrought wire clasps for retention. Furthermore, all schools teach students to deal with free-end saddles or distal extension cases by either providing a removable partial denture, or a shortened dental arch with or without distally cantilevered bridge. In addition, all schools (except one school) teach impression techniques which allow for the difference in displaceability between the denture bearing mucosa and the direct abutment tooth. All participating dental schools used different methods of teaching working impression with a majority of them teach the altered cast technique [60].

The RPI/RPA clasping systems for removable partial dentures with free-end saddles cases is also taught in all schools. However, technical work for the clinical cases, that students treat, mostly finished by lab technicians among most of the participating schools. Students’ assessment for the removable partial denture occurs in different ways among these schools. Ten of them have continuous assessment in combination with other assessment methods except one school which depends on the continuous assessment alone. The remaining school has non-degree/internal examination as the only method of assessment [60].

Teaching prosthodontics in a multidisciplinary clinical environment while giving the clinical work a broader context does have the disadvantage that less teaching is done by specialists, or dentists with different discipline interest. For example, some staff are as weak as the students in denture design [60]. In addition, in many schools the students may not treat more than one patient requiring removable partial dentures with cobalt-chromium frameworks. Clinical cases undertaken by students may have slightly decreased while the amount of technical work has decreased significantly. Clinical exposure may be less than what was reported ten years ago, although, this is compensated by increasing the academic and audio-visual input [60].

In 2011, de Oyagüe and Lynch assessed teaching methods of removable partial dentures in 15 Spanish dental schools. Similarly, all schools have dedicated preclinical course with the majority start in the third year. Three schools start in the fourth year and the remaining school teach this course during the third and fourth year. The total average duration of preclinical course including both theoretical and practical was 44 hours (range 12-120 hours) which is less than the UK schools average by 35%. It also found that the course duration averge varied between public schools (38 hours) and the private schools (60.5 hours). Distribution of these hours between practical and teaching is as follows; the averge preclinical practical course is 16.6 hours in public school and 32.6 hours in the private. For the teaching lectures, the average is 14.2 hours in the public schools and 25.2 hours in the private. Tutorials and seminars averge is 5.8 hours in the public schools and 10.1 hours in the private schools [61].

The Spanish public dental schools showed better staff: student ratios for lectures and laboratory demonstrations, while private schools reported better ratios for tutorials. Regarding the teaching topics in the preclinical course, all the private schools teach students how to use a surveyor (mean: 3.8 hours), while only four out of eleven public dental schools teach this topic. Six out of fifteen schools teach the students how to complete tooth preparations on patient simulator units as part of the preclinical course. Moreover, thirteen schools have a one-hour lecture to teach prescription writing for removable partial dentures. In addition, two dental schools (one public and one private) dedicated an average of 1.5 hours for tutorials/seminars on prescription writing. Generally, all the Spanish dental schools teach the use of semi-adjustable articulators, despite the wide variation in the articulator type and commercial brands [61].

Ten public and three private schools reported that they had an evaluation at the end of the preclinical course. In seven public and three private schools this examination included both written and practical assessments. Two public schools rely only on practical assessment, while one public school relies solely on the written examination. Regarding clinical practice, all the Spanish schools have dedicated clinical sessions for removable partial dentures. In eight of them, students start treating patients in the fourth year, in five schools their students start in the fifth year while two schools in the third year, however, there is paired teaching for clinical sessions in fourteen schools. Private schools have better staff: student ratio than the public schools. During the clinical course, thirteen schools have further teaching of RPD design and prescription writing. However, students in seven public and two private schools do not use a surveyor when designing RPDs [61].

A wide variety of impression-making techniques are taught for making master impressions, including different combinations of trays and impression materials. Both metallic and special trays were widely taught, irreversible hydrocolloid and polyvinylsiloxane. However, no school teaches students to use plastic stock trays when recording master impressions. All Spanish Public schools set a required minimum number of RPDs to be completed by student before graduation which is one acrylic and one cobalt-chromium RPD. In private schools, although it is not mandatory for the students to complete any acrylic RPD before graduation; they must complete at least two cobalt-chromium RPDs. The general students' clinical assessments are surveying and design, mounting casts in an articulator and prescription writing [61].

Lack of suitable patients mainly due to the decreased demand for RPDs and pressures on teaching time from other sources, are the most common challenges facing the teaching of removable partial dentures over the next few years as reported by the investigated Spanish dental schools [61]. The study results are comparable to teaching methods discrepancies that were found in Lynch and Allen (2007) study among the public dental schools in the UK and Ireland. It also comparable with another two older studies amongst US dental schools which concluded that preclinical and clinical removable partial denture programs showed a discrepancy from school to school, nonetheless, a large percentage of schools agreed on several topics [62] [63].

The results of removable dentures teaching have been reported to be a reflection of the current pressures on contemporary dental education, with increases in student numbers and limited availability of suitable staff. This could explain why divergences in the amount and content of teaching on removable partial dentures among dental schools has increased progressively over time. Students who graduated in 2009/10 will continue to practice dentistry into the mid of 2050s, so the teaching they receive in contemporary education will influence their approaches in treating patients over many years [61].

In 2003, Christensen had some suggestions around the education of partial dentures in dental schools. For instance, he suggested to teach easier procedures to construct the RPD, hiring competent prosthodontic practitioners who will be willing to serve as part-time faculty members as they usually developed techniques that are efficient, clinically acceptable and financially rewarding. Furthermore, he suggested incorporating competent laboratory technicians into dental school prosthodontic faculties and enriching dental implant education in the dental schools so it can be used to increase RPD support and retention in future practice [64].

2.2.2 Fixed prosthodontics teaching

Fixed prostheses replace teeth using restorations that are fixed into the patient's teeth. They are also known as indirect restorations as they are fabricated in the dental laboratory. Different types of fixed prostheses are available which can be made with different materials and techniques. Crowns cover the remaining structure of the natural tooth when a large amount of the natural tooth crown has been lost. Inlays are a conservative option for a crown. It is possible to provide an inlay if a relatively small amount of tooth tissue is missing within the confines of the tooth cusps. Onlays are similar to inlays, but they cover over the tooth cusps. They are particularly useful if the tooth needs to be strengthened or reinforced. Veneers are a relatively thin layer of ceramic or resin that are bonded onto the labial/buccal surface of a tooth. They can be used to restore damaged teeth, rotated teeth, or mainly to improve aesthetics, while bridges are made to restore gaps between natural teeth. Bridges can be held in place by a crowned adjacent tooth, or they can be bonded onto the adjacent tooth by a metal/zirconia wing, with resin base adhesive (resin-retained bridges). These bridges are held in place on either side of the gap (conventional), or on just one side (cantilever) [33].

In 2010, Lynch *et al*. investigated the teaching of fixed partial dentures (FPDs) within 12 Irish and UK schools. All twelve dental schools had dedicated teaching of FPDs which starts in the third year among five schools and in the fouth year among the remaining seven schools. During the preclinical course eleven schools devoted a number of lectures to teach FPDs, ranging from 2-12 hours teaching (mean: 5.7 hours). One school did not provide any lectures in relation to FPD teaching, instead, FPD teaching was delivered via small group teaching. The number of hours devoted to preclinical ⁄phantom head teaching of FPDs ranged from 3-42 hours (mean: 16 hours). The staff: student ratio for preclinical teaching courses in FPDs ranged from 1:6 to 1:18 (mode: 1:12). Preclinical teaching such as tooth preparation for conventional FPDs, tooth preparation for resin-retained FPDs and tooth preparation for all – ceramic FPDs varied within the respondent schools [65].

A preclinical assessment was mandatory in seven schools before students were allowed to provide FPDs clinically. Examples of such assessments included: a crown preparation (four schools); 2 tooth-preparations for a conventional FPD (three schools); 3 preparations for a resin-bonded FPD (two schools) [65]. In the clinical fixed prosthodontics, Lynch *et al*. (2010), reported that five out of twelve dental schools in Ireland and UK had clinical requirements which students have to complete before they graduate. Three schools required clinical provision of one

FPD, while the remaining two schools required provision of a prescribed number of units of fixed prosthodontics ranging from a single crown to 3-units FPD [65].

There was variation in the impression techniques that were taught among the dental schools in Ireland and UK. For conventional FPDs and resin retained FPDs, two schools taught the use of light bodied polyvinylsiloxane in special trays, two schools taught the use of medium bodied polyvinylsiloxane in special trays and five schools taught their students the putty and wash polyvinylsiloxane in stock trays technique. For the all ceramic FPDs, one school out of the nine respondent schools taught the use of light bodied polyvinylsiloxane in special trays and one school also taught the use of the putty and wash polyvinylsiloxane in stock trays technique.

The cementation techniques of FPDs that were taught in these dental schools varied widely. Three out of twelve schools do not teach their students about adhesive resin cements for conventional FPDs as they instead place emphasis on correct retentive preparation and degree of retrievability. Placing of the rubber dam while cementing the FPDs is taught in nine out of twelve schools. However, one school reported that using rubber dam may not always be feasible while other schools commented that rubber dam often interferes with cervical margin of FPDs in students' hands [65].

A most recent study by Virdee *et al.* in 2018 [66], aimed to investigate the teaching methods of fixed partial dentures among 18 UK and Ireland dental schools. This study showed that all participating schools have a dedicated course to teach fixed prosthodontics. Eight schools commenced teaching in Year 4, nine in Year 3 and one in the first year of the typically five-year long programme. The preclinical and clinical skills teaching ranged from 5-60 hours, with an average of 19.4 hours. Furthermore, the staff to student ratio ranged from 1:6 to 1:24, with 1:10 being the most commonly reported ratio. During the preclinical course, students need to practice different skills which also varies among these schools. For the preparation of conventional fixed bridges, ten schools required their students to practice fixed-fixed anterior bridges and, fourteen schools required the practice of fixed-fixed posterior bridges. The practice of anterior and posterior cantilever bridges was required in six and five schools, respectively [66].

Additionally, for preparation of resin-retained fixed bridges, seven schools required their students to provide fixed-fixed anterior bridges and, nine schools taught fixed-fixed posterior bridges. Thirteen schools taught cantilever anterior and nine schools taught cantilever posterior bridges. For the preparation of all-ceramic fixed bridge, only three schools allowed their students to practice for anterior all-ceramic, while none of the students in the participating eighteen schools practice posterior all-ceramic fixed bridges. Nine schools have waxing up exercises during the preclinical course. The most common textbook used to teach fixed bridges was Shillingburg HT *et al.* Fundamentals of fixed prosthodontics, Quintessence Publishing Co. (1997) (thirteen dental schools) followed by Wassell RW *et al.* A clinical guide to crowns and other extra-coronal restorations, BDJ Book (2002) (eleven schools) [66].

Fourteen out of eighteen schools (78%) reported that students are required to successfully complete a preclinical assessment before being allowed to provide bridges in a clinical setting. This assessment involved crown preparation (nine schools), tooth preparation for a conventional bridge (five schools), tooth preparation for a resin-retained bridge (two schools) and oral examination (one school). In the clinical course, there was variation in the level of clinical experience gained by students among these schools. It was found that anterior cantilevered, resin-retained bridges were the most commonly provided bridges per student per respondent school. The mean number of anterior cantilever resin-retained bridges in 2018 was twice as that reported in 2009. In addition, an increase in the student clinical experience of providing fixed-fixed anterior bridgework since the time of the 2009 survey was noted, although, it is still considered low. Requirements for completion of bridgework before graduation were mandatory in five out of eighteen dental schools. These requirements included the provision of two resin-retained bridges (one school), one resin-retained bridge and one conventional bridge (one school), two bridges of any design (one school) and one bridge of any design (two schools). Furthermore, two schools required their students to complete 5-6 units of fixed prosthodontic treatment (crowns or bridges) [66].

Regarding the clinical techniques, eleven schools required their students to have articulated study casts for the planning of bridges. The remaining seven schools reported that articulation depended on the clinical scenario (including the number of units, occlusal guidance, position and type of bridge). For the impression techniques taught for recording the master impression for fixed bridges, light-bodied polyvinylsiloxane in special trays for conventional bridge is taught in four schools, medium-bodied polyvinylsiloxane in a special tray is taught in three schools and putty and wash polyvinylsiloxane in a stock tray is taught in twelve schools. For resin retained bridgework, light-bodied polyvinylsiloxane in special trays is taught in six schools, medium-bodied polyvinylsiloxane in a special tray is taught in four schools and putty and wash polyvinylsiloxane in a stock tray is taught in twelve schools as well. While for an all ceramic bridge, light-bodied polyvinylsiloxane in special tray is taught in one school, medium-bodied polyvinylsiloxane in a special tray is taught in three schools and putty and wash polyvinylsiloxane in a stock tray is taught in eight dental schools [66].

Cementation techniques also varies among these schools; however, glass-ionomer cements were the most popular luting cement taught for conventional bridgework. One school reported that they do not teach adhesive cements for conventional bridges to allow for easier retrievability. Rubber dam placement during cementation of the resin-retained bridge is taught in eleven schools. One of the respondent schools reported that rubber dam placement is dependent on the position of the margin on the abutment tooth. Two schools reported that the teaching of bridges had increased, five reported that the teaching of bridges had decreased while eleven schools reported that the teaching of bridges had remained unchanged over the past 5 years. Overall, respondent schools suggested that the changes in teaching were predominantly related to advancements in bridge technology, including adhesive cements, resin-retained bridges and implant-supported restorations [66].

2.2.3 Dental Implants teaching

Dental implants are alloplastic materials (usually a titanium screw or more recently zirconia screw) which are surgically inserted into residual alveolar bone primarily as a prosthetic foundation. Implants have special surface features that allow them to become accepted by the body and hold in the surrounding alveolar bone (osseointegration). Dental implants as a treatment to replace single or multiple teeth in partially or completely edentulous patients is a well-established clinical method in dentistry [67]. Dental implants not only restore the missing tooth but also maintain the surrounding alveolar bone and consequently the related periodontium especially when they are placed immediately after tooth extraction. Since the introduction of dental implants by Branemark, it took about 20 years for them to be introduced into the undergraduate curriculum of the dental schools. Then, in 1990 the American College of Implantology presented undergraduate curriculum guidelines for implant placement [68].

In 2005 a study examined the teaching of dental implants among 40 European dental schools representing 23 countries. Two-thirds of these dental schools have an implant course for undergraduate students while the remaining one-third reported that they did not have an implant course at all. Reasons for not providing an implant course in these schools were due to lack of curriculum time, lack of financial resources, the topic integrated within the prosthodontic or restorative lectures or their view that implants should not be in the undergraduate curriculum. In most of dental schools which offered an implant course, teaching was conducted during the fourth year (37%), fifth year (20%) or both (17%) [69].

The course duration varied between the reported schools with a median of 4.5 months. It was less than two months in twelve schools and three to six months among fourteen schools. However, three schools reported that the duration was between seven and twelve months and in only one school the course duration was more than thirteen months. The median number of lecture hours was 15.5 (ranging from 10-50 hours) dedicated for the implant course. The most commonly used textbook was Branemark's 'Tissue Integrated Prosthesis Osseointegration in Implant Dentistry' (39%) followed by Spiekermann's 'Implantology'. A laboratory course in conjunction with the course was reported in 11 schools with median of 8 hours (ranging from 5-23 hours). During the laboratory course, 91% of the schools used a partially dentate dentoform/model, 45% used a manikin head and live demonstrations while 75% used pre-recorded video demonstrations [69].

In the clinical phase of the course, nineteen out of thirty schools reported that students are required to be present during implant surgery while eleven schools required their students to restore implant cases. Thirteen schools reported that they advocate connection of natural teeth with implants for fixed partial dentures. Three schools reported that students are required to do implant-related laboratory work. However, only one school required students to do all the laboratory work while in the other two schools students pour up models, fabricate transitional prostheses and fabricate surgical stents. Regarding the used implant system, Nobel Biocare (Yorba Linda, CA) and ITI (Straumann, Waldenburg, Switzerland) implant systems were used most frequently, 15% and 19%, respectively, both in the surgical and restorative phases of treatment [69].

In 2008, a study aimed to assess dental implant teaching among 15 dental schools in the UK and Ireland. A significant variation in the extent, timing, nature and delivery of this teaching was found. However, 13 out of 15 schools provided dental implant training for their undergraduate students. Most of this training occurred during the fourth and the fifth year; however, six schools reported that implant teaching occurred in the third year. This training either provided by both the restorative dentistry and oral and maxillofacial surgery departments (61% of schools) or solely by the restorative department (38%). Prosthodontists or prosthodontists together with the periodontists were the most frequent member of staff teaching dental implants (five and four schools respectively) [70].

In their implant course, eight schools (53%) had a phantom head component in conjunction with either a symposium or lecture programme. Four schools (27%) incorporated patient treatment into their teaching course. There was also variation in the number of sessions devoted to implant teaching; seven schools devoted between four and six teaching sessions; three schools devoted between one and three sessions and three schools had more than six teaching sessions. During the course, students in seven schools gained experience of treatment planning patients for implants and in seven schools students also observed restoration of dental implants. Students in five schools observed live implant surgery, and in addition, eleven schools did not provide direct clinical experience of restoring dental implants for their undergraduate students [70].

In the clinical session of the course, four schools expected their students to provide restorative treatment for either one case or two (for partially edentulous or single unit). Only one school allowed undergraduates to place dental implants for either edentulous cases or for single missing unit cases. The most system used was Nobel Biocare, Yorba Linda, CA, (in 7 schools); followed by ITI, Straumann, Waldenburg, Switzerland, (in 4 schools). Additionally, Astra, Dentsply and 3i Biomet implant systems were also reported to be used. Moreover, more than half of participating schools reported receiving support from implant companies for the provision of their implant training programme. This support may come as provision of simulated models for surgery and implant restoration (7 schools), provision of implants (5 schools), provision of restorative components (3 schools), laboratory funding support (2 schools) or funding for clinical staff (1 school). However, the most common challenges that faced by respondent schools were; funding issues, lack of available time within existing teaching curricula and insufficient numbers of suitable trained staff [70].

A study conducted in 2011, aimed to assess the dental implant curriculum for undergraduate dental students around the world. This study included 92 dental schools across 49 countries. Approximately,14% of the participating schools did not have implant dentistry in their curriculum. The explanations for not teaching implant dentistry included: inadequate curriculum time, lack of financial resources, content more suited to a postgraduate program and lack of qualified teaching staff. Most of the schools (86%, 79 schools) stated implant dentistry is part of their curriculum for undergraduate students; 35 schools were from North America and Europe; 44 were from Asia, Africa and South America. The staff: student ratio for their implant dentistry course was ranging from 1:5 to 1:15. Furthermore, 20 out of 35 dental schools from North American and Europe introduced an implant course before 2000 compared to only 4 schools from Asia, Africa and South America. In 33 of the respondents schools offered an implant course by more than one department in the school (multidisciplinary). Individual departments such as removable prosthodontics (14 schools) oral surgery (12 schools), fixed prosthodontics (11 schools) and periodontology (9 schools) also delivered the dental implant course [67].

Many of these schools delivered an implant course during the fifth and sixth year (31 and 28 schools respectively). Whereas 12 schools delivered their implant course in the fourth year and the remaining 8 schools delivered the course during the third year. The lecture hours in the implant course were ranged from less than 10 hours to 40 hours in 31 and 5 schools respectively, where ten schools had the lectures available online. Although 37 schools did not require a textbook, 11 dental schools did not respond to the question and 31 dental schools required a textbook for the course: eleven schools of them used Misch's “Dental Implant Prosthesis” and “Contemporary Implant Dentistry”. Other textbooks also used for the course included, Spiekermann’s “Implantology” (5 schools) , Branemark’s “Tissue Integrated Prosthesis Osseointegration in Implant Dentistry” (3 schools), Worthlington’s “Osseointegration in Dentistry” (3 schools), Zarb’s “Prosthodontic Treatment for Edentulous Patient ” (2 schools) and others textbooks (7 schools) [67].

Regarding the implant systems used, the ITI and Nobel Biocare were the most common systems. 3i, Paragon, Astra Tech, Steri-Oss and other systems were also reported to be used. In conjunction with the dental implant programme, 32 dental schools offered a laboratory course. In the clinic, 39 dental schools reported that they involve their students in surgical and prosthodontics procedures mainly as observers. Only 11 schools allowed their students place implants surgically. Moreover, 26 out of the 79 dental schools allowed their students to restore implant cases which is in the most a single unit followed by implant-supported overdenture and implant-supported bridge. This study also found that the hands-on total practice hours during the course are higher in North America and Europe than in Asia, South America and Africa. In addition, some of these countries did not have a comprehensive undergraduate curriculum guidelines for implant dentistry [67].

In 2008, a workshop amongst university teachers and opinion leaders was organised in Europe to promote consensus on implant dentistry where guidelines on both under- and postgraduate education were issued. As a result, after five years, the average amount of implant dentistry in undergraduate curricula has increased to 74 h, compared to 36 h in 2008, and the inclusion of preclinical and clinical education has also increased [71]. Implant dentistry should be taught as a core item within treatment planning for replacing missing teeth and especially where conventional treatment modalities have failed or are inappropriate. It has been shown that implant therapy and treatment is more likely to be offered to patients if it was an integral part of undergraduate education and training. This way, dental graduates will have a good grounding in basic implant theory and practice with a good competence for future practice [72].

2.2.4 Innovative teaching methods

During the twentieth century, the practice of dentistry remained relatively static. New products and technologies were introduced at a rate that allowed dentists to provide effective and efficient patient care using the procedures learned in dental schools. Many dental schools have now developed sophisticated simulation laboratories that take advantages of virtual reality technologies to teach preclinical skills and use of electronic tools which have an influence on improving the learning environments. Furthermore, technology has the ability to revolutionize patient care through rapid and efficient management of large amounts of clinical information and to make dental teaching less faculty-intensive [73]. Also, a recent systematic review reported that technology-enhanced teaching and assessment tools used in preclinical skills training of undergraduate dental students have the potential to improve students' performance [74]. Another recent systematic review revealed that current intelligence and educational quality enhancements from digitalization in the dental curriculum revolutionized dental education and helped prepare future dentists for their daily practice [75]. Digitalization in dental industry, was considered by the National Academies of Sciences, Engineering, and Medicine meeting in 2016 the Fourth Industrial Revolution. Hence, inclusion of digital dentistry components in undergraduate curriculum will make dental graduates well prepared for this revolution and it will rapidly change the healthcare sector to serve the society in a better way [76]. Digital dentistry is believed to be one of the important elements of dental education and practice and a rapidly expanding field that is becoming the face of modern dentistry [77].

Incorporation of new technologies into the curriculum or into dental practice depends on the level of acceptance by users; some of these innovative teaching methods will be discussed in the next section.

1. Virtual Reality-Based Technology:

Advancements in the computer hardware and software industries have led to the development of virtual worlds that support the field of advanced simulation. Virtual reality creates virtual worlds using mathematical models and computer programs, allowing users to move in the created virtual world in a way similar to real life. Some experts have referred to this technology as the “third dimension”. A unit designed for the instruction of dental procedures using virtual reality-based technology (VRBT) was introduced into the dental education marketplace in the late 1990s. This unit has the ability to give consistent, unbiased feedback based on evaluation of the tooth preparation in terms of tenths of millimetres. The computer can evaluate the tooth preparation both immediately and at the student’s request, in addition, real-time evaluation for critical, non-correctable errors is given as immediate feedback. Virtual Reality-Based Technology is a powerful educational method that has a potential to significantly affect dental education [78]. However, there has been little discussion in the dental literature about how modern theories of learning can provide a sound rationale for change in dental education [79].

2. Outreach education:

   Outreach education is a form of learning that supports formal or classroom-based education, as well as informal education that occurs outside the classroom such as placement of dental students in private clinics. Dental outreach teaching and training take place at sites outside university teaching hospitals or clinics, usually under the direction and guidance of academic departments. The aim is to give students experience of providing comprehensive care for patients in clinical settings and to focus on developing the required skills in practice. Outreach education allows dental students to be utilized as oral healthcare work force, act as a team member and be familiar with the 'real world' conditions [80].

Outreach teaching forms a significant part of the present initiatives. In this setting, teaching and supervision are the responsibility of primary care practitioners, with support from dental nurses [81]. Lynch *et al.* (2010), reported that students showed their enthusiasm for training in an outreach teaching unit, preferring it to traditional dental schools environments. Students had a sense of growing confidence in their abilities and development of reflective practice [82]. It also found that clinical exposure and being in a general practice environment appeared to be the most beneficial factors to students in their development and preparation for the future general practice [83].

3. E-learning education:

E-learning utilizes electronic technologies to access an educational curriculum outside the traditional classrooms. It reduces time and removes the need for classroom-based training which allow student-centred learning and efficient use of time. E-learning is a broad term which includes computer-assisted teaching aids (CD and DVDs), online courses and web-based learning. It also offers various advantages such as, increased access to a greater variety of learning materials, flexibility of learning, better visualization, control over the pace and sequence of learning. Additionally, it provides teachers with a multimedia platform for interactive teaching which makes the update and learning outcomes improvement easier [84].

When e-learning is applied via distance learning, it may enhance students' knowledge and performance [85]. A study found that online learning for both students and teachers is one of the fastest growing trends in educational uses of technology. These technologies were not significantly different from regular classroom learning in terms of effectiveness. Moreover, interest in hybrid approaches that blend in-class and online activities is increasing [86]. Students who took all or part of their class online performed better, on average, than those taking the same course through traditional face-to-face instruction. Learning outcomes for students who engaged in online learning exceeded those of students receiving face-to-face instruction. Furthermore, instruction combining online and face-to-face methods had a larger advantage than relaying purely on one of these methods. In addition, learners in the online condition spent more time on task than students in the face-to-face setting, which have a great benefit for online learners [86].

In contrast, a recent study assessed the students' perspective on the implementation of two computer-aided learning modules in the undergraduate prosthodontics preclinical curriculum at the Justus Liebig University Giessen. The study showed that students rated this implementation of digital aspects in teaching as positive in terms of handling, didactic benefit, and motivation, but gave preference to the assessment of the tooth preparations by dental teachers [87].

Another recent example of utilising e-learning or the digital workflow was at New York university. Owing to the decrease in student laboratory time caused by COVID-19 pandemic, the college of dentistry incorporated a web-based digital platform (DENTCA Academy, DENTCA Inc., Torrance, CA, USA) for arranging denture teeth into their removable prosthodontics curriculum. This platform allowed students to master several prosthodontic concepts such as occlusion, midline, positions/inclinations/rotations of artificial teeth by using such an intuitive and easy to navigate programme [88].

Incorporating this digital programme allowed students to apply the knowledge learned in didactic courses to correctly arrange digital teeth for denture fabrication. After that students' work is automatically graded by comparing to the previously established ideal arrangement immediately after the students had completed the exercise. This digital software for denture teeth arrangement allows students to use a computer/mouse, instead of their hands, to learn the same concepts without the need for costly physical materials such as wax, acrylic resin, and artificial teeth. Laboratory work is a labour-intensive, time-consuming, and expensive operation for teaching institutions [88]. Thus, e-learning technology can minimise the loaded laboratory teaching course for prosthodontics.

4. Interactive Dental Video Game:

   Dental students nowadays belong to a much different generation compared to those of years ago. Since not all dental clinical procedures require a refined psychomotor skill (such as that required to prepare a tooth or cavity) and while some procedures only require following specific steps and timing each step (e.g., applying a resin bonding system to a tooth). A less expensive computer interactive program, in the form of a video game, may provide the information and training needed. This method provides many advantages over a more traditional, passive way of teaching this kind of procedures that need psychomotor skill [89].

Interactive Dental Video Games can be used in large classrooms as well as in smaller ones. Moreover, students can use this game module without supervision to learn the proper sequencing procedures at any time on or off campus. It also allows students to receive anonymous feedback to learn from their mistakes. Using an interactive dental video game are as good as a passive, non-interactive way of teaching. Also dental students preferred this method of teaching compared to the traditional way of learning such as lectures [89].

5. Interactive multimedia “rich media”:

   This type of learning combines text, illustrations, videos, etc. with feedback, which are a very powerful tool for teaching and learning. With its high storage capacity, CD-ROMs and DVDs are ideal for computer-assisted learning (CAL) programs for continuing education programs [90]. A study from Hong Kong on the effectiveness of CAL in undergraduate clinical teaching showed equivocal learning improvements with other teaching methods in clinical dentistry. It also found that computer-based education in undergraduate clinical dental programmes, and the Internet can provide better access to materials [91]. The educational psychology literature indicates that good multimedia teaching modules will provide intellectual stimulation for the student and immediate feedback. Navigation of the module will be intuitive, and interactivity will engage the student in active learning. As a result, the students will have maximum control over the module (Brearley Messer, Kan et al. 2002).

6. Social Media:

   Social networking websites can help facilitate teaching such as, Facebook, YouTube and Twitter [92]. YouTube is currently being utilized to teach dental students. In 2011, a study assessed the dental videos found on YouTube and separated them on basis of education with further sorting done based on the most relevant and viewed videos. They reported a large number of dentistry-related videos are currently available on YouTube including videos on education, advertising and entertainment. The videos falling under the category of education had suitable information for general public and dental professionals. The study concluded that dental students found YouTube a valuable medium offering educational opportunities [93].

   Another study also explored YouTube as an educational forum and created forty videos on the content of anatomy, physiology and pharmacology of local analgesia. These videos were uploaded to YouTube to gather data about their viewings. Data indicated that the videos were watched nearly 71,000 times over an eighteen-month period and accessed primarily by viewers from the US and Australia followed by developing countries. Dental videos available on YouTube can thus be used as an auxiliary tool to access and teach a widespread audience. However, great care must be taken while utilizing the social media forum to ensure authenticity of information and credibility of authors [92].

7. Problem-Based or Enquiry-Based Learning:

   Problem-based learning is defined as an approach in which a problem serves as a stimulus for active student learning. Teaching basic science subjects with this approach enables students to correlate basic knowledge with clinical scenarios. It allows vertical and horizontal integration of knowledge and leads to better results [94]. Problem-Based Learning has three objectives: to organize biomedical and clinical knowledge around a patient problem; to develop the clinical reasoning process; and to enable self-directed learning. Problem-Based Learning gives students the opportunity to assimilate information and provides in-depth understanding of the problem [95]. In Problem-Based Learning, learning is driven by challenging, open-ended problems. Students work in small collaborative groups, and teachers take on the role as facilitators of learning.

   It is a student-centred, instructional strategy in which students collaboratively solve problems and reflect on their experiences [90]. A study was conducted to improve cognitive and psychomotor skill development of dental students while learning tooth morphology. It found a significant increase in students' psychomotor skill development and performance as evaluated by their final tooth morphology waxing project [96]. In addition, these innovative learning methods will lead to a cohort of dental students who will be multi-talented, highly skilled and have a better knowledge of dental topic [97].

8. Small Group Teaching:

Small group or similarly case-based learning is a critical component in of the problem-based learning curriculum where discussion of illustrative patient cases is a routine informative tool. In this discussion an introduction of clinically meaningful problems presented to small group of students headed by senior student or academic clinician which combines the knowledge of both biomedical science and clinical topics. In general, patient care tasks require the participation of teams of clinicians with different specialties, it is a cooperative tasks [98]. Furthermore, discussion that occur within small groups, provide a common ground for students to construct mutual knowledge about beliefs and assumptions; consequently, they engage in collaborative knowledge building [99].

However, the traditional curricular format, such as lectures, does not prepare students for the collaborative nature of practice in clinical settings. Lecture provides little chance for interaction among students and between students and the lecturers. In addition, scientific knowledge taught abstractly, as it occurs in lecture-based curricula, does not help students to integrate this knowledge with clinical practice because basic science is taught separately from the teaching of clinical disciplines. Thus, small-group teaching, attempts to narrow the gap between biomedical knowledge and clinical practice and constitutes an important instructional scheme in promoting learning [98].

In medicine, the adoption of small group teaching as a component of curricula has been supported by its contribution to gains in student satisfaction, promotion of students' knowledge structures, enhanced self-directed learning skills, improved student performance, intrinsic interest in and motivated learning of the subject matter [98]. Although it is easy to integrate biomedical knowledge into the clinical structure, which is a necessary prerequisite to differential diagnosis and an understanding of clinical conditions, the clinical understanding cannot be easily integrated into the biomedical knowledge [98].

A qualitative study was conducted exploring how medical students linked their problem-based learning experiences to their clinical experiences using open-ended questions among focus groups. It reported that students used their clinical experiences in two ways: 1) as a basis for elaborating their knowledge when encountering a patient, and 2) as a source of discussion in small group sessions [100]. Clinical instruction through lectures emphasizes issues relating to the continuity principle, rather than the interaction principle, whereas small group teaching emphasizes the importance of meaningful interaction over continuity of learning [98].

In Dublin Dental School a study investigating case-based learning, found that the discussion group facilitated debate between the tutors and students on the advantages and disadvantages of selected treatment plans. Students were exposed to the expert opinions of tutors in various disciplines and learned that experienced clinicians did not always agree on every treatment plan. The study brings into being that Case-based learning requires creativity, facilitator skills, a reduced focus on traditional lecture presentations and a dedication to encouraging students to use reasoning and decision-making skills [101].

Patel *et al.* (2004), stated that combination of lectures and small group sessions seem to offer the student the most appropriate means of education. If the curriculum consisted only of lectures, learning might be superficial and less applicable to the practice of medicine, but if it were limited to small group sessions, students would lack a common core of basic knowledge that allows them to engage in abstract and more advanced discussions. Small group learning serves to integrate knowledge previously acquired in lectures and through reading. It is an integrative approach to instruction for the health disciplines and a step toward more effective education [98].

2.3 Approaches to assessment of prosthodontics in dental schools

Assessments in dental schools should be designed to include all required learning outcomes. Assessment is designed to evaluate the level of attainment of knowledge, behaviours or skills of students. Assessments are usually the main focus for students which is the driving force for them to engage in the learning process [102]. Assessments should be rigorous, appropriate and reliable as a gateway for dental graduates to become qualified to practise independently [102].

Assessment can be summative or formative: summative assessments are designed to evaluate knowledge and provide formal recognition that usually happen at the end of a course or unit and often used to determine student progression. Formative assessments are used as more of a diagnostic tool to provide feedback about the student's progression, which can be reflected upon in order to make any required improvements that may aid the learning process [103]. Workplace based assessment, portfolios, projects and exams are assessment types that usually set for students in dental schools. Furthermore, a system in place should set appropriate standards for the assessment process to decide whether students have achieved the required outcomes or not [2]. However, the most commonly used assessment methods were glance and grade marking and target setting which are not perceived as valuable method [104].

An ideal assessment tool would have the following features: reliability, validity, accountability, flexibility, comprehensiveness, feasibility, timeliness and relevance. In this respect, reliability refers to an indication of the consistency of scores over time. If an assessment method is reliable, then the same results should occur regardless of who administers it and when. Validity refers to the ability of the assessment to measure what it is supposed to. In many situations it is not possible to satisfy all of these requirements and many assessment tools that used do not fulfil many of these criteria. Nevertheless, the subjectivity associated with evaluation by assessors (teachers/staff) can affect the reliability and credibility of the assessment process. [102].

Students' readiness to graduate is traditionally measured by written and oral examination combined with the completion of a target number of clinical procedures. In British dental schools, Clark *et al*. (2011) reported that all schools examine students' competence in the removable partial denture field, although, a variety and combination of methods are used in many schools, with a reliance on summative examinations either during, or at the end of the programme [60].

Various methods of assessment can be used depending upon the competency that need to be tested. Written examination such as open-ended questions can either be context-rich or context-poor. Context-rich questions need complex cognitive processes that are required in clinical practice. Context-poor questions are used to test basic factual knowledge, but they are not relevant or transferable to clinical situations. Assessment by multiple-choice questions (MCQs) is a popular method, as a large number of topics can be covered. The exam can be objectively graded by computers and hence can be standardized. However, it is not useful or may prove counterproductive when testing diagnostic astuteness of the trainee [90]. Assessment by supervising clinicians is the most commonly used method to evaluate trainees' performance, though subjectivity can play a role in such assessment. Also, direct observation of trainees by the busy clinician supervisor when they are interacting with the patients may be too infrequent [105].

Clinical simulation is method of assessment which is accomplished by using standardized patients or on mannequins. The advantage of using standardized patients is that the students gain realistic experience which could be used for learning to perform clinical examination, diagnosis, and treatment planning [106]. Multisource (360-degree) assessment is method can be performed by peers, other members of clinical team, and the patients, but the sources should be reliable. With thoughtful ratings and comments by peers and support from advisors, the process of 360-degree assessment is powerful, insightful, and instructive. Even though, it requires trust and scrupulous attention to confidentiality. Patients' ratings are typically high, but ratings by nurses are considered valuable [107].

Progress testing is a form of longitudinal, feedback-oriented, summative academic assessment of the development and sustainability of cognitive knowledge at regular intervals over the course. This type of assessment allows to monitor students' progress unlike the traditional methods that involve assessment at the end of each module which may promote rote learning and short-term memorisation of facts. Progress testing also provides immediate and comprehensive feedback on students' performance which is being increasingly used in medical education. Thus, it was found that application of progress testing in undergraduate dental educational programmes offers a valid and reliable tool to measure growth in knowledge [108, 109]. Additionally, undergraduate students in medicine, dentistry, and dental therapy and hygiene considered the progress test as a useful assessment to support their learning needs [110].

Ali *et al.* (2017) carried out a study in Peninsula Dental School, UK to develop scale to measure preparedness of new dental graduates using modern psychometric methods scale conformed to the Rasch measurement model. Preparedness can be measured by examining the responses of a participant to a set of items related to the underlying construct. Then the investigators can assign a score that approximates the person's level of ability on the latent trait. However, preparedness has several dimensions and it is a latent construct as it not directly observable. The study evaluated graduated students' preparedness in several aspects such as, scientific knowledge, treatment plan, partial denture, non-surgical extraction and so on. The study claimed that the developed method (Preparedness Assessment Scale, PAS) is providing evidence for its uni-dimensionality and ability to provide an interval-level measurement and the scale was valid and reliable which offers promise for its use in the assessment of dental students and new graduates [111].

A further study by Ali *et al*. to evaluate the self-perceived preparedness of final year dental undergraduate students in the UK used the same previously developed scale. The study investigated the cognitive attributes, clinical and affective skills of undergraduate students using the Dental Undergraduates Preparedness Assessment Scale (DU PAS). Study results showed that students were confident undertaking basic assessments of patients such as obtaining a medical history, carrying out clinical oral examination, undertaking intra-oral radiographs, administering inferior alveolar nerve blocks, restoring teeth with tooth-coloured filling materials and amalgam and providing non- surgical periodontal treatments, caries removal, non-surgical extractions, and provision of partial and complete dentures [112].

However, students were less confident in prescribing and interpreting findings on dental radiographs, assessing orthodontic treatment needs of patients, comprehensive treatment planning for patients, referring suspected oral cancer, recognising oral cancer, undertaking endodontics and providing crowns, using evidence-informed research in their clinical practice, evaluating new dental materials and interpreting the results of research. By using the PAS, the study concluded that students felt prepared for the majority of the attributes expected from dentists, even though, students need further training in some identified area e.g., fixed prosthodontics, endodontics and orthodontics treatments. Nevertheless, the scale items were based on self-assessment by the students and it is possible that the mean person ability (perceived preparedness) may be inflated which considered to be a limitation for the scale [112].

A study was conducted in Cardiff Dental School and University College Cork Dental School to investigate the confidence level of the final year students who were five months away from graduation. The study used a questionnaire with 41 procedures listed in section two of General Dental Council document ‘The First Five Years’ [57]. The list of questions was not an exhaustive list of clinical procedures but was representative of experience at undergraduate level. The study found that simple procedures such as scale and polish, history and examination, diagnosis of caries, simple fillings and paediatric dentistry were the areas in which students at Cardiff and Cork had the most confidence. However, complex procedures such as surgical extraction, veneer preparation, orthodontic emergencies, molar endodontics and conventional bridgework were the procedures in which the students had least confidence [113]. These results are consistent with a recent review study that revealed that new graduates possess excellent theoretical knowledge, well-prepared and confident in basic clinical skills, but they are lacking experience of complex treatments which may reduce preparedness for future practice [114]. Moreover, a recent British study reported a strong association between the amount of exposure students had to certain treatment stages and their perceived confidence levels. While the students' confidence levels may be boosted further with increased clinical experience [115].

European consensus in implant assessment methods was published as a guideline for the dental schools implant dentistry education. They recommended the model described by Miller in the 1990s as appropriate in implant dentistry assessment. They also strongly encouraged the use of reflective forms of assessment methods which engage the students in a process of self-appraisal, identification of individual learning needs and self-directed learning. The ultimate goal of this would be to allow the student to appreciative the fundamental importance of lifelong learning. Various forms of written or oral assessment methodologies, such as essay or multiple choice questions may be more applicable at the lowest competence levels and can particularly helpful as summative assessment tools for large student numbers. They also encouraged the use of interactive assessment methods, whenever possible, which require the synthesis of several disciplines and aspects of the theoretical knowledge and their application to relevant clinical scenarios [116].

Miller's pyramid provides a framework for planning assessment of clinical competency. In this pyramid model, the facets of clinical assessment are 'knows or knowledge', 'knows how or competence', 'shows how or performance' and 'does or action' [117]. It explains how students in professions such as Medicine and Dentistry develop their skills. Written examination measures what a student 'knows' or 'knows how' while to assess "shows how" from the Miller's Pyramid, the objective structured clinical examination (OSCE), laboratory practical (technical skill evaluation in labs), computer-based simulations and students' self-assessment have been introduced as well as assessment of single practical procedures in different disciplines. A variety of assessment methods at the top of

Miller's pyramid ('does') have been presented in dental education such as assessment of real patient treatment and use of standardised patients (patient-instructors or simulated patients), portfolios, self-evaluation, daily evaluation in a clinic and longitudinal assessment (longitudinal evaluation of performance, LEP) in the clinic [118].

The OSCE for example, which is commonly used in dental schools, was developed to provide a standardised way to assess clinical skills and theoretical knowledge. It has been reported that the OSCE is a suitable tool for testing qualities such as problem-solving ability, critical thinking, communication skills and diagnostic, interpretation, treatment planning skills and have good reproducibility. During the OSCE, students rotate through a series of stations where they are required to perform a variety of clinical tasks within a specified time which can test the core of clinical knowledge, skills and procedures. On the other hand, longitudinal assessment (comprehensive evaluation) can be defined as a summary assessment of many aspects of performance and across several competency domains over extended periods (8-12 weeks) of observation of a student's performance by faculty members who have daily interactions with the students. Thus, it was reported that both the OSCE and constant longitudinal assessment are needed in clinical dental assessment because both play an important role in the overall assessment [118].

Since each method of assessment measures a different student's performance, the correlation between these methods of assessment was inspected by Ali *et al* (2017). They studied the correlation between: 1) Progress Test which is a method of assessment of the students' applied dental knowledge (knowledge-based) 2) Case Presentation which is used at final year to demonstrate competence in clinical treatments of patients 3) the final year Integrated Structured Clinical Examinations

(ISCEs). The ISCE is similar to a traditional OSCE but with longer stations (four stations with 30 minutes for each) at which students must demonstrate complex combinations of skills in four different clinical disciplines [112].

The study found that performance of the participant final year students (n=304) on a progress test was a significant predictor of their performance on clinical skills examinations, similarly was their performance on exit case presentations. Furthermore, in combination, a progress test and the case presentation performance were significantly related to ISCE performance. This study result showed a significant correlation between various dental students' skills and performance in the applied dental knowledge, clinical skills, professionalism, communication skills, management and leadership skills, even if in different settings and situations. However, the study were limited to dental students from a single dental school and one curriculum, therefore, it may not be possible to generalize its findings in the absence of harmony in dental schools curriculum and assessment methods [112].

Recently, a study was conducted in VSPM's Dental College & Research Centre, India to evaluate the final year undergraduate students' knowledge in the taught topic of prosthodontics by using Structured Oral Examination Assessment in compared to Traditional Oral Examination. This investigation found that, in comparison to the traditional viva voce, a significant increase in the scores of the students from structured viva. Also, the structured oral examination tend to be beneficial to students to understand the subject, be more confident and also to create a sense of honesty & fairness to both students as well as faculty [119].

Furthermore, transition from undergraduate dental student to independent dental practitioner is a difficult step, especially at the confidence level. In the UK, this transition is staged through Dental Foundation Training (DFT, previously known as Vocational Training) which is a one-year programme where new graduates work within dental practices and are mentored by a Foundation Trainer (FT) within a structured training environment. This programme became mandatory since 1993 and the main goal was to prepare the dental graduates to practice independently through supervised education and training and to support high standard in dental care [120].

In 2006 a study was conducted to examine the level of confidence of dental graduates after they completed the DFT. The study found that students felt well prepared for practice in history taking, diagnosis, treatment planning, routine restorative dentistry and oral pathology. The results also suggested that they felt less prepared for more complicated procedures such as molar endodontics, surgical endodontics, surgical extraction of teeth and the practice of orthodontics [121]. Comparably, a recent study was conducted in school of dentistry at the University of Jordan reported that final year dental students generally have high confidence levels in doing simple dental procedures and less confidence in more complex ones [122]. Another older study demonstrated comparable results where respondents had high confidence in simple procedures such as simple periodontal treatment but reduced confidence in more complicated procedures such as surgical extraction and molar endodontics [123]. In prosthodontics, Gilmour *et al*. reported that fixed prosthodontics was the procedure that scored lowest in the mean of final year undergraduate students' confidence level [120].

A more recent study investigated the level of foundation dentists' preparedness in England and Wales at the sixth week of DFT. The study used the Graduate Assessment of Preparedness for Practice (GAPP) questionnaire. The GAPP questionnaire is composed of three sections: the first section regarding the respondents' descriptive data, including gender, age, school of qualification and length of course. The second section comprised of 34 questions representing all four domains of Preparing for Practice, namely, Clinical, Communications, Professionalism and Management and leadership. The third section contains open questions which designed to allow respondents to further expand and develop their responses in the second section. Similarly, this study found that foundation dentists felt "well prepared or very well" in 21 of the 24 clinical areas with only orthodontic appliance repair, surgical extractions and TMJ management being ranked lower "poorly prepared or not well" [124].

Furthermore, it was found that over 46-50% of DFT dentists were unable to design a chrome-cobalt removable partial denture (CCRPD) correctly. Moreover, 90% of DFTs did not have access to a surveyor in their practice and a group of dentists who thought that they did not need a surveyor to design a CCRPD were identified. It was reported that a serious deficiency in the teaching of CCRPDs during Dental Foundation Training were identified. Such findings raise concerns. In more generic terms, it is believed that performing a procedure a number of times increase not only expertise, but also confidence is common. Conversely, experience alone may not improve performance unless this experience is structured [120].

2.4 Competence of dental students

In dentistry, competence is defined as the behaviour expected of a beginning independent practitioner. This behaviour combines the understanding, skills, and values in an integrated response to the full range of circumstances encountered in general dental professional practice. It is related to professional performance or behaviour, while competency is a transition state toward expertise [125]. In addition, a wide range of personal attributes and qualities such as perceptiveness, receptivity, openness, creativity, and social skills are contained within the competence [126]. Generally, competence is a combination of context and underlying attributes, including knowledge, skills, attitude and performance [127].

Thus, performance is considered to be part of the competence as it only focuses on a skill or ability, for instance, the psychomotor ability that precedes the skill component of competencies [128]. In dental education, the boundary between the terms competence, competency and performance are still vague. Though, it can be concise as follows: competency is one stage within the process of becoming an expert, competence is a capability which covers a broad scope of professional attributes and performance is a set of skills which a professional performs [128].

Dental education is a complex area because the development of clinical competence requires the assimilation of knowledge combined with the acquisition of clinical skills and problem-solving ability [129]. Problems with the discipline-based curricula, which tends to be backward-looking curricula, have led to the development of the competency-based curriculum which places focus on learning outcomes, vertical and horizontal integration of the curriculum, and authentic assessment. However, the two approaches are not mutually exclusive and there is some common ground between them [130] [131].

The nature of dental practice involves not only learning and teaching, and the educator-student relationship, but also patient welfare and expectation, clinical outcomes, and complex materials and procedures [128]. Teaching and learning in dentistry involve tacit knowledge which is gradually developed implicitly within individuals. Students are exposed to this knowledge throughout an undergraduate curriculum and the rest of their career, in addition, practice in dentistry requires a high degree of judgement and technical skills [35, 132]. In dentistry, competence relates to what dental professionals do on a regular basis [125].

Competency-based education has been suggested to enhance student performance with problem-solving, critical assessment, discipline integration, and progressive autonomous self-assessment, improvement of interdisciplinary understanding, better research skills and record-keeping, and improved links with practice settings and public institutions regarding dental educational matters [133]. Competency-based education fundamentally oriented to graduate outcome abilities and organized around competencies which derived from an analysis of societal and patient needs [134].

At Qassim University School of Dentistry, Saudi Arabia a study evaluated the application of competency-based clinical education on the final scores in clinical prosthodontics, for the prefinal- and final-year students of the academic year 2017-2018, as a new method of training compared to the students' final scores in traditional clinical education during the academic year 2016-2017. The results showed that competency-based clinical education was thought to present a better clinical training experience, compared to traditional clinical education. Also, the competency-based clinical education assessment sheets, with certain competency levels required to pass, were considered another advantage over the traditional clinical education. This helped with a better student assessment process, allowed immediate visualization of students lagging behind their colleagues, increased the interaction between the students and their teachers, required a lower clinical instructor-to-student ratio, and encouraged students to score higher grades [135].

Becoming a competent dental practitioner is not a simple process, there are five stages to becoming an expert: novice, beginner, competent, proficient and expert [128]. Dental students are in the novice stage at the outset of their clinical journeys. Their learning and development rely on well-structured strategies and direct support from educators. They gradually develop foundation knowledge, skills and values essential for dental practice to progress to the beginner stage. Then they begin to develop decision-making skills and transfer their knowledge and skills to different contexts. In the first two stages, students gradually take more responsibility for their learning. On graduation, students are expected to be in the competent stage [128].

However, students require different amounts of time to develop different skills and reach the competent stage which depends on both the individual and the skill. A few years after graduation, dental practitioners enter the proficient stage as they gain more in-depth understanding and skills to handle a wider range of professional problems. Later, when they practice for more than ten years from the beginning of their training (undergraduate education), they could reach the expert stage. This stage contains the integration and internalisation of professional practice [128].

Dental students' clinical skills deficiencies are extensively reported, nevertheless, it is important to know that clinical competence of students only represents a point on a continuum and needs several years of consolidation in clinical practice settings. The role of the undergraduate curriculum is to ensure that students have gained the required experience in clinical settings in order to achieve a realistic level of competence at the time of graduation. However, keeping, losing or enhancing the acquired level of competence in clinical dental practice depends on a habit of lifelong learning [136].

At Islamabad Medical & Dental College, a study was conducted between 2011 and 2013 to investigate the impact of adding clinical rotation sessions to a group of first year students during teaching of undergraduate dental materials science and compared it to the traditional teaching technique (no clinical rotations). The study results showed a significant improvement in first year students' understanding when clinical sessions are integrated with dental materials science teaching [137].

The Association for Dental Education in Europe and the DentEd Thematic Network have set a document "Profile and Competences for the European Dentists" to be a guidance for the dental education providers in Europe. The document involves seven major competence domains that the dental graduate should have at graduation. These domains represent the basic level of professional behaviour, knowledge and skills necessary for a graduating dentist to be able to respond to the full range of circumstances encountered in general professional practice. The agreed competence domains are: 1. professionalism 2. Interpersonal, communication and social skills 3. Knowledge base, information and information literacy 4. Clinical information gathering 5. Diagnosis and treatment planning 6. Therapy to establish and maintain oral health 7. Prevention and health promotion [138].

In dentistry, there are three elements of competency: intellectual competence, physical-technical competence, and interpersonal competence. To evaluate these elements, Chambers has proposed two methods of evaluation, namely, authentic and portfolio evaluations. Authentic evaluation includes any class of examination in which the test is similar to the work that will be done after passing the test. It is a judgment about an individual's capacity to perform in realistic settings. Portfolio evaluations which is a collection of evidence demonstrating the clinical competency of a dental student. A competent student might present a portfolio or logbook of completed cases that meet certain criteria [38].

In a study to review the competency- based dental education Yip and Smales (2000) reported competencies offer a different way of looking at the dental and allied-dental curricula, and view learning as continuous and holistic. Competency-based education focuses on the essentials that students must be able to do on their own when they begin to practice and forms the basis for a career in which continuing education is self-directed and ongoing. Competency-bases dental education is closely linked to problem-based learning, reducing passive dependence on teachers, and that may encourage student teamwork and critical self-assessment. Competency includes the development of behaviour patterns that are open to broader evaluation protocols than are traditionally used in formal teaching [133].

2.5 Summary/ conclusions

Overall, there was a wide variation in curriculums worldwide, this variation was not only in the nature and technical teaching methods but also in the year of commencing prosthodontics (removable, fixed and implants) teaching. Also, teaching hours, staff: student ratio, recommended textbooks and assessment criteria were varied.

In regard to the removable prosthodontics, the range of treatments completed by students for removable prostheses has reduced over the past 20 years. Among all UK dental schools, the number of required completed cases before graduation varies from 1-6 cases. However, in US, Spanish and Portuguese dental schools, no minimum number of completed cases is required.

For the fixed prosthodontics, the teaching hours and required cases have increased by approximately 50% in the UK, Ireland and other European dental schools over the last 10 years. Whereas there is a wide variation in dental implant teaching. Surveys of European and international programmes reveal 33 – 40% of schools have no dedicated undergraduate programme in dental implants teaching. Among 15 UK and Irish dental schools, 86% do not include hands-on training in dental implants.

The most commonly used assessment methods were “glance and grade” marking and target setting. Additionally, for the preclinical course, gateway assessments along with continuous and other methods of assessment are widely used by most of the UK and Irish dental schools. Continuous assessment, internal non-degree examination, “glance and grade” marking and progress testing were the most usual used methods. Fixed schedules of clinical requirement (portfolio), peer-assessment, self-assessment and case presentation were also used. Practical tests at the end of the preclinical course (gateway) and the final written exam were widely used. Undergraduate students in dentistry considered the progress test a useful assessment to support their learning needs [110].

However, Preparedness Assessment Scale (PAS), Integrated Structured Clinical Examinations (ISCE), The Objective Structured Clinical Examination (OSCE) and

Longitudinal Assessment are reported to have the most reliable tools for testing undergraduate dental students' qualities, such as problem-solving ability, critical thinking, communication skills and diagnostic, interpretation, treatment planning skills and have good reproducibility. Combination of these methods plays an important role in the overall dental students' assessment [118].

In conclusion, there is significant divergence among prosthodontics curricula in dental schools in terms of teaching methods, assessment criteria and how students' competence is determined. These variations may cause confusion in future dental graduates. In addition, this divergence in undergraduate dental teaching and assessment might affect the patient safety nowadays especially with mobility of students and academic staff internationally.

Chapter 3: Undergraduate Complete Dentures Curriculum: An International Study of Current Teaching and Assessment Methods

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3.1 Abstract

Objectives: The aim of this study was to describe the current teaching and competence assessment methods of Complete Dentures (CDs) amongst dental schools in several countries.

Materials and methods: A questionnaire consisting of 51 questions was set and constructed using SurveyMonkey. The questions included preclinical and clinical teaching and assessments. Following approval from the Social Research Ethics Committee (SREC) at University College Cork, Ireland (2019-216), an email, including an invitation to participate in the survey, along with a hyperlink to the survey, was sent to the senior clinical academic identified as being responsible for the teaching of CDs course in Spring 2020. One hundred and forty-two dental schools in 12 countries were included.

Results: Forty dental schools from 10 countries participated in the study. All respondent schools have a preclinical complete denture course except 1 British School only has a clinical course. Preclinical teaching ranges from 22 to 100 hours. 60% of participating schools teach their students their complete dentures processing steps. The most frequent assessment methods in preclinical courses are written and practical exams and the assessment guideline is the most used method to ensure the consistency in assessment. Thirteen schools have dedicated clinical courses, and the digital workflow is used within 6% of schools. Before graduation the number of cases that students are required to complete are varies from 0 to 30. Additionally, 23 schools have a criterion-based assessment, where taking impression is the most assessment method used.

Conclusions: International divergence of undergraduate CDs teaching and assessment trends among dental schools is significant. It includes both preclinical and clinical course of CDs, whereas geographical distribution was found to have no impact on this divergence.

3.2 Introduction

Complete dentures (CDs)/ Removable complete prosthodontics is one of the main subjects that dental students are taught in undergraduate dental schools. However, how, and what are taught depends on many factors such as, dental school strategy and the needs of the community. Population-based studies have found that retention of natural teeth among elderly people especially in western countries, has increased [139-141]. At the same time, the percentage of edentulous adult decreased to less than 50% in general [142]. This decrease in the number of edentulous populations has impacted on the dental schools' education. As a result, curriculum time for CDs teaching has reduced to the point where concerns have been expressed that students may not be adequately equipped with the requisite skills for treating CDs patients when they qualify [50].

In the UK, a study by Clark *et al.* was conducted in 2009 which is the most recent to comprehensively report on trends in CDs teaching. In this study, 12 UK dental schools were surveyed by asking 33 questions. They reported that dental schools fell into three groups; those in which students were required to treat 4-6 complete denture cases, those that required 2-3 cases and those who only required 1-2 cases to be treated prior to graduation [48]. At the time, half of UK schools required their students to complete immediate CD cases. Most students have the opportunity to make an immediate denture in addition to an existing dentures (repair) although, it is an elective requirement among half of schools [48]. Conversely, three decades ago, dental undergraduates on average treated eleven CD cases and two immediate replacement complete denture cases before qualifying [49].

A US-based study conducted in 2001 found that 16% of United States dental schools allowing students to graduate without a set number of required CDs.

Additionally, the study did not report the minimum number of CDs requirements before students' graduation. However, 55% of US dental schools reported incorporating new educational materials such as the use of dental implants and treatment of patients with implant retained overdentures at undergraduate level. Also, the study showed that 16% of schools are using newer techniques such as injection moulding and microwave processing technique in addition to the conventional CDs processing technique [53].

Wieder *et al*. (2013) investigated the undergraduate teaching of complete dentures in 13 UK dental schools. They asked four main questions; how many lecture hours, how much clinical time, how much laboratory time devoted to CDs and how many CD cases is an undergraduate student expected to finish before graduation, in addition to one open question. Authors found that variation in the curricula was not only noted in the nature and technical teaching methods, but also in the year of commencing teaching, teaching hours, staff student ratio, recommended textbooks and assessment criteria [54].

In addition, a more recent study in 2019 investigated and evaluated the teaching of occlusion in undergraduate among dental schools in the UK and Ireland (18 schools). Teaching of occlusion in undergraduate curriculum was reported by all these schools, although, the dedicated teaching time varied from 11 to 310 hours. Five schools (28%) referred this to insufficient time for the teaching of occlusion in the curriculum. Also, variation was reported in the teaching methods, resources employed, assessment strategies to evaluate competency in occlusion and how well prepared students were [143].

In 2010, Clark *et al.* reported that continuous assessment and module examination are the most used methods of testing students' competence in CDs. Four out of 12 UK dental schools had a specific final examination in CDs, while only one school has a comprehensive exam in prosthodontics [48]. Näpänkangas *et al.* reported that Preparedness Assessment Scale (PAS), Integrated Structured Clinical Examinations (ISCE), the Objective Structured Clinical Examination (OSCE) and Longitudinal Assessment are the most reliable tools for testing undergraduate dental students' competence. They also stated that combination between these methods plays an important role in the overall students' assessment [118].

Clark *et al.* expressed concerns about the ability of new dental school graduates to provide CDs to the standard expected by the General Dental Council. Moreover, Dental schools reduced the CD curriculum in response to the reduction in edentulous population until it is considered to be one of weakest area after graduation. Thus, graduates feel unconfident and unwilling to do this procedure which leads to a crisis in CDs treatment in the UK [48].

Despite a reduction in the prevalence of edentulousness, there is a still a requirement for dentists to be able to fabricate high quality CDs for those patients in need of this treatment. A failure to provide high quality and well-fitting dentures can adversely affect function, nutrition and quality of life for CD patients. [57]. The undergraduate curriculum currently has challenges such as; time pressures, lack of suitable clinical teaching staff, lack of available clinical areas for teaching, increasing student numbers and unsuitable patients [53, 59]. Against this backdrop, how are dental schools preparing contemporary dental students to meet the needs of complete denture patients in the 2020s and beyond? The aim of this study was to describe the current teaching and competence assessment methods of CDs across dental schools in several countries.

3.3 Materials and Methods

A questionnaire consisting of 51 questions was set and constructed using SurveyMonkey (Appendix 1). Following receipt of positive approval from the Social Research Ethics Committee (SREC) at University College Cork, Ireland (#2019-216), an email, including an invitation to participate in the survey, along with a hyperlink to the survey, was sent to senior clinical academic identified as being responsible for the teaching of CDs course in Spring 2020. One hundred and forty-two dental schools in 12 countries were included (Ireland, United Kingdom (UK), United States (US), Canada, Australia, New Zealand, Norway, Sweden, Denmark, Germany, Hong Kong and Saudi Arabia). It was requested that if the person who received the e-mail was not the most suitable person in the institution that they would forward it to the more appropriate person. The questionnaire was divided into two sections, the preclinical teaching and assessment (20 questions) and clinical teaching and assessment in CDs (30 questions). The initial e-mail was followed up by a second e-mail four weeks later to those who had not responded, and this was followed up about three weeks later by a third e-mail to those who had still not replied. A final fourth reminder e-mail sent 10 weeks later to encourage the non-respondent schools to participate. Recipients were assured of anonymity in any resulting publication. Moreover, to assess the effect of the geographical distribution on CDs teaching, we categorized the 10 participated countries into five geographical groups. These groups as following: UK/ Ireland, Europe, US, Asia-pacific and Saudi Arabia. We used one-way analysis of variance (ANOVA) to examine the mean differences in continuous variables across the geographical area, whereas chi-square test was used for categorical variables. All analyses were conducted using IBM SPSS Statistics software (version 26, 2019) and the *p*-value <0.05 was considered to be statistically significant.

3.4 Results

3.4.1 Preclinical teaching trends:

Forty dental schools from 10 countries out of the 142 invited schools participated, provided a response rate of 28% (Fig. 3.1). The geographical distribution of received responses were from United Kingdom, Ireland, Sweden, Denmark, Germany, Australia, New Zealand, Hong Kong, Saudi Arabia and United States. Thirty-nine schools have dedicated CDs preclinical course except one school based in UK. The majority of respondent schools commence the preclinical teaching during second and the third year of their programme (43% (n=17) and 46% (n=18) respectively), while 5% (n=2) of schools commence this teaching in the first year, and another 5% (n=2) in the fourth year. One school does not have dedicated preclinical teaching course in CDs, instead, teaching CDs starts with the clinical course. The average devoted teaching hours received by each student is 57.5 hours (range: 22-100 hours). The dedicated teaching/academic hours ranged from 5-60 hours (mean: 21.7 hours). These academic hours are divided as shown in Table 3.1. While the allocated hands on/practical skills hours ranged from 0-90 hours (mean: 39.8 hours).

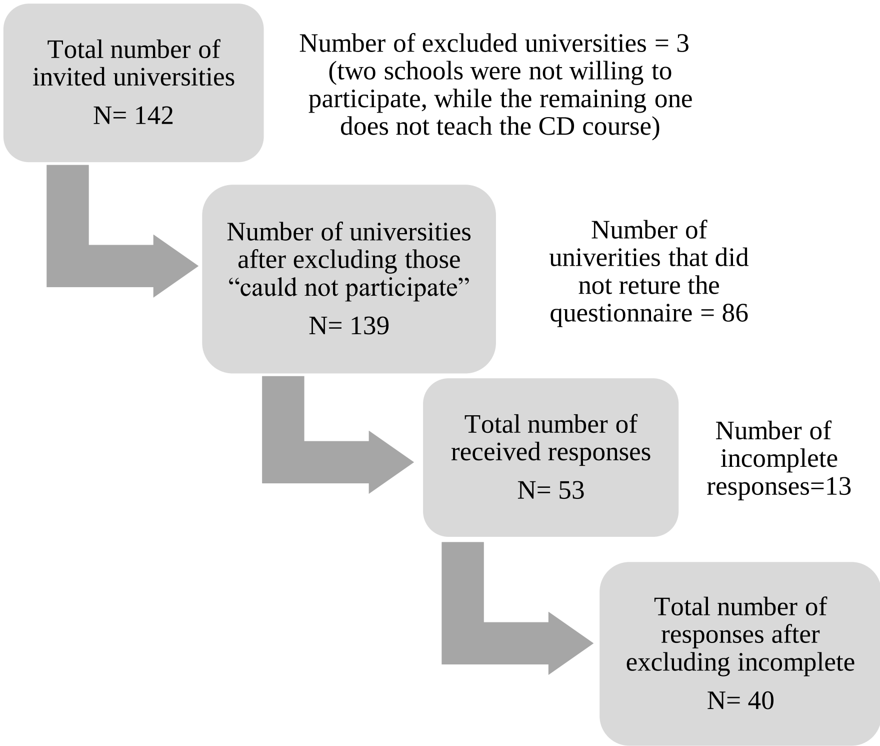

Figure 3.1 Number of total responses

Table 3.1 Distribution of academic/didactic preclinical teaching in CDs course

	N	Minimum	Maximum	Mean
Formal lectures/hour:	36	1.00	60.00	12.88
Laboratory demonstrations/hour:	34	0.00	60.00	18.76
Small groups, tutorials or seminars/hour	26	0.00	60.00	11.11
Other/hour*	8	0.00	50.00	9.25

*Such as: 1- clinical demonstration. 2- Several hours of Directed Self Study (Reading materials, Videos (SDEO + Internal)). 3- Application of didactic learning and demonstration in practical work.

The staff: student ratio for preclinical course in CDs for formal lectures ranged from 1:10 to 1:160 (mode: 1:20); laboratory demonstrations ranged from 1:4 to 1:56 (mode: 1:10); and small groups/tutorial ranged from 1:3 to 1:26 (mode: 1:10). Table 3.2 shows who is/are responsible for directing the preclinical teaching in CDs. Around 85% of the schools (n=31) reported that the course is directed either by professor or senior lecturer/associate professor.

The experience that students gain in the CDs course are reported in Table 3.3. Details of supervision of these experiences are reported in Table 3.4. These experiences take the form of either formal lectures, lab demonstrations or practical exercises. Only one school reported using the three teaching forms. Use of the articulator, CDs prescription writing and the teeth setting & waxing-up denture were the most common practical exercises (48.6% (n=17), 45.4% (n=15) and 70% (n=26) respectively), while the packing, flasking & de-flasking (denture processing) were usually provided during lab demonstration (45%) (Table 3.5).

The Arcon/semi-adjustable is the most common used articulator (50%, 19 schools), followed by the Non-arcon/semi-adjustable (42%, 16 schools) and then the average value articulators (39.5%, 15 schools), while four schools use simple hinge articulator (10.5%).

Textbooks and reading materials that recommended for undergraduate teaching of CDs are reported in Table 3.6. The most recommended textbook was George A. Zarb et al. “Prosthodontic Treatment for Edentulous Patients: Complete Dentures and Implant-Supported Prostheses”.

Table 3.2 Member of staff who is/are responsible for directing the preclinical teaching in CDs (total number of respondents =37)

Dental school	Position	Dental school	Position	Dental school	Position	Dental school	Position
1	consultant	**11**	Did not answer	**21**	Senior lecturer	**31**	Did not answer
2	Professor & consultant	**12**	Professor	**22**	Professor	**32**	Professor, consultant, senior lecturer, lecturer & technician
3	Senior lecturer	**13**	Professor	**23**	Consultant	**33**	Professor, lecturer & technician
4	Consultant	**14**	Consultant, senior lecturer, lecturer & technician	**24**	Senior lecturer	**34**	Senior lecturer
5	Senior lecturer & technician	**15**	Senior lecturer	**25**	Professor	**35**	Senior lecturer & lecturer
6	Lecturer, technician & GDP	**16**	Professor & senior lecturer	**26**	Professor	**36**	Professor
7	Senior lecturer	**17**	Senior lecturer	**27**	Senior lecturer	**37**	Professor
8	Senior lecturer	**18**	Professor, senior lecturer & technician	**28**	Senior lecturer	**38**	Consultant & senior lecturer
9	Senior lecturer, lecturer, technician & GDP	**19**	Lecturer	**29**	Professor	**39**	Professor
10	Professor	**20**	Did not answer	**30**	Senior lecturer & lecturer	**40**	Lecturer

Table 3.3 List of the gained experiences in CDs preclinical course

Gained experience	Number of schools	Percentage
Teeth setting & waxing-up denture	37	92%
Casting impression	34	85%
Using articulator	34	85%
Complete dentures prescription writing	29	72%
Packing, Flasking & De-flasking (denture processing)	24	60%

Table 3.4 Students' supervision during gained experiences in CDs preclinical course

Gained experience	Clinician	Technician	Number of respondent schools
Using articulator	86%	43%	35
Complete dentures prescription writing	97%	22.6%	31
Casting impression	59%	62%	34
Teeth setting & waxing-up denture	73%	62%	37
Packing, Flasking & de-flasking (denture processing)	52%	74%	27

Table 3.5 Teaching form of the gained experience sessions in CDs preclinical course

Gained experience	Formal lecture	Laboratory demonstration	Practical exercise	Number of respondent schools
Using articulator	14.3%	37.1%	48.6%	35
Complete dentures prescription writing	42.4%	12.1%	45.4%	33
Teeth setting & waxing-up denture	8.1%	22%	70%	37
Packing, Flasking & De-flasking (denture processing)	31%	45%	24%	39

Table 3.6 Recommended textbooks and reading materials for student teaching (35 respondent schools)

Textbook	Number of schools
George A. Zarb *et al.* "Prosthodontic Treatment for Edentulous Patients: Complete Dentures and Implant-Supported Prostheses", Elsevier - Health Sciences Division, Mosby	11
Arthur O. Rahn *et al.* "Textbook of Complete Dentures", Medical Publishing House-USA (2009)	8
BDJ article series on Complete Dentures and other complete dentures related articles.	7
Carl O. Boucher *et al.* "Bouchers Prosthodontic Treatment for Edentulous Patients", C.V. Mosby (1997)	4
J. Fraser McCord, Alan A. Grant "A Clinical Guide to Complete Denture Prosthetics", British Dental Journal (2000)	4
Hassaballa, M.H *et al.* "Principles of Complete Denture Prosthodontics", King Saud University-Academic Publishing and Press (2004)	3
Rodney Phoenix *et al.* "Stewart's Removable Partial Prosthodontics", Quintessence Publishing Co, Inc. (2008)	3
D. J. Neill, R. I. Nairn "Complete Denture Prosthetics", Wright (1990)	2
J. Fraser McCord *et al.* "Treatment of Edentulous Patients", Churchill Livingstone (2004)	2
R. M. Basker *et al.* "Prosthetic Treatment of the Edentulous Patient", Wiley-Blackwell (2011)	2
Alan B. *et al.* "McCracken's Removable Prosthodontics", Elsevier Mosby (2011)	1
"Guidelines for preclinical complete denture technology", Mansoura removable prosthodontic department (2015)	1
Herbert T. Shillingburg "Fundamentals of Fixed Prosthodontics", Quintessence Publishing Co Inc. (2012)	1
Herbert T. Shillingburg *et al.* "Guide to occlusal waxing", Quintessence Publishing Co, Inc.	1

Michael I. MacEntee "The Complete Denture: A Clinical Pathway", Quintessence Publishing Co, Inc.	1
Margareta Molin Thorén & Johan Gunne "Textbook of Removable Prosthodontics. The Scandinavian Approach", Munksgaard (2012)	1
Robert Clark "An Introduction to clinical prosthodontics", Hong Kong University Press (1998)	1
Robert M. Morrow *et al.* "Dental Laboratory Procedures: Removable partial dentures", Mosby (1986)	1
Sheldon Winkler "Essential of Complete Dentures Prosthodontics", AITBS Publishers (2009)	1
Peter Ludwig, Wilhelm Niedermeier "Prothetik", Thieme (2002)	1

3.4.2 Preclinical assessment trends:

In 35 dental schools, students are required to sit an assessment at the end of the preclinical course prior to providing CDs clinically. The preclinical assessment involves:

- Written and practical exams (21 schools);
- Written exam (8 schools);
- Practical/gateway exam (4 schools);
- Oral presentation (1 school).

In addition, some schools use other assessment methods in combination with the above methods such as submission of laboratory work (1 school), Objective Structured Practical Examination (OSPE) (1 school), Objective Structured Clinical Examination (OSCE) (1 school), requirements for each step (1 school) and weekly continuous practical evaluation of students work in the laboratory (1 school). One school use the course approval through participation and written assignment as the only assessment method.

The majority of schools (79%, 26 schools out of 33 respondents) use the teeth setting and waxing-up dentures as the assessed skill in the practical exam either alone or in combination of other skills. Nineteen schools use mounting of the casts

(57%), 18 schools use cast and trimming of models (54%), 10 schools use impression technique (30%), 8 schools use prescription writing (24%), 4 schools use fabrication of custom tray and occlusal rims (12%) and only 1 school uses CDs finishing and polishing (3%). Clinicians supervise these exams in 31 schools out of the 33 respondent schools (94%) while technicians supervise exams in the remaining two schools.

3.4.2.1 The preclinical assessment is standardised in 26 schools by using:

- Assessment guideline (20 schools);
- Training (3 schools);
- Rubric scoring guide (2 schools);
- Calibration and double-blind marking (1 school).

In the case of failure in the preclinical assessments, 18 schools out of respondents 34 require student to re-sit the assessment. In addition, students of 13 schools cannot provide clinical procedures unless they pass the re-sit assessment. Though, 10 schools only reduced grades in overall course result. Participants were asked how they ensure their students are ready to provide CDs clinically. Responses are reported in Table 3.7.

Table 3.7 Measurement of students' readiness prior to commencing CDs clinical course

UK and Ireland
Students have close teaching supervision 1:6 on the Prosthetics Specialty Clinic where dentures are constructed.
Completion and attendance of the above course
All students are graded for every clinical session
Completion of the didactic teaching allows the student to undertake complete denture cases in clinic under supervision. Liftupp is used to award Development Index Scores on their clinical performance. This can indicate additional teaching support required on a student cantered manner. We do not believe an assessment can be devised to indicate students' competence to undertake clinical cases, the validity of the

assessment is also doubtful. We believe it only increase the assessment load and assessment related stress for the student.
Pass the tests (didactic & practical exams)
Complete denture assessment form
Gateway assessments
They have a longitudinal assessment as they progress through the course and have a clinical readiness examination that includes complete dentures
Asia-Pacific
They need to have passed exams
Didactic assessment followed by refresher clinical simulation sessions (foundation sessions) in the following year when they start seeing complete denture patients
Assessment criteria
The students are closely supervised by clinicians
Saudi Arabia
When passing the overall course
After passing competency exams
They must pass the course and competencies
Pass infection control exam attain MPES of 60 percent criteria
We assess their overall grades in the module.
Passing the course with his total grade
Passing the preclinical course and exposed to all the clinical steps theoretically followed by live and video demonstration of each clinical step of Complete denture construction steps
Passing the competency exam in the preclinical course
If they successfully finish their preclinical course.
Clinical conference is required before proceeding to any clinical procedures, students who will not be able perform well in the clinical conference will be asked to review again until such time he is approved to proceed in the clinical procedures.
Europe
They are not fully ready, but have also learn similar procedures in the course of partial removable dental prostheses
Passed preclinical course
United States
Pass the preclinical course, both the didactic and laboratory components
Passing the course
Successful completion of Denture Course
Oral exam of concepts.
Pass course
Other (those who did not identify the location of their school)
Pass exam and competence test
Minimum marks required to pass on the basis of standard answer guide to specific questions and viva
Performance in lab.
Practical exams and psychomotor skill gradings
When the students have received enough signatures from the clinicians for every practical step.

One-way ANOVA test was conducted to assess the impact of the geographical distribution on academic dedicated teaching/hour (*p*-value= 0.91), hands-on (practical skills)/hour (*p*-value=0.186), formal lecture/hour (*p*-value= 0.323), laboratory demonstration/hour (*p*-value= 0.972), small groups (tutorial or seminar)/hour (*p*-value= 0.945). The *p*-values of ANOVA test were not significant, suggesting that geographical distribution has no impact on these teaching trends. Also, it was statistically not significant when ANOVA test used to examine the impact of the geographical distribution on having assessment at the end of the preclinical course (*p*-value= 0.055) (Appendix 2).

3.4.3 Clinical teaching trends:

Thirty-one dental schools reported that they have dedicated clinical course in CDs. Most of the schools commence this course either in third or fourth year (13 schools for each year) while five schools commence it in the second year. However, 21 schools (out of 30 respondents) have devoted clinical sessions for instruction of CDs.

In the clinical sessions, the staff: student ratio ranged from 1:3 to 1:20 (mode: 1:6), for the formal clinical lectures, the ratio ranged from 1:20 to 1:160 (mode: 1:20), and for the small groups/tutorials ranged from 1:3 to 1:24 (mode: 1:10). Sixteen schools (out of 29 respondents) have paired teaching.

3.4.3.1 Impression techniques taught for recording the master impressions for CDs:

Thirty schools provided information on master impression recording technique they taught students, most of them use polyvinylsiloxane impression material in special/custom tray for recording the master impressions for CDs. More of this information reported in Table 3.8.

Students encounter CDs first in their clinical work in 12 out of 30 respondent schools, while they encounter CDs and removable partial dentures in another 12 schools. Students of 6 schools encounter the removable partial denture before the CDs in the clinical work.

Table 3.8 Impression techniques for recoding CDs master impression

Impression technique	Number of schools	Impression technique	Number of schools
Polyvinylsiloxane in Special tray	16	Alginate in special tray	9
Zinc-oxide eugenol in Special tray	7	Putty and wash alginate in stock tray	1
Polysulfide in special or metal tray	4	Alginate in stock/metal tray	6
Polyether in special tray	2	Impression compound in stock tray	7

3.4.3.2 Supervising guidelines:

Guidelines for supervising staff in undergraduate clinical teaching are reported in 27 schools, while these guidelines are missing in 2 schools out of the 29 respondent schools. In the clinical sessions, staff supervision contribution is distributed as following:

- Professors ranged from 5% to 100% (mean: 26.4%);
- Consultants ranged from 1% to 90% (mean: 24%);
- GDP (part-time teacher) ranged from 5% to 100% (mean: 46.3%);
- Senior lecturers ranged from 2% to 100% (mean: 42.4%);
- Lecturers ranged from 4% to 100% (mean: 30%);
- Technicians ranged from 5% to 70% (mean: 17.2%)

3.4.3.3 CDs Prescription writing:

Prescription writing of CDs is taught in 29 schools during the clinical course (97% of respondent 30 schools). This teaching mostly takes the form of small group/tutorial session (14 schools) or formal lecture (10 schools). However, some schools taught this in:

- Formal lecture, workshops and laboratory sessions (1 school);
- During the clinic supplementing the information covered at the preclinical sessions (1 school);
- In the simulation laboratory and in formal lecture (1 school);
- Prescribing for their patients that is supervised by clinicians and lab technician and fed back to students about the clarity and quality of prescription (1 school);
- Individual teaching (1 school).

3.4.3.4 CDs requirements:

Prior to students' graduation, 27 schools provide information for the required CDs cases that need to be completed. The required CDs ranged from 0-30 (mean: 5; mode: 2), 0-10 of them are required as immediate dentures (mode: 1) and 0-25 as a combination of complete and removable partial dentures (mode: 1). Within these 27 respondent schools, only 6% of the students' clinical work completed by using the digital workflow among six schools. Amongst 30 schools, students use an internal laboratory to complete the clinical work in 14 schools while six schools use external laboratories, and 10 schools use both.

Crosstabulation and Pearson Chi-square test were conducted to examine the geographical distribution impact on the number of CDs cases that students need to complete before graduation (*p*-value= 0.475), staff: students ratio for formal lecture (*p*-value= 0.391), staff: students ratio for lab demonstration (*p*-value= 0.501), staff: students ratio for small groups (*p*-value= 0.539). The *p*-values of Pearson Chi-square test were not significant, suggesting that geographical distribution has no impact on the assessed teaching trends (Appendix 2).

3.4.4 Clinical assessment trends:

Criterion-referenced assessment exercises in clinical CDs course are reported by 23 schools out of 30 respondents. This criterion takes the form of a practical exam in 15 schools (65%) and as a written exam in eight schools (35%). In the practical exam, the assessed skills are:

- Impression technique (15 schools)
- Prescription writing (10 schools)
- Teeth setting and waxing-up denture (8 schools)
- Mounting of casts (8 schools)
- Cast and trimming of models (6 schools)
- Facebow and occlusal registration records (3 schools)
- Preliminary Impressions, wax try-in, delivery and post-operative treatment (1 school)
- Every clinical aspect including communication skills, teamwork and programmatic assessment such as using LiftUpp (a digital educational platform designed to support quality-assured assessment and feedback) (1 school)
- CDs insertion (1 school)

- Recording jaw relations, prescribing facial form and tooth position and size (1 school)
- Border-moulding (1 school)

The responsibility to assess students' clinical work and competence during the clinical sessions among 30 respondent schools were as follows:

- Senior lecturer/associate professor (17 schools)
- Professor or GDP (part-time teacher) (15 schools)
- Lecturer (13 schools)
- Consultant (10 schools)

In the CDs clinical sessions, the most used students' assessment method is the day-to-day observation and judgement (glance and mark) (23 schools). Also, fixed schedules of clinical requirement are used in 13 schools, tests based on observation and implicit judgement in 10 schools, self-assessment in 10 schools and peer-assessment in three schools. Additionally, other schools reported using formative assessment and summative assessment (1 school), Rubrics (1 school) and Clinical Scenario Based Written Examination (SBA) (2 school).

3.4.4.1 CDs competency assessment:

Prior to graduation, CDs final assessment examination takes place in 22 schools out of 30 respondents. Forms of the final assessment are summarized in Table 3.9. Instead, eight schools assess their students during the course using different forms e.g., Clinical observation, number of cases and knowledge in temporomandibular anatomy, assessment is combined with other aspects of the course and final year subjects, clinical competency assessment, quality and quantity and portfolio.

Table 3.9 Type of assessment of students' clinical competency in CDs prior to graduation

UK and Ireland
Completion of a C/C denture live case.
Number of cases and knowledge in temporomandibular anatomy
They must have completed a double marked case-based assessment, being assessed for competency at each clinical stage over year 3, 4 or 5 of the course.
Based on their clinical work, performance at clinical scenario based written examination, (SBA)
Clinical & practical exams
Clinical grades and written assessments
In course assessments summative assessment in stage exams at stage 3 ,4 and 5.
Based on portfolio
OSCE
Satisfactory completion of the course and provision of the prostheses at the required level of competency. Also questions in written papers and OSCE.
Asia-Pacific
Written examination
Completion of clinical quota, satisfactory completion of each clinical step from history recording to maintenance; written examination
Assessment is combined with other aspects of the course and final year subjects
None
Saudi Arabia
Competency exam in final impression and border moulding
Requirement achieved quality and quantity
Clinical exam and MPE'S
Based on their overall grades in the modules
Rubrics for the clinical steps used for the competency exam
We follow the guidelines set by the department. There is also a continues clinical evaluation and OSCE
United States
Clinical observation
Practical exams in addition to each clinical appointment being graded.
Clinical competency assessment
Quality and quantity
Other (those who did not report related school)
Follow the guidelines set by the university

3.4.4.2 Outreach teaching:

Twenty-nine schools provide information for the outreach /community-based clinical teaching. Thirteen schools have a clinical outreach teaching programme. Nine schools included the completed CDs treated cases in the final students' assessment. However, the staff in the outreach centre are employed by the same university in two schools (mixed: NHS and university employees in one of them). Instead, they are:

- NHS/health sector employees in 8 schools
- Private practitioners in 3 schools

When the participants were asked; how they ensure that the staff in the outreach centres teach and assess CDs to the same standards as in the base dental schools, they answered as following:

- There are guidelines (5 schools)
- Regular teachers meeting (3 schools)
- Both of the above (2 schools)
- Not sure (1 school)
- CDs are not part of external clinics treatment (1 school)
- Regular contact with the outreach lead at base and outreach centres (1 school)

3.4.4.3 Learning outcome assessments:

Consistency in assessment of CDs is achieved by following guidelines in 22 schools out of 30 respondent schools. Regular teachers meeting (3 schools), regular teacher meetings and guidelines (1 school), staff calibrated on Liftupp in addition to clinical guidelines (1 school) and using rubrics (1 school). Only one school is not sure how to achieve consistency in assessment.

Among 30 respondent schools, 12 schools are satisfied that they adequately assess their students' competence in CDs prior to graduation. Fourteen schools are "mostly" satisfied, three schools are unsatisfied while one school is not sure. Two of the unsatisfied schools explained their responses as follows: *"not enough experience and exposure"* and *"faculty calibration does not assure equitable grading"*. Also, two of the mostly satisfied commented: *"Need for more number of edentulous patients"*, and *"Within a busy curriculum, and based on shifting demographics - CDs need, I believe on balance students are mostly satisfactorily assessed. In this area we consider continued training in VT and beyond is critical"*.

Most of the schools believe that competence of students in CDs is worse now compared to that of students who graduated 10 years ago (13 schools out of 29 respondents). Seven schools think no change and five schools believe it is better now while four schools are not sure. From those who believe it is worse they commented:

- *"Insufficient cases (reduced requirements) and less clinical time available"*
- *"Faculty numbers have diminished as well as requirements"*.

Also, those who believe it is better now, they commented:

- *"In the last 6 years the teaching has transformed at our school. We introduced a blended learning model"*.
- *"As students are using advanced materials and also more aware geriatric patients"*.

3.4.4.4 Perceived challenges to the teaching of CDs:

Participants were asked to indicate the main challenges that might encounter them in teaching CDs to undergraduate students over the next few years. Answers included:

- Lack of suitable patients for students to treat (20 schools)
- Pressures on teaching time from other sources in the undergraduate curriculum (16 schools)
- Lack of adequately trained staff for teaching (15 schools)
- Increasing use of alternate technologies such as implants (7 schools)

At last, participants were asked to write any further comments they might have in relation to students' CDs teaching and assessment. Comments as follows:

- *"Standardising learning and teaching remain a challenge. Over prescription of full-mouth clearance and immediate dentures by non-academic staff".*
- *"Complete denture is treated first (September) and then RPD (January) of the 3rd year. However, students may start either a CD or a RPD case depending on the case they get first. In the next year there is proposal to teach both CD and RPD together during the same period, and even fixed pros (bridges). To bring all tooth replacement options together so that students can provide whole patient care more conveniently. The complete denture cases may be conventional, copy, immediate, overdenture or combination case depending on what the individual student is allocated. Students do not do one of each".*

- *"US schools are mostly 4 years, not 5. We have an expectation for number of arches, not specified as immediate, combination, etc".*
- *"Because dentistry today become smart, so CAD/CAM technology applications with complete denture is mandatory. If the digital work of complete denture can be added to the clinical work, it will improve the learning outcomes of the students".*
- *"Given the reduced opportunities to gain clinical experience there is an increased need for the development of preclinical skills in a similar way that this is applied to operative dentistry and fixed prosthodontics. With the possibility of digital applications of technology this will require a greater knowledge and understanding of the integration of clinical and technical factors in CD provision".*

3.5 Discussion

The result of this study showed international diversity in undergraduate teaching trends of CDs. This diversity also noted among dental schools in the same country, and it is not subject to the geographical area. Methods of students' assessment also varies from one dental school to another. Moreover, this study revealed that dental schools have different approaches to assess students' readiness and clinical competency prior to graduation. Large proportion of surveyed dental schools agreed on most of the technical steps of CDs fabrication such as the technique that used for recording master impression or using of Arcon/semi-adjustable articulator as found among US dental schools in previous study [53].

These results are comparable with Clark *et al.*, Wieder *et al*. and Rashidi *et al*. studies [48, 53, 54]. The Findings of this present study showed that most of the schools commence the preclinical teaching during the 2nd or 3rd year while Clark *et al*. found that most of UK schools commence CDs teaching in the 3rd and 4th year [48]. This finding proposes that early commence of the CDs course, so clinics have moved earlier in dental school programmes in compared to 10 years ago. It was found that earlier clinical exposure gives students more time to consolidate their knowledge [144]. Also, the number of devoted teaching hours for CDs varied which is compatible with Wieder *et al*. finding [54].

Additionally, most of the schools have minimum cases of required CDs before graduation with an average of five cases which is consistent with Rashidi *et al*. study [53]. Similarly, Clark *et al*. found that the required CDs before graduation ranged from 1-6 among UK schools. Also, Wieder *et al*. stated that most of the UK schools expected their students to complete three cases [54]. However, we found that lack or difficulty to find suitable patients for treatment to be a challenge facing most of the UK/ Ireland schools (9 out of 10 schools) and the Asia-pacific countries schools (3 out of 5 schools). Although, the difference in the required number of CDs cases before graduation is not affected by the geographical distribution in the present study.

The most frequently used students' assessment in preclinical course was found to be the longitudinal assessment or passing the course gateway test (35 out of 40 respondent schools). Likewise, Clark *et al*. study reported that continuous assessment and examination were the commonly used students' competence test [48]. Diversities in CDs teaching and assessment outcomes can be clearly noticed when we asked about the students' level of competence in comparison to students graduated 10 years ago. Most schools believed it is worse now compared to 10 years ago (13 schools), and other schools (7 schools) felt there was no change. According to respondents' comments, reduction in requirements and faculty members were responsible for the reduction in students' competence. Yet, five respondent schools believed that students now are more competent. While Clark e*t al*. reported that UK dental schools divided into three equal thirds; who believed students better, equal or less competent [48]. However, this survey showed that most of the schools are satisfied or mostly satisfied that they adequately assessed their students' competence before graduation.

Despite the development of curative and preventive dental care in the last decades, edentulism continues to be a challenging problem [145]. It still exists and existence of a such oral health status makes it imperative for the dental professionals and education to deal with. Edentulism is believed to be on a steady decrease in developed countries and vice versa in the developing countries [146]. On the other hand, Douglass *et al*. suggested that edentulism continues to grow due to aging and the increasing numbers of the older adult [147]. It is a multifactorial disease and its prevalence varies from country to another and from region to another [148]. There is no doubt that removable prostheses remain the first choice of treatment for many edentulous cases. For many years CDs has occupied portion in the dental curricula and education, also, it is one of the main skills that dental undergraduate students have to master before graduation.

Clinical exposure is considered to be the centre of learning in dental education and it provides the dental students with essential clinical skills and ensures developing communication skills and professionalism in future practice [149]. Finding of this study indicated that students' clinical exposure in CDs vary from schools to another. This variation of learning contradicts with the Association for Dental Education in Europe (ADEE) and the General Dental Council (GDC) recommendations to harmonise dental education [150, 151]. However, competence in clinical practice is dependent on a lifelong learning [144]. In addition, providing clinical exposure in the initial years of dental learning has appeared to enhance students' understanding and had a positive impact on students' future practice [144].

It was recommended that ideals should be taught, and the undergraduate students should be encouraged to strive towards these ideals. They should be taught that there is a wide range of denture tolerance in the population and most patients can be provided with satisfactory dentures constructed by simple techniques. Also, the more exacting patient would require more complex forms of treatment and it should be within the novice dentist's capabilities to provide all patient needs and care [48]. Dental undergraduates must develop skills and have sufficient preclinical practice to become comfortable with clinical procedures. Additionally, they should have adequate feedback about the quality of their work so that they can perform every procedure independently in the clinic [59].

To facilitate convergence in dental education has been the goal of ADEE since 1998. In their last updated framework (2017), ADEE simplified the original domains for the learning outcomes ,which is comparable with GDC guidelines, to be the following four domains: Professionalism, Safe and Effective Clinical Practice, Patient-Centred Care and Dentistry in Society [150, 151]. These domains provide a basis from which graduates can build confidence and competence towards becoming an independent practitioner, who accepts the importance of continuing professional development throughout their career [151]. On graduation, the GDC requires students to be competent in assessing the need for removable prostheses, able to design, prescribe and provide biomechanically sound partial or complete dentures [150].

This study aimed to investigate the current teaching and assessment trends in CDs among dental schools internationally. Forty dental schools from 10 countries participated which makes this study reflective of a wider perspective in undergraduate CDs education than previous similar studies. However, this study has some limitations need to be addressed. The response rate considered to be low, although, we sent three reminder emails after the initial email to encourage the non-respondents to participate. In addition, it should be noted that the survey was sent during COVID-19 pandemic which might explain the low response rate.

3.6 Conclusion

International divergence of undergraduate complete dentures teaching and assessment trends among dental schools is significant. It includes both preclinical and clinical course of CDs, whereas the geographical distribution found to have no impact on this divergence. The majority of dental schools agreed on evaluate students' competence in CDs prior to graduation. Although, each school has its method of evaluation, passing the course appears to be the competency standard. Future studies to investigate recently graduated students' view will be helpful to understand their competence level in CDs.

Chapter 4. Undergraduate Removable Partial Dentures Curriculum: An International Study of Current Teaching and Assessment Methods

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4.1 Abstract

Objectives: The aim of this study was to investigate the current teaching and assessment methods of Removable Partial Dentures (RPDs) among dental schools in different selected countries.

Materials and methods: After receiving of a positive approval from the Social Research Ethics Committee (SREC) at University College Cork, Ireland (2019-216), an email, including an invitation to participate in the study, along with a hyperlink to the survey, was sent to the senior clinical academics identified as being responsible for the teaching of RPDs course in Spring 2020. Within 12 selected countries, 142 dental schools were invited to participate in this study. A questionnaire consisting of 56 questions (55 close-ended and 1 open-ended question) was set and structured by Using SurveyMonkey. The questionnaire was divided into the preclinical teaching and assessment (21 questions) and the clinical teaching and assessment (34 questions), The final question was an invitation for further comments and opinion.

Results: Twenty-three dental schools from 9 countries completed our questionnaire in removable partial dentures. All these schools have a dedicated preclinical course except for one British dental school. The duration of the preclinical courses ranged from 16 to 100 hours. The majority of schools use RPD surveying and design as the assessed skills in the practical exam (74%, n=17). Digital workflow is used within 4 schools (17%). Before graduation, the number of cases students are required to treat varied from 1 to 8, either acrylic or cobalt chromium. Seven schools (30%) are teaching flexible dentures and 15 schools (65%) have a criterion-based assessments (surveying and design are the most used methods). Glance and the grade is the most assessment method that used in clinical sessions (74%, n=17).

Conclusions: Discrepancies in teaching and assessment of RPDs amongst undergraduate dental schools were seen.

4.2 Introduction

Tooth replacement with RPDs can restore aesthetics, speech, occlusal balance when some teeth have been lost. They can also serve as a preparation for complete dentures [58]. RPDs are also cost-effective when compared to other treatment options [152]. RPDs have a number of disadvantages, such as tissue damage, plaque accumulation and release of material components into the oral cavity, even from the non-toxic materials [58]. So, when the decision is made to use RPDs to restore missing teeth, it is important to avoid damaging the remaining dentition and supporting tissues and focus on restoration of occlusal function and aesthetics [153]. RPD fabrication requires mouth preparation to provide adequate support, stability, retention, and a harmonious occlusion. Failure to do so leads to destructive force to the abutment teeth and periodontal tissues [154].

Consequently, dental schools need to adequately assess the quality of prescriptions, design and the fabrication of RPDs by future dentists. In 2007, Lynch *et al*. investigated RPDs teaching and assessment trends among 11 dental schools in UK and Ireland [59]. The study turned the attention to the RPDs curricula among dental schools after the existence of a major problem among the dental profession when prescribing, designing, and fabricating RPDs [155, 156]. Authors of the study found that RPDs teaching programmes among surveyed schools were variable in the amount and the content. These variations were a consequence of the pressures on dental education. However, efforts were made to ensure that students received the best possible training prior to emerging into future clinical practice [59]. Their results were comparable with a previous study conducted among dental schools in the United States, which found variations in the RPDs preclinical curricula from school to school, although, high agreement on certain topics also found [62].

An investigation of the RPDs programme among 15 Spanish dental schools (11 public and 4 private schools) were also conducted by de Oyagüe and Lynch in 2009. The study assessed the preclinical and clinical teaching of RPDs. They found divergences in preclinical amount and content of RPDs teaching within and between public and private dental schools [61]. These divergences were noticeable in the course duration (ranging from a minimum of 12 hours to a maximum of 120 hours), practical preclinical course in the private schools was twofold as long as in the public dental schools, sixty present of the surveyed schools their students did not gain experience at tooth preparations on phantom-heads and did not routinely use a surveyor when designing their RPDs [61].

In the UK, a study by Clark *et al.* in 2011 surveyed 11 dental schools to investigate the teaching methods in RPDs. The study found that the amount of RPDs clinical work undertaken by students decreased slightly while the amount of technical work decreased significantly, even though the surveyed schools met the General Dental Council's (GDC) requirements in RPDs teaching [60]. These requirements are stated as follows: new dental graduates should be competent at designing effective indirect restorations of complete and partial dentures [150]. Competency is defined by the GDC to be that "*Students should have a sound knowledge and understanding of the subject together with an adequate clinical experience to be able to resolve clinical problems encountered, independently or without assistance*" [150].

Clark *et al.* also reported that a number of schools still have a dedicated prosthetics clinic where the students treat patients under the supervision of specialist staff, however, among all schools some RPDs cases were treated in multidisciplinary restorative clinics [60]. In addition, requirements in terms of cases treated by students were varied from 3-9 cases among the investigated schools while three cases was the most common target number [60]. Amongst these schools, at least one RPDs case is expected to be cobalt-chromium framework design. In regard to assessments, all schools assess students' competence. However, methods of assessment varied between non-degree examination, continuous assessment, as a part in final examination in prosthetic dentistry or combination of these methods [60].

In Nigeria, a descriptive study was conducted during the summer of 2018 to assess the methods used to teach removable partial denture prosthodontics to undergraduate dental students in seven Nigerian dental schools with the purpose of determining efficiency and uniformity. The study included the 5th and 6th year students who were provided with a learner's questionnaire to complete, containing factual and opinion questions on their educational journey in removable prosthetics at their schools. It also included all prosthetic teachers and demonstrators in prosthetic laboratories in each of the dental school. The study showed that the teaching of removable partial denture was mostly undertaken during the 5th and 6th year in Nigerian dental schools. In addition, the study reported a lack of efficiency in learning experience. It also highlighted the problems encountered by both the teachers and students in terms of teaching methods, the variation in the curriculum trends, availability of dental materials and equipment and provision of clinic and laboratory facilities [157].

Another recent study investigated the teaching trends of RPDs is conducted in 2020 by Loch *et al*. The study surveyed nine dental schools in Oceania (New Zealand, Australia, Fiji and Papua New Guinea). Results of the study were comparable to the previous studies in regard to course duration, content and clinical requirements [158]. Also, among these countries the lack of adequately trained staff to teach

RPDs to large cohorts of students was found to be the most common challenge faced by dental schools. Similar to previous studies [59-62], variations in the RPDs curricula content and methods of teaching within Oceania dental schools were reported [158]. These variations and challenges in RPDs teaching and assessment were noticeable since the first study of this kind which was published in 1979 [159].

Another recent study (2021) investigated the current trends in undergraduate teaching of removable partial prosthodontics was conducted among 26 dental schools of Pakistan. It was the first study to comprehensively describe the teaching practices of removable denture prosthodontics in undergraduate dental schools of Pakistan. The study found that 19 dental schools out of 26, teach RPDs over a period of at least two years of undergraduate education. In six dental schools, students fabricate 10-12 RPDs during their prosthodontic rotation. Lectures and live clinical demonstration for construction of removable acrylic dentures are reported to be carried out in all the dental schools. The simple hinge articulator is the articulator of choice in 22 (84.6%) schools. The altered cast technique is taught in 24 schools (92.3%) in lecture form, however, none of the student fabricate dentures by using this technique [160].

On the other hand, teaching trends of RPDs across the world can be very similar in the matter of used materials and methods to fabricate. This is what a Saudi Arabian recent study [161] revealed when it investigated the contemporary teaching methods and principles of fabrication of RPD in Saudi dental schools and compared it to the RPD curriculum of North American dental schools and Turkish dental schools. This investigation revealed that Saudi dental schools have similar standards of RPDs education at the undergraduate level, with variations in a few aspects. In addition, RPDs undergraduate teaching programmes in Saudi Arabian dental schools are comparable to programs in dental schools of the United States and Turkey [161].

Divergence in dental education has been a concern for years due to its impact on the quality of the dental care that will be offered by future dental graduates. Harmonizing RPDs and other dental education curricula and addressing challenges to improve the dental profession and enhance the quality of dental care were urged by the British GDC and the Association for Dental Education in Europe (ADEE) [150, 151]. The ADEE and GDC recommendations to reduce the discrepancy in dental education, harmonize dental schools undergraduate curricula and reinforced the importance of outcome-based learning have been directed to the European countries. However, these recommendations are applicable to dental schools worldwide [150, 151]. Therefore, the aim of this study was to investigate the current teaching and assessment methods of RPDs among dental schools in different selected countries.

4.3 Materials and methods

A questionnaire consisting of 56 questions (55 close-ended and 1 open-ended question) was set and structured by Using SurveyMonkey (Appendix 3). After receiving of a positive approval from the Social Research Ethics Committee (SREC) at University College Cork, Ireland (#2019-216), an email, including an invitation to participate in the study, along with a hyperlink to the survey, was sent to the senior clinical academic identified as being responsible for the teaching of RPDs course in Spring 2020. Within 12 selected countries, 142 dental schools were invited to participate in this study (Ireland, United Kingdom (UK), United States

(US), Canada, Australia, New Zealand, Norway, Sweden, Denmark, Germany, Hong Kong and Saudi Arabia). It was requested that if the person who received the e-mail was not the most suitable person in the institution that they would forward it to the more appropriate person. The questionnaire was divided into two sections, the first is the preclinical teaching and assessment in RPDs (21 questions). While the second section is the clinical teaching and assessment in RPDs (34 questions), The final question was an invitation for further comments and opinion. The initial e-mail was followed up by a second e-mail four weeks later to those who had not responded, and this was followed up about three weeks later by a third e-mail to those who had still not replied. A final fourth reminder e-mail sent 10 weeks later to encourage the non-respondent schools to participate. Recipients were assured of anonymity for them and their institution in any resulting publication. Moreover, to assess the effect of the geographical distribution on RPDs teaching and assessment, we categorized the participated countries into five geographical groups. These groups as following: UK/ Ireland, Europe, US, Asia-pacific and Saudi Arabia. We used one-way analysis of variance (ANOVA) to examine the mean differences in continuous variables across the geographical area, whereas Chi-square test was used for categorical variables. All analyses were conducted using IBM SPSS Statistics software (version 26, 2019) and the *p*-value <0.05 was considered to be statistically significant.

4.4 Results

4.4.1 Preclinical teaching trends:

Out of 142 invited dental schools from 12 countries, 23 dental schools representing nine countries responded (response rate = 16%). The geographical distribution of received responses were from United Kingdom, Ireland, Denmark, Germany, Saudi Arabia, United States, Australia, New Zealand and Hong Kong. All participating dental schools, except one school based in UK, have dedicated preclinical course in teaching RPDs. Most of the respondent schools commence this teaching during year 3 (12 schools) and during year 2 (10 schools). Only one school based in US commences RPDs teaching during year 4. The average devoted teaching hours received by each student is 56 hours. It is ranging from 16 hours among two schools up to 100 hours in one school (mode: 60 hours among 4 schools). The dedicated teaching/academic hours ranged from 4-40 hours (mean: 15.6 hours). These academic hours are divided as shown in Table 4.1. While the allocated hands on/practical skills hours ranged from 8-72 hours (mean: 38.3 hours).

Table 4.1 Distribution of academic/didactic teaching in preclinical RPDs course

	N	Minimum	Maximum	Mean
Formal lectures/hour:	23	0	30	10.30
Laboratory demonstrations/hour:	20	3	60	17.00
Small groups, tutorials or seminars/hour	8	0	20	8.12
Other/hour*	3	8	40	19.00

*Such as: 1- demonstration on phantom head. 2- Simulation 3- podcasts, videos, formative on surveying.

The staff: student ratio for preclinical course in RPDs for formal lectures ranged from 1:3 to 1:160; laboratory demonstrations ranged from 1:4 to 1:56 (mode: 1:10);

and small groups/tutorial ranged from 1:5 to 1:26 (mode: 1:10). Forty-four percent of the schools (n=10) reported that the course is directed either by professor or senior lecturer/associate professor. Table 4.2 shows who is/are responsible for directing the preclinical teaching in RPDs course.

In regard to the experiences that students gain during the RPDs preclinical course, using surveyor is the most skill that students gain (n=22). Among 21 schools out of the 23 respondents, students learn how to use the articulator, writing RPDs prescription and teeth preparation on patient simulators. Casting impressions and altered cast impression technique are also experiences students gain during the course (n=17, n=10 respectively). Details of supervision of these experiences are reported in Table 4.3. While the average hours of teaching that students received in each experience is reported in Table 4.4.

Table 4.2 Member of staff who is/are responsible for directing the preclinical teaching in RPDs course

	Number of schools	**Percentage (%)**
Senior lecturer/associate professor	10	44
Professor	8	35
Consultant	5	22
Lecturer	6	26
Technician	3	13
GDP (part-time lecturer)	2	9
Senior clinical teacher	1	4
Clinical trainer in restorative dentistry	1	4

Table 4.3 Students' supervision during gained experiences in preclinical RPDs course

Gained experience	Clinician	Technician	Number of schools
Using surveyor	83%	44%	22
Teeth preparation on patient simulators	91.3%	8.7	21
Using articulator	74%	44%	21
RPDs prescription writing	87%	35%	21
Casting impression	39%	48%	17
Altered cast technique	44%	17.4%	10

Table 4.4 Average hours of teaching that students received in each preclinical experience

Gained experience	Minimum hours	Maximum hours	Average hours
Using surveyor	1	30	6.45
Teeth preparation on patient simulators	1	20	6.32
RPDs prescription writing	1/2	20	4.39
Casting impression	0	12	3.37
Using articulator	1	12	3.36
Altered cast technique	0	12	3.45

These experiences take the form of either formal lecture, laboratory demonstration or practical exercise, with only one schools reported using the three teaching forms. RPDs prescription writing, use of the surveyor and use of the articulator are mostly provided in practical exercises (78% (n=18), 65% (n=15) and 52% (n=12) respectively), Table 4.5 for more details.

Table 4.5 Teaching form of the gained experience sessions in RPDs preclinical course

Gained experience	Formal lecture	Lab demonstration	Practical exercise	Number of respondent schools
RPDs prescription writing	17.4%	0%	78.3%	22
Use of surveyor	4.3%	26.1%	65.2%	22
Use of articulator	8.7%	39.1%	52.2%	23

Regarding the most commonly used articulator, Arcon/semi-adjustable is the most common used articulator (57%, 13 schools), followed by the average value articulator (47.8%, 11 schools), and then the Non-arcon/semi-adjustable (34.8%, 8 schools) while the simple hinge articulator is not used.

Textbooks and reading materials that recommended for undergraduate teaching of RPDs are reported in Table 4.6. The most recommended textbook was Alan B. Carr and David T. Brown “McCracken's Removable Partial Prosthodontics” followed by Rodney Phoenix, David R. Cagna and Charles F. DeFreest “Stewart’s Clinical Removable Partial Prosthodontics”.

Table 4.6 Recommended textbooks and reading materials for student teaching in RPDs course (21 respondent schools)

Textbook	Number of schools
Alan B. Carr and David T. Brown “McCracken's Removable Partial Prosthodontics, 13th (2015) and 12th Editions (2011), Elsevier Mosby Publishers”.	7
Rodney Phoenix, David R. Cagna and Charles F. DeFreest “Stewart’s Clinical Removable Partial Prosthodontics, 3rd edition (2008) Quintessence Publishing Co. Inc, IL”.	6
J.C. Davenport, J.R. Heath and R. M. Basker “A Clinical Guide to Removable Partial Dentures (2000), British Dental Journal Books, London.	5
BDJ article series on RPDs and other RPDs related articles.	3
Arthur J. Krol, Theodore E. Jacobson and Frederick C. Finzen “Removable Partial Denture Design: Outline Syllabus, 5th edition, Indent Publisher (1999).	1
J.C. Davenport, R. M. Basker and J.R. Heath “A Clinical Guide to Removable Partial Denture Design, British Dental Journal Publisher, London (2000).	1
Margareta Molin Thoren and Johan Gunne “Textbook of removable prosthodontics: The scandinavian approach, Gyldendal Akademisk A/S Publisher (2012).	1
Peter Ludwig and W. Niedermeier “Checkliste Prothetik (McCracken's Prothetik), Thieme, 1st Edition (2002).	1
P. Finbarr Allen and N. J. A. Jepson “Removable Partial Dentures: 18 (Quintessential of Dental Practice), 1st edition (2004), Quintessence Publishing Co Ltd.	1

Robert Clark "An Introduction to clinical prosthodontics (1988) Hong Kong, Hong Kong University Press.	1
R.J. Stratten, Frank Wiebelt and Russell J. Stratton "An Atlas of Removable Partial Denture Design (1988) Quintessence Publishing Co Inc., U.S.	1
Robert M. Morrow, Keneth D. Rudd and Harold F. Eissmann "Dental Laboratory Procedures (Removable Partial Dentures), Vol. III 2nd Edition, 1986, The C.V. Mosby Co., St. Loius	1

4.4.2 Preclinical assessment trends:

Amongst all the 23 participating dental schools, students are required to sit an assessment at the end of the preclinical course prior to provide RPDs clinical treatments. The methods of the preclinical assessment involve:

- Written and practical exams (9 schools)
- Practical/gateway exam (7 schools)
- Written exam (4 schools)
- Formative assessment on surveying and designing a case (1 school)
- Formative case presentation with poster, demonstrating holistic patient care with a justified partial denture design and peer assessment (1 school)

The majority of schools (74%, 17 schools out of 23 respondents) use RPDs surveying and design as the assessment skills in the practical exam either alone or in combination of other skills. Twelve schools use prescription writing (52%), ten schools use rest seat preparations (43%), seven schools use impression technique (30%), three schools use cast and trimming of models (13%), three schools use mounting of casts (13%), only one school uses teeth placement in wax (4%) and one school uses registration of jaw relations and prescription of teeth position (4%). Also, one respondent school based in Europe uses weekly clinical assessment as the sole method of assessment. Clinicians supervise these exams in 20 schools out of the 21 respondent schools (95%) while technicians supervise exams in the remaining school. These preclinical assessments are standardised in 17 dental schools by using:

- Assessment guidelines (12 schools)
- Training (3 schools)
- Rubric scoring guide (1 school)
- Calibration through discussion (1 school)

When a student fails in the preclinical assessments, 16 schools out of respondents 23 require student to re-sit the assessment. In addition, students of seven schools cannot provide clinical procedures unless they pass the re-sit assessment. Although, five schools only reduced grade in overall course result. Students of one school based in the UK require nothing to do in case they failed in the assessment. Yet, when this school was asked how students readiness to undertake RPDs case in the clinic is checked, the school commented: "*formative assessment helps to an extent. However, we believe the teaching is ongoing, and experiential in nature. Do not think a gateway test adds value to teaching. We use Liftupp that can trace the transition of a student in this skill and help provide appropriate supervision and support*". Comments of other 21 participants when they were asked how they ensure their students are ready to provide RPDs clinically are reported in Table 4.7.

Table 4.7 Measurement of students' readiness prior to commencing RPDs clinical course

UK and Ireland
Assessment as described and completion of the RPD preclinical course
Attendance at preclinical course
They must have passed the capability assessment. If they are found to be below standard having already passed the capability, they must complete remediation
Formative assessment helps to an extent. However, we believe the teaching is ongoing, and experiential in nature. Do not think a gateway test adds value to teaching. We use Liftupp that can trace the transition of a student in this skill and help provide appropriate supervision and support.

We do not specifically check as our didactic and clinical teaching run synchronously
Gateway assessment
Pass clinical readiness examination & OSCE
Asia-Pacific
Completion of the module to the appropriate standard
Complete the simulation and lecture programme
All the planning steps and RPD design are checked by the supervising clinician
Summative end of year written assessment. Foundation course prior to starting clinical training
Pass the "exit" tests
Saudi Arabia
Passing the course and competencies
Must pass the preclinical course
Previous semester grade
MPES of 60 percent criteria and requirements
Through clinical conference prior to start the clinical procedures. Student will be given a chance to review the procedures and also ask to perform again in model prior to handle patient.
Europe
The overall grades in the preclinical module
When the students have achieved a signature for every step
United States
Passing the predoctoral course, which has both didactic and practice examinations as well as evaluating their preparation prior to starting an RPD treatment for a patient
Successful completion of RPD course.
Passing course

One-way ANOVA test was conducted to assess the impact of the geographical distribution on academic dedicated teaching/hour (*p*-value= 0.95), hands-on (practical skills)/hour (*p*-value=0.27), formal lecture/hour (*p*-value= 0.67), laboratory demonstration/hour (*p*-value= 0.46), small groups (tutorial or seminar)/hour (*p*-value= 0.60). The *p*-values of ANOVA test were not significant, suggesting that geographical distribution has no impact on these teaching trends. Also, it was statistically not significant when ANOVA test used to examine the impact of the geographical distribution on having assessment at the end of the preclinical course (*p*-value= 0.77) (Appendix 4).

4.4.3 Clinical teaching trends:

Twelve dental schools out of 23 respondents reported that they have dedicated clinical sessions for instruction of RPDs. Most of the schools commence clinical teaching of RPDs either in third or fourth year (9 schools and 6 schools respectively) while three schools commence this teaching in the second year.

In the clinical sessions, the staff: student ratio ranged from 1:3 to 1:15 (mode 1:6), for the formal clinical lectures, the ratio ranged from 1:18 to 1:160 (mode 1:100), and for the small groups/tutorials ranged from 1:5 to 1:16 (mode 1:5). Eleven schools (out of 18 respondents) have paired teaching. When it comes to students' routine usage of surveyor, 17 schools (out of 18 respondents) said "yes", their students use surveyor routinely while five schools skipped the question and one school said "no".

4.4.3.1 Impression techniques taught for recording the master impressions for RPDs:

Eighteen schools provided information on master impression recording technique they taught students, most of them use polyvinylsiloxane impression material in special/custom tray for recording the master impressions for RPDs. More of this information reported in Table 4.8.

In the clinical sessions, students encounter both complete dentures and RPDs first in their clinical work in seven out of 18 respondent schools, while they encounter RPDs in another six schools. Students of five schools encounter the complete dentures before the RPDs in the clinical work.

Table 4.8 Impression techniques for recoding RPDs master impression

Impression technique	Number of schools
Polyvinylsiloxane in Special tray	9
Alginate in special tray	6
Alginate in stock/metal tray	5
Polyether in special tray	2

4.4.3.2 Supervising guidelines:

Guidelines for supervising staff in undergraduate clinical teaching is reported in 17 schools out of the 18 respondent schools, while these guidelines are missing in one school based in the Asia-pacific area. In the clinical sessions, staff supervision contribution is distributed as following:

- Professor: ranged from 10% to 90% (mean: 32%)
- Consultant: ranged from 5% to 90% (mean: 26%)
- GDP (part-time teacher): ranged from 25% to 100% (mean: 51%)
- Senior lecturer: ranged from 10% to 100% (mean: 40.1%)
- Lecturer: ranged from 10% to 100% (mean: 31%)
- Technician: ranged from 5% to 25% (mean: 14%)

4.4.3.3 RPDs design and prescription writing:

Design of RPDs and prescription writing are taught in 17 schools out of 18 respondents during the clinical course. This teaching mostly takes the form of either small group/tutorial session or formal lecture (6 schools for each). The remaining five schools taught this as follows:

- Formal lecture, workshops, and lab-based teaching
- Discussion during the clinic
- Small groups and individual treatment planning session. All RPDs designs must be approved by one of three Academics
- Case based learning and discussion
- Demonstration and discussion.

4.4.3.4 RPDs requirements:

Before students' graduation, all the participating schools provide information for the required RPDs cases that need to be completed. The required RPDs ranged from 1-8 (mean: 4; mode:4 and 5), 1-6 of them are required as acrylic RPDs (mode: 1) and also 1-6 as a cobalt-chromium RPDs (mode: 1 and 2). When we asked about the average number of acrylic and cobalt-chromium RPDs that completed by students, the average number were as follows:

- Acrylic RPDs average ranged from 1-6 cases completed by each student.
- Cobalt-chromium average ranged from 1-6 completed by each student.

Within 18 respondent schools, only seven schools are teaching flexible dentures. Teaching of this usually takes the form of formal lectures (6 schools) and, as small groups/tutorial (2 schools) or during the clinical sessions (2 schools). Within the 23 participated schools, students' clinical work completed by using the digital workflow among four schools which is ranging from 1% to 25%. Among 18 schools, students use both internal and external laboratory to complete the clinical work in seven schools while six schools use external laboratory, and five schools use internal laboratory.

Crosstabulation and Pearson Chi-square test were conducted to examine the geographical distribution impact on the number of RPDs cases that students need to complete before graduation (p-value= 0.579), staff: students ratio for formal lecture (p-value= 0.665), The p-values of Pearson Chi-square test were not significant, suggesting that geographical distribution has no impact on the assessed teaching trends (Appendix 4).

4.4.4 Clinical assessment trends:

Criterion-referenced assessment exercises in clinical RPDs course is reported by 15 schools out of 18 respondents. This criterion takes the form of written exam in nine schools (60%) and as practical exam in six schools (40%). In the practical exam, the assessed skills are:

- Surveying and design (8 schools)
- Prescription writing (6 schools)
- Rest seat preparations (3 schools)
- Impression taking (3 schools)
- Try-in and delivery (3 schools)
- All the above skills are included (1 school)

The responsible to assess students' clinical work and competence during the clinical sessions among 18 respondent schools were as follows:

- Senior lecturer/associate professor (10 schools)

- Professor or GDP (part-time teacher) (10 schools)
- Professor (9 schools)
- Consultant (7 schools)
- Lecturer (7 schools)

During the RPDs clinical sessions, the most used students' assessment method is the day-to-day observation and judgement (glance and mark) (17 schools). Also, fixed schedules of clinical requirement are used in 11 schools, tests based on observation and implicit judgement in four schools, self-assessment in four schools and peer-assessment in two schools. Also, one school reported using Liftupp and another school reported using prescription writing and design examination.

4.4.4.1 RPDs competency assessment:

Prior to graduation, RPDs final assessment exam takes place in 12 schools out of 18 respondents. Forms of the final assessment are summarized in Table 4.9. Instead, two schools assess their students during the course using different forms e.g., the use of guidelines and regular teachers' meetings and teachers are calibrated on use of Liftupp.

Table 4.9 Type of assessment of students' clinical competency in RPDs prior to graduation

UK and Ireland
Completion of the simulation course and course requirements.
Completed cases, success and reflection
Minimum requirements, exit cases and in course assessment
Liftupp progression data based on their clinical performance
Portfolio

SBA, OSCE
Asia-Pacific
Written examination
It is combined within the overall curriculum
Quota and day-to-day assessments
Continuous assessment
Saudi Arabia
Competency exam and requirements
Completion of the clinical requirements and exit exam.
United States
Prescription writing and design examination
Quality and Quantity
Before final examination, the students have to finalize 2 written task/essays and be evaluated for their clinical skills and their ability to transfer theoretical knowledge into the clinic
Independent patient exercise, daily grades
Europe
Overall grades in the module.

4.4.4.2 Outreach teaching:

Eighteen schools provided information for the outreach/community-based clinical teaching. 11 schools have a clinical outreach teaching programme while only five of them included the completed RPDs treated cases in the final students' assessment. One school does not provide removable prosthodontic treatment in the outreach clinic though. Staff in the outreach centre employed by the same university in two schools. Instead, they are:

- NHS/health sector employees in 4 schools.
- Private practitioners in 4 schools.

When the participants were asked; how they ensure that the staff in the outreach centres teach and assess RPDs to the same standards as in the base dental schools, they answered as follows:

- There are guidelines (7 schools).
- Not sure (2 school).
- Regular teachers meeting (1 schools).
- Guidelines and regular teachers meeting (1 schools).

4.4.4.3 Learning outcome assessments:

Consistency in assessment of RPDs is achieved by following guidelines in 18 schools out of 23 respondent schools. Clinical guidelines (14 schools), Regular teachers meeting (2 schools), regular teacher meetings and guidelines (1 school), staff calibrated on Liftupp (1 school). Among 18 respondent schools, nine schools are satisfied that they adequately assess their students' competence in RPDs prior to graduation. Seven schools are "mostly" satisfied, two schools are unsatisfied while one school is not sure. Two of the unsatisfied schools explained their responses as follows; "*insufficient experience in removable prosthodontics in general*" and "*there should be a clinical competency exam before graduation*". Also, the not sure school commented: "*need for faculty calibration*".

Most of the schools believe that competence of students in RPDs is worse now than that of students who graduated 10 years ago (6 schools out of 17 respondents). Five schools think no change and three schools believe it is better now while another three schools are not sure. From those who believe it is worse they commented:

- *"Reduce number of suitable patients"*
- *"Faculty numbers have diminished"*

- *"Nowadays, teaching RPD is focus only on the clinical aspects not in the laboratory. Also, most students are not much interested with RPDs due to the high demands of patients in fixed restoration".*

4.4.4.4 Perceived challenges to the teaching of RPDs:

Participants were asked to indicate the main challenges that might encounter them in teaching RPDs to undergraduate students over the next few years. Answers were as following:

- Lack of adequately trained staff for teaching (10 schools)
- Increasing use of alternate technologies such as implants (10 schools)
- Lack of suitable patients for students to treat (9 schools)
- Pressures on teaching time from other sources in the undergraduate curriculum (8 schools)
- Use of CAD/CAM (1 school)

At the end of the survey, participants were asked to write any further comments they might have in relation to students' RPDs teaching and assessment. Comments were as following:

- "*We have moved away from formal lecture and practical based teaching to a blended learning and teaching. We use podcasts and videos. In addition, students are required to read materials uploaded on the virtual learning platform. Students are examined on these in yearly summative assessments. Therefore, students spent more hours than the stated 25 hours of teaching while studying RPDs*".

- "*I would say that teaching is very challenging to get the interest of the students in this type of prosthodontic rehabilitation, given the fact that kind of complicated the fabrication of RPDs. I would suggest that every school shall have clinical competency for the course so that students will be forced to do their best and consider the RPDs as a good option in restoring missing teeth*".
- "*Difficult to find patients*".

4.5 Discussion

Dental schools' curricula and methods of teaching are crucial in building students' knowledge and skills. As the integrity of the received knowledge and skills during undergraduate learning will be reflected on the future dentists and eventually on the delivered treatments. International teaching trends of RPDs, which is a major part of the prosthodontics, has been investigated in this study. Similar to previous studies [59-63, 158] ,variation in teaching methods and contents among the investigated dental schools were demonstrated in this study. In addition, variation in teaching and assessment trends that noted in the present study were not subjected to the geographical distribution.

All participating dental schools, except one, have a dedicated preclinical RPDs course. Comparable to Loch *et al.* [158], Clark *et al.* [60], Lynch *et al*. [59] and de Oyagüe *et al.* [61] studies, this course is mostly commenced in year 3. A concerning finding is that one schools commenced the RPDs preclinical course during year 4. In addition, the average teaching hours that received by students were only 16 hours in one school. Also, the academic hours were 4 hours while the practical hands-on were only 8 hours in another two schools. This low academic teaching hours or hands-on practice might rise the concern that students would not be adequately prepared or ready for the clinical sessions. The average preclinical teaching duration of the RPDs course was 56 hours among the participating dental schools. In comparable to previous studies, the duration average of the preclinical RPDs course was 107 hours in Oceania [158], 76 hours in the US [63], 67 hours in the UK and Ireland [59] while it was only 44 hours in the Spanish dental schools [61].

The result of this study also showed a wide range variation in preclinical RPDs staff: student ratio during the formal lectures (ranged: 1:3-1:160), laboratory demonstration (ranged: 1:4-1:56) or during the small groups/ tutorials (ranged: 1:5-1:26). This wide variation could rise a concern that large number of students may compromise the teaching quality and quantity during the preclinical course. Senior lecturer/associate professor was the most common staff grade directing the preclinical RPDs course. While a dental technician was the course director in three dental schools. Adequate technical skills can be provided by dental technicians, although, they are not qualified to teach students clinical information related to RPDs treatment or biological considerations. Result of this study also showed that clinical course of RPDs was most commonly started in the third year. This result is similar to Loch *et al.* [158] and Lynch *et al.* [59] findings while de Oyagüe *et al.* reported that most dental schools in Spain commence the RPDs clinical course during year 4 [61].

However, only twelve schools (55%) have dedicated clinical sessions for the provision and delivery of RPDs. Also, the required RPDs cases that are needed to be completed before students' graduation were considerably varied. The number of the required cases ranged from 1-8 (mean: 4) and from them an average of two cases are required as a cobalt-chromium and average of three as acrylic RPDs.

Among eight schools, students completed as few as one acrylic RPDs, and in seven schools, they were required to complete only one Co-Cr RPD. These results are also comparable to previous studies, in Oceania countries, students were required to complete on average six acrylic and two Co-Cr RPD cases [158] while the average cases in Spanish schools were three to four acrylic and one Co-Cr RPD cases [61]. Students in the UK and Ireland were required to provide an average of two acrylic and three Co-Cr RPD [59] and amongst the British dental schools the average cases number were three to nine unspecified RPDs [60]. Also, students of the US schools were required to complete an average of three unspecified RPDs [63].

The present study also reported that seven schools (30%) are teaching flexible RPDs and that is comparable to a recent similar study that reported 34% of Oceania dental schools are teaching flexible RPDs [158]. In addition, students of four schools only (17%) completed part of their clinical work by using the digital workflow. These results demonstrated a significant variation in the contents of teaching and showed gap or limited learning exposure which indicate that dental students worldwide do not receive the same knowledge and experience, and this will eventually be reflected on the quality of the provided treatments in future.

Despite this variation, common teaching trends were also reported in this study such as designing of RPDs and prescription writing were taught in seventeen schools (74%). However, a study was conducted in Pakistan over a period of three years, from 2016-2019 reported that in the majority of Pakistani dental schools, students tend to depend on the teachers and technical staff to design and fabricate the partial dentures [162]. This dependency is carried forwards in general dental practice in the form of complete reliance on dental technicians which might lead to a lack of expertise and skill in professional life for partial denture design [59]. Alternatively, utilising digital workflow in RPDs design reported to be very successfully teaching approach that can achieve the educational goals and enriched students' knowledge and expanded their understanding of RPD design [163].

Fifteen schools (65%) had criterion-referenced assessment exercises during clinical RPDs course. In addition, seventeen schools (74%) used the day-to-day observation and judgement (glance and mark) as students' assessment method in clinical sessions and the consistency in assessment of RPDs is achieved by following guidelines in eighteen schools (78%). But then disagreement on assessing students' competence demonstrated the divergence in the teaching of RPDs. Six schools believed that competence of students in RPDs is worse now compared to that of students who graduated 10 years ago. While five schools thought no change and three schools believed it is better now and another three schools were not sure. Conversely, in 2011, Clark *et al.* reported that the majority of the British schools thought their students were as well prepared as ten years ago [60].

Challenges that may face dental schools during the teaching process could play a role in creating this wide variation and its progression over time. For example, the lack of adequately trained staff for teaching RPDs (reported by ten schools) and the pressures on teaching time from other sources in the undergraduate curriculum (reported by 8 schools) were also major challenges facing Oceania dental schools [158]. Similarly, the increasing use of alternate technologies such as implants (reported by 10 schools) or the lack of suitable patients for students to treat (reported by 9 schools) were reported challenges amongst dental schools in the UK and Ireland [59].

However, these challenges need to be overcome to ensure that RPDs curricula among dental schools offer the required knowledge and experience for the future dentists. The need for RPDs as treatment option will remain among the elderly or other populations and failure of providing such an option with a decent quality might create a gap between the community needs and the availability of dental treatment. It was urged that to perform every procedure independently in the clinic, dental undergraduate students must build adequate skills and have sufficient preclinical practice to become comfortable with clinical procedures. As well, dental students should have sufficient feedback about the quality of their work [144].

Since 1998, the goal of ADEE is to facilitate convergence in dental education. In their original domains for the learning outcomes, which are comparable with GDC guidelines, are the following four domains: Professionalism, Safe and Effective Clinical Practice, Patient-Centred Care and Dentistry in Society [150, 151]. These four learning outcome domains will not be applied unless the dental schools curricula are balanced and structured base on these domains. These domains provide a basis from which graduates can build confidence and competence towards becoming an independent practitioner, who accepts the importance of continuing professional development throughout their career [151]. The GDC requires graduate dental students to be competent in assess the need for removable prostheses, able to design, prescribe and provide biomechanically sound partial or complete dentures [150].

This study aimed to investigate the current teaching and assessment trends in RPDs amongst dental schools internationally. Twenty-three dental schools from nine countries participated which makes this study reflects a wider prospective in undergraduate RPDs education than previous similar studies. However, this study has some limitations need to be addressed. The response rate considered to be low, although, we sent three reminder emails after the initial email to encourage the non-respondents to participate. In addition, it should be noted that the survey was sent during COVID-19 pandemic which might explain the low response rate.

4.6 Conclusion

International discrepancy of undergraduate RPDs teaching and assessment trends between dental schools was substantial. It was reported among both preclinical and clinical course of RPDs, whereas the geographical distribution found to have no impact on this discrepancy. The variations also reported on how to evaluate students' competence in RPDs prior to graduation. Although, consistency in assessment of RPDs is mostly achieved by following clinical guidelines. Future research to investigate recently graduated students' viewpoints would be helpful to understand their competence level in RPDs.

Chapter 5. Undergraduate Fixed Prosthodontics Curriculum (Crown and Bridge): An International Study of Current Teaching and Assessment Methods

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5.1 Abstract

Objectives: The aim of this study was to investigate the contemporary teaching and assessments trends of Fixed Prosthodontics (FPs) within undergraduate dental schools programmes on an international setting.

Materials and methods: A questionnaire consisting of 60 questions (59 close-ended and 1 open-ended question) was devised. This questionnaire was set-up in an online format Using SurveyMonkey. After receiving of a positive approval from the Social Research Ethics Committee (SREC) at University College Cork, Ireland (2019-216), an email, including an invitation to participate in the study, along with a hyperlink to the survey, was sent to senior clinical academics identified as being responsible for the teaching of FPs course in Spring 2020. Within 12 selected countries, 142 dental schools were invited to participate. The questionnaire was divided into preclinical teaching and assessment in FPs (26 questions) and clinical teaching and assessment in FPs (33 questions), The final question was an invitation for further comments and opinion.

Results: Twenty-five schools from eight countries participated. All respondent schools have a dedicated preclinical course with teaching hours ranging from 2-100 hours. The practical skills teaching ranged from 3-177 hours, while the Phantom head teaching hours ranged from 6-100. Crown preparation followed by conventional bridge preparation are the most common exercises that students completed during the preclinical course. Veneer preparation average teaching was 5 hours, while the resin-retained bridge exercises averaged 3 hours. Crown preparations were the most commonly the assessed practical skill in the practical exam. Sixteen schools students gain clinical experience in CAD-CAM restorations. Eleven schools use digital workflow for fabrication of crown and bridgework.

Completion of a number of single porcelain fused to metal crowns is the most common clinical requirement before graduation.

Conclusions: International discrepancy of undergraduate FPs teaching and assessment trends among dental schools was considerable. It was reported among both preclinical and clinical course of FPs, whereas the geographical distribution has no impact on this discrepancy.

5.2 Introduction

Replacing or restoring partially dentate patients with fixed prostheses is popular amongst patients due to the high degree of aesthetics achievable as well as avoiding the need for a removable prosthesis. Fixed prosthodontics (FPs), crown or bridgework, have the advantage of being attached to natural teeth. Also, fixed prostheses, either crowns or bridgeworks have high survival rates (an estimated survival rate of crowns ≥ 92.1% while bridgework ≥ 86.2%) in 5 years of function [164, 165]. In addition, development of reliable adhesive cementation techniques has resulted in increased predictability of resin-bonded fixed partial dentures (FPDs). A long term clinical performance study of two-unit cantilevered resin-bonded FPDs found that they had a retention rate of 86.7%, success rate of 84.4% and survival rate of 90.0% with a mean service life of 9.4 years [166].

Over the last decades innovative technologies for FPs for the rehabilitation of partially dentate patients have been developed, including the use of digital dental impressions, CAD-CAM systems, minimally invasive approaches to treatment and all-ceramic restorations. However, these innovative technologies in FPs keep dental schools programmes under increasing pressure to produce dental graduates who are fit for future practice [66]. Dental schools already face challenges such as increased student numbers, decrease of suitably trained clinical academics to provide teaching and learning, difficulty in finding suitable patients, and increased administrative challenges [65]. Dental schools which already have busy programmes of study, face the criticism that they are “no longer as good as they used to be” [167, 168].

In 2009, Lynch *et al*. found variation in teaching of fixed bridgework within the fifteen Irish and UK dental schools. Also, they found that cantilever resin-retained bridgework was the most popular form of bridgework provided clinically followed by conventional cantilever bridgework. In addition, no schools reported that their students gained clinical experience in the provision of all-ceramic bridges [65]. More recently, a further study by Lynch *et al.* investigated teaching of FPDs within eighteen dental schools in Ireland and UK. They found that the most commonly preparation exercises is fixed-fixed posterior conventional bridges followed by cantilever anterior resin-retained bridges. Their result also showed an increased in students experience in the clinical provision of bridgework, particularly in provision of anterior cantilever resin-retained bridges, compared to the survey conducted in 2009 [66].

The ultimate goal of graduated dentists is to provide preventive and therapeutic services for oral and dental diseases using theoretical knowledge and clinical skills acquired during their education. To achieve this goal, there is a need for educational planning based on clinical education principles, so that graduated students do not feel unable to perform these skills after graduation [169]. Additionally, dental graduates are expected to adapt and improve their skills, knowledge and capable to use innovative technologies during their career [66].

Safe beginners with skills and understanding of increasingly complex technologies is the exit point of dental school training within the UK [66]. The General Dental Council (GCD) in UK define the safe beginner as "*a rounded professional who, in addition to being a competent clinician, will have the range of professional skills required to begin working as part of a dental team and be well prepared for independent practice*" [150]. However, a recent survey study of dental foundation trainers in England, Northern Ireland and Wales found that 85% of those surveyed had concerns about the skills of recent dental graduates in relation to crown and bridge [170]. These concerns, to be not adequately prepared or experienced difficulty in practice are not new among novice dentists [171]. Existence of such concerns among novice dentists creates an area of concern in regard to the teaching of FPs. With this in mind, the aim of this study was to investigate the contemporary teaching and assessments trends of FPs (crowns and bridges) within dental schools internationally.

5.3 Materials and methods

A questionnaire consisting of 60 questions (59 close-ended and 1 open-ended question) was devised and structured using SurveyMonkey (Appendix 5). After receiving of a positive approval from the Social Research Ethics Committee (SREC) at University College Cork, Ireland (#2019-216), an email, including an invitation to participate in the study, along with a hyperlink to the survey, was sent to the senior clinical academic identified as being responsible for the teaching of FPs course in Spring 2020. Within 12 selected countries, 142 dental schools were invited to participate in this study (Ireland, United Kingdom (UK), United States (US), Canada, Australia, New Zealand, Norway, Sweden, Denmark, Germany, Hong Kong and Saudi Arabia). It was requested that if the person who received the e-mail was not the most suitable person in the institution that they would forward it to the more appropriate person. The questionnaire was divided into two sections, the first dealing with preclinical teaching and assessment in FPs (26 questions), and the second dealing with clinical teaching and assessment in FPs (33 questions). The initial e-mail was followed up by a second e-mail four weeks later to those who had not responded, and this was followed up about three weeks later by a third e-mail to those who had still not replied. A final fourth reminder e-mail sent 10 weeks later to encourage the non-respondent schools to participate. Recipients were assured of anonymity for them and their institution in any resulting publication. Moreover, to assess the effect of the geographical distribution on FPs teaching and assessment, we categorized the participated countries into five geographical groups. These groups as following: UK/ Ireland, Europe, US, Asia-pacific and Saudi Arabia. One-way analysis of variance (ANOVA) was used to examine the mean differences in continuous variables across the geographical area, whereas chi-square test was used for categorical variables. All analyses were conducted using IBM SPSS Statistics software (version 26, 2019) and the p-value <0.05 was considered to be statistically significant.

5.4 Results

<u>5.4.1 Preclinical teaching trends:</u>

Out of 142 invited dental schools from 12 countries, 25 dental schools representing eight countries responded (response rate = 18%). The geographical distribution of received responses were from UK, Ireland, Germany, Saudi Arabia, US, Australia, New Zealand and Hong Kong. All participating dental schools have dedicated preclinical course in teaching FPs. Most of the respondent schools commence this teaching during year 3 (10 schools) and during year 2 (8 schools). Also, six schools commence this course during year 4. The average devoted teaching hours received by each student was 70 hours. It was ranging from 2 hours in one school up to 100 hours among seven schools. The dedicated teaching/academic hours ranged from 1-60 hours (mean: 20.4 hours). These academic hours are divided as shown in Table 5.1. The duration of allocated hours for hands-on/practical skills ranged from 3-177 hours (mean: 55.3 hours).

Table 5.1 Distribution of academic/didactic teaching in preclinical FPs course

	N	Minimum	Maximum	Mean
Formal lectures/hour:	23	0	60	13.7
Laboratory demonstrations/hour:	19	0	80	23.9
Small groups, tutorials or seminars/hour:	13	0	20	8.0
Other/hour*	5	1	80	23.6

*Such as: 1- Case presentation/discussions. 2- Simulation 3- Question walls- the number of dedicated hours vary. One school noted: FPD – also has four X 3-hour sessions on RBB dental laboratory fabrication

The staff: student ratio for preclinical course in FPs for laboratory demonstrations ranged from 1:6 to 1:100 (mode: 1:10); and small groups/tutorial ranged from 1:5 to 1:20 (mode: 1:10). Forty-eight percent of the schools (n=12) reported that the course is directed by professor followed by senior lecturer/associate professor (44%; n=11). Table 5.2 shows who is/are responsible for directing the preclinical teaching in FPs course.

Table 5.2 Member of staff who is/are responsible for directing the preclinical teaching in FPs course

	Number of schools	Percentage (%)
Professor	12	48
Senior lecturer/associate professor	11	44
Consultant	7	28
Lecturer	5	20
Technician	1	4
GDP (part-time lecturer)	1	4
GDP (full-time lecturer)	1	4
Clinical Dental Instructor	1	4
Clinical Fellow	1	4

Phantom head teaching in relation to FPs (crowns and bridgework) is included in all participant schools (n=24) (one school did not respond to the question). This teaching mostly occurs in the 3rd year (n=12) followed by 2nd year (n=8) (see Table 5.3). The staff: student ratio during phantom head teaching sessions ranged from 1: 6 to 1: 35 (mode 1:10; n=10). Teaching hours received by each student during these sessions ranged from 6-100 hours (mean: 46 hours).

Table 5.3 Commencing of phantom head/ hands-on practical teaching in preclinical FPs course

	Number of schools	Percentage (%)
3rd year	12	48
2nd year	8	32
4th year	3	12
1st year	1	4

All respondent schools required their students to gain preclinical experience of crown preparation (n=24) (one school did not respond to the question). Almost all respondent schools (n=22) required their students to undertake bridge preparation in the preclinical setting. Sixty-eight percent of the participant schools (n=17) teach their students veneer preparation during the phantom head sessions. Table 5.4 shows details regarding the experience that is gained by students during phantom head sessions. Clinicians are responsible for supervising students during these experiences. However, technicians supervise students during lab prescription writing and shade selection among five schools and on how to use facebow in one school.

Table 5.4 List of experience that gained by students during phantom head/ hands-on practical sessions in preclinical FPs course

	Number of schools	Percentage (%)
Crown preparation	24	96
Bridge preparation	22	88
Lab prescription writing	21	84
Shade selection	19	76
Using facebow	18	72
Veneer preparation	17	68
Resin-retained bridge preparation	15	60

The average teaching hours that received by each student during crown and bridge preparation was 38 hours (ranged: 5-72 hours), veneer preparation average was 5 hours (ranged: 3-15 hours), resin-retained bridge preparation average was 3.2 hours (ranged: 0-6 hours), using facebow average was 2.7 hours (ranged: 1-6 hours), laboratory prescription writing average was 2.5 hours (ranged: 1-8 hours) and shade selection average was 2.2 hours (ranged: 1-5 hours). In addition, using facebow and shade selection teaching were mostly provided as practical exercise while lab prescription writing was mostly provided in formal lectures (see Table 5.5).

Table 5.5 Form of teaching of some experiences during the preclinical FPs course

	Formal lecture	Lab demonstration	Practical exercise
Using facebow	3	5	12
Shade selection	7	5	9
Lab prescription writing	10	5	7

At the end of the phantom head sessions, the most completed exercises by students (23 schools; 92% of participants) are the preparations for porcelain fused to metal crown, full ceramic crown and provisional bridge. On the other hand, various preclinical exercises are only completed by students of less than fifty percent of the participant schools. Table 5.6 shows more details regarding the gained experiences and completed exercise by students in the phantom head sessions.

The Arcon (semi-adjustable) is the most commonly used articulator (18 schools) followed by the Non-arcon (semi-adjustable) articulator (6 schools). The average value articulator is used among four schools while the simple hinge articulator is used in one school. Yet, one participant school reported that they show their students the articulators but they do not use them.

Table 5.6 List of gained experiences in the phantom head sessions in preclinical FPs course

Phantom head exercise	Number of schools (%)	Phantom head exercise	Number of schools (%)
Preparation for porcelain fused to metal crown	23 (92%)	Preparation for resin retained bridge replacing posterior teeth	7 (28%)
Preparation for full ceramic crown	23 (92%)	Preparation for conventional cantilever bridge replacing anterior teeth	6 (24%)
Provisional bridge fabrication	23 (92%)	Preparation for cantilever resin retained bridge replacing posterior teeth	6 (24%)
Preparation for conventional bridge replacing posterior teeth	21 (84%)	Preparation for inlay/onlay	5 (20%)
Preparation for conventional bridge replacing anterior teeth	20 (80%)	Preparation for conventional cantilever bridge replacing posterior teeth	2 (8%)
preparation for Veneer	20 (80%)	Preparation for full metal crown	2 (8%)
Waxing up study casts	15 (60%)	Metal frameworks try-in	2 (8%)
Preparation for all ceramic bridge replacing anterior teeth	11 (44%)	Final impression taking	2 (8%)
Preparation for all ceramic bridge replacing posterior teeth	11 (44%)	Preparation for gold crown	1 (4%)
Preparation for cantilever resin retained bridge replacing anterior teeth	10 (40%)	Preparation for post & core	1 (4%)
Preparation for resin retained bridge replacing anterior teeth	9 (36%)	Cementation	1 (4%)

5.4.2 Preclinical assessment trends:

In twenty-three schools out of the 25 dental schools, students are required to sit an assessment at the end of the preclinical course prior to providing FPs clinically. Additionally, clinicians supervise students during these assessment among all the 23 schools. The methods of the preclinical assessment involve:

- Written and practical exams (14 schools)
- Practical/gateway exam (8 schools)
- Oral exam (2 schools)
- In class assessments (1 school)
- Students' work/ activity is assessed throughout the course & plans for further development made when required (1 school)

During the practical exam, crown preparation is the most commonly used exercise to assess students (84%, 21 schools out of 25 respondents), followed by bridge preparation (64%,16 schools), veneer preparation among six schools (24% of participants), preparation of resin-retained bridge and using facebow are used in 4 schools (16% of participants). In addition, provisional restorations (3 schools, 12% of participants) are assessed in practical examination.

These preclinical assessments are standardised in 20 dental schools by using:

- Assessment guideline only (14 schools)
- Training only (3 schools)
- Assessment guideline and training (1 school)
- Assessment guideline and continuous calibration (1 school)
- Faculty calibrations sessions (1 school)

In the case of failure in the preclinical assessments, 16 schools out of 23 respondents stated that their students cannot provide clinical procedures unless they pass the re-sit assessment. In addition, 14 schools required their students to re-sit the assessment whereas six schools only reduced the grade in the overall course result. Moreover, when participating schools were asked how they ensure their students are ready to provide FPs clinically, 21 schools comment as reported in Table 5.7.

Table 5.7 Measurement of students' readiness prior to commencing FPs clinical course

UK and Ireland
Practical based gateway assessment. Informal viva on knowledge for those scoring low in formative assessments at end of course
Assessment Data Base
Pass gateway tests, performance at in-class assessments; students' self-assessment
End of year exam they have to pass
Pass test
Phantom head competency test to assess adequate clinical skill
For re-sit another clinician checks it
This is performed through continuous close monitoring of students' development throughout the course and by assessing their performance and the tutors' feedback from each session.
Asia-Pacific
Paraclinical skills assessment in the simulation lab
Complete simulation exercises and lecture series
Via the preclinical exam
By assessment in end of course practical assessment in simulation lab
Saudi Arabia
According to their performance in the practical part if they passed so they can continue otherwise no
Should have gained competency grades in assessment evaluation at the preclinical level, before doing it in clinic
If they pass the preclinical practical and didactic evaluation
Overall grades in the module.
United States
They need to pass the competency test
Competency exams
Successful completion of course to include a passing grade in all written and practical examinations as well as in all "project" exercises.
Passing course
Unknown
By exam

Textbooks and reading materials that recommended for undergraduate teaching of FPs are reported in Table 5.8. The most recommended textbook was "Fundamentals of Fixed Prosthodontics", Shillingburg *et al*. followed by "Contemporary Fixed Prosthodontics", Rosenstiel *et al*.

Table 5.8 Recommended textbooks and reading materials for student in FP teaching (24 respondent schools)

Textbook	Number of schools
Herbert T. Shillingburg et al. "Fundamentals of Fixed Prosthodontics, 4th Edition (2012), Quintessence Publishing Co Ltd".	16
Rosenstiel et al. "Contemporary Fixed Prosthodontics", 5th Edition (2015), Elsevier Mosby Publishers, US"	15
Internal/ school manuals/ documentation/ handouts/ research publications	12
David W. Bartlett "Clinical Problem Solving in Prosthodontics, Illustrated edition (2003), Churchill Livingstone Publishing"	7
J. Fraser McCord et al. "Missing Teeth: A Guide to Treatment Options (2002), Churchill Livingstone Publishing"	1
Peter Ludwig et al. prosthetic by peter ludwig and wilhelm niedermeier, 1st Edition (2002).	1
Wassell et al . "A Clinical Guide to Crowns and other Extra-Coronal Restorations, BDJ Book" and the updated edition.	1
Evidence Based Plenaries	1

One-way ANOVA test was conducted to assess the impact of the geographical distribution average number of hours of teaching received by an individual student in FPs course (*p*-value= 0.31), academic dedicated teaching/hour (*p*-value= 0.18), hands-on (practical skills)/hour (*p*-value=0.38), formal lecture/hour (*p*-value= 0.20), laboratory demonstration/hour (*p*-value= 0.66), small groups (tutorial or seminar)/hour (*p*-value= 0.08). The *p*-values of ANOVA test were not significant, suggesting that geographical distribution has no impact on these teaching trends (Appendix 6).

5.4.3 Clinical teaching trends:

Most of the schools commence clinical teaching and allow their students to provide treatment of patients with FPs in fourth year (13 schools, 52%). Nine schools commence this teaching in the third year (36%) (one of them has 4 year long programme) while only one school based in Saudi Arabia commences this teaching in the fifth year (4%) of five year long programme. However, 12 schools of these 23 have dedicated clinical sessions for instruction in the provision of crown and bridgework.

In the clinical sessions, the staff: student ratio ranged from 1:4 to 1:12 (mode 1:10), for the formal clinical lectures, the ratio ranged from 1:20 to 1:101 (mode 1:20), and for the small groups/tutorials ranged from 1:3 to 1:20 (mode 1:10). Eleven schools (out of 21 respondents) have paired teaching.

5.4.3.1 Impression techniques taught for recording the master impressions for FPs:

The most commonly taught to use impression technique for recording master impression of the crown and bridgework is “one step: medium bodies & light bodies wash in stock tray. More information is available in Table 5.9. In regard to cementation, the most cementation material taught to use for conventional FPs is the glass ionomer cement while the adhesive resin cement for cementation of resin-retained and all ceramic FPs. Further information reported in Table 5.10.

Table 5.9 Impression techniques for recording FPs master impression (crown & bridge)

Impression technique	Conventional	Resin-retained	All ceramic
Light bodied polyvinylsiloxane in a special tray	7	5	5
Medium bodied polyvinylsiloxane in a special tray	6	3	3
One step: Medium bodies & light bodies wash in stock tray	13	9	12
Two steps: Medium bodies & light bodies wash in stock tray	6	2	4
One step: Putty & wash polyvinylsiloxane in a stock tray	8	6	5
Two steps: Putty & wash polyvinylsiloxane in a stock tray	5	2	4
Polyether impression material	5	4	3

Table 5.10 List of cementation materials for crown & bridge in FPs course

Cementation material	Conventional	Resin-retained	All ceramic
Adhesive resin cement (e.g., Panavia F, Rely X)	**12**	**19**	**18**
Conventional resin cement (e.g., Calibra)	**9**	**2**	**10**
Glass ionomer cement (e.g., AquaCem)	**13**	**2**	**5**
Zinc oxide eugenol	**3**	**1**	**0**
Zinc phosphate	**8**	**0**	**1**
Zinc polycarboxylate	**4**	**0**	**0**

In the FPs clinical sessions, students encounter crown preparations first in their clinical work (16 schools out of respondents 23 schools), while students encounter crown and bridge together in another six schools. Students of one school encounter the bridgework before crowns during clinical sessions.

Moreover, 21 schools (respondents 23) taught their students the lab-work steps for FPs, although only four of these 21 schools require students to finish the lab-work for crown and bridgework. During lab-work sessions, technicians supervise students in three schools while clinicians supervise students in the remaining school.

Twenty-two dental schools require their students to communicate with lab technicians to follow-up the lab-work. Sixteen schools out of the 21 schools that taught their students the lab-work steps, their students gain experience at using CAD/CAM technology and students of 11 schools gain experience at using other digital workflow.

5.4.3.2 Supervising guidelines:

In the clinical sessions, the GDP (part-time teacher) has the highest supervising average (57%) followed by the senior lecturer (35%) and professor (33%). staff supervision contribution average is distributed as following:

- GDP (part-time teacher): 57%
- Senior lecturer: 35%
- Professor: 33%
- Lecturer: 31%
- Consultant: 24%
- Technician: 6%

Guidelines for supervising staff in undergraduate clinical FPs teaching is reported in 23 schools out of the 25 participant schools.

5.4.3.3 Clinical requirements:

Prior to graduation, the single porcelain fused to metal crown (PFM) is the most common prosthesis type provided by undergraduate students (mean: 5.08 within 22 schools). Details of what bridge type students have to provide patients as following:

- **Single porcelain fused to metal crown (PFM)**: ranged 1-12 (mean:5.08 in 22 schools)
- **Single full ceramic crown**: ranged 1-12 (mean:2.47 in 22 schools)
- **Composite/ porcelain veneer**: ranged 1-6 (mean:1.46 in 14 schools)
- **Conventional bridge replacing anterior teeth**: ranged 1-3 (mean:0.94 in 17 schools)
- **Conventional bridge replacing posterior teeth**: ranged 1-3 (mean:0.88 in 16 schools)
- **Conventional cantilever bridge**: mean 0.45 within 5 schools
- **Resin retained bridge replacing anterior teeth**: mean 0.75 within 9 schools
- **Resin retained bridge replacing posterior teeth**: mean 0.58 within 7 schools
- **Cantilever resin retained bridge**: ranged 1-4 (mean:1.07 in 9 schools)
- **All ceramic bridge replacing anterior teeth**: ranged 1-3 (mean:0.81 in 11 schools)
- **All ceramic bridge replacing posterior teeth**: ranged 1-3 (mean:0.64 in 7 schools)

Of these, 2-75% (mode:20%) are completed by using digital workflow among 22 dental schools of the respondents 25 school. When we asked the participants which of these fixed prosthesis types do you intend to begin teaching clinically over the next five years if it is not in the curriculum, the answers as following:

- **Single porcelain fused to metal crown (PFM)**: 1 school
- **Single full ceramic crown**: 1 school
- **Composite/ porcelain veneer**: 1 school
- **Conventional bridge replacing anterior teeth**: 1 school
- **Conventional bridge replacing posterior teeth**: 2 schools
- **Conventional cantilever bridge**: 2 schools
- **Resin retained bridge replacing anterior teeth**: 2 schools
- **Resin retained bridge replacing posterior teeth**: 1 school
- **Cantilever resin retained bridge**: 4 schools
- **All ceramic bridge replacing anterior teeth**: 2 schools
- **All ceramic bridge replacing posterior teeth**: 2 schools

Furthermore, 19 schools out of the 25 respondents have requirements for FPs that students must complete prior to graduation. Though, three schools reported that they do not have requirements while the remining school said: “the requirements are not absolute”. Details of the requirements in Table 5.11.

Table 5.11 Type of requirements for FPs that students must complete prior to graduation

Type of requirements
10 crowns any variety as a minimal and 2 RBB
2 units

10 units
At least 6 tooth-borne units. Can be anything
2 PFM crowns, 1 post and core, 3 conventional (PFM or ceramic) bridges
2 fixed prosthodontics patients with 2 complete fixed prosthesis
Post and core and crown
5 crowns of any description and 1 Bridge of any description
Crown competency - 3 crowns before doing competency test.
2 Ceramic Crowns manufactured via digital modality
As key skill assessment for clinical competency in RBB and crowns
A minimum of 2 single crowns, at least 2 bridgework, radicular restoration with final crown as final restoration, resin bonded cases, partial veneer if there is available cases.
12 units of crown and bridge
7 fixed prosthodontics need to be built
Clinical independent assessment
Own department criteria in line with GDC guidelines

Crosstabulation and Pearson Chi-square test were conducted to examine the geographical distribution impact on having requirements for FPs that students must complete prior to graduation (*p*-value= 0.709), dedicated hours for clinical sessions (*p*-value= 0.139), dedicated hours for formal lectures (*p*-value= 0.351) and the dedicated hours for small groups (*p*-value= 0.878). The *p*-values of Pearson Chi-square test were not significant, suggesting that geographical distribution has no impact on the assessed teaching trends (Appendix 6).

5.4.3.4 Using articulators and facebow:

Seventeen schools (23 respondent schools) taught their students that fully articulated casts are essential for treatment planning of the bridgework. Five schools do not require their students to do that while one school said that *"it is not essential but students advised to do so"*. In regard to facebow using, 13 schools let their students to use facebow routinely while five schools said *"no"* and the remaining seven schools did not respond to the question.

5.4.4 Clinical assessment trends:

During the FPs clinical sessions, the most used students' assessment method is the day-to-day observation and judgement (glance and mark) (22 schools). Also, fixed schedules of clinical requirement are used in 15 schools, tests based on observation and implicit judgement in 13 schools, self-assessment in eight schools and peer-assessment in four schools. Also, one school reported using Liftupp and another school reported that procedure of assessments based on grade sheet.

The responsible to assess students' clinical work and competence during the clinical sessions among 21 respondent schools were as follows:

- Professor (15 schools)
- Professor or GDP (part-time teacher) (14 schools)
- Senior lecturer/associate professor (13 schools)
- Consultant (10 schools)
- Lecturer (10 schools)

In addition, criterion-referenced assessment exercises in clinical FPs course is reported by 15 schools out of 22 respondents. The type of final clinical assessment as reported in Table 5.12.

Table 5.12 Type of final clinical assessment for FPs course prior to graduation

UK & Ireland
Gateway clinical competency. Part of finals
Variety of means continually assessed, knowledge based and clinical
Monitor the Liftupp data for competence progression and consistency of development index on liftupp
Clinical Competency and gate way exams in year 3 and 4 for crown and bridge
overall course behaviours
clinical targets and clinical grades/performance with staff feedback. Portfolio of clinical work submitted for assessment
Through assessing their development in this area as they progress & by going through the feedback provided by their tutors and assessing how they improved as a result of the feedback.
United States
Faculty meeting
Finishing the requirements with satisfactory level
Procedural requirements are met numerically. Part time faculty declare competency
Independent patient assessment, daily grades
Asia-Pacific
Clinical assessment
Clinical logbook and assessment sheets
Continuous assessment and key skill competency assessment
Saudi Arabia
Assessment based on rubrics
Final written exam and final clinical exam
The clinical work and presents case presentation and oral exam
Overall grades in the module
Completion of clinical requirements and written exam

5.4.4.1 Outreach teaching:

Twenty-three schools provide information for the outreach/community-based clinical teaching. Fifteen schools have a clinical outreach teaching programme while only ten of them included the completed FPs treated cases in the final students' assessment. Staff in the outreach centre employed by the same university in seven schools. Instead, they are:

- NHS/health sector employees in 6 schools.

- Private practitioners in 2 schools.
- Community Health Centre Employees (USA) in 1 school.

When the participants were asked; how they ensure that the staff in the outreach centres teach and assess FPs to the same standards as in the base dental schools, they answer as following:

- There are guidelines (7 schools).
- Regular teachers meeting (5 schools).
- Not sure (4 schools).
- Staff members from the school make regular visits to outreach centres to ensure being in-line with our standards (1 schools).

5.4.4.2 Learning outcome assessments:

Consistency in assessment of FPs is achieved by following guidelines in 23 schools out of 25 respondent schools. Clinical guidelines (12 schools), Regular teachers meeting (7schools), clinical handbook defining standards and every six weeks meeting to calibrate (1 school), teachers are calibrated on the use of Liftupp (1 school). Additionally, 11 schools out of 23 respondent schools think that the teaching of crown and bridge has stayed the same over the past five years. Conversely, nine schools think that this teaching increased while three schools believe it is decreased over the past five years.

Among 23 respondent schools, fifteen schools are satisfied that they adequately assess their students' competence in FPs prior to graduation. Seven schools are "mostly" satisfied while two schools are unsatisfied. One of the unsatisfied schools explained its response as follow; "*Students should be more expose in various cases from conventional to minimally invasive fixed restoration".*

Most of the schools believe that competence of students in FPs is better now compared to that of students who graduated 10 years ago (9 schools out of 23 respondents). One of these schools commented: "*I would say it improve because of the advanced technology, procedures are shortened and easy to find cases*".

Six schools believe that there is no change while five schools think it is worse now and three schools were not sure. One of those who were not sure commented:

"*This is controversial! You are comparing apples and oranges as there are fewer conventional FPDs and the students are different. I would say the ones now are the same or better*".

5.4.4.3 Perceived challenges to the teaching of FPs:

Participants were asked to indicate the main challenges that might encounter them in teaching FPs to undergraduate students over the next few years. Answers were as following:

- Increasing use of alternate technologies such CAD-CAM and implants (17 schools)
- Lack of suitable patients for students to treat (10 schools)
- Pressures on teaching time from other sources in the undergraduate curriculum (7 schools)
- Lack of adequately trained staff for teaching (5 schools)

- Lack of interest in traditional prosthodontics from school administration due to the fact that these procedures do not generate maximal clinical revenues (1 school)
- Lab cost, quality of lab support / work (1 school)
- Covid-19 (1 school)

At the end of the survey, participants were asked to write any further comments they might have in relation to students' FPs teaching and assessment. Comments were as following:

- "*Provision of fixed prosthodontics is not covered by Queensland Health (equivalent to NHS), hence is fee-based and available for private paying patients only".*
- *"The range of fixed prosthodontic treatment completed by each student is dependent on the patient mix that the student has available for them to treat".*
- *"There are general clinical targets in crown and bridge work. However, this is not prescriptive to types of crowns and bridges. Since the competence is transferable, they have to do 5 crowns of any description, including inlay/onlay. Any one bridge type is adequate. This is due to multiple factors such as case availability, patient safety, time availability etc. Demonstration time is included in the practical hands-on teaching. Impression (alginate) making, facebow transfer, RAP registration, and occlusal assessment are all taught as part of operative teaching. Prior to preclinical operative teaching, students are taught these so they can articulate an operative case to assess occlusion and plan treatment. Students spend considerable self-*

study hours to catch up on study materials uploaded as part of blended learning. The contents of these materials are assessed in formative and summative assessments".

- *"For final assessment they submit a log case that may include a FPD".*
- *"Teachers and students should be more adept in the technologies with regards to the fixed restoration".*

5.5 Discussion

Teaching of FPs in dental schools is considered to be one of the most important topics for students' practice after graduation [172]. Provision of such prostheses have reliable and predictable survival rates as well as being popular among patients. As well as this, there have been many innovations and refinements of clinical techniques in this area in recent years. In the presence of such reasons, novice dentists who recently graduated need to be well-prepared and capable to offer the best choice of treatment depending on their acquired knowledge and skills with the aid of available technologies. Whereas the results of this study demonstrated variations in teaching and assessment trends among dental schools, it also showed that some parts of FPs teaching are promising. In addition, variation in teaching and assessment trends or those promising teaching trends that noted in the present study were not subject to the geographical distribution.

All participating dental schools, except one, have a dedicated preclinical FPs course. Similar to a previous study [66], most of these schools commence the preclinical course during year 3 of the five year long programme. The average devoted teaching hours of the preclinical course is 70 hours which is two-folds and a half higher than the Lynch *et al.* study where the average was 19.4 hours [66].

However, the Lynch *et al.* study was based on UK and Ireland dental schools, while this present study considers a large number of schools from a wider geographic setting. These teaching hours divided to be one-third for the academic lectures (average 20.4 hours) and two-thirds for the practical skills teaching (average 55.3 hours). Of these hours, on average, 48 hours are devoted for the phantom-head teaching sessions. This finding might reflect the international focus on the practical skills teaching during FPs preclinical course.

Findings of this study also showed that the majority of the students' time during phantom-head sessions was spent on gaining experience on single crown and conventional bridge preparation (average of both 38 hours). While experiences such as veneer preparation or resin-bonded bridge having the lowest average of teaching (5 hours and 3.2 hours respectively). On the contrary to Lynch *et al.* findings that teaching of resin-bonded bridge has increased among UK and Irish dental schools [66], our findings suggested that this is not an international trend. It is well known that resin-retained bridges having a high rate of survival and offer many advantages over conventional bridges such as the avoidance of the iatrogenic damage associated with conventional bridge preparations [173]. Instead, results of this study showed that the most bridge type that students exercised most frequently during preclinical courses are porcelain fused to metal, all-ceramic and provisional bridges.

The results of this study indicate that most of the FPs clinical teaching course commence in year 4 of the five year long programme. It was surprisingly when two schools reported that this teaching is commenced during the final year of the programme. Also, less than 50% of the participating schools (12 schools) have a dedicated clinical course for FPs teaching. In addition, where professors are the most common preclinical course director, the clinical course is mostly directed by GDPs. These findings may raise concerns that undergraduate students do not have sufficient clinical practice to build adequate skills to become confident and comfortable with such procedures. They could also explain the low clinical requirement average (quota) among participating schools.

This survey indicates that each student on average completed 5.08 single PFM crowns, 2.47 full ceramic crowns among 23 schools. In regard to bridgework, each student completed, on average 1.07 cantilever resin-retained bridge which is the most commonly completed bridgework in clinical sessions among 13 schools. Lynch *et al.* reported that the average of the completed cantilever resin-retained bridge among Irish and the UK schools, which was also the most common provided bridge, was 0.84 in 2009 [65] and increased by two-folds in 2017 to be 1.67 [66]. Although low, our survey indicates that the completed conventional anterior bridge per students is 0.94 which is slightly higher than Lynch *et al.* findings (mean was 0.74 per student) [66].

The current survey shows that most of the participating dental schools taught their students the lab-work steps for FPs. Also, students of 16 schools (64%) are exposed to CAD/CAM technology and students of 11 schools (44%) gain experience on using other digital workflow. Offering of these teaching trends during undergraduate programme is a step in the right direction and comparable with the GDC recommendations that dentists on graduation should: " *recognise and evaluate the impact of new techniques and technologies in clinical practice*" [150]. Moreover, this survey found that teaching trends such as using articulator or facebow for treatment planning of bridgework are not routine for all students. Use of the articulator is routine among 17 schools (68% of participants schools) which is close to Lynch *et al.* findings (61% of participants) [66]. In contrast, Lynch *et al.* reported that all participant schools required their students to take a facebow record for mounting the maxillary cast [66], whereas our findings indicates that only 11 participating schools required this (44%).

This diversity is not confined to the teaching trends in FPs, assessments methods are also diverse among the surveyed schools. ninety-three percent of the surveyed schools (n=23) have a sit assessment at the end of the preclinical course, although the method of this assessment vary amongst them. Our results showed that written exam along with practical exam is the most commonly assessment sit. Similar to Lynch *et al.* findings [66], students' assessment prior them being allowed to provide crown and bridges in a clinical setting (gateway) was linked to assessments of the preparation of teeth to receive single crowns (84%, n=21) followed by teeth preparation for conventional bridge (64%, n=16). Additionally, most assessment methods in the clinical setting among the surveyed schools is day-to-day observation (glance and grade) followed by fixed schedule requirement.

Within these reported variation in FPs teaching and assessment trends, the majority of the surveyed schools were satisfied or mostly satisfied they adequately assessed their students' competence prior to graduation. Although, one of the two schools were unsatisfied its comment highlighted on a major concern that we reported to be low in this survey that students should be more exposed to minimally invasive fixed restoration. Moreover, most of the surveyed schools believed that students now are better than students who graduated 10 years ago (9 schools) and this is because of the advanced technology, procedures are shortened and easy to find cases as one of participants commented. It is not a surprise that current survey findings are comparable with Lynch *et al.* surveys that conducted in 2017 or 2009 [65, 66].

Participants in this survey believe that teaching of FPs either stayed the same over the past five years (11 schools) or increased (9 schools).

This study aimed to investigate the contemporary teaching and assessment trends in FPs amongst dental schools internationally. Twenty-five dental schools from eight countries participated which makes this study reflective of a wider perspective in undergraduate FPs education than previous similar studies. This current study shows that the international FPs teaching trends focused on the preclinical practical skills over the clinical teaching. Also, the integration of innovative technologies in the FPs programme curricula has been noted. Although clinical teaching considered to be low, the majority of the participants were satisfied with their students' competence on graduation.

It is believed that if certain forms of treatment are difficult to recruit for care in undergraduate dental student clinics, then such treatment can no longer be considered common to everyday clinical practice, and should not be a barrier to dental students graduating [66]. However, this study has some limitations need to be addressed. The response rate considered to be low, although, we sent three reminder emails after the initial email to encourage the non-respondents to participate. In addition, it should be noted that the survey was sent during COVID-19 pandemic which might explain the low response rate.

5.6 Conclusion

International discrepancy of undergraduate FPs teaching and assessment trends among dental schools was considerable. It was reported among both preclinical and clinical course of FPs, whereas the geographical distribution found to have no impact on this discrepancy. The variations also reported on how to evaluate students' competence in FPs prior to graduation. Although, consistency in assessment of FPs is mostly achieved by following clinical guidelines and using glance and grade. Minimally invasive treatments, integration of technologies and new teaching approaches, such as e-learning and engaging with community-based clinical teaching are to be encouraged. Future research to investigate recently graduated students' viewpoint will be helpful to understand their competence level in FPs.

Chapter 6. Undergraduate Dental Implants Curriculum: An International Study of Current Teaching and Assessment Methods

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6.1 Abstract

Objectives: The aim of this study was to investigate the current teaching and assessment methods of dental implants (DIs) among dental schools on an international basis.

Materials and methods: Questionnaire consisting of 46 questions (45 close-ended and 1 open-ended question) was set and structured by Using SurveyMonkey. The questionnaire was divided into preclinical teaching and assessment in DIs (27 questions) and clinical teaching and assessment in DIs (18 questions), The final question was an invitation for further comments and opinion. After receiving of a positive approval from the Social Research Ethics Committee (SREC) at University College Cork, Ireland (#2019-216), an email, including an invitation to participate in the study, along with a hyperlink to the survey, was sent to the senior clinical academic identified as being responsible for the teaching of DIs course in Spring 2020. Within 12 selected countries, 142 dental schools were invited to participate in this study.

Results: Twenty-two schools from eight countries participated. Twenty schools have dedicated a preclinical course. The preclinical teaching hours ranged from 2-80 hours. Practical skills teaching ranged from 0-40 hours, while the hands-on prosthetic training ranged from 3-75 hours. Eight dental schools have a clinical surgical course with a training ranging from 1-28 hours. Eleven schools have an assessment at the end of the preclinical course. Twelve schools have a dedicated clinical dental implants course which mostly commenced in year 5 except in one school where it commenced in year 2. Three (US-based) dental schools have clinical requirements before graduation for the dental implants. Four schools of the

12 school with a clinical course in dental implants expect their students to be competent in dental implants at graduation.

Conclusions: Significant variations in undergraduate dental implants teaching and assessment was seen on an international level. Such variation was reported at both preclinical and clinical courses. The majority of the surveyed schools did not have requirements or evaluate students’ competence in dental implants prior to graduation.

6.2 Introduction

Modern dental implant history started during World War II when Dr. Norman Goldberg experimented with the use of metals that were used to restore other body parts. In 1948, he and Dr. Aaron Gershkoff developed the first successful subperiosteal implant [174]. This success formed the foundation for implant dentistry, which they were pioneers in teaching in dental schools worldwide [174]. Studying bone healing and regeneration in 1957 by Per-Ingvar Brånemark, discovered that bone can grow in proximity to Titanium. Also, he noticed that bone can be effectively attached to that material without being rejected. This discovery led to the development of the concept of osseointegration [174]. Over the past century, various techniques and materials have been used to improve the quality and anchorage of dental implants. After the mid-1980s, further developments in dental implantology were focused on the aesthetic restorations. Nowadays, about 450,000 osseointegrated dental implants are being placed every year, with an expectation of 95% success rate (in the case of single tooth replacement with an implant supported crown), with minimum related complications [175].

This explosion in new knowledge has presented significant challenges to the training of dentists, in addition, these breakthroughs do not rapidly enter educational curricula. Combination of appropriate medical training for dental professionals and increased competence in managing patients with systemic implications, with competence in the newest technological developments in prosthodontics dentistry are essential [176]. Dental implant therapy is the clearest example of such combination [177]. Dental implant treatment procedures have become more predictable, efficient, and cost-effective, also, implant therapy reaches a growing part of the population as an important treatment alternative in reconstructive dentistry [116, 178]. Therefore, dental schools must make sure that students acquire the necessary knowledge and clinical competence required to be capable of operating a general dental practice independently, without any supervision but with recognition of their limitations [179]. However, dental implant therapy is not currently taught fully in dental schools ,and therefore both old and new graduates may not be sufficiently competent in these emerging technologies and biomedical applications [176].

In 2009 when the British Society for the Study of Prosthetic Dentistry's (BSSPD) education group met at the 56th Annual Conference in York. After discussion they felt that implant therapy should be taught as a core item within treatment planning for replacing missing teeth and especially where conventional treatment modalities had failed or were inappropriate [72]. Four years later, in 2013, Ucer *et al.* conducted a survey-based study among 24 European countries including UK and Turkey. They found that 73% of the respondents (66% excluding Turkey and the UK) did not think that newly graduated dentists acquired the necessary surgical skills in the undergraduate curriculum to provide straightforward surgical implant treatment. However, 41% (54% excluding Turkey and the UK) indicated that newly graduated dentists obtained skills during their undergraduate education to treat straightforward prosthodontic case. Also, a small minority of the surveyed experts think that newly graduated dentist gained adequate clinical skills needed to provide surgical (5%) or prosthodontic implant treatment (8%) in advanced or complex cases [180].

Restoration of oral function and chewing comfort, preservation of dental tissues and reconstructions and the replacement of missing teeth are the main indications for implant therapy [181]. Therefore, dentists require the necessary skills for delivering and maintaining implant retained prostheses. Without gaining this knowledge and clinical skills in dental implant treatment, which is of fundamental importance, dentists will be incompetent in implant therapy. There is much advantage in developing this teaching within the undergraduate programme: including laboratory, preclinical and clinical skills [72]. If such teaching is included, the challenge becomes how these skills are assessed. The aim of this study was to investigate the current teaching and assessment methods of dental implants among dental schools in different selected countries.

6.3 Materials and methods

A questionnaire consisting of 46 questions (45 close-ended and 1 open-ended question) was set and structured by Using SurveyMonkey (Appendix 7). After receiving of a positive approval from the Social Research Ethics Committee (SREC) at University College Cork, Ireland (#2019-216), an email, including an invitation to participate in the study, along with a hyperlink to the survey, was sent to the senior clinical academic identified as being responsible for the teaching of DIs course in Spring 2020. Within 12 selected countries, 142 dental schools were invited to participate in this study (Ireland, United Kingdom (UK), United States (US), Canada, Australia, New Zealand, Norway, Sweden, Denmark, Germany, Hong Kong and Saudi Arabia). It was requested that if the person who received the e-mail was not the most suitable person in the institution that they would forward it to the more appropriate person. The questionnaire was divided into two sections: the first dealing with the preclinical teaching and assessment in DIs (27 questions), and the second section dealing with the clinical teaching and assessment in DIs (18 questions). The initial e-mail was followed up by a second e-mail four weeks later to those who had not responded, and this was followed up about three weeks later by a third e-mail to those who had still not replied. A final fourth reminder e-mail sent 10 weeks later to encourage the non-respondent schools to participate. Recipients were assured of anonymity for them and their institution in any resulting publication. Moreover, to assess the effect of the geographical distribution on DIs teaching and assessment, we categorized the participated countries into five geographical groups. These groups as following: UK/ Ireland, Europe, US, Asia-pacific and Saudi Arabia. We used one-way analysis of variance (ANOVA) to examine the mean differences in continuous variables across the geographical area, whereas chi-square test was used for categorical variables. All analyses were conducted using IBM SPSS Statistics software (version 26, 2019) and the *p*-value <0.05 was considered to be statistically significant.

6.4 Results

6.4.1 Preclinical teaching trends:

Out of 142 invited dental schools from 12 countries, 22 dental schools representing eight countries responded (response rate = 15%). The geographical distribution of received responses were from UK, Ireland, Germany, Saudi Arabia, US, Australia, New Zealand and Hong Kong. Twenty dental schools out of the 22 participants, have a dedicated preclinical course in teaching DIs. The remaining two dental schools are integrating this teaching with other courses. Also, these two schools are from different geographical area. Most of the respondent schools commence this teaching during year 3 (8 schools) and during year 4 (6 schools). Also, two schools commence this course during year 2 and four schools during year 5 of five years long programme. The average devoted teaching hours received by each student is 28 hours and 30 minutes. It ranged from 2 hours in one school up to 80 hours within two schools (mode: 20 hours among 3 schools). The dedicated teaching/academic hours ranged from 2-60 hours (mean: 15.5 hours). These academic hours are divided as shown in Table 6.1. The allocated hands on/practical skills hours ranged from 0-40 hours (mean: 13.25 hours).

Table 6.1 Distribution of academic/didactic teaching in preclinical DIs course

	N	Minimum	Maximum	Mean
Formal lectures/hour:	19	1	40	12.15
Laboratory demonstrations/hour:	14	0	75	8.78
Small groups, tutorials or seminars/hour:	10	0	10	5.60
Other/hour*:	4	0	25	14.00

*Such as: 1- Simulation combined with lab demonstrations. 2- Digital Implant Planning 3- Individual simulation lab exercises. 4- A phantom head course in year 3 and then teaching as part of prosthodontics but not specific.

The staff: student ratio for preclinical course in DIs for formal lectures ranged from 1:5 to 1:107 (mode: 1: 100 and 1: 150); laboratory demonstrations ranged from 4:10 to 1:75 (mode: 1:10); and small groups/tutorial ranged from 1:3 to 1:75 (mode: 1:10). Forty percent of the schools (n=9) reported that the course is directed by senior lecturer/associate followed by professor (36%; n=8). Table 6.2 shows who is/are responsible for directing the preclinical teaching in DIs course.

Table 6.2 Member of staff who is/are responsible for directing the preclinical teaching in DIs course

	Number of schools	Percentage (%)
Senior lecturer/associate professor	9	40.9
Professor	8	36.4
Consultant	4	18.2

Lecturer	4	18.2
GDP (part-time lecturer)	2	9.0
Technician	1	4.5
GDP (full-time lecturer)	1	4.5
Different implant systems are presented by the representatives	1	4.5

Hands-on prosthetic training sessions in relation to DIs is included in seventeen participating schools (77.3%) while three schools do not have this training and two schools did not respond to the question. The average devoted training hours received by each student among these seventeen schools is 20.24 hours, ranging from 3-75 hours (mode: 3 hours). During these training sessions, the staff: student ratio ranged from 1:6 to 1:75 (mode: 1:10 among 4 schools).

The most common experiences gained by students was impression making (n=19) followed by identification of prosthetic components of dental implants (n=17). Fifty-nine percent of the participant schools (n=13) teach their students how to select the correct DIs abutments and fit the completed implant retained prosthesis during the hands-on sessions. Table 6.3 shows details regarding the experience that is gained by students during DIs hands-on sessions. Clinicians are responsible for supervising students during these experiences among 19 schools while technicians supervise students within the remaining three schools. Additionally, these experiences are commonly provided in the form of formal lectures, laboratory demonstrations or small groups/tutorial sessions Table 6.4 for more details.

Table 6.3 List of experiences that gained by students during hands-on practical sessions in preclinical DIs course

	Number of schools	Percentage (%)
Impression technique for dental implants	19	86.4
Recognition of prosthetic parts of dental implants	17	77.3
How to select the correct dental implants abutments	13	59.1
How to insert the final prosthesis for dental implants	13	59.1

Table 6.4 Form of hands-on training sessions teaching in preclinical DIs course

	Number of schools	Percentage (%)
Formal lectures	14	63.6
Laboratory demonstration	14	63.6
Small groups/ tutorial	10	45.5
Individual simulation laboratory exercises	3	13.5
Videos, Digital implant planning experiences	1	4.5

Dental implant systems taught during the undergraduate hands-on training sessions are reported in Table 6.5. The most common used system is the Straumann followed by Nobel BioCare. One respondent school commented “We *have historically used Nobel BioCare but we are re-working the course and may use a different system. However, we try to keep the course "system agnostic" and focus on general concepts”.*

Table 6.5 List of used DIs systems during hands-on training sessions in preclinical DIs course

	Number of schools	Percentage (%)
Straumann	9	40.9
Nobel BioCare	8	36.3
Astra Tech	7	77.3
Zimmer Biomet	3	31.8
Biomet 3i	1	4.5

During preclinical course, eight schools out of the 22 participants have a preclinical surgical course. This teaching mostly takes the form of formal lectures (7 schools) and/or laboratory demonstration (4 schools). It is also provided during small groups/ tutorial (3 schools) or as a simulation lab exercise (3 schools). The average devoted training hours received by each student during this preclinical surgical course ranged from 1 hour to 28 hours (mode: 3 hours). Table 6.6 shows who is responsible for supervising students during this teaching.

Table 6.6 Member of staff who is/are responsible for supervising students during surgical teaching sessions in preclinical DIs course

	Number of schools
Prosthodontic faculty	3
Periodontics faculty	2
Oral Surgeons	1
Implant company representative and clinician	1

6.4.2 Preclinical assessment trends:

Students are required to sit an assessment at the end of the DIs pre-clinical course in 11 dental schools out of the 22 participating dental schools. Another eight schools do not require students to sit an assessment while the remaining three schools did not answer this question. The 11 dental schools that have a preclinical assessment, assign clinicians to supervise it. The methods of the preclinical assessment include:

- Written exam (6 schools)
- Practical/gateway exam (4 schools)
- MCQ exam (1 school)
- OSCE (1 school)

Where multiple assessors undertook this assessment, standardisation of the assessments was undertaken in all schools. In the case of failure in the preclinical assessments, seven schools required their students to re-sit the assessment exam. Students in two schools cannot provide clinical procedures unless they pass the preclinical assessment while nothing is required from failed students in one school. Moreover, when participating schools were asked how they ensure their students are ready to undertake implant cases in the clinic, eight schools comment as reported in Table 6.7.

Table 6.7 Measurement of students' readiness prior to commencing DIs clinical course

UK and Ireland
Students would require extra postgraduate qualifications and mentored experience to undertake implant cases in clinics.
Students do not undertake implant treatments on clinic, only simulation in the skills lab.
Asia-Pacific
Complete the practice and lecturer components of the course.
No clinical exercise.
NIL - students are required to assist postgraduate students and that is the sole exposure to live implant placement and restoration. All other training is simulated.
Saudi Arabia
No clinical course.
United States
Simulated implant competency in 3rd year.
They must pass the preclinical course.
The students are exposed and restore dental implants in the 3rd and 4th year. In Year 3, single units, over dentures, and implant retained RPD. In year 4th, multiple units restoration and over dentures.
Our implant curriculum is actually 3 different courses and they need to pass the first two.
Successful completion of the Implant Course.
Passing grade in course.
Successful completion of the preclinical implant coursework.

Textbooks and reading materials that recommended for undergraduate teaching of DIs are reported in Table 6.8. The most recommended textbook was Carl E Misch "Contemporary implant dentistry" and "Dental Implants prosthetic".

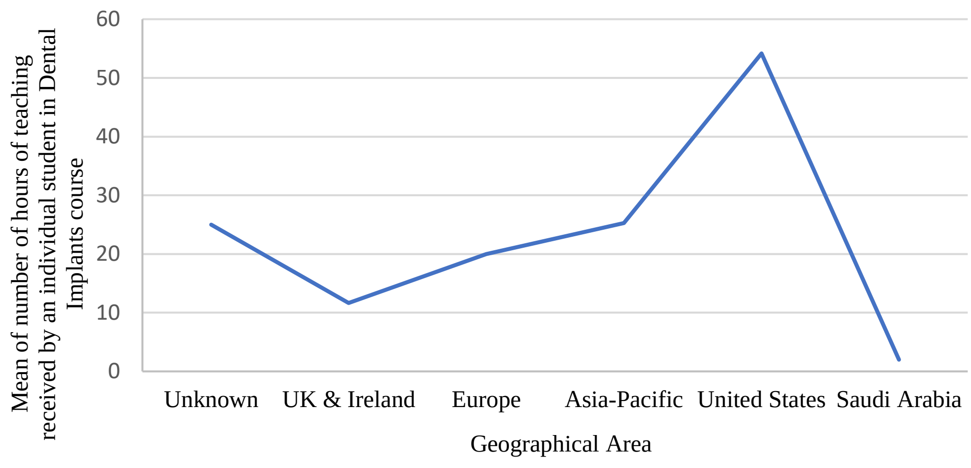
Table 6.8 Recommended textbooks and reading materials for student in DIs teaching (12 respondents)

Textbook	**Number of schools**
Carl E Misch "Contemporary implant dentistry, 3rd Edition (2008) Elsevier Mosby Publishers, US"	4
Carl E Misch "Dental Implants prosthetic, 2nd Edition (2014) Elsevier Mosby Publishers, US"	4
Directed articles from journals: Updated literature and classic articles from Journal of Prosthodontics, Journal of Prosthetic Dentistry, Periodontology 2000, Clinical Oral Implants Research, Clinical Implant Dentistry and Related Research, Journal of Dental Research	4
German Gallucci *et al.* "ITI Treatment Guide, 1st Edition (2019) Quintessence Publishing Co.".	2
Richard M. Palmer *et al.* "Implants in Clinical Dentistry, 2nd Edition (2011) CRC Publisher".	2
Evidence Based Plenaries.	1
Gerard Byrne "Fundamentals of Implant Dentistry, 1st Edition (2014) Wiley-Blackwell Publishers".	1
Jacques Malet "Implant Dentistry at a Glance, 2nd Edition (2018) Wiley-Blackwell Publishers".	1
Per-Ingvar Branemark *et al*. "Tissue Integrated Prosthesis Osseointegration in Implant Dentistry (1985), Quintessence Publishing Co.".	1
Philip Worthington *et al.* "Osseointegration in Dentistry: An Overview 2nd Edition (2003) Quintessence Publishing Co.".	1
University lectures and presentations.	1

One-way ANOVA test was conducted to assess the impact of the geographical distribution on average number of hours of teaching received by an individual student in the DIs course. The *p*-value of ANOVA test was significant (p= 0.008), suggesting that geographical distribution has an impact on the average DIs teaching hours Figure 6.1. Additionally, the formal lecture/hour *p*-value of ANOVA test was also significant (p= 0.03) (Appendix 8).

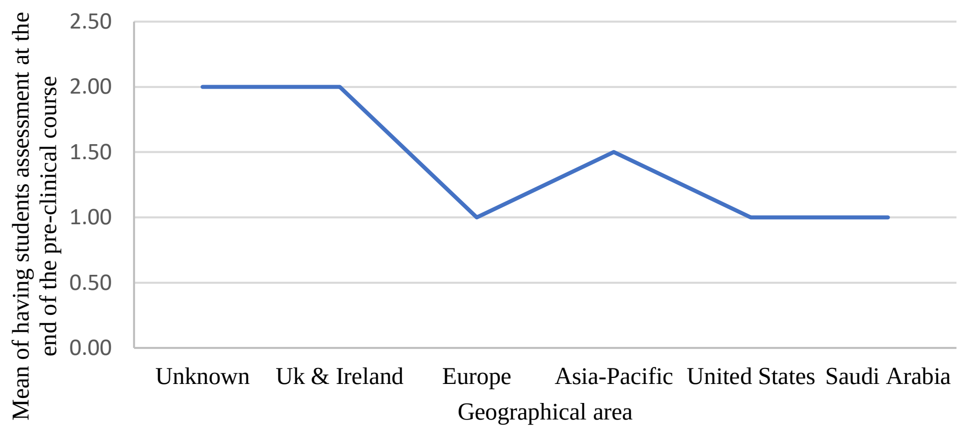
Although the academic dedicated teaching/hour (p= 0.14), hands-on (practical skills)/hour (p=0.01), laboratory demonstration/hour (p= 0.83), small groups (tutorial or seminar)/hour (p= 0.45) *p*-values of ANOVA test were not significant, suggesting that geographical distribution has no impact on these teaching trends (Appendix 8).

Figure 6.1 Average hours of undergraduate dental implants teaching across different geographical area



Also, it was statistically significant when ANOVA test used to examine the impact of the geographical distribution on having students assessment at the end of the preclinical DIs course (*p*-value= 0.001) Figure 6.2 (Appendix 8).

Figure 6.2 Average of having students' assessment at the end of the pre-clinical dental implants course across geographical area



<u>6.4.3 Clinical teaching trends:</u>

Fifty-four percent of the participating dental schools (n=12) have a dedicated clinical course in DIs for undergraduate students. Most of these schools commence this clinical teaching in year 5 (5 schools). Four schools commence this teaching in the year 3, two schools in year 4 while only one school commences this teaching in year 2 of five-year long programme. During the clinical course, prosthetic and surgical teaching sessions are provided among eight schools. Three schools provide the prosthetic teaching sessions whereas one school provides the surgical teaching sessions only. For those schools providing the prosthetic teaching, students are mostly supervised by clinicians except in one school a technician supervises them. Supervising staff during the clinical sessions are listed in Table 6.9.

Table 6.9 Member of staff who supervise students during DIs clinical sessions (9 schools)

Member of staff	Number of schools
Clinicians	3
Periodontist and Oral Surgeon	2
Periodontics faculty	1
Periodontics, Oral Surgery and Prosthodontics trained in oral surgery, implant dentistry or with dual degree perio-prostho	1
Professor	1
The surgical course is a "selective" for interested students and is supervised by surgically competent general dentists.	1

In the clinical sessions, students commonly assisted or observed the clinician Table 6.10. The staff: student ratio in the prosthetic sessions ranged from 1:2 to 1:75 (mode 1:8). Likewise, staff: student ratio in the clinical sessions ranged from 1:1 to 1:75 (mode 1:4).

Table 6.10 Type of students' clinical work during surgical sessions in DIs course (9 schools)

Students' clinical work	Number of schools
Assisting only	3
Inserting dental implants under supervision	2
Observation only	2
Observing and assisting	1
There is a variety	1

6.4.3.1 Clinical requirements:

Prior to graduation, only three dental schools have requirements for DIs that students must complete. In addition, these three schools are located in the US and their requirements are as following:

- Restoration of one implant case and 3 assist/observations of surgery or prosthetics.
- There is a cumulative number of implant restorations: Single implant crowns:4 or more, Implant bridges:1 or more and implant over denture: 2 or more.
- They have to have a certain number of implant clinic hours (i.e., certain number of procedures) and they need to pass a clinical competency.

Crosstabulation and Pearson Chi-square test were conducted to examine the geographical distribution impact on having requirements for DIs that students must complete prior to graduation (*p*-value= 0.342) and if students have a final assessment exam before graduation (*p*-value= 0.767). The *p*-values of Pearson Chi-square test were not significant, suggesting that geographical distribution has no impact on the assessed teaching trends. Although, Crosstabulation and Pearson Chi-square test were also conducted to examine the geographical distribution impact on having a dedicated clinical course in DIs for undergraduate students. The result was statistically significant (*p*-value=0.049), suggesting that geographical distribution has an impact on having undergraduate clinical course in DIs (Appendix 8).

6.4.4 Clinical assessment trends:

During the DIs clinical sessions, the most used students' assessment method is the day-to-day observation and judgement (glance and mark) (9 schools). Also, self-assessment is used in five schools, tests based on observation and implicit judgement in three schools and fixed schedules of clinical requirement are used in two schools. Peer-assessment is used in one school, knowledge-based assessment in one school and OSCE with school-based assessment (SBA) in one school.

Responsibility for assessment of students' clinical work and competence during the clinical sessions among 12 respondent schools were as follows:

- Professor (10 schools)
- Senior lecturer/associate professor (4 schools)
- GDP (part-time teacher) (3 schools)
- Consultant (2 schools)
- Lecturer (1 school)

In addition, criterion-referenced assessment exercises in clinical DIs course is reported by six schools out of these 12 schools which have clinical teaching sessions. The type of final clinical assessment is reported in Table 6.11. Instead, three schools that do not have this final assessment exercise commented:

- "*We do not have a dental implant competency for students to graduate although we are examining this".*
- *"We use clinical assessment in clinic".*
- *"We impart knowledge required to be safe beginner".*

Table 6.11 Type of final clinical assessment for DIs course prior to graduation

UK & Ireland
Assessments mapped to Preparing for Practice GDC outcomes
United States
OSCE exam
They must pass the final exam
The student must have passed the Implantology course in the 3rd year. The student should have completed the minimal requirements for single implant restorations, implant bridges and over dentures
They all have to pass an implant competency clinical examination
Asia-Pacific
OSCA and paper assessment

6.4.4.1 Learning outcome assessments:

Consistency in assessment of DIs is achieved by following guidelines in seven schools out of 12 respondent schools. Regular teachers meeting (2 schools), standard setting of Hofstee-Angoff method (1 school), peer reviewed and mapped to Preparing for Practice GDC outcome (1 school) while the remaining school were not sure. Among 22 respondent schools, five schools are "mostly" satisfied that they adequately assess their students' competence in DIs prior to graduation. Four schools are satisfied while two schools are not sure, and another two schools are unsatisfied. One of the satisfied schools explained its response as "*in respect to GDC Preparing for Practice in 2015".*

However, four schools out of the 12 schools that have clinical DIs teaching consider their students competent in DIs at graduation. Seven schools consider their students not competent while the remaining school is not sure. One school with competent students commented:

- "*Competent at level of safe beginner i.e., monitoring, implants as treatment option, appropriate referral*".

Schools with incompetent students commented:

- "*Their education in dental implants is a basic course. Competency requires additional learning and practice*".
- "*Most students are competent in restoration of single unit restorations, and many in implant overdentures. But I cannot say all students are competent in these clinical treatments as it is not required*".
- "*Graduates wishing to undertake dental implants will require mentoring and postgraduate training after qualification*".

Also, two schools that did not answer this question commented:

- "*Students are competent in basic restorative only".*
- *"Students are informed that they are incompetent in dental implants".*

Moreover, ten schools out of 14 respondent schools believe that competence of students in DIs is better now compared to that of students who graduated 10 years ago. One school believe that there is no change while another school think it is worse now due to lack of faculty. Also, two schools were not sure and one of them commented: "*That may not be necessarily relevant to the undergraduate curriculum".*

6.4.4.2 Perceived challenges to the teaching of DIs:

Participants were asked to indicate the main challenges that might encounter them in teaching DIs to undergraduate students over the next few years. Answers were as following:

- Pressures on teaching time from other sources in the undergraduate curriculum (10 schools)
- Lack of adequately trained staff for teaching (7 schools)
- Lack of suitable patients for students to treat (6 schools)
- Lack of the financial resources (5 schools)
- Difficulties of maintain non-bias, students are not equipped with adequate basic prosthodontics and surgical skills (1 school)
- Lack of suitable references for undergraduate courses (1 school)
- GDC and NHS limitations (1 school)
- Implant dentistry training differ slightly in oral surgery, periodontics and prosthodontics. The students receive variable feedback from different specialties. The patients must be spread within all the programs including general practice residency, oral surgery residency, periodontics residency, prosthodontics residency for the surgical part. For the prosthetic phase patients are spread in GPR, Prosthodontics, ant years 3rd and 4th (1 school)
- Undergraduates should be safe beginners so equipped with knowledge on implants as an option and when to refer appropriately (1 school).

At the end of the survey, participants were asked to write any further comments they might have in relation to students' DIs teaching and assessment. Comments were as following:

- "*We comply with all elements of GDC Preparing for Practice".*
- *"I don't believe there is a way to conduct the course so that graduate students are ready to place and restore implants confidently. There are so*

many clinical scenarios (even with single implant) that we won't have the time to cover".

- *"Previously, students restored single dental implants as part of their undergraduate curriculum. This was discontinued due to significant resource issues".*

6.5 Discussion

Results of this study have shown that while the majority of the participating schools (20 schools; 91%) have a dedicated preclinical course of dental implants, the average spent teaching time was widely divergent ranging from 2-80 hours. Also, the practical skills teaching range was from 0-40 hours while the hands-on prosthetic training range was from 3-75 hours. In addition, only one-third of schools have preclinical surgical course with training ranged from 1-28 hours. The most required textbooks used were Misch's "Dental Implant Prosthesis" and "Contemporary Implant Dentistry" perhaps due to its step-by-step guidance, and this is consistent with previously conducted surveys [67, 69]. This study results also have shown that 55% of the participating schools have dedicated clinical course of dental implants and only 25% (3 schools) of them have requirements that students must complete prior to graduation.

Similarly, Afsharzand *et al.* conducted a survey among the European universities in 2005 to investigate the undergraduate implant dentistry course curricular structure, teaching philosophies and materials. They reported that 80% of the responding schools have a course in implant dentistry and 87% of the schools have some prosthodontics teaching. Also, they found 37% of schools are offering a laboratory course in conjunction with the implant course while 63% of the schools are not restoring implant cases at the undergraduate level. In addition, only 10% of schools had implant-related laboratory work requirements that should be completed by their students [69].

Within the US and Canadian dental schools, a survey-based study in 2004 reported that the majority of the schools (97 %) offer at least some didactic instruction in dental implants. The survey demonstrated that implant dentistry domain in the US dental schools has steadily increased from 33 % in 1974, 84 % in 2002 to 97% in 2004 [69, 182]. In addition, the majority of the schools (86 %) offered their students clinical experience in restoring dental implants but did not include it as a graduation requirement [182]. In comparison to what we found in this study, the average number of teaching hours and assessment at the end of the preclinical course were with the highest average in the US universities compared to other geographical area. In contrast, we found that some US dental schools have requirements for dental implants that students must complete prior to graduation.

A study by Koole *et al.* (2013) investigated the status of the teaching of implant dentistry amongst European universities. They found that from 2009 the average time spent on implant dentistry in the undergraduate curriculum increased from 36 hours to 74 hours. This teaching of implant dentistry was mostly orientated towards theoretical education. Also, the instructional methods were evolving to a mainly combined approach of theoretical and preclinical teaching. Participated academics in this study acknowledged the ability of adequately trained general dentists to undertake simple and straightforward implant treatments, although, complex treatments remain the domain of specialists.

Whereas a previous study conducted in 2008 to investigate the undergraduate dental implants teaching in UK and Ireland reported that dental implant education in UK and Ireland undergraduate programmes, the situation is still somewhat behind the level being provided in schools in the US and Canada [70]. Moreover, their results indicated that in some schools, educational practices were falling behind what is recommended by the UK General Dental Council [70]. Another survey also conducted during 2008 showed that undergraduate implant dentistry in educational program is rapidly increasing in Asia, South America and Africa, while the amount of hands-on course is higher in North America and Europe than in Asia, South America and Africa [67].

A more recent study assessed the perspectives of novices, clinical educators, and experienced dentists with regard to the importance of theoretical and practical implant dentistry teaching content in undergraduate dental education. The study revealed that undergraduate students and novice dentists preferred a comprehensive undergraduate education that included implant dentistry. In contrast, dentists working in private practice, and especially dentists working as university educators, were critical towards the integration of implant-related learning content into undergraduate education [183].

To keep up with the Association of Dental Education in Europe (ADEE) and the General Dental Council (GDC) recommendations [150, 151], universities face the challenge to develop and implement implant dentistry education at all levels to prepare dental professionals with sufficient competences to fulfil the patient demands and treatment needs of today [71]. Converting dental students into competent and skilful dental practitioners needs the education programme to follow the pace of innovations and remains well-adjusted with everyday professional practice [184]. Dental education has to keep an eye on clinical practice and integrate any new developments in the domain of dentistry to stay relevant. Hence, the dental implant has been found to be increasingly integrated into undergraduate curricula. However, challenges remain in developing strategies to implement existing competence profiles and the extent of experience-based education [185]. Also, the constant improvement in implant materials, surgical protocols and prosthetic techniques has made implant therapy a valuable and predictable treatment alternative in reconstructive dentistry [178].

6.6 Conclusion

The international difference in undergraduate dental implants teaching and assessment trends among dental schools was obvious between different schools. It was reported among both preclinical and clinical courses of the dental implants domain. Additionally, the geographical distribution was found to have impact on the average number of teaching hours and on having an assessment at the end of the preclinical course. The majority of the surveyed schools did not have requirements or evaluate students' competence prior to graduation. Although, consistency in assessment of dental implants is mainly achieved by following clinical guidelines and using glance and grade.

It has been more than two decades since the Declaration of La Sorbonne which called for the harmonization of higher education qualification systems in Europe and worldwide [4]. Thus, challenges that prevent dental schools from accommodating the dental implants domain in the undergraduate curriculum must be resolved. Is it the lack of an adequately trained faculty, insufficient time in an already overfilled dental school curriculum, or limited financial resources? Nowadays, many specialists have been trained; thus, it should not be an issue. Other challenges are considering dental implants as a postgraduate domain or the unwillingness to modify the dental school traditional curriculum to accommodate dental implant education. This study has limitations need to be addressed, the response rate considered to be low, although, three reminder emails were sent after the initial email to encourage the non-respondents to participate. However, it should be noted that this survey was sent during COVID-19 pandemic which might explain the low response rate.

CHAPTER 7: Undergraduate Teaching and Assessment Methods in Prosthodontics Curriculum: An International Delphi Survey

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Published in: *Journal of Dentistry (J.Dent)*, August 2022

https://doi.org/10.1016/j.jdent.2022.104207

(Paper 1)

7.1 Abstract

Objectives: To achieve consensus amongst an expert panel of prosthodontics/restorative dentistry academics on the best undergraduate teaching and assessments, and to develop recommendations regarding teaching and assessment of undergraduate prosthodontics.

Methods: Semi-structured electronic questionnaires were used to collect data from senior clinical academics involved in the teaching of prosthodontics on three consecutive occasions (Delphi method). The questionnaires asked the experts' opinion on best teaching and assessment methods in the undergraduate prosthodontics curriculum. Invitation emails, with a hyperlink to the Round 1 questionnaire, were sent to 36 international dental academic experts. In later rounds, panellists were invited to consider their previous responses in light of the overall group response in attempt to bring the panel to a consensus. The group response was summarized using simple descriptive statistics, and the target level of consensus for each question was set at ≥ 70%. A response rate of at least 70% between rounds was deemed appropriate to maintain rigour.

Results: Twenty-three senior academic experts from eleven countries agreed to participate. Eighteen (representing nine different countries) completed the questionnaires in its entirety (response rate 78.3%). The number of statements that attained consensus agreement was much higher than the number of non-consensus statements—92.6%, 175 statements out of 189 over three iterative rounds. Only 14 statements did not obtain a consensus during this Delphi study.

Conclusions: A total of 175 consensus statements represent the agreement expert views of participated senior academics in prosthodontics from nine different

countries and across four continents. These consensus statements could be considered detailed guidelines and recommendations to improve future undergraduates’ curriculum in prosthodontics.

7.2 Introduction

Dental schools' undergraduate curricula include a range of disciplines that often start with the teaching of basic sciences and conclude with more focussed clinical scientific topics. Prosthodontics is one of the main dental sciences in the undergraduate curriculum and is defined as "*the dental specialty pertaining to the diagnosis, treatment planning, rehabilitation and maintenance of the oral function, comfort, appearance and health of patients with clinical conditions associated with missing or deficient teeth or oral and maxillofacial tissues using biocompatible substitutes*" [186]. It has four disciplines namely: Complete Dentures (CD), Removable Partial Dentures (RPD), Fixed Prosthodontics (FP) and Dental Implants (DI).

A dental school's optimal goal is to have at graduation, qualified, skilful and safe practitioner dentists. Thus, undergraduate curricula have to ensure that students gain the required experience in preclinical and clinical settings in order to realistically achieve a level of competence at the time of graduation [136]. However, keeping and enhancing the acquired level of competence in clinical dental practice depends on a habit of lifelong learning [136]. A review of the literature shows a divergence in approach to teaching and assessment of the dental curricula among dental schools in the same country and among dental schools internationally [53, 63, 65]. Prosthodontics and the teaching and assessment of its four disciplines are not an exception of this divergence [48, 60, 65, 66, 71, 158].

Generally, competence is a combination of context and underlying attributes including knowledge, skills, attitude and performance [127]. In dentistry, competence is defined as the basic level of professional behaviours and skills required by graduating dentists in order to respond to the full range of circumstances encountered in general professional practice [138]. Dental education is a complex area because the development of clinical competence requires the assimilation of knowledge combined with the acquisition of clinical skills and problem-solving ability [129].

Therefore, the importance of delivering quality teaching to future dental practitioners will guarantee patient safety - the golden practice principle “do no harm” [3]. Additionally, assessments in dental schools should be tailored to assess undergraduate students against all required learning outcomes. They should be designed to evaluate students' level of attainment of knowledge, behaviours, or skills [102]. Assessments are also usually the main focus for students, and the driving force for them to engage in the learning process. Thus, it is recommended that “*assessment processes should be rigorous, appropriate and reliable as a gateway for dental graduates to become qualified to practise independently*” [102].

Assessments can be summative or formative; summative assessments are designed to evaluate knowledge and provide formal recognition that usually happens at the end of a course or unit and is often used to determine student progression. Formative assessments are used as a diagnostic tool to provide feedback about the student’s progression and competence [103]. If an assessment method is reliable, then the same results should occur regardless of who administers it and when. Nevertheless, the subjectivity associated with evaluation by assessors (teachers/staff) can affect the reliability and credibility of the assessment process [102].

The divergence in dental undergraduate curricula as previously reported [48, 60, 65, 66, 71, 158], affects students’ gained knowledge and skills, and creates a gap between future dentists and dental treatments provided in clinical practice.

Therefore, the General Dental Council (GDC) of each country typically set out guidelines and requirements which are expected to be followed by registered dental professionals, and the dental school's role is to design curricula that fulfil these requirements [150]. Furthermore, the Association for Dental Education in Europe (ADEE) lays a well-justified and harmonized basis for training high-quality dentists by promoting convergence towards a higher standard of dental education, training and service to the ultimate benefit of the patients. Then, in 2017 the ADEE called for further refinement and harmonization of the dental undergraduate curricula across Europe, which also can be applied globally [151].

Therefore, there is a need to investigate the undergraduate prosthodontics curriculum and attempt to minimize the national and international divergence in teaching and assessment methods. This study aims to survey and elicit the opinions of senior academics in prosthodontics/ restorative dentistry on an international basis, to achieve consensus on the most suitable undergraduate teaching and assessment methods to be employed in prosthodontics to ensure students' competence at graduation.

7.3 Materials and Methods

This study was designed as a mixed method, observational, international 3-round Delphi study. The Delphi technique is described as a structured group communication process that affords an opportunity for a group of experts within a specific field to resolve differences of opinion over a series of information-sharing, iterative rounds, and attain a collective consensus that, in turn, may be used to guide future decision-making [187]. This method belongs to the subjective-intuitive methods of foresight, especially useful for long-range forecasting, as expert opinions are the only source of information available [188]. It refines expert opinion data through consideration of anonymous input from other peer experts, generating a considered consensus over repeated applications. Although there is no standard statistical process for determining a sample size for a Delphi study [189], a target of 10 to 50 respondents has been recommended [188, 190]. It is considered a “flexible” research method that can be tailored to meet a study’s specific objectives [188].

Ethical approval (Log 2021-063) for the study was granted on 21/05/2021 by the Social Research Ethics Committee (SREC), University College Cork, Ireland (UCC).

An advisory panel consisting of seven experts in prosthodontics/ restorative dentistry was assembled to validate the initial questionnaire beforehand. This panel also, reviewed participants' answers after each Delphi survey round, provided feedback about received responses and suggested any additional questions based on the previous round answers. Furthermore, the draft version of the Round 1 questionnaire was piloted with this panel to determine its ease of use, clarity, and understanding [187], then appropriate modifications were made before the final version was approved. In order to have different opinions, this panel members were from five different countries, namely, Ireland, New Zealand, Switzerland, United Kingdom (UK) and United states (US). Members of the advisory panel were excluded from participating in the main study.

After discussion with the advisory panel, 36 dental academics in prosthodontics/ restorative dentistry from 12 different countries were selected to participate in the “experts panel”. The selected number of the participants were in consistent with previous recent studies used Delphi method [191-194]. The inclusion criteria were – "any academic or specialist in prosthodontics/ restorative dentistry who is actively involved in the teaching and assessment methods in undergraduate prosthodontics curriculum". These potential participants were invited to take part in the study via invitation email. The email included study information along with the Round 1 questionnaire hyperlink. The final version of the questionnaire was constructed using an online software (SurveyMonkey Inc, San Mateo, CA, U.S.A). Following Dillman's method, after an initial email, we followed-up non-respondents with two subsequent emails [195]. The target number for the experts panel was 15 to 20, as recommended by previous studies [187, 196]. All candidates who were eligible and willing to participate were recruited to complete a series of questionnaires over three separate, iterative rounds:

7.2.1 Round 1

The Round 1 questionnaire was designed to be completed in approximately 30 minutes. It contained 28 close-ended questions (154 statements) and one final open-ended question (Appendix 9). Participants were also given the option to write comments at the end of each question. The questionnaire was divided into five sections. Section 1 included, demographic questions on participants' academic institution, title and job role, and years of undergraduate teaching experience. Sections 2 to 5 included questions on the preclinical teaching and assessment methods in prosthodontics (14 questions), and the clinical teaching and assessments methods in prosthodontics (15 questions). The final open-ended question asked participants for their opinion about the minimum competence level that undergraduate dental students should have at graduation. In the Round 1 questionnaire, there were two types of close-ended questions: multiple choice and ranking questions. In the ranking questions, participants were asked to rate the level of importance on a 9-point Likert scale ('not important at all' – 'extremely important').

7.2.2 Round 2

Following analysis of data from Round 1 (using simple descriptive statistics), a Round 2 questionnaire was constructed based on the experts' previous responses (Appendix 9). Questions/ statements that had reached a consensus in Round 1 were banked and excluded from the following rounds. In Round 2, in order to inform decision making, the overall group response to each question from Round 1 was presented. Panellists were invited to consider/ changing or keeping their previous responses in light of the overall group response, in an attempt to bring the panel to a consensus. Furthermore, answers to the ranking questions from Round 1 were grouped into three groups (1 to 3 not important, 4 to 6 not important nor important "neutral" and 7 to 9 important).

7.2.3 Round 3

A similar procedure was followed for analysing Round 2 data (simple statistics) and subsequent construction of the Round 3 questionnaire (Appendix 9). Questions/ statements that had reached a consensus in Round 2 were also banked and excluded from Round 3. Participant's own responses, and the overall group responses to each question from Round 2, were presented. Also, in light of the overall group response and in an attempt to bring the expert panel to a consensus, "agree/ do not agree" questions (dichotomous options) were used instead of ranking questions. In addition, expert panels' comments from all the rounds were analysed to clarify the responses or to add questions in the subsequent round.

7.2.4 Consensus agreement

The target level of consensus agreement for each question/ statement was set priori at ≥ 70% [187, 190, 193, 196]. Statements that did not attain consensus after Round 1 or 2 were modified based on the expert panel's comments (and in consultation with the advisory committee) and included in the subsequent round questionnaire. In addition, at least a 70% response rate was needed to maintain rigour between each round.

7.2.5 Statistical analysis

After each iterative round, the answers to every question were individually analysed through simple descriptive statistics with data presented as absolute values and percentages using IBM SPSS Statistics 28 software (IBM Corporation, Armonk, New York, USA).

7.4 Results

The expert panel consisted of 23 senior academics from eleven different countries (in Round 1). These countries were Australia, Canada, Hong Kong, Ireland, New Zealand, Saudi Arabia, Singapore, Spain, Sweden, UK and US, of whom, 13 were professors, 3 were consultants, 3 were senior lecturers, 2 were lecturers, 1 was an associate professor and 1 was an assistant professor. Also, 17 of them had 10 years or more of experience, 3 had 6-9 years, 1 had 2-5 years and 2 of them had less than 2 years of experience.

7.4.1 Round 1

Twenty-three eligible senior academics in prosthodontics/ restorative dentistry agreed to participate in the study after the initial invitation email. Eighteen of them, representing nine different countries completed it in its entirety (response rate 78.3%).

In Round 1, the total level of consensus was 37.7% (58 statements out of 154). Thirty-one of these 58 statements were on preclinical teaching and assessment methods and 27 clinical teaching and assessment methods. Of statements that reached consensus, 12 out of 34 in the CD domain (35.3%), 18 out of 37 in the RPD domain (48.6), 19 out of 36 in the FP domain (52.8%) and only 7 out of 41 in the DI domain (17.1%). The highest reached consensus level was in the FP domain, followed by RPD and CD domains. However, the DI domain had the lowest consensus level in Round 1. Statements which obtained consensus in Round 1 are summarised in Table 1.

7.4.2 Round 2

Eighteen participants completed Round 2 and subsequently Round 3 (drop-out of 5 participants from Round 1). In this round, the questionnaire consisted of 131 questions/ statements (96 questions from Round 1 and 35 questions on minimum competency level, which were modified based on the experts' panel comments in Round 1 and in consultation with the advisory committee). A total of 66 out of 131 statements reached a consensus (50.4% in total). Eighteen of these 66 statements were on preclinical teaching and assessment methods, 16 on clinical teaching and assessment methods and 32 on the minimum competency level. The highest attained consensus level was in the RPD domain (26 out of 37 questions; 70.3%), followed by FP and CD domains (25 out of 36 questions; 69.4% and 22 out or 34 questions; 64.7%, respectively). DI domain still had the lowest consensus level, with only 16 out of 41 questions reaching consensus (39.0%). Additionally, the experts panel agreed on the majority of questions/ statements regarding the minimum competency level except for three questions regarding the DI domain. Statements which obtained consensus in Round 2 are summarised in Table 1 and 2.

7.4.3 Round 3

In this round, the questionnaire consisted of 65 questions/ statements (which were modified based on the experts' panel comments in Round 2 and in consultation with the advisory committee), of these, 51 obtained a consensus. Compared to the previous rounds (37.7% in Round 1 and 50.4% in Round 2), the consensus level rose to 78.5% (51 questions out of 65). The statements with consensus agreement in Round 3 are summarised in Table 7.1 and 7.2.

Table 7.1 Consisting of statements that achieved consensus agreement among the expert panel

Teaching and assessment of undergraduate prosthodontics	Consensus statement (number of participants: *consensus level percentage*)		
	Round 1	Round 2	Round 3
Preclinical teaching trends			
Complete dentures			
Importance level that students gain experience in teeth setting and waxing-up	Important (18:*78*)		
Importance level that students gain experience in impression technique	Important (20:*87*)		
Importance level that students have a dedicated preclinical course		Important (14:*78*)	
The best staff: student ratio during the hands-on/ practical skills sessions		1:6-1:8 (15:*83*)	
Importance level that students gain experience in prescription writing		Important (14:*78*)	
Importance level that students gain experience in cast and trimming of models		Important (16:*89*)	
Importance level that students gain experience in mounting casts		Important (16:*89*)	
Year of study that students should commence preclinical course			Year 3 (16:*89*)
The suitable/the best range of hours of Hands-on/ practical skills			20-30 (18:*100*)
The most suitable to direct the preclinical courses			Senior lecturer (16:*89*)
Removable partial dentures			
Importance level that students have a dedicated preclinical course	Important (19:*83*)		
Year of study that students should commence preclinical course	Year 3 (17:*74*)		
Importance level that students gain experience in tooth preparation on patient simulators	Important (23:*100*)		
Importance level that students gain experience in using surveyor	Important (22:*96*)		
Importance level that students gain experience in using articulator	Important (20:*87*)		
Importance level that students gain experience in prescription writing	Important (20:*87*)		
The best staff: student ratio during the hands-on/ practical skills sessions		1:6-1:8 (15:*83*)	
Importance level that students gain experience in casting impression		Important (17:*94*)	
The suitable/the best range of hours of Hands-on/ practical skills			20-30 (16:89)
The most suitable to direct the preclinical courses			Senior lecturer (16:*89*)
Importance level that students gain experience in altered cast impression technique			Not important nor important (16:*89*)
Fixed prosthodontics			
Importance level that students have a dedicated preclinical course	Important (22:*96*)		
Importance level that students gain experience in tooth preparation for crown	Important (23:*100*)		
Importance level that students gain experience in preparation for bridge	Important (21:*91*)		
Importance level that students gain experience in veneer preparation	Important (20:*87*)		
Importance level that students gain experience in using facebow	Important (18:*78*)		
Importance level that students gain experience in shade selection	Important (23:*100*)		

Importance level that students gain experience in prescription writing	Important (20:*87*)		
The most suitable director of the preclinical fixed prosthodontics course		Senior lecturer (14:*78*)	
The best staff: student ratio during the hands-on/ practical skills sessions		1:6-1:8 (13:*72*)	
Year of study that students should commence preclinical course			Year 3 (16:*89*)
The suitable/the best range of hours of Hands-on/ practical skills			40-50 (16:*89*)
Dental Implants (surgical placement)			
	No consensus	No consensus	
Importance level that students have a dedicated preclinical course			Not important nor important (17:*94*)
Importance level that students gain experience in fabrication of surgical stent			Important (15:*83*)
Dental implants (restorations)			
Importance level that students have a dedicated preclinical course	Important (17:*74*)		
Importance level that students gain experience in recognition of prosthetic parts	Important (16:*70*)		
Importance level that students gain experience in fitting of final restoration	Important (16:*70*)		
Year of study that students should commence preclinical course		Year 4 (15:*83*)	
The best staff: student ratio during the hands-on/ practical skills sessions		1:6-1:8 (15:*83*)	
Importance level that students gain experience in impression technique		Important (14:*78*)	
The suitable/the best range of hours of Hands-on/ practical skills			<10 (16:89)
The most suitable to direct the preclinical courses			Senior lecturer (13:*72*)
Preclinical assessment trends			
Complete dentures			
Importance level that students complete practical assessment at the end of preclinical course	Important (17:*74*)		
Importance level that students complete written assessment at the end of preclinical course	Important (16:*70*)		
Importance level that the person who assesses students in the practical skills lab be involved in preclinical teaching of the module	Important (20:*87*)		
Best progression path if a student fails the assessment	Cannot undertake clinical procedures until passing a re-sit (16:*70*)		
The best method to achieve consistency in assessment during the hands-on/ practical skills sessions		Follow guidelines/criteria set-up by the department (16:*89*)	
The most suitable/ the best to be responsible for assessing students' work and competence during the preclinical sessions			Senior lecturer (13:*72*)
Removable partial dentures			
Importance level that students complete practical assessment at the end of preclinical course	Important (21:*74*)		
Importance level that students complete written assessment at the end of preclinical course	Important (17:*74*)		
Importance level that the person who assesses students in the practical skills lab be involved in preclinical teaching of the module	Important (20:*87*)		
The best method to achieve consistency in assessment during the hands-on/ practical skills sessions		Follow guidelines/criteria set-up by the	

		department (16:*89*)	
Best progression path if a student fails the assessment		Cannot undertake clinical procedures until passing a re-sit (13:*72*)	
Importance level that students complete an oral/ viva voce assessment at the end of the preclinical course			Not important (13:*72*)
The most suitable/ the best to be responsible for assessing students' work and competence during the preclinical sessions			Senior lecturer (13:*72*)
Fixed prosthodontics			
Importance level that students complete practical assessment at the end of preclinical course	Important (23:*100*)		
Importance level that students complete written assessment at the end of preclinical course	Important (17:*74*)		
Importance level that the person who assesses students in the practical skills lab be involved in preclinical teaching of the module	Important (20:*87*)		
Best progression path if a student fails the assessment	Cannot undertake clinical procedures until passing a re-sit (19:*83*)		
The best method to achieve consistency in assessment during the hands-on/ practical skills sessions		Follow guidelines/criteria set-up by the department (16:*89*)	
Importance level that students complete an oral/ viva voce assessment at the end of the preclinical course			Not important (13:*72*)
The most suitable/ the best to be responsible for assessing students' work and competence during the preclinical sessions			Senior lecturer (14:*78*)
Dental implants (surgical placement)			
	No consensus		
Importance level that students complete oral/ viva voce assessment at the end of the preclinical course		Not important (13:*72*)	
Importance level that students complete a practical assessment at the end of the preclinical course			Not important (15:*83*)
Importance level that students complete a written assessment at the end of the preclinical course			Not important nor important (15:*83*)
Dental implants (restoration)			
Importance level that the person who assesses students in the practical skills lab be involved in preclinical teaching of the module	Important (20:*87*)		
Best progression path if a student fails the assessment	Cannot undertake clinical procedures until passing a re-sit (17:*74*)		
The best method to achieve consistency in assessment during the hands-on/ practical skills sessions		Follow guidelines/criteria set-up by the department (16:*89*)	
Importance level that students complete a practical assessment at the end of the preclinical course			Important (13:*72*)
Importance level that students complete a written assessment at the end of the preclinical course			Important (13:*72*)
Importance level that students complete an oral/ viva voce assessment at the end of the preclinical course			Not important (16:*89*)
The most suitable/ the best to be responsible for assessing students' work and competence during the preclinical sessions			Senior lecturer (13:*72*)
Clinical teaching trends			

Complete dentures			
	No consensus		
Year of study that students should commence clinical course		Year 3 (16:*83*)	
The best number of units of complete dentures to be required to complete before graduation		3-6 (16:*89*)	
The best staff: student ratio during the clinical sessions			1:6-1:9 (18:*100*)
The importance level to have a paired teaching (e.g., students working in pairs together: one operating/ one assisting)			Important in some experience in a limited number of cases (16:*89*)
Importance level that students gain experience in digital workflow (e.g., intra-oral scanning and fitting lab work manufactured using 3-d printing, etc.)			Not important nor important (15:*83*)
Importance level that students gain experience in completing the production/ laboratory work for their own cases			Important (16:*89*)
Removable partial dentures			
	No consensus		
Year of study that students should commence clinical course		Year 3 (16:*83*)	
The best number of units of removable partial dentures to be required to complete before graduation		3-6 (18:*100*)	
The best staff: student ratio during the clinical sessions			1:6-1:9 (17:*94*)
The importance level to have a paired teaching (e.g., students working in pairs together: one operating/ one assisting)			Important in some experience in a limited number of cases (16:*89*)
Importance level that students gain experience in digital workflow (e.g., intra-oral scanning and fitting lab work manufactured using 3-d printing, etc)			Not important nor important (15:*83*)
Fixed prosthodontics			
Importance level that students gain experience in digital workflow	Important (18:*78*)		
The best number of units of single crowns to be required to complete before graduation		3-6 (13:*72*)	
The best number of units of bridges to be required to complete before graduation		3-6 (15:*83*)	
The best staff: student ratio during the clinical sessions			1:3-1:5 (18:*100*)
The importance level to have a paired teaching (e.g., students working in pairs together: one operating/ one assisting)			Important in some experience in a limited number of cases (15:*83*)
The most suitable to supervise students during the clinical sessions			Senior lecturer (13:*72*)
Importance level that students gain experience in digital workflow (e.g., intra-oral scanning and fitting lab work manufactured using 3-d printing, etc)			Important (13:*72*)
Importance level that students gain experience in completing the production/ laboratory work for their own cases			Important (14:*78*)
Dental implants (surgical placement)			
Units number of prosthesis are the best to be required to complete before graduation	0-2 (17:*74*)		
		No consensus	
Importance level that students gain experience in completing the production/ laboratory work for their own cases			Not important nor important (14:*78*)

Dental implants (restoration)			
	No consensus	No consensus	
Year of study that students should commence clinical course			Year 4 13:*72*)
The best number of units of dental implants restorations to be required to complete before graduation			0-2 (13:*72*)
The best staff: student ratio during the clinical sessions			1:3-1:5 (16:*89*)
The importance level to have a paired teaching (e.g., students working in pairs together: one operating/ one assisting)			Important in some experience in a limited number of cases (14:*78*)
Importance level that students gain experience in digital workflow (e.g., intra-oral scanning and fitting lab work manufactured using 3-d printing, etc)			Important (14:*78*)
Importance level that students gain experience in completing the production/ laboratory work for their own cases			Not important (14:*78*)
Clinical assessment trends			
Importance level that criterion referenced assessed exercises determining student's suitability/ competence for graduation	Important (19:*83*)		
Importance level that case presentation determining student's suitability/ competence for graduation	Important (16:*70*)		
Importance level of grades achieved in clinical sessions in determining a student's suitability/ competence for graduation		Important (17:*94*)	
Importance level that completion of an end-of-programme clinical exercise in clinical sessions in determining a student's suitability/ competence for graduation		Important (14:*78*)	
Importance level that the number of treatments (targets/ requirements) completed in determining a student's suitability/ competence for graduation			Important (15:*83*)
Importance level that viva voce in determining a student's suitability/ competence for graduation			Important (14:*78*)
Complete dentures			
Importance level that criterion referenced assessed exercises in master impression	Important (19:*83*)		
Importance level that criterion referenced assessed exercises in occlusal registration	Important (19:*83*)		
Importance level that criterion referenced assessed exercises in try-in	Important (17:*74*)		
Importance level that criterion referenced assessed exercises in fitting	Important (17:*74*)		
Importance level that the person who assesses students in the clinic be involved in clinical teaching of the module	Important (17:*74*)		
Best method to achieve consistency in assessment during clinical sessions	Follow guidelines/criteria set-up by the department (16:*70*)		
Should a final assessment/examination before graduation be set for students		Yes (14:*78*)	
The best method to assess students' clinical competence in complete dentures before graduation		day-to-day assessments (13:*72*)	
The most suitable/ the best to be responsible for assessing students' work and competence during the clinical sessions			Senior lecturer (13:*72*)
Removable partial dentures			
Importance level that criterion referenced assessed exercises in denture design	Important (19:*83*)		
Importance level that criterion referenced assessed exercises in master impression	Important (18:*78*)		
Importance level that criterion referenced assessed exercises in occlusal registration	Important (18:*78*)		

Importance level that criterion referenced assessed exercises in teeth preparation	Important (18:*78*)		
Importance level that criterion referenced assessed exercises in try-in	Important (17:*74*)		
Importance level that criterion referenced assessed exercises in fitting	Important (18:*78*)		
Importance level that the person who assesses students in the clinic be involved in clinical teaching of the module	Important (18:*78*)		
Best method to achieve consistency in assessment during clinical sessions	Follow guidelines/criteria set-up by the department (16:*70*)		
Should a final assessment/examination before graduation be set for students	Yes (16:*70*)		
The best method to assess students' clinical competence in removable partial dentures before graduation		day-to-day assessments (13:*72*)	
Fixed prosthodontics			
Importance level that criterion referenced assessed exercises in tooth preparation	Important (20:*87*)		
Importance level that criterion referenced assessed exercises in master impression	Important (20:*87*)		
Importance level that criterion referenced assessed exercises in temporization	Important (19:*83*)		
Importance level that criterion referenced assessed exercises in fitting	Important (19:*83*)		
Importance level that the person who assesses students in the clinic be involved in clinical teaching of the module	Important (19:*83*)		
Best method to achieve consistency in assessment during clinical sessions	Follow guidelines/criteria set-up by the department (16:*70*)		
Should a final assessment/examination before graduation be set for students	Yes (18:*78*)		
The best method to assess students' clinical competence in fixed prosthodontics before graduation		day-to-day assessments (13:*72*)	
The most suitable/ the best to be responsible for assessing students' work and competence during the clinical sessions			Senior lecturer (14:*78*)
Dental implants (surgical placement)			
	No consensus	No consensus	
Importance level of the criterion referenced assessed exercises in dental implants surgical placement			Not important (16:*89*)
Dental implants (restoration)			
Importance level that the person who assesses students in the clinic be involved in clinical teaching of the module	Important (19:*83*)		
The best method to achieve consistency in assessment during clinical sessions		Follow guidelines/criteria set-up by the department (16:*89*)	
The best method to assess students' clinical competence in dental implants before graduation		day-to-day assessments (14:*78*)	
Importance level of the criterion referenced assessed exercises in dental implants restorations			Important (15:*83*)
Importance level that criterion referenced assessed exercises in dental implants master impression			Important (15:*83*)
Importance level that criterion referenced assessed exercises in dental implants dental implants fitting			Important (13:*72*)
The most suitable/ the best to be responsible for assessing students' work and competence during the clinical sessions			Senior lecturer (13:*72*)

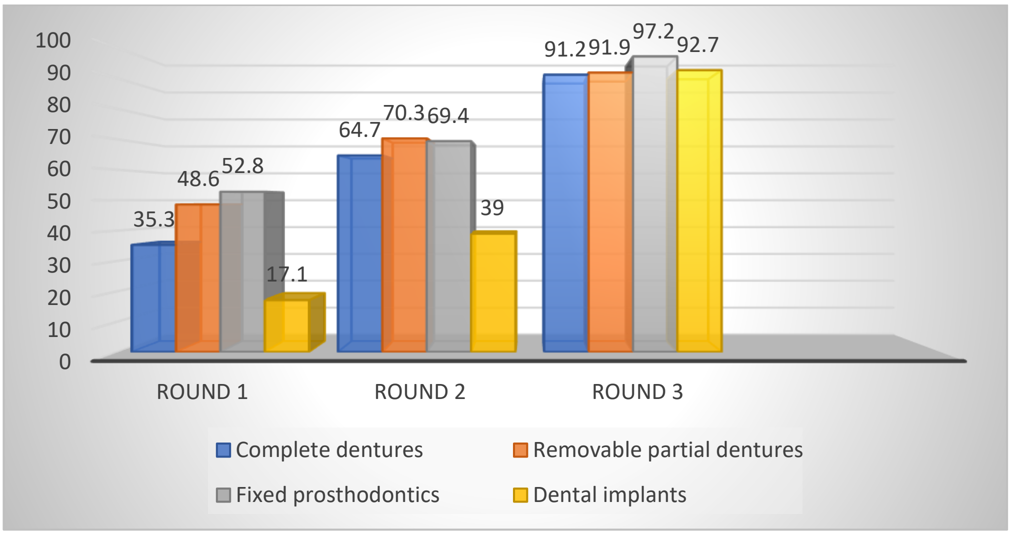
Table 7.2 Consisting of the minimum competence level statements that achieved consensus agreement among the expert panel in Round 2 and 3

The minimum competence level that undergraduate dental students should have at graduation (Round 2)	Consensus statement (number of participants: *consensus level percentage*)
Complete dentures	
Being able to diagnose and formulate treatment plan for fully-edentulous patients.	Agree (18:*100*)
Having the knowledge of complete dentures preparation and construction.	Agree (18:*100*)
Being able to perform all the clinical steps that used to construct conventional and interim complete dentures.	Agree (17:*94*)
Completing all preclinical exercises and fabricating a number of clinical cases (2-3 cases).	Agree (15:*83*)
Being able to perform ideal final impression, proper centric relation registration, knowledge in denture occlusion and handling post-insertion complications (e.g., perform relining and rebasing procedures).	Agree (17:*94*)
Fabricating non-complex complete dentures in cases from start to finish	Agree (15:*83*)
Being able to treat patients with dentures and achieve patient satisfaction	Agree (17:*94*)
Removable partial dentures	
Being able to diagnose and formulate treatment plan for partially-edentulous patients.	Agree (18:*100*)
Having the knowledge of removable partial dentures preparation and construction.	Agree (18:*100*)
Being able to generate removable partial denture designs for various partially edentulous cases and evaluate the aesthetics and occlusion of the removable partial dentures.	Agree (18:*100*)
Being able to rehabilitate cases using Cobalt-Chromium and acrylic based dentures, free-end saddles and anterior saddles.	Agree (18:*100*)
Completing all preclinical exercises and fabricating a number of clinical cases (3-8 cases).	Agree (16:*89*)
Being able to assess patients, tooth preparations, primary and definitive impressions, review partial dentures and solve problem.	Agree (18:*100*)
Being able to design and make non-complex Co-Cr and acrylic RPD cases from start to finish.	Agree (16:*89*)
Knowing how to survey and select proper design, ideal tooth preparation, ideal final impression, proper bite registration, knowledge in denture occlusion and handling post-insertion complications.	Agree (18:*100*)
Fixed prosthodontics	
Be able to diagnose and formulate treatment planning of fixed prostheses and successfully manage clinical fixed prosthodontics cases.	Agree (17:*94*)
Have the knowledge of all aspects of fixed prostheses preparation and construction.	Agree (18:*100*)
Be able to rehabilitate a range of cases using crowns, resin-retained bridges and conventional bridges.	Agree (17:*94*)
Practice different types of tooth preparations of abutments of fixed prostheses and practicing with different types of prosthetic/restorative materials.	Agree (17:*94*)
Be able to produce biologically compatible and aesthetically and functionally acceptable provisional crowns and safely manipulate soft tissues during impression making for prepared tooth/teeth.	Agree (18:*100*)
Be able to utilize inter-occlusal records and articulators for mounting clinical cases.	Agree (15:*83*)
Have the knowledge and good experience in preparation and manufacturing veneer, single crown (porcelain/metal/porcelain only), resin-retained bridges, conventional bridges and cantilever bridges.	Agree (16:*89*)
Be able to assess, tooth/teeth preparation, preform primary and definitive impressions, review final restoration and solve problem.	Agree (18:*100*)
Competently complete all preclinical exercises and a number of clinical cases (6-15 units).	Agree (15:*83*)
Be able to perform crown or bridge abutments preparation clinically, impression, temporization and fitting final restoration.	Agree (18:*100*)

Be able to treat patients with fixed prostheses and achieve patient satisfaction.	Agree (18:*100*)
Dental Implants	
Only have a theoretical understanding of how implants work.	Agree (13:*72*)
Being able to perform treatment plan and restore missing tooth/teeth with dental implant prostheses (removable or fixed prostheses).	Agree (13:*72*)
Have a thorough knowledge in implant parts for simple implant restorations (such as single implant supported crowns), impression techniques and their indications, fabrication of radiographic and surgical stints.	Agree (16:*89*)
Have the knowledge of all aspects of dental implants restoration and surgical sequence, indications and limitations.	Agree (15:*83*)
Be able to perform impression and fit screw retained crown.	Agree (14:*78*)
Minimum competence in dental implants is not needed for graduation but desirable	Agree (15:*83*)
The minimum competence level that undergraduate dental students should have at graduation (Round 3)	Consensus statement (number of participants: *consensus level percentage*)
Dental Implants	
Students should not be able to select patient, preform case assessment and surgical treatment planning of a single tooth cases at graduation	Agree (14:*78*)
Students should not be able to treat patients with Dental implants and achieve patient satisfaction	Agree (14:*78*)

A bar chart summarising consensus level throughout this Delphi study is presented in Figure 7.1. The highest reached consensus level in this round was in the FP domain (97.2%) followed by DI, RPD and CD domains (92.7%, 91.9% and 91.2%, respectively).

Figure 7.1 Consensus level throughout study rounds



7.4.4 Non-consensus statements

After three separate and iterative rounds, 14 statements did not obtain consensus among this Delphi study expert panel. Statements with non-consensus in this study are summarised in Table 7.3.

Table 7.3 Consisting of statements that did not achieve consensus agreement among the expert panel

Non-consensus statements	Most common response (%)
Complete dentures	
Who would be suitable to supervise students during the hands-on/ practical skills sessions?	Senior lecturer (67)
How important is it that students complete an oral/ viva voce assessment at the end of the preclinical course?	Not important (67)
Who would be most suitable to supervise students during the clinical sessions?	Senior lecturer (67)
Removable partial dentures	
Who would be suitable to supervise students during the hands-on/ practical skills sessions?	Senior lecturer (67)
Who would be most suitable to supervise students during the clinical sessions?	Senior lecturer (67)
How important is it that students gain experience in completing the production/ laboratory work for their own cases?	Important (67)
Who should be responsible for assessing students' work and competence during the clinical sessions?	Senior lecturer (67)
Fixed prosthodontics	
Who would be suitable to supervise students during the hands-on/ practical skills sessions?	Senior lecturer (67)
During which year of study should students commence clinical treatment of fixed prosthodontics patients?	Year 3 (67)
Dental implants	
Who would be suitable to supervise students during the hands-on/ practical skills sessions?	Senior lecturer (61)
Who would be most suitable to supervise students during the clinical sessions?	Senior lecturer (67)
How important are criterion referenced assessed exercises in dental implants abutment selection?	Important (67)
Should a final assessment/examination before graduation be set for students?	Not to be set (67)
Should students have to competently completed all preclinical exercises and a number of clinical cases (2-3 cases) at graduation?	Students should not (61)

7.5 Discussion

Various studies have investigated the teaching and assessment methods used in prosthodontics over the last two decades [48, 55, 59, 60, 62, 65, 66, 71, 158]. The authors of these studies presented a clear picture of the curricula contents, trends and challenges in teaching and assessing dental undergraduates. A close look at the literature depicts curricula divergence among the investigated universities, even though minimizing this divergence on a global basis has been recommended [151]. Thus, this study aimed to gather perspective and achieve consensus among academic experts in teaching and assessing of prosthodontics.

After three rounds of the Delphi survey, a total of 175 (92.6%) consensus statements represent the agreement expert views of senior academics in prosthodontics from nine different countries and across four continents. The consensus statements are relevant to the curriculum stakeholders in all dental schools. The level of consensus evolved throughout the study, which started from 37.7% in Round 1 to 78.5% in Round 3. Additional 14 statements did not achieve consensus at the end of Round 3, although these statements were close to reaching the consensus level (twelve statements attained 67% of agreement and 61% for the remaining two).

The topic that resulted in the fewest number of consensus statements was the faculty member deemed to be most suitable for supervising students during the "preclinical practical skills and clinical sessions" (7 statements). However, the "senior lecturer" was the most common response throughout the three rounds. A shortage of senior lecturers or lack of clinical experience are possible reasons for lack of consensus. One of the experts commented, *"We don't have enough senior lecturers to have this depth of coverage*" while another expert said, "*I cannot find senior people who are willing to lead full denture classes*". Also, regarding the DI course, one of the experts stated, "*Unless the Senior lecturer holds a relevant consultant contract underscoring extensive clinical experience with dental implants, I would recommend for this director role a clinician who places and/or restores dental implants frequently*".

The ADEE [151], GDC [150] and the European Workshop of Dental Implant Education [197] recommended embedding the DI domain in undergraduate curricula, the experts' consensus was that it is important for students to have a dedicated preclinical course in DI restoration (prosthetic part) but it is not important nor important to have a preclinical surgical course. The majority of the DI teaching and assessment methods achieved consensus during Round 3 which reflects the wide variation among the experts' opinion. The total percentage of DI domain consensus in Round 1 was only 17.1% and 39% in Round 2, and then it surged to be 92.7% in Round 3. However, statements such as the "importance of criterion-referenced assessed exercises in DI abutment selection", "setting a final assessment/examination before graduation for students" or "if students have to competently complete all preclinical exercises and a number of clinical cases (2-3 cases) at graduation", did not achieve consensus. Experts in a recent Delphi study agreed on the need for appropriate training and education for those providing implant treatments particularly in light of the widespread provision of such treatment. Thus, to meet these needs, appropriate education is required at both undergraduate and postgraduate levels [198].

Other areas where the expert' consensus was not achieved in this study, were regarding the "importance of an oral/ viva voce assessment at the end of the CD preclinical course", the "importance that students gain experience in completing the production/ laboratory work for their own RPD cases", "who should be responsible for assessing students' work and competence during the RPD clinical sessions?" and "during which year of study should students commence clinical treatment of FP patients. These non-consensus statement represent variation in expert academics' opinion regarding prosthodontics teaching and assessment methods.

Nevertheless, the number of statements that attained expert' consensus agreement in this study was much higher than the non-consensus statements—92.6% consensus agreement, and 175 statements out of 189 over three iterative rounds.

Topics that achieved the experts' consensus in Round 1 reflect a high level of agreement. Such as "having dedicated preclinical courses in RPD, FP and DI restoration", "the importance of completing practical and written assessments at the end of the CD, RPD and FP preclinical course", and "the importance that the faculty who assesses students in the practical skills lab and clinical sessions be involved in the teaching of the module". Also, in Round 1, the experts agreed that "if a student fails the preclinical assessment in CD, FP and DI, he/she cannot undertake clinical procedures until passing a re-sit", "it is important that students gain experience in digital workflow for FP", and "it is important to set criterion-referenced assessed exercises in all CD, RPD and FP clinical teaching methods". In addition, the experts panel agreed that "following guidelines/criteria set-up by the department is the best method to achieve consistency in assessment during CD, RPD and FP clinical sessions", and "before graduation, a final examination should be set for students in RPD and FP courses".

Delphi methodology was followed in this study which is considered "*art as well as science*" [190]. It affords anonymity of responses, multiple iterations with controlled feedback, and simple statistical summaries [199]. Delphi surveys provide a group of experts with relevant questions on an important practice topic. It provides them with a well-defined set of choices for which there is a demonstrated need for consensus information that must be established. Each subsequent round will incorporate summary of item responses from the previous survey; thus, respondents can consider this in their new response. Rigour should be obtained by achieving at least a 70% response rate in each round [187]; which was achieved for each round in this study (78.3%).

The definition of group consensus significantly varies among Delphi method studies. However, the most recommended and used cut-offs are either based on a percentage level of agreement (e.g., greater than or equal to 70% agreement), median scores (e.g., 4 or 5 on a 5-point Likert scale), or a combination of both. Also, the interquartile range (IQR – less than or equal to 2) has been considered an objective and rigorous method for determining group consensus [187]. Consensus levels in the literature range between 51% and 80%, though the required level of consensus should be defined in advance of a study [200]. In this study, ≥ 70% was pre-set as the cut-off point to determine the experts' panel consensus, which is the most commonly used benchmark in Delphi studies [201].

7.5.1 *Strengths and limitations*

This study was conducted during the Covid-19 pandemic (May-November 2021). However, researchers followed the best research practice guided by the commonly reported features of Delphi survey methodology [202]. As a result, the anonymity of participants, multiple iterative rounds with detailed feedback, pre-setting of consensus level, and consistency in response rate were achieved.

It could be argued that the Delphi survey is vulnerable to bias such as the invitation of panel members, participants' previous experience or recall availability, participants' aim to please or avoid embarrassment and information-sharing between rounds [187, 202]. However, the Delphi method can be a pathway for valid, credible and justifiable conclusions based on up-to-date expert' opinions [202]. It is important to be aware that in a Delphi survey, the achieved experts' consensus does not implicitly imply that the “right” answer or a conclusive result has been achieved [202].

The authors feel that participants' diversity, different backgrounds, and experiences, would provide non-biased and reliable opinions. The Round 1 survey encompassed 23 experts from eleven different countries and four continents, and in subsequent rounds, the view of 18 experts from nine different countries. Participants who withdrew after Round 1 related their withdrawal to either the length of questionnaires being “time-consuming” or unavailability.

7.6 Conclusions

The results from the presented Delphi study have provide relevant and valuable information to the stakeholders involved in developing undergraduate dental curricula. A total of 175 consensus statements attained represent the consensus professional views of participating senior academics in prosthodontics\ restorative dentistry regarding the teaching and assessment methods used in prosthodontics across four disciplines. In addition, the results could be considered as detailed guidelines and recommendations to improve the future undergraduates’ curriculum in prosthodontics.

CHAPTER 8: Senior Academics' Perceptions of Undergraduate Prosthodontics Curriculum and Teaching: A Qualitative Study

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Accepted for publication in: *Journal of Irish Dental Association (JIDA)*, September 2022

(Paper 2)

8.1 Abstract

Introduction: Divergence in undergraduate teaching methods in prosthodontics are widely reported, and this could impact graduate dentists' competence and affect patients' safety.

Objectives: To explore the perspectives held by senior dental academics worldwide regarding the undergraduate prosthodontics curriculum, teaching and assessment methods, and teaching staff profile.

Materials and methods: Twelve senior dental academics from seven countries participated in semi-structured interviews exploring their perspectives and opinions of the undergraduate prosthodontics curriculum, and current and best teaching and assessment methods. Interviews were undertaken virtually, video-recorded and auto-transcribed. Semantic thematic analysis was used for data analysis.

Results: Academic professors, consultants and specialists were considered the most suitable staff members to supervise students during preclinical hands-on sessions due to their experience level. Additionally, participants mentioned the availability of suitable patients for treatment, dental schools' curriculum and the level of students' skills as factors influencing the start of clinical sessions in fixed prosthodontics. The course content and extent of teaching on dental implants were different among schools. Tailoring the curriculum according to what is expected from the graduating dentists and allowing students to observe dental implants cases before dealing with simple cases were suggestions made by the participants to include an implant course at undergraduate level.

Conclusions: Despite some differences in opinions and current practices in different institutions, barriers to the implementation of an ideal curriculum seemed

to be similar in the different institutions. This study provided deeper understanding of the current divergence in prosthodontics teaching which would allow for future improvement in the dental curriculum.

8.2 Introduction

Prosthodontics is a broad and complex course consisting of four main disciplines namely: Complete Dentures (CD), Removable Partial Dentures (RPD), Fixed Prosthodontics (FP) (which includes crowns and bridges) and Dental Implants (DI). Learning of these disciplines may start at early stages of dentistry courses and continue until the completion of the bachelor’s degree [203]. Traditionally, undergraduate dental education engages students in lectures for basic sciences along with dental sciences and laboratory settings during the first two years of their preclinical training. Afterward, clinical subjects and training are introduced until the end of the programme, followed by one year of internship or vocational training (dental foundation training) in some countries.

However, dental school programmes around the world are not similar and programme curricula are tailored according to various aspects such as available resources, but mostly according to the local dental council guidelines. As a result, discrepancies in undergraduate prosthodontics curriculum and dental students’ teaching and assessment methods can be seen nationally and internationally [65, 204]. In addition, discrepancies in the teaching and assessment methods of the four disciplines in prosthodontic have also been reported in the literature [48, 53, 59, 60, 63, 71, 158, 182]. These differences encouraged organizations such as the Association for Dental Education in Europe (ADEE) to set a well-justified and harmonised basis for training high-quality dentists by promoting convergence towards a higher standard of dental education, training and service to the ultimate benefit of patients. Furthermore, the ADEE called dental schools for further refinement and harmonisation of the dental undergraduate curricula across Europe, which are also recommended to be applied internationally [151].

In the first phase of this study, a comprehensive survey was conducted using the Delphi method [205]. Delphi methodology is a process used to arrive at a group opinion or decision by surveying a panel of experts. It has been used to determine the range of opinions on particular matters, to test questions of policy or clinical relevance, and to explore or achieve consensus on disputed topics [196]. The aim was to investigate what the best teaching and assessment methods in prosthodontics are, and to attain consensus among senior academics of dental schools internationally. Although, consensus was achieved in the majority of the areas assessed, there were still some divergent opinions regarding some teaching and assessment methods such as "who would be most suitable to supervise students during the hands-on/ practical skills sessions?" or "who would be most suitable to supervise students during the clinical sessions?".

Therefore, this qualitative study aimed to further explore the perspectives and opinions held by senior dental academics worldwide regarding undergraduate prosthodontics teaching and assessment methods.

8.3 Materials and Methods

8.3.1 Participants and setting

The study participants included senior dental academics who are active in teaching undergraduate prosthodontics, nine of whom had taken part in Phase 1 of this study (Delphi study) [205]. An invitation email was sent including the study information leaflet, the consent statement (Appendix 10) and a hyperlink to a meeting organizer form using Google Forms. Participation in the study was voluntary and completing the meeting organizer form was considered an agreement to participate. In addition, verbal consent was obtained at the beginning of each interview. The interviews were conducted until data saturation was reached. This is when the participants' responses do not provide new information or new themes for analysis [206].

8.3.2 Ethical Approval

Ethical approval (Log 2021-063A1) for this study was granted on 04/02/2022 by the Social Research Ethics Committee (SREC), University College Cork, Ireland.

8.3.3 Interview Procedure

A semi-structured interview guide, including nine open-ended questions followed by prompting questions to probe into details, was followed during interviews to elicit responses about current and best teaching and assessment methods in undergraduate prosthodontics. Topic guide questions were taken from our previous work using the Delphi method, and this included questions that had not reached consensus (Appendix 10). The interviews were conducted virtually via Microsoft Teams or ZOOM Platform. Interviews were undertaken in March 2022 and lasted between 10-30 minutes; they were video-recorded, auto-transcribed and then all transcripts were checked by the lead researcher to ensure verbatim transcriptions.

8.3.4 Thematic Analysis Process and Coding

After transcription, phrases were first coded into "current teaching and assessment methods", "ideal or best teaching and assessment methods" and "sub-themes" such as "teaching challenges and their resolution". The initial codes were then peer-validated by a second researcher to ensure the rigour and appropriateness of the codes (NVivo 12 Software).

8.4 Results

Twelve senior dental academics who are active in teaching undergraduate prosthodontics participated in this study (5 professors, 3 associate professors, 2 assistant professors and 2 consultants/senior lecturers). The participants were from 7 different countries, namely, Australia, Ireland, New Zealand, Qatar, Singapore, United Kingdom, and United States (Table 8.1). Out of the 12 interviews, 322 phrases were identified and coded, followed by thematic analysis. These phrases were assigned to nine main themes and a number of sub-themes associated with the ideal teaching methods, challenges in teaching and how the challenges could be resolved (Figure 8.1).

Table 8.1 Study participants' demographic information

Sequence number	Participants' title	Years of experience	Country
01	Consultant/ Senior lecturer	Less than 5 years	Ireland
02	Professor	More than 15 years	New Zealand
03	Professor	More than 20 years	Singapore
04	Consultant/ Senior lecturer	More than 10 years	United Kingdom
05	Associate professor	More than 20 years	United States
06	Assistant Professor	Less than 10 years	Singapore
07	Professor	More than 20 years	United Kingdom
08	Assistant Professor	Less than 10 years	Qatar
09	Associate Professor	More than 20 years	Australia
10	Professor	More than 15 years	United States
11	Professor	More than 10 years	United Kingdom
12	Associate Professor	Less than 10 years	Ireland

*All professors were consultants but not all consultants were professor.
*Professor, associate professor, assistant professor and senior lecturer are academic titles.

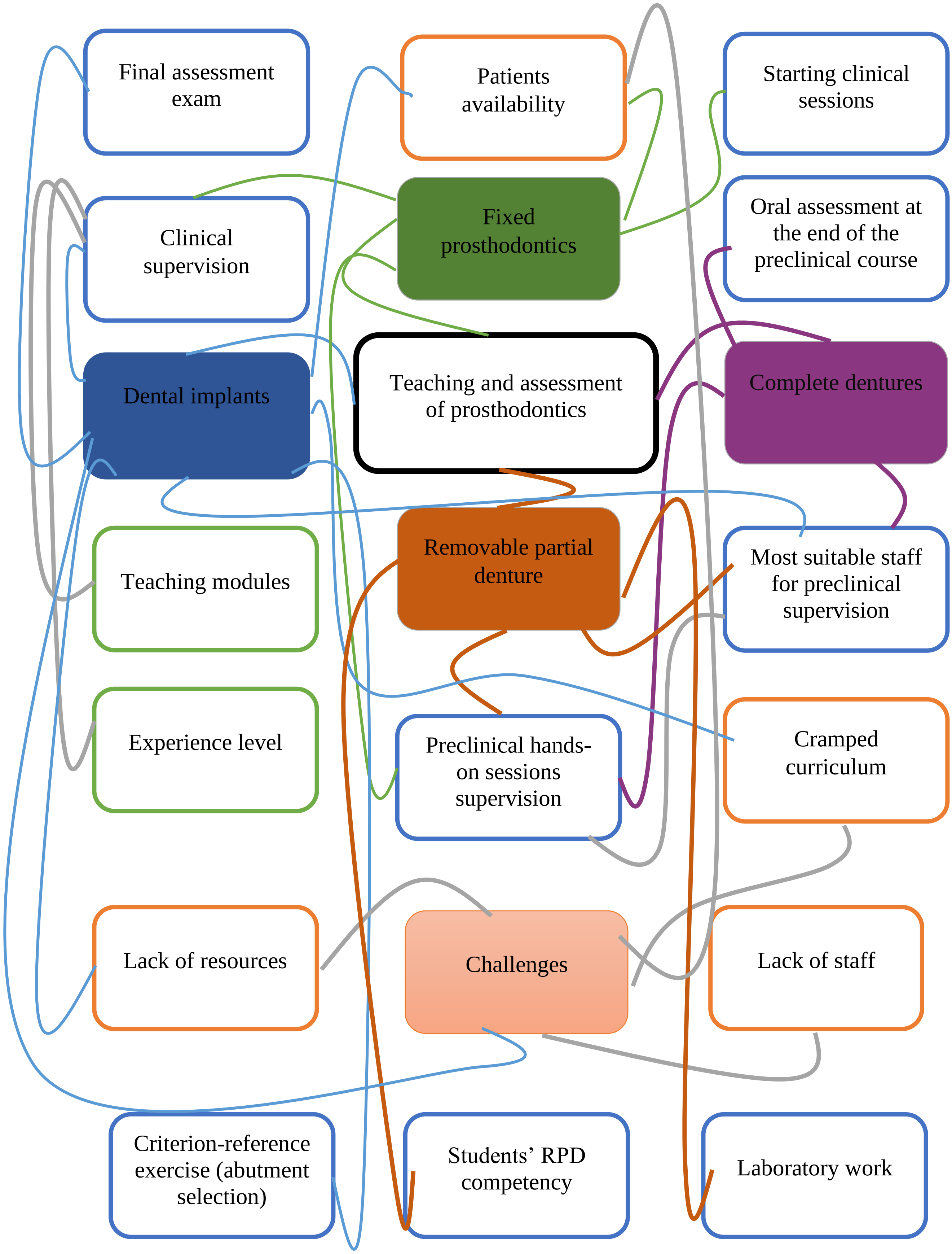

Figure 8.1 Study's emerging themes and sub-themes

8.4.1 Teaching and Assessment Methods in Removable and Fixed Prosthodontics

Five participants stated that senior lecturers currently supervise students during the hands-on preclinical sessions on the CD, RPD and FP courses in their teaching institution. In the remaining schools, these sessions are supervised by consultants or specialists (4), general dentists (2) and lecturers (1).

Experience was considered the most important factor in deciding who is the best member of staff to supervise students in the preclinical hands-on sessions:

"…depending on the experience rather than the actual title if you like…" (04).

"…it's important when you're given the preclinical and all the theory that it's someone with some academic background as well as having their clinical expertise in that area…" (12).

A lack of academics at professor level was one of the reasons for members of staff at junior level to currently supervise students in some institutions:

"…few clinical academics who are professors. we've got 4, and so, the reason I selected senior lecturer was because of that…" (02).

The majority of participants believed that the beginning of clinical sessions of FP should happen in the third year of the course (6). Three participants stated that beginning these sessions in fourth year is the ideal:

"…I would say 3rd, if the earlier the better to start always, but you need to consider what are the previous experiences or where it's located in relation to other

disciplines in the curriculum? Right. So, it's never that alone, it's that in combination with a multitude of other things…" (05).

"…In 4th year, because the students have time to develop the skills to get patients dentally fit as well before doing fixed prostheses…" (02).

Applying an "integrated curriculum" in one dental school allows students to start the clinical FP sessions during the second year.

Table 8.2 illustrates the teaching staff currently supervising students in CD and RPD clinical sessions

Table 8.2 Teaching staff supervising students during the clinical sessions of removable prosthodontics (CD and RPD)

Staff member level	Number of dental schools
Consultant/ specialist	3
Senior lecturer	4
Lecturer	2
General practitioner	2
Dental technician	1
Total	**12**

Participants from dental schools that have lecturers and general dentists to supervise CD and RPD clinical sessions explained that as following:

"…For conventional dentures and partial dentures, I would be OK with it being a generalist, and again, that could be somebody at lecturer level…generalist because (they are the ones treating more cases of CD and RPDs), and the amount of people

who are comfortable teaching removable prostheses, in my experience is going in that direction (pointed down) …" (03).

Most participants' opinions were that those who supervise students in the clinical sessions should be familiar with module teaching:

"…not necessarily, they do not have to be involved with the teaching of the module, but they should be familiar with it…" (07).

Fifty percent of the participating dental schools (6 out of 12) believed that it is important for students to complete the laboratory work of the acrylic RPD (1-2 cases) by themselves in order to gain experience:

"…I don't think it's important that they do all of their own lab work, but I think it's useful for them to get experience, one or two cases just to get experience, yeah…" (03).

The other half of participants considered it "*not important*" but desirable. The lack of resources or the overcrowded curriculum were reasons why it is not currently done in those schools:

"…I would say that it would be ideal if they could do the lab work, but practically the reason that we don't sustain that now is because of the curriculum. We just don't have space so ideally, yes, yes, practically, no…" (02).

The majority of participants (9 out of 12) believed that oral assessments at the end of preclinical CD courses are not important:

"…if you're looking to assess theoretical knowledge, I don't think oral examination is the best way to do it. I prefer competency testing…" (03).

“…if you're doing a good simulation assessment or a good clinical assessment associated with a written exam…well, you don't need an oral examination…” (05).

8.4.2 Teaching and Assessment Methods in Dental Implants Course

Half of the participants (6 out of 12) have a DI course, either preclinical only or preclinical and clinical, and consultants or specialists were considered to be the most suitable members of staff to supervise students in six dental schools, whereas senior lecturers (5) and lecturers (1) were considered suitable in the remaining schools.

Most of the participants considered DIs too advanced for undergraduate level or difficult to teach due to overcrowded curricula:

“…as things progress that may change in the future where you know, restoring implants may become part of the undergraduate curriculum but at the moment I don't see space for that and I don't see it as a priority…” (01).

“…I think it's probably too advanced, certainly in our institution, we cannot incorporate that as part of the undergraduate education, but it is important for them to know the theoretical steps. I think beyond the scope of undergraduate education at the moment – five-year course…” (04).

Four out of the six dental schools that have a dental implants course, set a minimum competence level for their students:

"...I would say, a single tooth for replacement, like a single crown and over-denture, lower over-denture case. I think that would be the minimal competence they should be able to do. It executes the prosthodontic phases..." (05).

Challenges in undergraduate prosthodontics teaching

Some challenges regarding teaching of the undergraduate prosthodontics course were identified during this study and resolution for them were also suggested by participants.

An overcrowded curriculum was considered by participants to be one of the greatest challenges in the teaching of undergraduate prosthodontics. It was pointed out as an obstacle to building students' skills and to adding new course material to the curriculum:

"I think you know there's a lot to fit into the undergraduate curriculum, and you know, treatment has become more complex…I think there is a challenge to get them enough experience and enough cases and treating…" (01).

Updating the curriculum regularly and starting the clinical sessions as early as possible were suggested as ways to overcome this problem.

Participants considered the curriculum, patients' availability, and lack of resources as barriers to incorporating the teaching of DIs at undergraduate level:

"*…Ideally yes, teaching dental implants in the programme I mean, the more…the more that we can have students competent on graduation across the full range of industry that better..." (02).*

"…Practically, it becomes quite difficult to actually make it really effective because the surgical disciplines and availability of patients…" (02).

Participants suggested some ways of incorporating/including DI teaching into the undergraduate curriculum, such as adjusting the curriculum according to what is expected from the graduating dentists, and allowing students to observe DI cases and then start dealing with simple and straightforward cases.

8.5 Discussion

This qualitative study explored topics in prosthodontics teaching and assessment methods. We demonstrated the divergence between participating dental schools and revealed to some extent the background of this divergence, which enable us to understand the views of senior academics from four different continents. Nine prosthodontics teaching and assessment topics that did not reach consensus in our previous study [205] were investigated. Of them, only the oral assessment at the end of the preclinical CD course topic reached consensus (not important) among the participants (9 out of 12). In comparison, the divergence in the remaining topics was clear between the participating dental schools. This divergence is referred to several reasons, such as the overcrowded curriculum, lack of experienced senior academics and lack of resources. In addition, the difference in the participants' opinions was clear between what teaching or assessment methods are currently used and what is ideal or should be applied. Although the ideal method was not always similar between the participants, for instance, some participants believed that teaching the prosthetic part of the dental implants course is the ideal. On the other hand, some participants believed that being familiar with the DI indications and considerations and then referring the patient is the ideal at the undergraduate level.

During the preclinical hands-on practical sessions in CD, RPD and FP, the majority of participants agreed that the level of experience is the most important factor in determining who is the most suitable to supervise students. These findings are similar to what was reported by Lynch *et al*. as they reported that members of staff who most currently supervised the removable prosthodontics clinical sessions were senior lecturers followed by consultants or specialists [59]. However, dental schools that selected junior members of staff to supervise the removable prosthodontics sessions did so either due to refusal of some members of staff to supervise these sessions or due to the lack of senior academic members as previously reported [158]. Overall, the staff's level of experience was considered as an important factor when deciding who should supervised students.

Being involved in the module teaching was also found to be the most important consideration when choosing the most suitable members of staff to assess students' competence level during RPD clinical sessions. In regard to students completion of laboratory work of their own RPD cases, half of the participating schools considered it important for at least one or two cases in order to gain experience. Whereas schools that did not consider the laboratory work as an important skill for their students, mentioned the lack of resources and the overcrowded curriculum as challenges they face.

Moreover, half of participating schools commence the FP clinical sessions in the year three of five-year course, followed by year four, which is comparable to the findings of a previous study [65]. However, applying an integrated curriculum allows one school to commence the FP clinical sessions in year two. Commencing FP clinical sessions was also reported to be subjected to various factors, such as the availability of suitable patients for treatment, school's curriculum and the level of students' skills. In 2017 a study reported that early clinical exposure in prosthodontics will help solve many problems encountered during learning and contribute to a better understanding [203]. Similarly, another two studies in 2018 and 2020 found that students' confidence levels in carrying out prosthodontics treatment would be improved further by increasing the clinical experience [207, 208].

DI course material complexity and the staff's level of experience were the main reasons for participating schools to select consultants or specialists as the most suitable members of staff to supervise the preclinical hands-on sessions and the clinical sessions if available. Dental schools that set a minimum competency level for their students expect them to know how to assess patients, treatment plan, be familiar with the medical considerations and restore at least one or two dental implants (prosthetic part only). Most of the participants believed that the course of DI at undergraduate level is too advanced for undergraduate students and it is only suitable for postgraduate students. In contrast, The ADEE [151] and the European Workshop of Dental Implant Education [197, 198] recommended that dental schools update their curricula and incorporate a DI course in undergraduate programmes.

The overcrowded curricula, lack of resources and the availability of patients were found in the current study to be the contemporary challenges that prevent some of the participating dental schools from teaching DIs; likewise challenges were reported by Chin *et al*. in 2018 [209]. Whereas tailoring the curriculum according to what is expected from the graduating dentists and allowing students to observe DI cases before dealing with simple and straightforward cases were suggested as ways of overcoming the some of these challenges. In comparison, it was recommended that further development and improvement of implant teaching in dental undergraduate schools in the UK and Ireland are required, particularly with respect to the amount of direct clinical experience provided [209]. It also was suggested by a recent study that knowledge of DIs should be enhanced among undergraduates by conducting more structured teaching programmes, and this should positively impact on dentists' future clinical practice [210].

8.6 Conclusion

This qualitative study presented a deeper understanding of the current divergence in prosthodontics teaching and assessment methods. These results could be considered as a reference to develop recommendations for stakeholders involved in undergraduate curricula among dental schools worldwide.

CHAPTER 9: Response Rates to Questionnaire-based Studies in the Contemporary Dental Literature: A Systematic Review

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Published in: *Journal of Dentistry (J.Dent),* September 2022

https://doi.org/10.1016/j.jdent.2022.104284

(**Paper 3**)

9.1 Abstract

Objectives: This systematic review aimed to investigate what is a reasonable response rate for dental questionnaire-based studies in recent literature and to assess the factors that affect the response rates.

Methods: We used MEDLINE/PubMed to search the dental literature of 2021 (January-October). Two reviewers independently assessed studies eligibility and extracted data using standardized electronic extraction form.

Results: One hundred and seventy-two studies were eligible, of these a total of 149 response rates were reported from 133 studies, whereas the remaining 39 studies were excluded as they did not report response rates. The median response rate across the included studies was 77% (mean= 70.8%). We found significant negative correlation between the response rate and the actual number of distributed questionnaires (sample size) (r = -0.4127; P < 0.001). We also found an association between the response rate and the area of distribution, e.g., national or international (P = 0.0012). However, a wide variation was observed in the quality of information reported within this review and we did not find clear evidence of association between the response rate and other variables such as questionnaire piloting, number of questions in the questionnaire and the journal impact factor.

Conclusions: The findings of this systematic review confirm the association between the response rate and the sample size, where the response rate increases when the sample size is less than 300 participants. In addition, a higher response rate could be achieved when the study conducted within the same institution (e.g., university).

9.2 Introduction

Questionnaire-based research are widely published within the dental literature. This methodology can offer an objective methods of collecting information about people's knowledge, beliefs, attitudes, and behaviour [211]. Questionnaires can be used as the sole research instrument e.g., cross-sectional surveys or within clinical trials and epidemiological studies [212]. However, concern exists in relation to what represents a 'reasonable' response rate – i.e., being of sufficient magnitude to reliably answer the questions posed, while excluding non-responder bias. Therefor a questionnaire should aim to obtain as representative a range of responses as possible and thereby provide reliable and valid answers to the research questions posed. [213].

A brief review of the dental literature reveals a wide range of response rates – from as low as 7% on the assessment of the knowledge and attitudes of western Australian dental health practitioners towards identifying and reporting child abuse [214] to as high as 100% on the assessment of the diagnostic skills of general dentists in different types of orthodontic malocclusions [215]. Thus, questionnaire response rates have become one of the "most controversial issues" which may affect the journal acceptance and publication of the questionnaire-based researches [216].

In 1997, Tan and Burke conducted a review that included sample of 77 articles from four dental journals during the period 1989-1992. Their aim was to investigate the range and factors affecting response rates for mailed distributed questionnaire-based studies [217]. The authors found that 64% is the average response rate for the investigated questionnaire-based studies. Additionally, they suggested that questionnaire subject, incentives offered and length of the questionnaire may influence response rates [217]. However, since then, research methods, computer technology, internet access, statistics and editorial policies have changed the practice of data collection.

Nowadays, electronic survey has become widely used among researchers. It minimises the processing costs because it automates the transformation of raw data into electronic form, and combines the advantages of interviews (e.g., complex branching) with those of paper-form surveys (e.g., standardization, anonymity) [218]. In 1984, Kraut used a computer network in an international corporation to conduct research on work behaviours and attitudes [219]. Then in 1986, a study aimed to conduct an experimental study by using both electronic and paper mail sample survey. The authors found that more respondents returned the paper surveys (75%) than the electronic surveys (67%). However, they reported less completion mistakes and faster returned response for the electronic surveys [218]. In literature, there is a conflict on whether email or paper-form questionnaires result in higher response rates. Some papers reported higher response rate for electronic questionnaires [220], others reported higher response rates for email questionnaires, [218, 221], while others reported comparable response rates [222, 223].

Furthermore, email propagation or social media can be utilized to ensure reaching the most significant number of the targeted population. Hence, a higher response rate for the questionnaire-based study and a minimum non-responder bias might be obtained. However, participant recruitment through social media platforms or email propagation might be a challenging process, and the response rate cannot always be measured. A recent descriptive WhatsApp messenger-based cross-sectional survey study found that social media platforms are reliable and could be used for disseminating information as well as a research tool among medical students and healthcare professionals. The study also found that more than two-thirds of medical students and healthcare professionals routinely use social media, although a 21% response rate was reported [224].

It has been claimed that using a mixed-mode approach will enhance the survey response rates or if mailed surveys are combined with e-mail follow-up [225] . In a study comparing different methods of administration, response rates close to 60% were achieved by mixed-mode contacts [222]. This approach, combining both mailed and e-mailed survey instruments with an Internet-based response mechanism, also is an approach to help reduce the problem of coverage error in the administration of surveys [222]. In comparison, Dillman *et al.* suggested that mixed-mode distribution of questionnaires may increase response rates with respondents choosing their preferred method of response [226]. Similarly, it was reported that 41% of electronic questionnaire respondents would not complete a telephone interview on the survey, confirming the potential of mixed-mode distribution to reduce non-response bias [227]. Moreover, a response rate of 72% was reported when a mixed-mode method was used, noticing that this technique "improved representativeness of the sample without biasing other results" [228].

Asch *et al*. reported that questionnaires distributed to medical professionals yield low response rates (mean response rate among medical doctors was 54% and it is ≈60% among mail surveys published in medical journals) [229]. This is confirmed in a systematic review by Cook *et al.* in 2009 (median response rate of 60%) on healthcare professionals' response rates which was significantly lower than the estimate for the prior 10-year period. Authors also highlight the importance of non-response analysis and indicated that sending reminders and conducting studies on less than 1000 population will increase the response rate [230].

The research question for this study is to determine "what is considered to be a 'reasonable' response rate to merit publication of a questionnaire-based study in the contemporary dental literature". Hence, we conducted a systematic review to investigate what is a reasonable response rate for dental questionnaire-based studies in recent literature and to assess the factors that affect the response rates.

9.3 Materials and methods

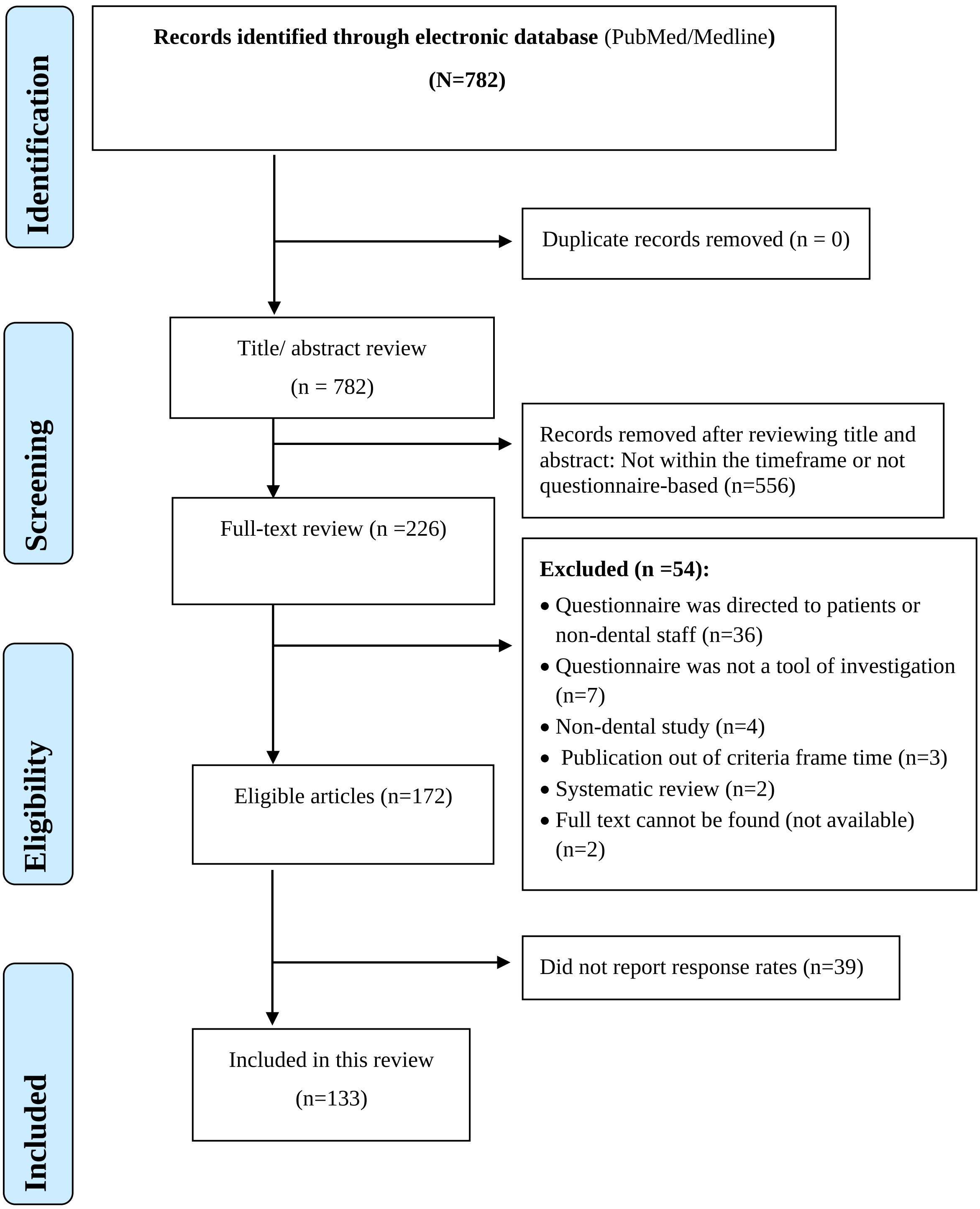
The Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines were used for all procedures and reporting [231].

9.3.1 Information sources and search strategy

i) Electronic database: In February 2022, an electronic search of the online MEDLINE/PubMed 2018 – present database using Ovid-dc2 interface was performed using the MeSH terms related to questionnaire and dental literature.

ii) Manual searching: To ensure a manageable number of articles, the search was restricted to articles published in the January-October 2021 period inclusive. At this stage, of the 782 citations, 556 articles were excluded after screening the title/abstract because they were not questionnaire-based studies or the date of publication was not within our study frame-time. When publication dates were unclear (e.g., Winter, Spring, etc.), journal websites were reviewed. Then, the remaining 226 articles were screened by 2 independent reviewers (K.A.) and (S.O'D.K.) to determine whether eligibility criteria were met. Following this, 54 articles were excluded and a total of 172 studies were eligible for inclusion in this review, of these 39 studies did not report information regarding to the response rate, therefore these studies were excluded (Figure 9.1).

Figure 9.1 PRISMA flow diagram of the identified studies



9.3.2 Selection process and eligibility criteria

Inclusion and exclusion criteria were set prior to the selection of articles for this systematic review. Inclusion criteria included: papers published between January and October 2021 (even if available online earlier), methodology sections reporting questionnaires as tools of investigation and subsequently reported on in the results section. In addition, the questionnaire in the study must be directed to the dental schools' faculties/academics, dental health practitioners (dentists, hygienist, therapists, etc) or dental students. Studies were excluded if: the reported questionnaire was used to collect participant baseline characteristics as part of a larger study (e.g., randomised controlled trial) or if the questionnaire was not subsequently reported on in the article.

9.3.3 Data collection process and quality assessment

An electronic standardized data extraction form was used to extract the data from the eligible studies. Two investigators (K.A.) and (S.O'D.K.) extracted data for all included studies. We extracted data on the article title, reference details (ISSN/Doi), study ID, country(ies), discipline, reported response rate, sample size, area of distribution (e.g., national or international), actual number of questionnaires distributed, participant population and sampling frame, method of distribution (electronic or paper questionnaire), provision of stamped-addressed envelope for return of postal questionnaires, ethical approval, questionnaire piloting, follow-up, incentives, questionnaire reproduced in published article, number of questions in questionnaire, reference to response rate in discussion section, validity testing of questionnaire and the impact factor. In addition, a third investigator (C.D.L.)

resolved any inconsistencies between the two investigators about included articles and data extraction.

9.3.4 Statistical analysis

While this project was mainly exploratory in nature, some potential associations of interest were investigated for statistical significance. Data distribution was considered to facilitate appropriate use of parametric/ non-parametric tests. We assessed the distribution of response rate and as it was not normally distributed, we used non-parametric tests for almost all reported results in this review. A Spearman's correlation was performed to assess the relationship between the response rates and the following numerical variables (actual number of distributed questionnaires, number of questions in questionnaire and journals impact factor). Furthermore, Kruskal-Wallis test was used to assess the pattern of response rate across the following categorical variables (area of distribution, geographical distribution, method of distribution, piloting, and follow up). A statistically significant *P* value was based on a threshold of <0.05 and all analyses were using Stata/MP software (version 16).

9.4 Results

A total of 172 articles were eligible to be included in this review. Of these, 14 articles had more than one population (e.g., dentists and dental assistants) with different response rate distribution. Thirty-nine articles did not report information regarding to the response rate; therefore, these studies were excluded. Eventually, a total of 133 articles with 149 reported response rates were included. The characteristics of included studies are presented in Table 9.1 according to the response rate.

Table 9.1 Study characteristics based on response rate

Variables \ Response rate	<50%	50-<70 %	≥70%
Actual number of questionnaires distributed n (%)			
50 or less	0	3 (*12*)	16 (*18.6*)
51-100	5 (*17.2*)	3 (*12*)	16 (*18.6*)
101-300	4 (*13.8*)	6 (*24*)	30 (*34.9*)
301-1000	11 (*37.9*)	8 (*32*)	18 (*20.9*)
>1000	9 (*31*)	5 (*20*)	6 (*6.9*)
Geographical area n(%)			
Africa	2 (*6.25*)	1 (*4*)	2 (*2.17*)
Asia	8 (*25*)	15 (*60*)	48 (*52.2*)
Europe	14 (*43.8*)	8 (*32*)	28 (*30.4*)
North America	4 (*12.5*)	0	5 (*5.43*)
South America	3 (*9.38*)	0	5 (*5.4*)
Other*	1 (*3.13*)	1 (*4*)	4 (*4.35*)
Method of distribution			
Paper	8 (*25.8*)	5 (*25*)	32 (*41*)
Electronic	23 (*74.2*)	14 (*70*)	45 (*57.7*)
Both	0	1 (*5*)	1 (*1.28*)
Number of questions n (%)			
< 50 questions	20 (*100*)	10 (*83.3*)	57 (*86.4*)
≥ 50 questions	0	2 (*16.7*)	9 (*13.6*)
Follow up reminders n (%)			
Yes	11 (*34.4*)	9 (*36*)	18 (*19.6*)
Not reported	20 (*62.5*)	15 (*60*)	60 (*65.2*)
Not applicable	1 (*3.13*)	1 (*4*)	14 (*15.2*)
Pilot study			
Yes	16 (*50*)	13 (*52*)	35 (*38*)
Not reported	16 (*50*)	12 (*48*)	57 (*62*)
Ethical Approval obtained, n (%)			
Yes	26 (*81.3*)	25 (*100*)	76 (*82.6*)
No or not reported	6 (*18.8*)	0	16 (*17.4*)

9.4.1 Reported response rate

Table 9.2 shows the distribution of response rates in the sample. Ninety-two of the reported response rates (61.7%) were greater than 70%. Thirty-seven reported response rates (24.8%) were of 40-69%, and 20 reported response rates (13.4%) were less than 40%.

Table 9.2 Reported response rate within the sample included in the review

Response rate (%)	**Articles**	
	n	**%**
<10	2	1.34
10-19	3	2.01
20-29	7	4.69
30-39	8	5.36
40-49	12	8.05
50-59	12	8.05
60-69	13	8.72
70-79	20	13.42
80-89	36	24.16
≥90	36	24.16
Total	**149**	**100**
The median response rate was 77% (min=7%, max=100%) and the mean was 70.8%		

9.4.2 Actual number of questionnaires distributed

Of the 149 reported response rates, 140 reported information about the number of questionnaires distributed to participants (93.9%). Nineteen studies reported questionnaires distributed to ≤50 participants (13.5%), 24 (17.1%) reported questionnaires distributed to participants between 51-100, 40 (28.5%) reported questionnaires distributed to 101-300 participants, 37 (26.4%) reported questionnaires distributed to 301-1000 participants and 20 (14.2%) reported questionnaires distributed to >1000 participants (Table 1). We also found a statistically significant moderate negative correlation between the number of questionnaires distributed and response rate (Spearman's Correlation coefficient = -0.4127; $P < 0.001$) suggesting that when the questionnaire was distributed to a smaller sample population, a higher response rate was achieved.

9.4.3 Area of distribution

A total of 55 (36.9%) studies were conducted within the same institution as the study investigators, 81 studies (54.3%) were conducted nationally, and 13 (8.7%) were international studies. Table 9.3 shows the pattern of response rate according to the area of distribution. Significant differences in response rates based on the area of distribution were found, with higher response rates among studies that conducted within the institute (Kruskal-Wallis test P value =0.0012). However, it should be noted that few international studies were included in our review (n=13).

Table 9.3 Response rates according to the area of distribution

Response rate (%)	**Area of distribution**		
	Within institute (%)	**National (%)**	**International (%)**
<10	0 (*0*)	2 (*2.47*)	0 (*0*)
10-19	0 (*0*)	3 (*3.70*)	0 (*0*)
20-29	0 (*0*)	6 (*7.41*)	1 (*7.69*)
30-39	1 (*1.82*)	7 (*8.64*)	0 (*0*)
40-49	4 (*7.27*)	7 (*8.64*)	1 (*7.69*)
50-59	2 (*3.64*)	9 (*11.11*)	1 (*7.69*)
60-69	6 (*10.91*)	5 (*6.17*)	2 (*15.38*)
70-79	12 (*21.82*)	8 (*9.88*)	0 (*0*)
80-89	10 (*18.18*)	22 (*27.16*)	4 (*30.77*)
≥90	20 (*36.36*)	12 (*14.81*)	4 (*30.77*)
Total	**55**	**81**	**13**
Minimum	36.1	7	20.4
Median	**84**	**73**	**84**
Maximum	100	100	99.4

9.4.4 Geographical distribution

The 149 reported response rate were categorised into six geographical area namely, Africa, Asia, Europe, North America, South America and other. Table 9.4 illustrates the pattern of response rate in regard to the geographical distribution. There were significant differences in response rate across the geographical distribution (Kruskal-Wallis test P value = 0.067). Approximately, two-thirds of studies in Asia had response rates ≥ 70%, whereas about half of European and north American studies had response rates ≥ 70%.

9.4.5 Method of distribution

The majority of the included studies reported electronic/ internet distribution of the questionnaires (82, 55%). Forty-five studies (30%) reported paper distribution whereas two studies (1.5%) reported mixed-mode distribution. No information was reported in the remaining 20 studies (13%). Table 9.4 shows the pattern of response rate according to the method of distribution. There is weak evidence of differences between the method of distribution and the response rate (Kruskal-Wallis test P value = 0.0489).

Table 9.4 Response rates according to the geographical distribution and method of distribution

Variable	Number of studies (*%*)	Min. response rate (%)	Median (%)	Max. response rate (%)	Mean ± SD
Geographical distribution					
Africa	5 (*3.36*)	25	60.8	91	60± 25.6
Asia	71 (*47.65*)	21.7	81.5	100	77± 19.4
Europe	50 (*33.56*)	20.4	73.5	100	65± 22.7
North America	9 (*6.04*)	9.4	80	100	56± 38.3
South America	8 (*5.37*)	16.8	73.7	97.4	65± 31.6
Other	6 (*4.03*)	7	88.9	100	71± 36.1

Method of distribution					
Electronic	82 (*63.5*)	7	72.8	100	65± 25.6
Paper	45 (*34.8*)	20.6	84.3	100	75± 21.6
Mixed-mode	2 (*1.5*)	52.6	68.1	83.7	68± 21.9

9.4.6 Provision of a stamped-addressed envelope for return of postal questionnaires

Only three studies out of the 45 (6.6%) that used paper distribution of the questionnaire reported provision of a stamped-addressed envelope for return.

9.4.7 Ethical approval

Of the 149 reported response rate, 127 (85.2%) reported ethical approval being sought, 20 studies (13.4%) did not report seeking ethical approval and two studies (1.3%) reported that ethical approval was not sought or being advised that ethical approval was not required.

9.4.8 Piloting

Of the 149 reported response rates, 64 (43%) had been piloted, while no information on piloting was reported in the remaining studies (85, 57%) (Table 9.5). There were no statistical significance differences in the response rates across these groups (Kruskal-Wallis test *P* value = 0.0877).

9.4.9 Follow-up

Of the 149 reported response rate, 38 studies (25.5%) reported follow-up was performed. Sixteen studies (10.7%) did not allow for follow-up and the remaining

95 studies (63.7%) did not report any follow-up (Table 9.5). Comparison of response rates across these groups was statistical significance (Kruskal-Wallis test *P* value = 0.0047).

Table 9.5 Response rates according to piloting and follow-up

Variable	Median (min, max) %
Piloting or not (n, *%*)	
Piloting (64, *43*)	79.5% (7%, 100%)
No piloting (85, *57*)	74.8% (13.5%, 100%)
Follow-up or not (n, *%*)	
Follow-up (38, *25.5*)	67.3% (7%, 100%)
No follow-up (16, *10.7*)	84.9% (42.6%, 100%)
Did not refer to follow-up (95, *63.7*)	77% (9.4%, 100%)

9.4.10 Incentives

One-hundred and forty-two studies (95.3%) did not report any incentives. Five studies (3.3%) reported that no incentives had been offered. Two studies (1.3%) reported incentives had been offered.

9.4.11 Questionnaire reproduced

Sixty-four out of the 133 included articles (48%) reproduced the original questionnaire within the published article. The remaining 69 articles (52%) did not reproduce their questionnaire.

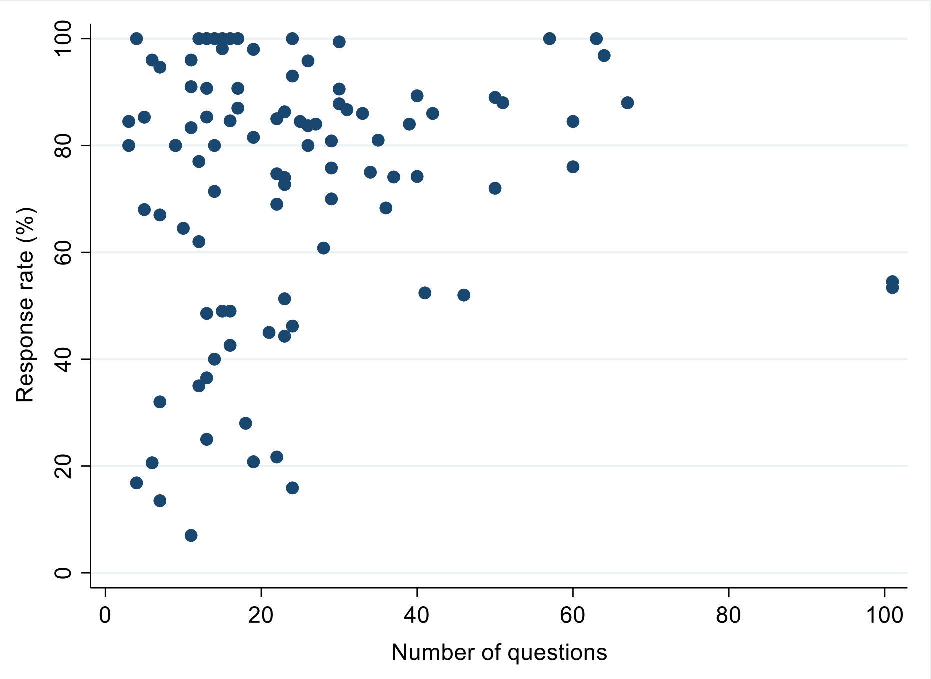
9.4.12 Number of questions in the questionnaire

Table 9.6 shows the number of questions included in the questionnaires and Figure 9.2 illustrates the association between number of questions and the response rate. It is clear from the scatter plot that there is no correlation between number of questions and response rate (Spearman's correlation coefficient: 0.1148; *P* = 0.2604).

Table 9.6 Number of questions used within the questionnaires

Number of questions	Number of studies (*%*)	Median (min, max) %
≤10	13 (*8.7*)	68 (13.5, 100)
11-20	33 (*22.1*)	83 (7, 100)
21-30	27 (*18.1*)	75.79 (15.9, 100)
31-40	9 (*6*)	81 (68.3, 89.3)
>40	11 (*7.3*)	88 (53.4, 100)
No information	56 (*37.5*)	72.45 (9.4, 100)
Total	**149 (*100*)**	**P value = 0.2604**

Figure 9.2 Association between number of questions and response rate



9.4.13 Reference to response rate in discussion section

Of the 149 reported response rate, 53 studies (35.5%) commented on the response rate achieved in their discussion or conclusion section. Ninety-six studies (64.4%) did not comment on the response rate.

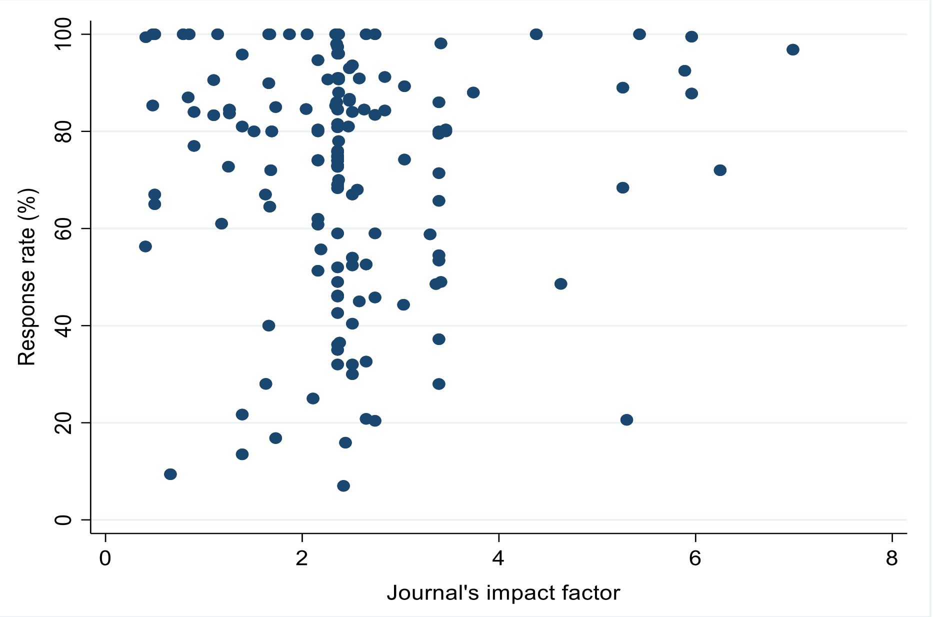
9.4.14 Validity testing of questionnaire

Fifty-nine studies (39%) reported that the questionnaire had been validated or was based on a previously-validated questionnaire. Three studies (2%) did not validate the used questionnaire and no information on validation was included in the remaining 87 studies (58%) out of the 149.

9.4.15 Impact factor

The range of journal impact factors was from 0.406 to 6.99. The scatter plot (Figure 9.3) shows no association between impact factor and response rate (Spearman's correlation coefficient: -0.0939; P = 0.2548).

Figure 9.3 Association between impact factor and response rate



9.5 Discussion

This systematic review included 133 questionnaire-based articles with a total of 149 reported response rates. The median of response rate across the dental literature was 77% (mean=70.8%). In 1997, Tan and Burke reviewed 77 articles that were published between 1989-1992, the response rates to “questionnaires mailed to dentists” had an average of 64% [217]. Thus, based on the information included in this systematic review, the response rate of the questionnaire-based dental studies is higher than what it was reported 25 years ago.

Furthermore, this review revealed that studies conducted within the institute (e.g., university) had higher response rates than the studies that conducted nationally or internationally. Moreover, we found that about two-thirds of studies in Asia had response rates ≥ 70%, whereas about half of the European and north American studies had response rates ≥ 70%. However, we found weak evidence that the method of distribution (e.g., electronic) could affect the response rate, and comparable response rates could be achieved with any method of distribution as previously reported [222, 223]. Thus, this finding does not support using of electronic questionnaire [220] or the mixed-mode method [225, 226, 228] to increase the response rate.

Beside the many advantages of electronic distribution of the questionnaire-base studies (e.g., automates the transformation of raw data into electronic form), concern has been expressed in relation to potential reduced response rates associated with this method. Yun *et al.* stated that “*e-mail research raises many ethical concerns because unsolicited e-mail invades a person’s private space*” [228]. Likewise, Dillman *et al*. also noted that junk email risks reducing response rates [226]. Comparable to older studies [232, 233], this systematic review has a median response rate for electronic distribution (72.8%) which was lower than that of paper distribution (84.3%).

More than two-thirds of the studies that reported ≥70% response rate had distributed their questionnaire to participants of 300 or less. This indicates that a higher response rate could be achieved when the questionnaire is distributed to a smaller population. Similarly, Cook *et al.* suggested that conducting studies on a population less than 1000 participants would increase the response rate [230]. Cook *et al.* also suggested that sending a reminder would increase the response rate [230] which is in keeping with the original recommendations of Dillman *et al.* [226]. However, we found that studies that reported sending a follow-up reminder had lower response rates than the studies that did not report any information on sending reminder. Therefore, our results could not support the importance of sending reminder to increase the response rate as 63.7% of articles did not report any information on follow-up.

While piloting is deemed essential and a recognised means of increasing response rate [226], the difference in response rates did not reach a significant level between the included studies reporting piloting (43%) and those which did not report any information (57%). A wide variation was also noted in the quality of information reported within the systematic review sample of publications. Thirteen percent of articles did not report seeking ethical approval for their questionnaire, 58% did not report whether or not their questionnaire had been validated, and 56% did not report whether their questionnaire was reproducible or not (i.e., can be used again). Additionally, we found no relationship between the number of questions in questionnaire and the response rate. In addition, 96 articles (64.4%) did not comment or mention the achieved response rate in the discussion section of their study and 142 studies (95.3%) did not report offering any incentives.

Questionnaire-based studies and the response rate achieved are controversial. There is no evidence base for specific thresholds for response rates among these studies [216]. However, conducting good research practice by following the core principle based on Dillman's work [226] which have achieved high levels of acceptance within the scientific community and considered as fundamental to high quality surveys [216]. Briefly, Dillman *et al*. recommended that: (1) more work and scientific rigour goes into the planning and execution of a questionnaire survey, the more likely the results are to be valid, (2) the quality and clarity of the survey's covering letter will improve response rates, (3) the questions set should be simple, short, specific without being too specific, unambiguous and should avoid bias, (4) the questionnaire should be piloted amongst colleagues, potential users of the information and also amongst the population to be surveyed, (5) the questionnaire recipients should be randomly selected, representative of the population as a whole (to avoid selection bias and ensure that results are 'generalisable') and of sufficient size, and (6) if one mailing achieves a poor response rate, then repeat the mailing twice and try to identify how non-responders differ (demographically) from responders [226].

Systematic reviews offer advantages such as efficiency, integration of information from a diverse range of related articles, while reducing bias and increasing reliability and accuracy of recommendations because of its formalised and thorough method of investigation [234]. We conducted a comprehensive search strategy and the investigation was exploratory in nature; some potential associations of interest were investigated for statistical significance. Due to the non-normal distribution of data, non-parametric tests were selected. These tests are valuable; however, they are less sensitive than parametric tests [235]. In addition, our review was limited to the English language studies that published between January and October 2021 which could be considered as limitations of this systematic review.

9.6 Conclusion

The findings of this systematic review confirm that a higher response rate is associated with smaller sample size and conducting the study within the same institute. However, we noted considerable variation exists amongst response rates and the reporting of other information. Questionnaire-based publications can effectively contribute to dental research; thus, dental journals should consider development of a minimum set of guidelines in the reporting of questionnaire-based manuscripts.

CHAPTER 10: Conclusion

The overall aim of this thesis was to investigate and describe the international current teaching and assessment methods in undergraduate prosthodontics curricula. At the outset, a total of 99 published sources related to the study were included in the thesis narrative review. Overall, despite some similarity in prosthodontics teaching material among dental schools, there was a wide variation in prosthodontics curricula among dental schools worldwide. The significant divergence was in terms of teaching methods, assessment criteria and how students' competence is determined. this divergence was not only in the nature and technical teaching methods, but also in the year of commencing prosthodontics (removable, fixed and implants) teaching. Also, teaching hours, staff: student ratio, recommended textbooks and assessment criteria varied among the schools.

The project then considered the response of a number of questionnaire-based surveys which examined current international trends in the teaching and assessment of various aspects of prosthodontics (complete dentures, removable partial dentures, fixed bridges and dental implants) on an international setting.

Given the variable response rate to the questionnaires in the earlier part of this project, the thesis also considered the response rates to questionnaires published in the literature. The last published study which considered this was published in 1997 and there has been much advancement in research methodologies, technology and academic publishing since then. The average response rate was 70.8% however, a wide variation was observed in the quality of information reported within this review and we did not find clear evidence of association between the response rate and other variables such as questionnaire piloting, number of questions in the questionnaire and the journal impact factor.

In the terms of limitations to the study, our quantitative studies response rates could be considered to be low, although, we sent three reminder emails after the initial email to encourage the non-respondents to participate. It should be noted that the surveys were sent during the COVID-19 pandemic (April-September 2020) which might explain the low response rate. The Delphi study was also conducted during the Covid-19 pandemic (May-November 2021) and it was not possible to collect the experts together in the same physical location – due to Covid-19 reasons, but also due to geographical limitations.

For the qualitative research, we cannot rule out the possibility of self-selection bias. Other limitations include small sample size and potential bias in answers which may not reflect the perceptions of a wider population of dental academic staff in prosthodontics. However, for both the Delphi project and the qualitative research, we included experts from different countries (11 countries in the Delphi study and 7 in the qualitative study) to capture perceptions regarding undergraduate teaching and assessment from different dental schools across different geographical areas.

In terms of future research, it would be of interest to ascertain opinions of undergraduate senior dental students and newly-graduated dentists regarding their studying experience and curricula contents. This investigation could help to understand potential weaknesses in the curriculum and facilitate the improvement of the undergraduate curricula among dental schools worldwide. In addition, future studies should focus on implantation of new innovations and utilizing the available technology to the teaching process e.g., virtual reality-based technology or digital workflow.

In summary, the findings of this thesis highlighted discrepancies in the contemporary teaching and assessment of undergraduate prosthodontics among dental schools worldwide. However, our results from the Delphi survey and the qualitative studies presented detailed recommendations and suggestions to reduce these discrepancies and facilitate convergence of dental education. We believe that the recommended harmonization of the dental curricula [151] is possible to be achieved internationally. This harmonization will ensure that newly qualified dentists have a similar level of competence. Thus, the movement of dentists around the world will be easier and they will be prepared to provide high quality professional and clinical care.

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Appendices

Appendix 1: Questionnaire of Undergraduate Complete Dentures Curriculum: An International Study of Current Teaching and Assessment Methods

Determining Competence in Prosthodontics in Dental School Training Programmes:
Complete Denture

Please identify the Dental School you are completing this survey on behalf of: (no schools will be identified in the survey report; this information is sought solely to track non-responders).

Preclinical Teaching and Assessment in Complete Dentures:

1. Does your dental school have a preclinical course in complete dentures?

☐ Yes ☐ No

2. Assuming your BDS programme is of 5 years duration, in which year does this course
take place?

☐ 1st Year ☐ 2nd Year ☐ 3rd Year ☐ 4th Year ☐ 5th Year

3. What is the approximate number of hours of teaching received by an individual student in this course?

Click or tap here to enter text.

4. How is this divided:

• Academic/didactic teaching: Click or tap here to enter text. hours
• Hands-on/ practical skills: Click or tap here to enter text. hours

5. Regarding the academic/didactic teaching how is this divided?

• Formal lectures: Click or tap here to enter text. hours
• Laboratory demonstrations: Click or tap here to enter text. hours
• Small groups/ Tutorials/ seminars Click or tap here to enter text. hours
• Other: Click or tap here to enter text. Hours

6. If you have answered "other" in question 5, please specify:

Click or tap here to enter text.

7. What is the staff: student ratio?

• For formal lectures: Click or tap here to enter text.
• For laboratory demonstrations: Click or tap here to enter text.
• For small groups/tutorials: Click or tap here to enter text.

8. Who is responsible for directing the preclinical course in complete dentures?

☐ Professor ☐ Consultant ☐ Senior lecturer/Associate professor ☐ Lecturer
☐ Technician ☐ GDP (part-time lecturer) ☐ Others: Click or tap here to enter text.

9. Do students gain experience at following: tick any

☐Using articulator ☐Complete dentures prescription writing
☐ Casting impression ☐Teeth setting & waxing-up denture
☐ Packing, Flasking & de-flasking (denture processing)

10. Who supervises students on these experiences?
• Using articulator: ☐Clinician ☐Technician
• Complete dentures prescription writing: ☐Clinician ☐Technician
• Casting impression: ☐Clinician ☐Technician
• Teeth setting & waxing-up denture: ☐Clinician ☐Technician
• Packing, Flasking & de-flasking (denture processing): ☐Clinician ☐Technician
11. What form does the teaching of these experiences take?
• Using articulator: ☐Formal lecture ☐Lab demonstration ☐ Practical exercise
• Complete denture prescription writing: ☐Formal lecture ☐Lab demonstration ☐ Practical exercise
• Teeth setting & waxing-up denture: ☐Formal lecture ☐Lab demonstration ☐ Practical exercise
• Packing, Flasking & de-flasking (denture processing): ☐Formal lecture ☐Lab demonstration ☐ Practical exercise

12. What type of articulator are the students taught to use? tick any
☐ Arcon/semi-adjustable ☐ Non-arcon/semi-adjustable ☐ Average value
☐Simple hinge ☐None ☐Other: Click or tap here to enter text.
13. Do the students have to complete an assessment at the end of the preclinical course?
☐ Yes ☐ No
14. If yes, what form does this assessment take?
☐ Written exam ☐ Practical exam (gateway)
☐ No Exam ☐ Other: Click or tap here to enter text.
15. If a practical examination exists, what skills are assessed? (tick more than one if appropriate)
☐ Prescription writing ☐ Teeth setting and waxing-up denture
☐ Cast and trimming of models ☐ Mounting of casts
☐ Impression technique ☐ No exam ☐Other:Click or tap here to enter text.
16. Who supervised the assessment?
☐Clinician ☐Technician
17. If there are more than one assessor, how do you standardise their assessment?
☐Assessment guideline ☐Training ☐Not applicable ☐Other please discuss:
18. What happens if the student fails this assessment? tick any
☐Nothing ☐Reduced grade in overall module result ☐Required to re-sit
☐Cannot undertake clinical procedure until passing a re-sit assessment
19. How do you know/check that your students are ready to undertake complete denture
cases in clinic?
Click or tap here to enter text.
20. What are the "recommended textbooks/articles" used for the teaching of complete
denture to your undergraduate students?
Click or tap here to enter text.

Clinical Teaching and Assessment in Complete Denture:

21. Assuming your BDS programme is of 5 years duration, in which year do your students commence treatment of patients with complete denture?

☐ 1st Year ☐ 2nd Year ☐ 3rd Year ☐ 4th Year ☐ 5th Year

22. Do the students have dedicated clinical sessions for instruction in the provision of
complete denture?

☐ Yes ☐ No

23. What is the staff: student ratio?
For clinical sessions: Click or tap here to enter text.
For formal lectures: Click or tap here to enter text.
For small groups/ tutorials: Click or tap here to enter text.

24. Is there paired teaching?

☐ Yes ☐ No

25. What impression tray(s) and impression material(s) are your students taught for recording master impressions? ***Check any that apply***

☐Plastic Stock Tray ☐Metal Stock Tray ☐Special Tray

☐Polysulfide ☐Impression compound ☐Alginate

☐Other: Click or tap here to enter text.

26. Which do students encounter first in their clinical work- complete or removable partial dentures?

☐Complete Dentures ☐Removable Partial Dentures ☐Both

27. Regarding the staff supervising the clinical sessions, please outline the percentage of
contribution of each of the following member of staff:

- Professor: Click or tap here to enter text.%
- Consultant: Click or tap here to enter text.%
- GDP (part-time teacher): Click or tap here to enter text.%
- Senior lecturer: Click or tap here to enter text.%
- Lecturer: Click or tap here to enter text.%
- Technician: Click or tap here to enter text.%

28. Are there guidelines for supervising staff in relation to clinical teaching of undergraduate students?

☐Yes ☐ No

29. Is there teaching of complete denture prescription writing during the clinical programme?

☐Yes ☐ No

30. What format does this teaching take?

☐Formal lecture ☐small groups/ Tutorial ☐ Other:

31. How many complete dentures are students required to complete before graduation?
Only numbers may be entered in this field.
Choose an item.

32. Of these, how many are immediate complete dentures?
Only numbers may be entered in this field.
Choose an item.

33. Of these, how many are combination (complete denture + removable partial

denture)? Only numbers may be entered in this field.
Click or tap here to enter text.
34. What percentage of complete denture approximately is completed by using digital
workflow?
Click or tap here to enter text.%
35. Do students use internal/ external laboratories for complete denture cases?
☐Internal ☐External ☐Both
36. Do students complete criterion referenced assessed exercises in clinical complete denture provision?
☐Yes ☐ No
37. What form does this examination take?
☐Written exam ☐Practical exam

38. If practical, what items are assessed? Tick any
☐ Prescription writing ☐ Teeth setting and waxing-up denture
☐ Cast and trimming of models ☐ Mounting of casts
☐ Impression technique ☐ Not applicable
☐Other: Click or tap here to enter text.
39. Who is/are responsible for assess students' clinical work and competence?
Check any that apply
☐Professor ☐Consultant ☐GDP (part-time teacher)
☐Senior lecturer/Associate professor ☐Lecturer
40. What method are you using to assess students? (tick more than one if appropriate)
☐ Day to-day observation and judgement (glance and mark)
☐ Tests based on observation and implicit judgement
☐ Fixed schedules of clinical requirement
☐ Peer-assessment
☐ Self-assessment
☐ Other: Click or tap here to enter text. Please specify
41. Is there a final assessment exam before graduation?
☐Yes ☐No
42. How do you assess the students' clinical competence in complete denture before graduation?
Click or tap here to enter text.
43. How is the consistency in assessment achieved?
☐I am not sure
☐There are guidelines
☐Regular teachers meeting
☐Other, please comment: Click or tap here to enter text.
44. Are you satisfied that you have adequately assess your students' competence in complete denture prior to graduation?
☐Yes ☐No ☐Mostly ☐Not sure
Comment please: ---------------------------

45. How do you think the competence of your students in complete denture compared to

that of students who graduated 10 years ago?
☐Better ☐Worse ☐No change ☐Not sure
Comment please:Click or tap here to enter text.
46. Does your school have an outreach/community based clinical teaching programme?
☐Yes ☐No
*If yes, please answer question no. 47, 48 and 49
47. Do your students complete complete denture treatments that are included in their final BDS assessment?
☐Yes ☐No
48. Are the teaching staff in the outreach centre employed by your university?
☐Yes ☐No
*If no, are they:☐Private practitioner
☐NHS employees
☐Other: Click or tap here to enter text.
49. How do you ensure that the staff in the outreach centre teach and assess complete denture to the same standards as in the base dental school?
☐I am not sure
☐There are guidelines
☐Regular teachers meeting
☐Other, please comment: Click or tap here to enter text.
50. What potential challenges do you perceive in the teaching of complete dentures over
the next few years?
Check any that apply
☐Lack of adequately trained staff for teaching
☐Lack of suitable patients for students to treat
☐Pressures on teaching time from other sources in the undergraduate curriculum
☐Increasing use of alternate technologies such as implants
☐Other:
51. Do you have any further comments in relation to students' complete denture teaching
and assessment?

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Appendix 2: Data analysis of Undergraduate Complete Dentures Curriculum: An International Study of Current Teaching and Assessment Methods

Table S2.1 Descriptive analysis of the academic/didactic teaching/hours

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound
UK	9	21.7778	12.51777	4.17259	12.1558	31.3998
Europ	3	13.3333	7.57188	4.37163	-5.4763	32.1429
US	5	25.0000	11.15796	4.98999	11.1456	38.8544
Asia	5	23.4000	22.45662	10.04291	-4.4836	51.2836
Saudi	11	22.3636	13.74244	4.14350	13.1313	31.5959
Unknown	4	20.0000	10.80123	5.40062	2.8128	37.1872
Total	37	21.7297	13.35134	2.19495	17.2782	26.1813

Table S2.2 One-way ANOVA test of the academic/didactic teaching/hours and geographical area

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	295.330	5	59.066	.299	.910
Within Groups	6121.968	31	197.483		
Total	6417.297	36			

Table S2.3 Descriptive analysis of Hands-on/ practical skills/hours

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound
UK	9	32.4444	14.62969	4.87656	21.1991	43.6898
Europ	2	40.0000	.00000	.00000	40.0000	40.0000
US	5	41.4000	13.31540	5.95483	24.8667	57.9333
Asia	5	26.2000	16.52876	7.39189	5.6768	46.7232
Saudi	11	49.3636	21.94663	6.61716	34.6197	64.1076
Unknown	4	45.0000	19.14854	9.57427	14.5304	75.4696
Total	36	39.8056	18.49296	3.08216	33.5484	46.0627

Table S2.4 One-way ANOVA test of Hands-on/ practical skills/hours and geographical area

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2538.871	5	507.774	1.615	.186
Within Groups	9430.768	30	314.359		
Total	11969.639	35			

Table S2.5 Descriptive analysis of Formal lectures/hour

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound
UK	8	12.5000	7.48331	2.64575	6.2438	18.7562
Europ	3	4.0000	2.00000	1.15470	-.9683	8.9683
US	5	16.4000	6.69328	2.99333	8.0892	24.7108
Asia	5	5.8000	4.02492	1.80000	.8024	10.7976
Saudi	11	17.2727	16.87656	5.08847	5.9349	28.6106
Unknown	4	12.7500	9.14239	4.57120	-1.7976	27.2976
Total	36	12.8889	11.34593	1.89099	9.0500	16.7278

Table S2.6 One-way ANOVA test of Formal lectures/hour and geographical area

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	762.624	5	152.525	1.223	.323
Within Groups	3742.932	30	124.764		
Total	4505.556	35			

Table S2.7 Descriptive analysis of Laboratory demonstrations/hour

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound
UK	8	15.5000	7.92825	2.80306	8.8718	22.1282
Europ	2	21.0000	26.87006	19.00000	-220.4179	262.4179
US	4	18.2500	12.01041	6.00521	-.8612	37.3612
Asia	5	16.2000	15.81771	7.07390	-3.4403	35.8403
Saudi	11	21.2727	19.61168	5.91315	8.0974	34.4480
Unknown	4	21.0000	16.85230	8.42615	-5.8158	47.8158

Total	34	18.7647	15.08774	2.58753	13.5003	24.0291

Table S2.8 One-way ANOVA test of Laboratory demonstrations/hour and geographical area

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	218.386	5	43.677	.168	.972
Within Groups	7293.732	28	260.490		
Total	7512.118	33			

Table S2.9 Descriptive analysis of small groups, tutorials or seminars/hour

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound
UK	6	10.0000	7.66812	3.13050	1.9528	18.0472
Europ	2	13.0000	7.07107	5.00000	-50.5310	76.5310
US	4	6.7500	5.37742	2.68871	-1.8067	15.3067
Asia	4	14.5000	9.74679	4.87340	-1.0093	30.0093
Saudi	6	13.8333	23.27588	9.50234	-10.5932	38.2599
Unknown	4	8.7500	6.29153	3.14576	-1.2612	18.7612
Total	26	11.1154	12.24198	2.40085	6.1707	16.0600

Table S2.10 One-way ANOVA test of small groups, tutorials or seminars/hour and geographical area

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	203.321	5	40.664	.230	.945
Within Groups	3543.333	20	177.167		
Total	3746.654	25			

Table S2.11 Descriptive analysis if the students have to complete an assessment at the end of the preclinical course

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound
UK	9	1.3333	.50000	.16667	.9490	1.7177
Europ	3	1.0000	.00000	.00000	1.0000	1.0000
US	6	1.0000	.00000	.00000	1.0000	1.0000
Asia	5	1.0000	.00000	.00000	1.0000	1.0000

Saudi	11	1.0000	.00000	.00000	1.0000	1.0000
Unknown	4	1.0000	.00000	.00000	1.0000	1.0000
Total	38	1.0789	.27328	.04433	.9891	1.1688

Table S2.12 One-way ANOVA test if the students have to complete an assessment at the end of the preclinical course

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.763	5	.153	2.442	.055
Within Groups	2.000	32	.063		
Total	2.763	37			

Table S2.13 Crosstabulation of how many complete dentures are students required to complete before graduation vs. country

Count

		country				
		UK	Europe	US	Asia	Saudi
How many complete dentures are students required to complete before graduation		1	2	2	0	6
	0	1	0	0	0	0
	1	1	0	0	1	0
	10	0	0	0	0	0
	2	2	0	1	2	0
	3	0	0	1	1	1
	30	1	0	0	0	0
	4	1	1	0	0	1
	5	3	0	1	0	0
	6	0	0	0	0	2
	8	0	0	1	1	1
Total		10	3	6	5	11

Table S2.14 Chi-Square Tests of how many complete dentures are students required to complete before graduation vs. country

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	49.967[a]	50	.475
Likelihood Ratio	53.920	50	.327
N of Valid Cases	40		

Table S2.15 Crosstabulation for formal lectures staff: student ratio vs. country

Count

		country				
		UK	Europe	US	Asia	Saudi
For formal lectures:		1	0	1	0	0
	1 to 20	0	0	0	0	1
	1 to 20 students	0	0	0	0	1
	1 to 56	1	0	0	0	0
	1 to 60	0	0	1	0	0
	1:1	0	0	0	0	1
	1:10	0	0	1	0	0
	1:100	0	0	0	1	0
	1:120	0	0	1	0	0
	1:130	0	0	1	0	0
	1:160	1	0	0	0	0
	1:20	1	0	0	0	1
	1:25	0	0	0	0	1
	1:55	1	1	0	0	1
	1:60	0	0	0	0	1
	1:65	1	0	0	0	0
	1:70	1	0	0	0	1
	1:80	1	0	0	2	0
	1:90	0	1	0	0	0
	1:full year	1	0	0	0	0
	1/45	0	0	0	0	0
	1/50	0	0	0	0	0
	1/70	0	1	0	0	0
	102	0	0	0	1	0
	2:82	0	0	1	0	0
	2:90	0	0	0	0	1
	3/100	0	0	0	0	0
	30:1	0	0	0	0	0
	40	0	0	0	0	1
	40/1	1	0	0	0	0
	56:1	0	0	0	1	0
	80/1	0	0	0	0	1
Total		10	3	6	5	11

Table S2.16 Chi-Square Tests for formal lectures staff: student ratio vs. country

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	159.232[a]	155	.391
Likelihood Ratio	114.522	155	.994
N of Valid Cases	40		

Table S.2.17 Crosstabulation for laboratory demonstrations staff: student ratio vs. country

Count

		country			
		UK	Europe	US	Asia
For laboratory demonstrations:		1	1	2	0
	1 to 12	0	0	1	0
	1 to 20	0	0	0	0
	1 to 8	1	0	0	0
	1: 10	1	0	0	0
	1:10	2	0	1	1
	1:12	1	1	0	1
	1:15	0	0	0	0
	1:16	1	0	0	0
	1:20	0	0	0	1
	1:7	0	0	0	0
	10/1	1	0	0	0
	2 to 20 students 1 for each 10 students group	0	0	0	0
	2/25	0	1	0	0
	2/40	0	0	0	0
	20	0	0	0	0
	25:2	0	0	0	0
	3:20	1	0	0	0
	4:1	0	0	0	0
	5:130	0	0	1	0
	5/50	0	0	0	0
	50	0	0	0	1
	56:1	0	0	0	1
	6/45	0	0	0	0
	8:82	0	0	1	0
	8:90	0	0	0	0

	variable 1:8 to 1:20	1	0	0	0
Total		10	3	6	5

Table S2.18 Chi-Square Tests for laboratory demonstrations staff: student ratio vs. country

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	129.289[a]	130	.501
Likelihood Ratio	97.690	130	.984
N of Valid Cases	40		

Table S2.19 Crosstabulation for small groups/tutorials staff: student ratio vs. country

Count

		country			
		UK	Europe	US	Asia
For small groups/tutorials:		2	1	2	0
	—	1	0	0	0
	1 for each 5 studnets group	0	0	0	0
	1 to 12	0	0	1	0
	1 to 7	0	0	0	0
	1 to 8	1	0	0	0
	1:10	0	0	1	1
	1:12	1	1	0	0
	1:16	1	0	0	0
	1:20	0	0	0	1
	1:25	0	0	0	1
	1:3	0	0	0	0
	1:4 to 1:8	1	0	0	0
	1:5	0	0	0	0
	1:6 (clinical tutorials as above)	1	0	0	0
	1:7	0	0	0	0
	1:9	1	0	0	0
	1/15	0	0	0	0
	1/8	0	1	0	0
	10	0	0	0	1
	10:1	0	0	0	1
	25:2	0	0	0	0
	3:20	1	0	0	0
	5:130	0	0	1	0

	5/50	0	0	0	0
	8:82	0	0	1	0
Total		10	3	6	5

Table S2.20 Chi-Square Tests for small groups/tutorials staff: student ratio vs. country

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	122.782[a]	125	.539
Likelihood Ratio	94.976	125	.979
N of Valid Cases	40		

Appendix 3: Questionnaire of Undergraduate Removable Partial Dentures Curriculum: An International Study of Current Teaching and Assessment Methods

Determining Competence in Prosthodontics in Dental School Training Programmes: Removable Partial Dentures

- Please identify the Dental School you are completing this survey on behalf of: (no schools will be identified in the survey report; this information is sought solely to track non-responders).

Preclinical teaching and assessment in Removable Partial Dentures:

1. Does your dental school have a preclinical course in removable partial denture (RPD) design and production?
   ☐ Yes ☐ No
2. Assuming your BDS programme is of 5 years duration, in which year does this course take place?
   ☐ 1st Year ☐ 2nd Year ☐ 3rd Year ☐ 4th Year ☐ 5th Year
3. What is the approximate number of hours of teaching received by an individual student in this course?

   Click or tap here to enter text.

4. How is this divided?
   - Academic/didactic teaching: Click or tap here to enter text. hours
   - Hands-on/ practical skills: Click or tap here to enter text. Hours

5. Regarding the academic/didactic teaching how is this divided?
   - Formal lectures: Click or tap here to enter text. hours
   - Laboratory demonstrations: Click or tap here to enter text. hours
   - Small groups/ Tutorials/ seminars Click or tap here to enter text. hours
   - Other: Click or tap here to enter text. Hours

6. If you have answered "other" in question 5, please specify:
   Click or tap here to enter text.
7. What is the staff: student ratio?
   - For formal lectures: Click or tap here to enter text.
   - For laboratory demonstrations: Click or tap here to enter text.
   - For small groups/tutorials: Click or tap here to enter text.

8. Who is responsible for directing the preclinical course in RPD?
☐ Professor ☐ Consultant ☐ Senior lecturer/Associate professor ☐ Lecturer
☐ Technician ☐ GDP (part-time lecturer) ☐ Others: Click or tap here to enter text.

9. Do students gain experience at following: tick any
☐Tooth preparation on patient simulators ☐Using surveyor
☐Using articulator ☐RPD prescription writing ☐Casting impression
☐Altered cast impression technique

10. Who supervises students on these experiences?
- Tooth preparation on patient simulators: ☐Clinician ☐Technician
- Using surveyor: ☐Clinician ☐Technician
- Using articulator: ☐Clinician ☐Technician
- RPD prescription writing: ☐Clinician ☐Technician
- Casting impression: ☐Clinician ☐Technician
- Altered cast impression technique: ☐Clinician ☐Technician

11. How many hours of teaching do students receive in each experience?
- Tooth preparation on patient simulators: Click or tap here to enter text. hours
- Using surveyor: Click or tap here to enter text. hours
- Using articulator: Click or tap here to enter text. hours
- RPD prescription writing: Click or tap here to enter text. hours
- Casting impression: Click or tap here to enter text. hours
- Altered cast impression technique Click or tap here to enter text. Hours

12. What form does the teaching of these experiences take? Tick any
- Using surveyor: ☐Formal lecture ☐Lab demonstration ☐Practical exercise
- Using articulator: ☐Formal lecture ☐Lab demonstration ☐Practical exercise
- RPD prescription writing: ☐Formal lecture ☐Lab demonstration ☐ Practical exercise

13. What type of articulator are the students taught to use?
☐Arcon (semi-adjustable) ☐Non-arcon (semi-adjustable) ☐Average value ☐Simple hinge ☐None ☐Other: Click or tap here to enter text.

14. Do the students have to complete an assessment at the end of the course?

☐ Yes ☐ No

15. If yes, what form does this assessment take?

☐ Written exam ☐ Practical exam (gateway)

☐ No exam ☐ Other: Click or tap here to enter text.

16. If a practical examination exists, what skills are assessed? (tick more than one if appropriate)

☐ Surveying and design ☐ Prescription writing ☐ Rest seat preparations

☐ Cast and trimming of models ☐ Mounting of casts

☐ Impression technique ☐ No exam ☐Other:Click or tap here to enter text.

17. Who supervise the assessment of the following?

- Surveying and design: ☐Clinician ☐Technician
- Prescription writing: ☐Clinician ☐Technician
- Rest seat preparation: ☐Clinician ☐Technician
- Cast and trimming of models: ☐Clinician ☐Technician
- Mounting of casts: ☐Clinician ☐Technician
- Impression technique: ☐Clinician ☐Technician

18. If there are more than one assessor, how do you standardise their assessment?

☐Assessment guideline ☐Training ☐Not applicable

☐Other please discuss: Click or tap here to enter text.

19. What happens if the student fails this assessment? tick any

☐Nothing ☐Reduced grade in overall module result ☐Required to re-sit

☐Cannot undertake clinical procedure until passing a re-sit assessment

20. How do you know that your students are ready to undertake RPDs case in clinic?

Click or tap here to enter text.

21. What are the "recommended textbooks/articles" used for the teaching of RPDs to your undergraduate students?

Click or tap here to enter text.

Clinical teaching and assessment in Removable Partial Dentures:

22. Assuming your BDS programme is of 5 years duration, in which year do your students commence treatment of patients with RPDs?

☐ 1st Year ☐ 2nd Year ☐ 3rd Year ☐ 4th Year ☐5th Year

23. Do the students have dedicated clinical sessions for instruction in the provision of RPDs?

☐ Yes ☐ No

24. What is the staff: student ratio?

For clinical sessions: Click or tap here to enter text.
For formal lectures: Click or tap here to enter text.
For small groups/ tutorials: Click or tap here to enter text.

25. Is there paired teaching?

☐ Yes ☐ No

26. Do students routinely use a surveyor in the provision of RPDs?

☐ Yes ☐ No

27. What impression tray(s) and impression material(s) are your students taught for recording master impressions? ***Check any that apply***

☐Plastic Stock Tray ☐Metal Stock Tray ☐Special Tray
☐Polyether ☐Polyvinylsiloxane ☐Alginate
☐Other: Click or tap here to enter text.

28. Which do students encounter first in their clinical work- complete or removable partial dentures?

☐Complete Dentures ☐Removable Partial Dentures ☐Both

29. Regarding the staff supervising the clinical sessions, please outline the percentage of contribution of each teaching member of staff:

- Professor: Click or tap here to enter text.%
- Consultant: Click or tap here to enter text.%
- GDP (part-time teacher): Click or tap here to enter text.%
- Senior lecturer: Click or tap here to enter text.%
- Lecturer: Click or tap here to enter text.%

- Technician: Click or tap here to enter text.%

30. Are there guidelines for supervising staff in relation to clinical teaching of undergraduate students?

☐Yes ☐ No

31. Is there teaching of RPD design and prescription writing during the clinical programme?

☐Yes ☐ No

32. What format does this teaching take?

☐Formal lecture ☐small groups/ Tutorial ☐Other:

33. How many RPDs are students required to complete before graduation?

Choose an item.

34. Of these, how many are acrylic (immediate/ transitional) RPDs?

Choose an item.

35. Of these, how many are cobalt-chromium RPDs?

Choose an item.

36. In general, what is the average number of acrylic and cobalt-chromium RPDs completed by your students?

Acrylic: Choose an item.
Cobalt-chromium: Choose an item.

37. Is there teaching of flexible partial denture case selection, design and delivery during the clinical programme?

☐Yes ☐No

38. What format does the teaching of flexible dentures take? *Check any that apply*

☐Formal lecture ☐small groups/ Tutorial ☐Clinical sessions

39. What percentage of RPDs approximately is completed by using digital workflow?

Click or tap here to enter text.%

40. Do students use internal/external laboratories for RPD cases?

☐Internal ☐External ☐Both

41. Do the students complete criterion referenced assessed exercises in clinical RPD provision?

☐Yes ☐ No

42. What form does this examination take?

☐Written exam ☐Practical exam

43. If practical, what items are assessed?

☐Surveying and design ☐Prescription writing ☐Rest seat preparations

☐Impression making ☐Try-In & delivery ☐Other:

44. Who is/are responsible for assess students' clinical work and competence?

Check any that apply

☐Professor ☐Consultant ☐GDP (part-time teacher)

☐Senior lecturer/Associate professor ☐Lecturer ☐ Others:

45. What method are you using to assess students? (tick more than one if appropriate)

☐ Day to-day observation and judgement (glance and mark)

☐ Tests based on observation and implicit judgement

☐ Fixed schedules of clinical requirement

☐ Peer-assessment

☐ Self-assessment

☐ Other: Click or tap here to enter text. Please specify

46. How is the consistency in assessment achieved?

☐I am not sure

☐There are guidelines

☐Regular teachers meeting

☐Other, Please comment: Click or tap here to enter text.

47. Is there a final assessment exam before graduation?

☐Yes ☐No

48. How do you assess the students' clinical competence in RPDs before graduation?

Click or tap here to enter text.

49. Are you satisfied that you have adequately assess your students' competence in RPDs prior to graduation?

☐Yes ☐No ☐Mostly ☐Not sure

Comment please: ---------------------------

50. How do you think the competence of your students in RPDs compared to that of students who graduated 10 years ago?

☐Better ☐Worse ☐No change ☐Not sure

Comment please:Click or tap here to enter text.

51. What potential challenges do you perceive in the teaching of removable partial dentures over the next few years?

Check any that apply

☐Lack of adequately trained staff for teaching

☐Lack of suitable patients for students to treat

☐Pressures on teaching time from other sources in the undergraduate curriculum

☐Increasing use of alternate technologies such as implants

☐Other:

52. Does your school have an outreach/community based clinical teaching programme?

☐Yes ☐No

*If yes, please answer question no. 53,54 and 55

53. Do your students complete RPDs treatments that are included in their final BDS assessment?

☐Yes ☐No

54. Are the teaching staff in the outreach centre employed by your university?

☐Yes ☐No

*If no, are they:☐Private practitioner

☐NHS employees

☐Other: Click or tap here to enter text.

55. How do you ensure that the staff in the outreach centre teach and assess RPDs to the same standards as in the base dental school?

☐I am not sure

☐There are guidelines

☐Regular teachers meeting

☐Other, Please comment: Click or tap here to enter text.

56. Do you have any further comments in relation to students' RPDs teaching and assessment?

Appendix 4: Data analysis of Undergraduate Removable Partial Dentures Curriculum: An International Study of Current Teaching and Assessment Methods

Table S4.1 One-way ANOVA tests for the amount of teaching/ hour vs. country

		Sum of Squares	df	Mean Square	F
Academic/didactic teaching/hours:	Between Groups	82.745	4	20.686	.163
	Within Groups	2280.907	18	126.717	
	Total	2363.652	22		
Hands-on/ practical skills/hours:	Between Groups	1719.170	4	429.793	1.412
	Within Groups	5479.264	18	304.404	
	Total	7198.435	22		
Formal lectures/hour:	Between Groups	226.712	4	56.678	.604
	Within Groups	1690.157	18	93.898	
	Total	1916.870	22		
Laboratory demonstrations/hour:	Between Groups	1380.550	4	345.138	.957
	Within Groups	5407.450	15	360.497	
	Total	6788.000	19		
Small groups, Tutorials or seminars/hour:	Between Groups	48.125	2	24.063	.566
	Within Groups	212.750	5	42.550	
	Total	260.875	7		
Other/hour:	Between Groups	932.250	2	466.125	932.250
	Within Groups	.500	1	.500	
	Total	932.750	3		

Table S4.2 One-way ANOVA tests of for the amount of teaching/ hour vs. country

		Sig.
Academic/didactic teaching/hours:	Between Groups	.954
	Within Groups	
	Total	
Hands-on/ practical skills/hours:	Between Groups	.270
	Within Groups	
	Total	
Formal lectures/hour:	Between Groups	.665
	Within Groups	
	Total	
Laboratory demonstrations/hour:	Between Groups	.459
	Within Groups	
	Total	

Small groups, Tutorials or seminars/hour:	Between Groups	.601
	Within Groups	
	Total	
Other/hour:	Between Groups	.023
	Within Groups	
	Total	

Table S4.3 One-way ANOVA test of if the students have to complete an assessment at the end of the preclinical course vs. country

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.169	4	.042	.459	.765
Within Groups	1.657	18	.092		
Total	1.826	22			

Table S4.4 Crosstabulation of how many RPDs are students required to complete before graduation vs. Geographical area

Count

		Total
How many RPDs are students required to complete before graduation?	1	1
	2	3
	3	3
	4	4
	5	4
	8	3
Total		18

Table S4.5 Chi-Square Tests of how many RPDs are students required to complete before graduation vs. Geographical area

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	18.125[a]	20	.579
Likelihood Ratio	21.188	20	.386
Linear-by-Linear Association	.537	1	.463
N of Valid Cases	18		

Table S4.6 Chi-Square Tests for formal lectures staff: student ratio vs. country

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	2.390[a]	4	.665
Likelihood Ratio	2.485	4	.647
N of Valid Cases	23		

Appendix 5: Questionnaire of Undergraduate Fixed Prosthodontics Curriculum (Crown and Bridge): An International Study of Current Teaching and Assessment Methods

Determining Competence in Prosthodontics in Dental School Training Programmes: Fixed Prosthodontics (Crowns & Bridges but not Implant)

- Please identify the Dental School you are completing this survey on behalf of: (no schools will be identified in the survey report; this information is sought solely to track non-responders).

Preclinical teaching and assessment in Fixed Prosthodontics (Crowns & Bridges but not Implant):

1. Does your dental school have a preclinical course in fixed prosthodontics?

☐Yes ☐ No

2. Assuming your BDS programme is of 5 years duration, in which year does this course take place?

☐ 1st Year ☐ 2nd Year ☐ 3rd Year ☐ 4th Year ☐ 5th Year

3. What are the "recommended textbooks/articles" used for the teaching of fixed prosthodontics to your undergraduate students?

☐"A Clinical Guide to Crowns and other Extra-Coronal Restorations": BDJ Book, Wassell et al.
☐"Fundamentals of Fixed Prosthodontics", Shillingburg et al.
☐"Contemporary Fixed Prosthodontics", Rosenstiel et al.
☐Internal/ school manuals/ documentation
☐Other (please specify): Click or tap here to enter text.

4. What is the approximate number of hours of teaching received by an individual student in this course?

Click or tap here to enter text.

5. How is this divided?
   - Academic/didactic teaching: Click or tap here to enter text. hours
   - Hands-on/ practical skills: Click or tap here to enter text. hours

6. Regarding the academic/didactic teaching how is this divided?
- Formal lectures: Click or tap here to enter text. hours
- Laboratory demonstrations: Click or tap here to enter text. hours
- Small groups/ Tutorials/ seminars Click or tap here to enter text. hours
- Other: Click or tap here to enter text. Hours

7. If you have answered "other" in question 6, please specify:
Click or tap here to enter text.

8. What is the staff: student ratio?
- For formal lectures: Click or tap here to enter text.
- For laboratory demonstrations: Click or tap here to enter text.
- For small groups/tutorials: Click or tap here to enter text.

9. Who is responsible for directing the preclinical course in fixed prosthodontics?
☐ Professor ☐ Consultant ☐ Senior lecturer/Associate Professor ☐ Lecturer
☐ GDP (part-time lecturer) ☐ Others: Click or tap here to enter text.

10. Dose the preclinical course includes a phantom head teaching in relation to crown and bridgework?
☐ Yes ☐ No

11. In which year does this teaching commence?
☐ 1st year ☐ 2nd year ☐ 3rd year ☐ 4th year ☐ 5th year

12. What is the staff: student teaching ratio for preclinical/ phantom head teaching sessions?

Click or tap here to enter text.

13. How many hours (approximately) of preclinical phantom head teaching does each student receive in relation to bridgework?

Click or tap here to enter text.

14. Do students gain experience at following: (tick any)
☐Crown preparation ☐Bridge preparation

☐Resin-retained bridge preparation ☐Veneer preparation
☐Using facebow ☐Shade selection ☐Lab prescription writing

15. Who supervises students on these experiences?
- Crown and bridges preparation: ☐Clinician ☐Technician
- Resin-retained bridge prep: ☐Clinician ☐Technician
- Veneer preparation: ☐Clinician ☐Technician
- Using facebow: ☐Clinician ☐Technician
- Shade selection: ☐Clinician ☐Technician
- Lab prescription writing: ☐Clinician ☐Technician

16. How many hours of teaching do students receive in each experience?
- Crown and bridge preparation: Click or tap here to enter text. hours
- Resin-retained bridge preparation: Click or tap here to enter text. hours
- Veneer preparation: Click or tap here to enter text. hours
- Using facebow: Click or tap here to enter text. hours
- Shade selection: Click or tap here to enter text. hours
- Lab prescription writing: Click or tap here to enter text. hours

17. What form does the teaching of these experiences take?
- Using facebow: ☐Formal lecture ☐Lab demonstration ☐Practical exercise
- Shade selection: ☐Formal lecture ☐Lab demonstration ☐Practical exercise
- Lab prescription writing: ☐Formal lecture ☐Lab demonstration ☐ Practical exercise

18. In phantom head/ preclinical, what exercises do students complete in relation to crown and bridgework? select all that apply

☐ Preparation for porcelain fused to metal crown
☐ Preparation for full ceramic crown
☐ Preparation for veneer
☐ Preparation for conventional bridge replacing anterior teeth
☐ Preparation for conventional bridge replacing posterior teeth
☐ Preparation for conventional cantilever bridge replacing anterior teeth
☐ Preparation for conventional cantilever bridge replacing posterior teeth
☐ Preparation for resin retained bridge replacing anterior teeth
☐ Preparation for resin retained bridge replacing posterior teeth
☐ Preparation for cantilever resin retained bridge replacing anterior teeth
☐ Preparation for cantilever resin retained bridge replacing posterior teeth
☐ Preparation for all ceramic bridge replacing anterior teeth

☐ Preparation for all ceramic bridge replacing posterior teeth
☐ Waxing up study casts
☐ Provisional bridge fabrication
☐ Other (please specify):

19. What type of articulator are the students taught to use?
☐Arcon (semi-adjustable) ☐Non-arcon (semi-adjustable) ☐Average value ☐Simple hinge ☐None ☐Other: Click or tap here to enter text.

20. Do the students have to complete an assessment at the end of the preclinical course?
☐ Yes ☐ No

21. If yes, what form does this assessment take?
☐ Written exam ☐ Practical exam (gateway)
☐ No exam ☐ Other: Click or tap here to enter text.

22. If a practical examination exists, what skills are assessed? (tick more than one if appropriate)
☐Crown preparation ☐Bridge preparation ☐Resin-retained bridge preparation
☐Veneer preparation ☐Using facebow
☐Not applicable ☐Other:Click or tap here to enter text.

23. Who supervised the assessment?
☐Clinician ☐Technician

24. If there are more than one assessors, how do you standardise their assessment?

☐Assessment guideline ☐Training ☐Not applicable ☐Other please discuss:

-

-

25. What happens if the student fails this assessment? tick any

☐Nothing ☐Reduced grade in overall module result ☐Required to re-sit

☐Cannot undertake clinical procedure until passing a re-sit assessment

26. How do you know/check that your students are ready to undertake crown and bridge cases in clinic?

Click or tap here to enter text.

<u>Clinical teaching and assessment in Fixed Prosthodontics:</u>

27. Assuming your BDS programme is of 5 years duration, in which year do your students commence treatment of patients with fixed prostheses?

☐ 1st Year ☐ 2nd Year ☐ 3rd Year ☐ 4th Year ☐5th Year

28. Do the students have dedicated clinical sessions for instruction in the provision of crown and bridgework?

☐ Yes ☐ No

29. What is the staff: student ratio?

For clinical sessions: Click or tap here to enter text.
For formal lectures: Click or tap here to enter text.
For small groups/ tutorials: Click or tap here to enter text.

30. Is there paired teaching?

☐ Yes ☐ No

31. Which type of impression technique do you teach your students to use clinically? ***Check any that apply***

	Conventional	Resin retained	All ceramic
Light bodied polyvinylsiloxane in a special tray			
Medium bodied polyvinylsiloxane in a special tray			
one step: Medium bodies & light bodies wash in stock tray			
Two steps: Medium bodies & light bodies wash in stock tray			
One step: Putty & wash polyvinylsiloxane in a stock tray			
Two steps: Putty & wash polyvinylsiloxane in a stock tray			
Polyether impression material			

32. Which type of cementation technique(s) do you teach your students to use clinically?

	Conventional	Resin retained	All ceramic
Adhesive resin cement (e.g. Panavia F, Rely X)			
Conventional resin cement (e.g. Calibra)			
Glass ionomer cement (e.g. AquaCem)			
Zinc oxide eugenol			
Zinc phosphate			
Zinc polycarboxylate			

33. Which do students encounter first in their clinical work sessions?

☐Crown ☐Bridge ☐Both

34. Regarding the staff supervising the clinical sessions, please outline the percentage of contribution of each of the following member of staff:

- Professor: Click or tap here to enter text.%
- Consultant: Click or tap here to enter text.%
- GDP (part-time teacher): Click or tap here to enter text.%
- Senior lecturer: Click or tap here to enter text.%
- Lecturer: Click or tap here to enter text.%

35. Are there guidelines for supervising staff in relation to clinical teaching of undergraduate students?

☐Yes ☐ No

36. Do your students learn the lab-work steps for fixed prostheses?

☐ Yes ☐ No

37. Do your students have to finish the lab-work for crown and bridge?

☐ Yes ☐ No

38. If yes, who is/are supervising students in lab?

☐Clinician ☐Technician

39. If no, do they have to communicate with the lab technicians to follow-up the lab-work?

☐ Yes ☐ No

40. Do your students gain experience at following:

☐ CAD-CAM technology

☐ Digital workflow

41. On average how many of each of the following bridge types do your students provide clinically on patients prior to graduation? Select number

- Single porcelain fused to metal crown (PFM):
- Single full ceramic crown:
- Composite/ porcelain veneer:
- Conventional bridge replacing anterior teeth:
- Conventional bridge replacing posterior teeth:
- Conventional cantilever bridge:
- Resin retained bridge replacing anterior teeth:
- Resin retained bridge replacing posterior teeth:
- Cantilever resin retained bridge:
- All ceramic bridge replacing anterior teeth:
- All ceramic bridge replacing posterior teeth:

42. What percentage of crown/bridgework approximately is completed by using digital workflow?

Click or tap here to enter text.%

43. If you answered "0" to any of the options in question 41, which of these do you intend to begin teaching clinically over the next 5 years?

☐Single porcelain fused to metal crown (PFM)
☐Single full ceramic crown
☐Composite/ porcelain veneer
☐Conventional bridge replacing anterior teeth
☐Conventional bridge replacing posterior teeth
☐Conventional cantilever bridge
☐Resin retained bridge replacing anterior teeth
☐Resin retained bridge replacing posterior teeth
☐Cantilever resin retained bridge
☐All ceramic bridge replacing anterior teeth
☐All ceramic bridge replacing posterior teeth

44. Does your school have requirements for crown and bridgework (i.e. targets/ quotas/ competencies) that your student must complete prior to graduation?

☐Yes ☐No ☐Other (please specify):

If you answered 'yes', can you please outline what these requirements are?

Click or tap here to enter text.

45. Do you teach that fully articulated study casts are essential for treatment planning of bridgework for student treatment?

☐Yes ☐No ☐Other *(please specify)*:

46. If you answered 'yes', do students routinely use facebow record?

☐Yes ☐No ☐Not applicable

47. Do you think that the teaching of crown and bridge has increased/ decreased/ stayed the same over the past five years?

☐ Increased ☐ Decreased ☐ Stayed the same

48. Who is/are responsible for assess students' clinical work and competence?

Check any that apply

☐ Professor ☐Consultant ☐GDP (part-time teacher)

☐Senior lecturer/Associate professor ☐Lecturer

49. What method are you using to assess students? (tick more than one if appropriate)

☐ Day to-day observation and judgement (glance and mark)

☐ Tests based on observation and implicit judgement

☐ Fixed schedules of clinical requirement

☐ Peer-assessment

☐ Self-assessment

☐ Other: Click or tap here to enter text. Please specify

50. How is the consistency in assessment achieved?

☐I am not sure

☐There are guidelines

☐Regular teachers meeting

☐Other, Please comment: Click or tap here to enter text.

51. Is there a final clinical assessment exam before graduation?

☐Yes ☐No

52. How do you assess the students' clinical competence in crown and bridgework before graduation?

Click or tap here to enter text.

53. Are you satisfied that you have adequately assess your students' competence in crown and bridge prior to graduation?

☐Yes ☐No ☐Mostly ☐Not sure

Comment please: ---------------------------

54. How do you think the competence of your students in crown and bridge compared to that of students who graduated 10 years ago?

☐Better ☐Worse ☐No change ☐Not sure

Comment please: Click or tap here to enter text.

----

55. What potential challenges do you perceive in the teaching of fixed prosthodontics over the next few years? Check any that apply

☐Lack of adequately trained staff for teaching

☐Lack of suitable patients for students to treat

☐Pressures on teaching time from other sources in the undergraduate curriculum

☐Increasing use of alternate technologies such CAD-CAM and implants

☐Other:

56. Does your school have an outreach/community based clinical teaching programme?

☐Yes ☐No

*If yes, please answer question no. 57,58 and 59

57. Do your students complete crown and bridge treatments that are included in their final BDS assessment?

☐Yes ☐No

58. Are the teaching staff in the outreach centre employed by your university?

☐Yes ☐No

*If no, are they: ☐Private practitioner

☐NHS employees

☐Other: Click or tap here to enter text.

59. How do you ensure that the staff in the outreach centre teach and assess crown and bridgework to the same standards as in the base dental school?

☐I am not sure

☐There are guidelines

☐Regular teachers meeting
☐Other, Please comment: Click or tap here to enter text.

60. Do you have any further comments in relation to students' fixed prosthodontics teaching and assessment?

Appendix 6: Data analysis of Undergraduate Fixed Prosthodontics Curriculum (Crown and Bridge): An International Study of Current Teaching and Assessment Methods

Table S6.1 One-way ANOVA tests of the approximate number of hours of teaching received by an individual student in this course vs. country

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4917.458	5	983.492	1.295	.309
Within Groups	13668.500	18	759.361		
Total	18585.958	23			

Table S6.2 One-way ANOVA tests of the amount of teaching/ hour vs. country

		Sig.
Academic/didactic teaching/hours:	Between Groups	.178
	Within Groups	
	Total	
Hands-on/ practical skills/hours:	Between Groups	.377
	Within Groups	
	Total	
Formal lectures/hour:	Between Groups	.200
	Within Groups	
	Total	
Laboratory demonstrations/hour:	Between Groups	.664
	Within Groups	
	Total	
Small groups, Tutorials or seminars/hour:	Between Groups	.080
	Within Groups	
	Total	

Table S6.3 One-way ANOVA test of if students have to complete an assessment at the end of the preclinical course vs. country

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.208	5	.042	1.000	.446
Within Groups	.750	18	.042		
Total	.958	23			

Table S6.4 Crosstabulation of if school have requirements for crown and bridgework (i.e. targets/ quotas/competencies) that your student must complete prior to graduation vs. country

Count

		Does your school have requirements for crown and bridgework (i.e. targets/ quotas/competencies) that your student must complete prior to graduation? Other (please specify)	Yes	No	Total
Geographic	1.00	1	5	2	8
	2.00	0	4	0	4
	3.00	0	1	0	1
	4.00	0	3	1	4
	5.00	0	6	0	6
Total		1	19	3	23

Table S6.5 Chi-Square Tests of if school have requirements for crown and bridgework (i.e. targets/ quotas/competencies) that your student must complete prior to graduation vs. country

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	5.447[a]	8	.709
Likelihood Ratio	6.850	8	.553
Linear-by-Linear Association	.039	1	.844
N of Valid Cases	23		

Table S6.6 Crosstabulation for clinical sessions staff: student ratio vs country

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Geographic * For clinical sessions:	25	100.0%	0	0.0%	25	100.0%

Count

		For clinical sessions:					
			1 to 7	1:10	1:4	1:5	1:6
Geographic	.00	1	0	0	0	0	0
	1.00	1	0	0	0	1	2
	2.00	1	1	0	0	1	0
	3.00	0	0	0	0	0	0
	4.00	0	0	0	0	0	2
	5.00	0	0	2	1	0	0

Total	3	1	2	1	2	4

Count

		For clinical sessions:					
		1:7	1:8	1:9	1/10	1/5	10
Geographic	.00	0	0	0	0	0	0
	1.00	0	1	0	0	0	2
	2.00	0	2	0	0	0	0
	3.00	0	0	0	0	0	0
	4.00	0	1	1	0	0	0
	5.00	1	0	0	1	1	0
Total		1	4	1	1	1	2

Count

		For clinical sessions:		Total
		16:2	25:2	
Geographic	.00	0	0	1
	1.00	1	0	8
	2.00	0	0	5
	3.00	0	1	1
	4.00	0	0	4
	5.00	0	0	6
Total		1	1	25

Table S6.7 Chi-Square tests for clinical sessions staff: student ratio vs country

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	77.448[a]	65	.139
Likelihood Ratio	55.760	65	.786
N of Valid Cases	25		

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Geographic * For formal lectures:	25	100.0%	0	0.0%	25	100.0%
Geographic * For small groups/ tutorials:	25	100.0%	0	0.0%	25	100.0%

Table S6.8 Crosstabulation for formal lectures teaching staff: student ratio vs country

Count

		For formal lectures:					
			1 to 80	1: 60	1:101	1:20	1:50
Geographic	.00	1	0	0	0	0	0
	1.00	1	0	1	0	1	1
	2.00	2	1	0	0	0	1
	3.00	0	0	0	0	0	0
	4.00	0	0	0	1	0	0
	5.00	1	0	0	0	2	0
Total		5	1	1	1	3	2

Count

		For formal lectures:					
		1:60	1:70	1:73	1:80	1:90	1:96
Geographic	.00	0	0	0	0	0	0
	1.00	0	1	0	0	0	0
	2.00	0	0	0	1	0	0
	3.00	0	0	0	0	0	0
	4.00	0	0	1	0	1	1
	5.00	1	0	0	0	0	0
Total		1	1	1	1	1	1

Count

		For formal lectures:					
		1/20	1/25	150	25:1	70:1	Total
Geographic	.00	0	0	0	0	0	1
	1.00	0	0	2	0	1	8
	2.00	0	0	0	0	0	5
	3.00	0	0	0	1	0	1
	4.00	0	0	0	0	0	4
	5.00	1	1	0	0	0	6
Total		1	1	2	1	1	25

Table S6.9 Chi-Square Tests for formal lectures teaching staff: student ratio vs country

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	84.243[a]	80	.351
Likelihood Ratio	59.073	80	.962
N of Valid Cases	25		

Table S6.10 Crosstabulation for small groups/ tutorials staff: student ratio vs country

Count

		For small groups/ tutorials:										
			1:10	1:3	1:7	1:8	1:9	1/5	20	8:1	Total
Geographic	.00	1	0	0	0	0	0	0	0	0	1
	1.00	1	2	0	0	1	1	0	2	1	8
	2.00	4	1	0	0	0	0	0	0	0	5
	3.00	1	0	0	0	0	0	0	0	0	1
	4.00	2	0	0	1	0	1	0	0	0	4
	5.00	4	0	1	0	0	0	1	0	0	6
Total		13	3	1	1	1	2	1	2	1	25

Table S6.11 Chi-Square Tests for small groups/ tutorials staff: student ratio vs country

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	29.896[a]	40	.878
Likelihood Ratio	30.660	40	.856
N of Valid Cases	25		

Appendix 7: Questionnaire of Undergraduate Dental Implants Curriculum: An International Study of Current Teaching and Assessment Methods

Determining Competence in Prosthodontics in Dental School Training Programmes: Dental Implants

Please identify the Dental School you are completing this survey on behalf of: (no schools will be identified in the survey report; this information is sought solely to track non-responders).

Preclinical Teaching and Assessment in Dental Implants

1. Does your dental school have a preclinical teaching in dental implants for undergraduate dental students?
☐Yes ☐ No

2. If “no”, please explain why?

Click or tap here to enter text.

If “yes”, please answer the following questions:

3. Assuming your BDS programme is of 5 years duration, in which year does this teaching take place?

☐ 1st Year ☐ 2nd Year ☐3rd Year ☐4th Year ☐5th Year

4. What are the "recommended textbooks/articles" used for the teaching of dental implants to your undergraduate students?

☐Tissue Integrated Prosthesis Osseointegration in Implant Dentistry (Per-Ingvar Branemark)

☐Implantology (Hubertus Spiekermann)

☐Contemporary implant dentistry (Carl E Misch)

☐Dental Implants prosthetic (Carl E Misch)

☐Practical Implant Dentistry (Ashok Seth and Thomas Kaus)

☐Fundamentals of Implant Dentistry (Gerard Byrne)

☐Other please specify:

5. What is the approximate number of hours of teaching received by an individual student in this course?

Click or tap here to enter text.

6. How is this divided?
Academic/didactic teaching: hours
Hands-on/ practical skills: hours

7. Regarding the academic/didactic teaching how is this divided?
- Formal lectures: hours
- Laboratory demonstrations: hours
- Small groups/ Tutorials/ seminars: hours
- Other: hours

8. If you have answered "other" in question 7, please specify:

Click or tap here to enter text.

9. What is the staff: student ratio?
- For formal lectures: Click or tap here to enter text.
- For laboratory demonstrations: Click or tap here to enter text.
- For small groups/tutorials: Click or tap here to enter text.

10. Who is responsible for directing the preclinical course in dental implants?

☐Professor ☐Consultant ☐Senior lecturer/Associate professor

☐Lecturer ☐GDP (part-time lecturer) ☐Other:

11. Dose the preclinical course include a hands-on prosthetic training in relation to dental implants?

☐Yes ☐ No

12. What is the staff: student teaching ratio for preclinical/ hands-on prosthetic training sessions?

Click or tap here to enter text.

13. How many hours (approximately) of preclinical hands-on prosthetic training does each student receive in relation to dental implants?

Click or tap here to enter text.

14. Do students gain experience at following: tick any

☐ Recognition of prosthetic parts of dental implants

☐ How to select the correct dental implants abutments

☐ Impression techniques for dental implants

☐ How to insert the final prosthesis for dental implant

15. Who supervises students on these experiences?

☐Clinician ☐Technician

16. What form does the teaching of these experiences take? tick any

☐ Formal lectures

☐ Small groups/ tutorial

☐ Lab demonstration

☐ Other:

17. What is the dental implants system do you use in this course?

Click or tap here to enter text.

18. Do your school has a preclinical surgical course in dental implants?

☐ Yes ☐ No

19. If yes, what form does the teaching of surgical dental implants take? tick any

☐ Formal lectures

☐ Small groups/ tutorial

☐ Live demonstration

☐ Other:

20. How many hours (approximately) in relation to preclinical surgical dental implants does each student receive?

Click or tap here to enter text.

21. Who is responsible for the surgical dental implants sessions?

Click or tap here to enter text.

22. Do the students have to complete an assessment at the end of the preclinical course?

☐ Yes ☐No

23. If yes, what form does this assessment take?

☐ Written exam ☐ Practical exam (gateway)

☐ No Exam ☐ Other: Click or tap here to enter text.

24. Who supervised the assessment?

☐Clinician ☐Technician

25. If there are more than one assessor, how do you standardise their assessment?

☐Assessment guideline ☐Training ☐Not applicable ☐Other please discuss:

26. What happens if the student fails this assessment? tick any

☐Nothing ☐Reduced grade in overall module result ☐Required to re-sit

☐Cannot undertake clinical procedure until passing a re-sit assessment

27. How do you know/check that your students are ready to undertake implant cases in clinic?

Click or tap here to enter text.

Clinical Teaching and Assessment in Dental Implants:

28. Does your dental school have a dedicated clinical course in dental implants for undergraduate dental students?

☐Yes ☐No

- If "yes", please answer the following questions:

29. Assuming your BDS programme is of 5 years duration, in which year do your students commence clinical sessions in dental implants?

☐1st Year ☐2nd Year ☐3rd Year ☐4th Year ☐5th Year

30. What does the clinical course include?

☐ Prosthetic sessions only

☐ Surgical sessions only

☐ Both

31. Assuming you have prosthetic session in dental implants, who is responsible to supervise students in this session?

☐Clinician ☐Technician

32. Assuming you have surgical session in dental implants, who is responsible to supervise students in this session?

Click or tap here to enter text.

33. What do students do in the surgical sessions?

☐ Observation only

☐ Assisting only

☐ Inserting dental implants under supervision

☐ Other:

34. What is the staff: student ratio for the clinical sessions?

Prosthetic:

Surgical:

35. Does your school have requirements for dental implants (i.e. targets/ quotas/ competencies) that your student must complete prior to graduation?

☐Yes ☐No ☐Other (please specify):

36. If you answered 'yes', can you please outline what these requirements are?

Click or tap here to enter text.

37. What method are you using to assess students' clinical work?

☐ Day to-day observation and judgement (glance and mark)

☐ Tests based on observation and implicit judgement

☐ Fixed schedules of clinical requirement

☐ Peer-assessment

☐ Self-assessment

☐ Other Please specify: Click or tap here to enter text.

38. How is the consistency in assessment achieved?

☐I am not sure
☐There are guidelines
☐Regular teachers meeting
☐Other, Please comment: Click or tap here to enter text.

39. Who is/are responsible for assess students' clinical work and competence?
Check any that apply

☐Professor ☐Consultant ☐GDP (part-time teacher)

☐Senior lecture/Associate professor ☐Lecturer

40. Is there a final assessment exam before graduation?
☐Yes ☐No

41. How do you assess the students' clinical competence in dental implants before graduation?

Click or tap here to enter text.

42. Are you satisfied that you have adequately assess your students' competence in dental implants prior to graduation?
☐Yes ☐No ☐Mostly ☐Not sure
Comment please: ---------------------------

43. Do you consider your students to be competent in dental implants at graduation?
☐Yes ☐No ☐Not sure
Comment please: ---------------------------

44. How do you think the competence of your students in dental implants compared to that of students who graduated 10 years ago?

☐Better ☐Worse ☐No change ☐Not sure

Comment please:Click or tap here to enter text.

----

45. What potential challenges do you perceive in the teaching of dental implants over the next few years? Check any that apply

☐Lack of adequately trained staff for teaching

☐Lack of suitable patients for students to treat

☐Pressures on teaching time from other sources in the undergraduate curriculum

☐Lack of the financial resources

☐Other:

46. Do you have any further comments in relation to students' dental implants teaching and assessment?

Appendix 8: Data analysis of Undergraduate Dental Implants Curriculum: An International Study of Current Teaching and Assessment Methods

Table S8.1 One-way ANOVA tests of the approximate number of hours of teaching received by an individual student in this course vs. country

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6481.715	5	1296.343	5.222	.008
Within Groups	3226.917	13	248.224		
Total	9708.632	18			

Means Plots

Figure 1. Average hours of undergradute dental implants teaching across different geographical area

Table S8.2 One-way ANOVA tests of the amount of teaching vs. country

		Sig.
Academic/didactic teaching/hours:	Between Groups	.140
	Within Groups	
	Total	
Hands-on/ practical skills/hours:	Between Groups	.014

	Within Groups	
	Total	
Formal lectures/hour:	Between Groups	.031
	Within Groups	
	Total	
Laboratory demonstrations/hour:	Between Groups	.836
	Within Groups	
	Total	
Small groups, Tutorials or seminars/hour:	Between Groups	.450
	Within Groups	
	Total	

Table S8.3 One-way ANOVA tests for if the students have to complete an assessment at the end of the preclinical course vs. country

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.632	5	.726	9.442	<.001
Within Groups	1.000	13	.077		
Total	4.632	18			

Means Plots

Figure 2. Average of having students assessment at the end of the pre-clinical dental implants course across geographical area

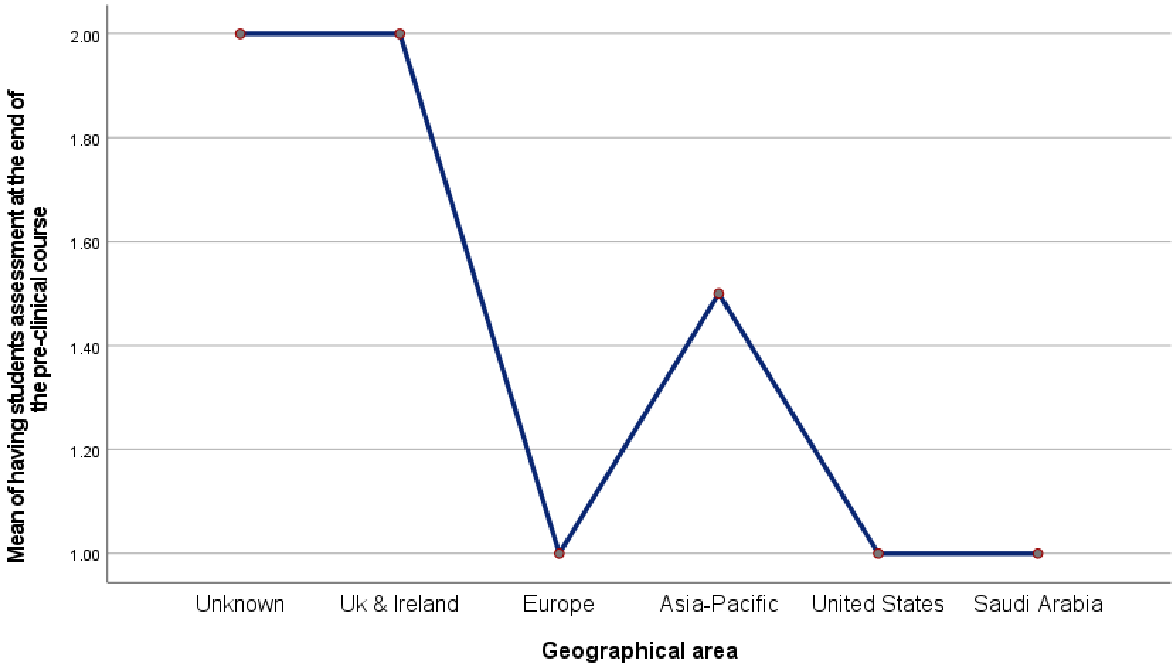

Table S8.4 Crosstabulation for if school have requirements for dental implants (i.e., targets/ quotas/competencies) that student must complete prior to graduation vs. country

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Geo * Does your school have requirements for dental implants (i.e. targets/ quotas/competencies) that your student must complete prior to graduation?	13	59.1%	9	40.9%	22	100.0%

Count

		Does your school have requirements for dental implants (i.e. targets/ quotas/competencies) that your student must complete prior to graduation?		
		Yes	No	Total
Geo	1.00	0	3	3
	2.00	0	1	1
	3.00	0	2	2
	4.00	3	4	7
Total		3	10	13

Table S.8.5 Chi-Square tests for if school have requirements for dental implants (i.e., targets/ quotas/competencies) that student must complete prior to graduation vs. country

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	3.343[a]	3	.342
Likelihood Ratio	4.485	3	.214
Linear-by-Linear Association	2.340	1	.126
N of Valid Cases	13		

Table S8.6 Crosstabulation for if there a final assessment exam before graduation vs. country

	Cases		
	Valid	Missing	Total

	N	Percent	N	Percent	N	Percent
Geo * Is there a final assessment exam before graduation?	12	54.5%	10	45.5%	22	100.0%

Count

		Is there a final assessment exam before graduation?		
		Yes	No	Total
Geo	1.00	1	1	2
	2.00	0	1	1
	3.00	1	1	2
	4.00	4	3	7
Total		6	6	12

Table S8.7 Chi-Square tests for if there a final assessment exam before graduation vs. country

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	1.143[a]	3	.767
Likelihood Ratio	1.530	3	.675
Linear-by-Linear Association	.234	1	.629
N of Valid Cases	12		

Table S8.8 Crosstabulation for if dental school have a dedicated clinical course in dental implants for undergraduate dental students vs. country

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Does your dental school have a dedicated clinical course in dental implants for undergraduate dental students?	22	100.0%	0	0.0%	22	100.0%

Count

		Does your dental school have a dedicated clinical course in dental implants for undergraduate dental students?		
		Yes	No	Total
Geo	.00	1	0	1

1.00	1	6	7
2.00	1	0	1
3.00	2	2	4
4.00	6	1	7
5.00	0	2	2
Total	11	11	22

Table S8.9 Chi-Square tests for if dental school have a dedicated clinical course in dental implants for undergraduate dental students vs. country

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	11.143[a]	5	.049
Likelihood Ratio	13.470	5	.019
Linear-by-Linear Association	.921	1	.337
N of Valid Cases	22		

Appendix 9: Questionnaires of Undergraduate Teaching and Assessment Methods in Prosthodontics Curriculum: An International Delphi Survey

Delphi Round 1 Questionnaire

Section 1: Demographic information:

A. Name of institute you work in:

B. Your title and job role:

- Professor
- Consultant
- Senior lecturer
- Lecturer
- Other (please specify):

C. Years of undergraduate teaching experience:

- Less than 2 years
- 2-5 years
- 6-9 years
- 10 years or more

Section 2: Preclinical teaching trends

Please tick/ select the best answer to the following questions/statements. Comments can be given under each question/statement.

1. How important is it that students have a dedicated preclinical course in?

Complete dentures:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Removable partial dentures:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Fixed prosthodontics:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Dental implants (surgical placement):

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Dental implants (restoration):

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

- Comment:

2. Assuming your programme is 5 years, during which year of study should students commence preclinical course of the following? *(if you have a 4 year programme, then the first year of your programme should correspond to Year 2 in the table)*

Prosthodontics disciplines	Year 1	Year 2	Year 3	Year 4	Year 5
Complete dentures					
Removable partial dentures					
Fixed partial dentures (crown & bridges)					
Dental implants					

- Comment:

3. What range of hours of hands-on/ practical skills will be suitable/the best during the preclinical course?

Prosthodontics disciplines	<10 hours	20-30 hours	30-40 hours	40-50 hours	>50 hours
Complete dentures					
Removable partial dentures					
Fixed partial dentures (crown & bridges)					
Dental implants					

- Comment:

4. Who would be the most suitable to direct the preclinical courses?

Prosthodontics disciplines	Professor	Consultant	Senior lecturer	Lecturer	GDP (part-time lecturer	Technician
Complete dentures						
Removable partial dentures						
Fixed partial dentures (crown & bridges)						
Dental implants						

- Comment:

5. Who would be suitable to supervise students during the hands-on/ practical skills sessions?

Prosthodontics disciplines	Professor	Consultant	Senior lecturer	Lecturer	GDP (part-time lecturer	Technician
Complete dentures						
Removable partial dentures						
Fixed partial dentures (crown & bridges)						
Dental implants						

- Comment:

6. What is the best staff: student ratio during the hands-on/ practical skills sessions?

Prosthodontics disciplines	<1:6	1:6-1:8	1:9-1:12	1:13-1:16	1:17-1:20	>1:20
Complete dentures						
Removable partial dentures						
Fixed partial dentures (crown & bridges)						
Dental implants						

- Comment:

Section 3: Preclinical assessment trends

7. How important is it that students gain experience in each of the following preclinical practical exercises?

   A. Complete dentures:

Prescription writing:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Teeth setting and waxing-up:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Cast and trimming of models:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Mounting casts:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Impression technique:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

B. <u>Removable partial dentures:</u>

Tooth preparation on patient simulators:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Using surveyor:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Using articulator:

Not important at all	Extremely important

1	2	3	4	5	6	7	8	9

Prescription writing (e.g. rest seat):

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Casting impression:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Altered cast impression technique:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

C. **Fixed prosthodontics:**

Tooth preparation for crown:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Teeth preparation for bridge:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Veneer preparation:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Using facebow:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Shade selection:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Prescription writing:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

D. <u>Dental implants:</u>

Recognition of prosthetic parts of dental implants:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Impression technique:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Fitting of final restoration:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

- Comment:

8. How important is it that students complete a practical assessment at the end of the preclinical course in?

Complete dentures:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Removable partial dentures:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Fixed prosthodontics:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Dental implants (surgical placement):

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Dental implants (restoration):

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

9. How important is it that students complete a written assessment at the end of the preclinical course in?

Complete dentures:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Removable partial dentures:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Fixed prosthodontics:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Dental implants (surgical placement):

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Dental implants (restoration):

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

- Comment:

10. How important is it that students complete an oral/ viva voce assessment at the end of the preclinical course in?

Complete dentures:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Removable partial dentures:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Fixed prosthodontics:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Dental implants (surgical placement):

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Dental implants (restoration):

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

- Comment:

11. Who should be responsible for assessing students' work and competence during the preclinical sessions?

Prosthodontics disciplines	Professor	Consultant	Senior lecturer	Lecturer	GDP (part-time lecturer	Technician
Complete dentures						
Removable partial dentures						
Fixed partial dentures (crown & bridges)						
Dental implants						

- Comment:

12. How important is it that the person who assesses students in the practical skills lab be involved in preclinical teaching of the module?

Complete dentures:

Not important at all								**Extremely important**
1	2	3	4	5	6	7	8	9

Removable partial dentures:

Not important at all								**Extremely important**
1	2	3	4	5	6	7	8	9

Fixed prosthodontics:

Not important at all								**Extremely important**
1	2	3	4	5	6	7	8	9

Dental implants:

Not important at all								**Extremely important**
1	2	3	4	5	6	7	8	9

- Comment:

13. What is the best method to achieve consistency in assessment during the hands-on/ practical skills sessions? (when more than one assessor/examiner is assessing/marking same student).

	Complete dentures	Removable partial dentures	Fixed prosthodontics	Dental implants
Follow guidelines/ criteria set-up by the department				
Regular teachers meeting				
Staff training				
Using digital software (e.g.: Liftupp)				
Left to individual teachers discretion				
Other (write in comment)				

- Comment:

14. What is the best progression path if a student fails the assessment?

Prosthodontics disciplines	Nothing/ student progresses to clinical treatment	Reduced grade in module (student still progresses to clinical module)	Required to re-sit (student still progresses to clinical module)	Cannot undertake clinical procedures until passing a re-sit
Complete dentures				
Removable partial dentures				
Fixed partial dentures (crown & bridges)				
Dental implants				

- Comment:

<u>Section 4: Clinical teaching trends:</u>

15. Assuming your programme is 5 years, during which year of study should students commence clinical treatment of the following patient groups? *(if you have a 4 year programme, then the first year of your programme should correspond to Year 2 in the table)*

Prosthodontics disciplines	Year 1	Year 2	Year 3	Year 4	Year 5
Complete dentures					
Removable partial dentures					
Fixed partial dentures (crown & bridges)					
Dental implants					

- Comment:

Prosthodontics disciplines	<1:3	1:3-1:5	1:6-1:9	1:10-1:13	1:14-1:17	>1:18
Complete dentures						

Removable partial dentures						
Fixed partial dentures (crown & bridges)						
Dental implants						

16. What would be the best staff: student ratio during the clinical sessions?

- Comment:

17. Is it important to have a paired teaching (i.e. students working in pairs together: one operating/ one assisting)?

Prosthodontics disciplines	No	Some experience in a limited number of cases	Majority experience for most cases	Essential at all times
Complete dentures				
Removable partial dentures				
Fixed partial dentures (crown & bridges)				
Dental implants				

- Comment:

18. Who would be most suitable to supervise students during the clinical sessions?

Prosthodontics disciplines	Professor	Consultant	Senior lecturer	Lecturer	GDP (part-time lecturer	Technician
Complete dentures						
Removable partial dentures						
Fixed partial dentures (crown & bridges)						
Dental implants						

- Comment:

19. How many units of prosthesis are the best to be required to complete before graduation?

Prosthodontics disciplines	0-2	3-6	7-10	10-13	>13
Complete dentures					
Removable partial dentures					
Fixed partial dentures (bridges)					
Single Crown					
Dental implants placement					

Dental implants restoration					

- Comment:

20. How important is it that students gain experience in digital workflow (e.g. intra-oral scanning and fitting lab work manufactured using 3-d printing, etc)?

Complete dentures:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Removable partial dentures:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Fixed prosthodontics:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Dental implants (surgical placement):

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Dental implants (restoration):

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

- Comment:

21. How important is it that students gain experience in completing the production/ laboratory work for their own cases?

Complete dentures:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Removable partial dentures:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Fixed prosthodontics:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Dental implants (surgical placement):

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Dental implants (restoration):

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

- Comment:

Section 5: Clinical assessment trends

22. How important are each of the following in determining a student's suitability/ competence for graduation:

Number of treatments (targets/ requirements) completed:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Grades achieved in clinical sessions:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Criterion referenced assessed exercises:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Completion of an end-of-programme clinical exercise (e.g. crown prep, occlusal registration for dentures):

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Viva voce:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Case presentation:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

- Comment:

23. How important are criterion referenced assessed exercises in each of the following?

D. Complete dentures:

Master impression:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Occlusal registration:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Try-in:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Fitting:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

E. Removable partial dentures:

Denture design:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Master impression:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Occlusal registration:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Teeth preparation (e.g. rest seat):

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Try-in:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Fitting:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

F. <u>Fixed prosthodontics:</u>

Tooth preparations:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Master impression:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Temporization:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Fitting:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

E. <u>Dental implants:</u>

Surgical placement:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Restoration:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Master impression:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Abutment selection:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Fitting:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

- Comment:

24. Who should be responsible to assess students' work and competence during the clinical sessions?

Prosthodontics disciplines	Professor	Consultant	Senior lecturer	Lecturer	GDP (part-time lecturer	Technician
Removable complete dentures						
Removable partial dentures						
Fixed partial dentures (crown & bridges)						
Dental implants						

- Comment:

25. How important is it that the person who assesses students in the clinic be involved in clinical teaching of the module?

Complete dentures:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Removable partial dentures:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Fixed prosthodontics:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

Dental implants:

Not important at all								Extremely important
1	2	3	4	5	6	7	8	9

- Comment:

26. What is the best method to achieve consistency in assessment during clinical sessions?

	Complete dentures	Removable Partial dentures	Fixed prosthodontics	Dental implants
Follow guidelines/criteria set-up by the department				
Regular teachers meeting				
Left to individual teachers discretion				
Using digital software (e.g.: Liftupp)				
Other (write in comment)				

- Comment:

27. Should a final assessment/ examination before graduation be set for students?

Prosthodontics disciplines	Yes	No
Complete dentures		
Removable partial dentures		
Fixed prosthodontics (crown & bridges)		
Dental implants		

- Comment:

28. What is/are the best method to assess students' clinical competence before graduation?

	Complete dentures	Removable Partial dentures	Fixed prosthodontics	Dental implants
Overall grades in the module				
Completion of the clinical requirements				
Competency or final clinical exam				
Written examination				
day-to-day assessments (Continuous assessment)				
Portfolio				
Other (write in comment)				

- Comment:

29. In your opinion, what is the minimum competence level that undergraduate dental students should have at graduation in? (e.g. list the skills that student should minimally have at graduation).

- Complete dentures:
- Removable partial dentures:
- Fixed prosthodontics:
- Dental implants:

Thank you for your time

Delphi Round 2 Questionnaire

Section 1: Demographic information:

- Name of institute you work in:

Section 2: Preclinical teaching trends

Please tick/ select the best answer to the following questions/statements. Comments can be given under each question/statement.

30. How important is it that students have a dedicated preclinical course in?

A. Based on round 1 questionnaire, a majority of the experts panel (65%) reported that a dedicated preclinical course for complete denture is important. Based on the overall group response, what do you think?
   - Not important
   - Not important nor important (neutral)
   - Important

B. Based on round 1 questionnaire, expert panel members reported that a dedicated preclinical course for dental implants (surgical placement) is not important (30%), not important nor important (neutral) (35%) and important (35%). Based on the overall group response, what do you think?
   - Not important
   - Not important nor important (neutral)
   - Important

- Comment:

31. Assuming your programme is 5 years, during which year of study should students commence preclinical course of the following? *(if you have a 4 year programme, then the first year of your programme should correspond to Year 2 in the table)*

Prosthodontics disciplines	Year 1	Year 2	Year 3	Year 4	Year 5
A. Based on round 1 questionnaire, a majority of the expert panel members reported that a dedicated preclinical course for complete denture should be commenced during year 2					

(39%) or year 3 (43%). Which of these years do you think would be most appropriate?					
B. Based on round 1 questionnaire, a majority of the expert panel members reported that a dedicated preclinical course for fixed prosthodontics should be commenced during year 2 (26%), year 3 (56%) or year 4 (13%). Which of these years do you think would be most appropriate?					
C. Based on round 1 questionnaire, a majority of the expert panel members reported that a dedicated preclinical course for dental implants should be commenced during year 4 (65%). Based on the overall group response, what do you think?					

- Comment:

32. What range of hours of hands-on/ practical skills will be suitable/the best during the preclinical course?

Prosthodontics disciplines	<10 hours	20-30 hours	30-40 hours	40-50 hours	>50 hours
A. Based on round 1 questionnaire, expert panel members reported that hours of Hands-on/ practical skills would be suitable/the best during the preclinical complete dentures course are <10 hours (22%) or 20-30 hours (30%). Which of these ranges do you think is more suitable?					
B. Based on round 1 questionnaire, expert panel members reported that hours of Hands-on/ practical skills would be suitable/the best during the preclinical removable partial dentures course are 20-30 hours (35%), 30-40 hours (17%) and 40-50 hours (22%). Which of these ranges do you think is more suitable?					
C. Based on round 1 questionnaire, expert panel members reported that hours of Hands-on/ practical skills would be suitable/the best during the preclinical fixed prosthodontics course are 40-50 hours (43%). Based on the overall group response, what do you think?					

D. Based on round 1 questionnaire, a majority of the expert panel members reported that hours of Hands-on/ practical skills would be suitable/the best during the preclinical dental implants course are <10 hours (52%). Based on the overall group response, what do you think?					

- Comment:

33. Who would be the most suitable to direct the preclinical courses?

Prosthodontics disciplines	Professor	Consultant	Senior lecturer	Lecturer	GDP (part-time lecturer	Technician
A. Based on round 1 questionnaire, expert panel members reported most suitable director of the preclinical complete dentures course are professor (26%) or senior lecturer (35%). Who of them do you think is the most suitable?						
B. Based on round 1 questionnaire, expert panel members reported most suitable director of the preclinical removable partial dentures course are professor (26%) or senior lecturer (26%). Who of them do you think is the most suitable?						
C. Based on round 1 questionnaire, expert panel members reported most suitable director of the preclinical fixed prosthodontics course are professor (30%) or senior lecturer (35%). Who of them do you think is the most suitable?						
D. Based on round 1 questionnaire, expert panel members reported most suitable director of the preclinical dental implants course are professor (30%), consultant (30%) or senior lecturer (26%). Who of them do you think is the most suitable?						

- Comment:

34. Who would be suitable to supervise students during the hands-on/ practical skills sessions?

Prosthodontics disciplines	Professor	Consultant	Senior lecturer	Lecturer	GDP (part-time lecturer	Technician
A. Based on round 1 questionnaire, expert panel members reported the most suitable professional to supervise students during hands-on of preclinical complete dentures course are professor (26%), senior lecturer (22%) or lecturer (22%). Who of them do you think is the most suitable?						
B. Based on round 1 questionnaire, expert panel members reported the most suitable professional to supervise students during hands-on of preclinical removable partial dentures course are professor (26%) or senior lecturer (26%). Who of them do you think is the most suitable?						
C. Based on round 1 questionnaire, expert panel members reported the most suitable professional to supervise students during hands-on of preclinical fixed prosthodontics course are professor (22%), senior lecturer (30%) or lecturer (22%). Who of them do you think is the most suitable?						
D. Based on round 1 questionnaire, expert panel members reported the most suitable professional to supervise students during hands-on of preclinical dental implants course are professor (26%), consultant (26%) or senior lecturer (26%). Who of them do you think is the most suitable?						

- Comment:

35. What is the best staff: student ratio during the hands-on/ practical skills sessions?

Prosthodontics disciplines	<1:6	1:6-1:8	1:9-1:12	1:13-1:16	1:17-1:20	>1:20
A. Based on round 1 questionnaire, a majority of the expert panel members reported that the best staff: student ratio during the hands-on/ practical skills sessions of preclinical complete dentures						

course is 1:6-1:8 (65%). Based on the overall group response, what do you think?						
B. Based on round 1 questionnaire, a majority of the expert panel members reported that the best staff: student ratio during the hands-on/ practical skills sessions of preclinical removable partial dentures course is 1:6-1:8 (61%). Based on the overall group response, what do you think?						
C. Based on round 1 questionnaire, a majority of the expert panel members reported that the best staff: student ratio during the hands-on/ practical skills sessions of preclinical fixed prosthodontics course is 1:6-1:8 (48%). Based on the overall group response, what do you think?						
D. Based on round 1 questionnaire, a majority of the expert panel members reported that the best staff: student ratio during the hands-on/ practical skills sessions of preclinical dental implants course is 1:6-1:8 (43%). Based on the overall group response, what do you think?						

- Comment:

Section 3: Preclinical assessment trends

36. How important is it that students gain experience in each of the following preclinical practical exercises?

Complete dentures:

A. Based on round 1 questionnaire, a majority of the expert panel members reported it is important that students gain experience in prescription writing during preclinical complete dentures course (56%). Based on the overall group response, what do you think?

- ○ Not important
- ○ Not important nor important (neutral)
- ○ Important

B. Based on round 1 questionnaire, a majority of the expert panel members reported it is important that students gain experience in Cast and trimming of models during preclinical complete dentures course (56%). Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

C. Based on round 1 questionnaire, expert panel members reported it is important that students gain experience in Mounting casts during preclinical complete dentures course (61%). Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

Removable partial dentures:

D. Based on round 1 questionnaire, a majority of the expert panel members reported it is important that students gain experience in Casting impression during preclinical removable partial dentures course (61%). Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

E. Based on round 1 questionnaire, a majority of the expert panel members reported that students gain experience in Altered cast impression technique during preclinical removable partial dentures course is not important nor important (neutral) (52%) or important (43%). What do you think?

- Not important
- Not important nor important
- Important

Dental implants:

F. Based on round 1 questionnaire, a majority of the expert panel members reported that students gain experience in Fabrication of surgical stent during dental implants course is not important nor important (neutral) (39%) or important (43%), What do you think?

- Not important
- Not important nor important (neutral)

- Important

G. Based on round 1 questionnaire, a majority of the expert panel members reported that students gain experience in Impression technique during dental implants dentures course is important (65%). Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

- Comment:

37. How important is it that students complete a practical assessment at the end of the preclinical course in?

Dental implants (surgical placement):

A. Based on round 1 questionnaire, 43% of the expert panel members reported it is not important that students complete a practical assessment at the end of the preclinical course in
Dental Implants (surgical placement). Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

Dental implants (restoration):

B. Based on round 1 questionnaire, a majority of the expert panel members reported it is important that students complete a practical assessment at the end of the preclinical course in
Dental Implants (restoration) (61%). Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

- Comment:

38. How important is it that students complete a written assessment at the end of the preclinical course in?

Dental implants (surgical placement):
A. Based on round 1 questionnaire, the expert panel members reported that students complete a written assessment at the end of the preclinical course in Dental Implants (surgical placement) is not important nor important (neutral) (43%) or important (35%). Based on the overall group response, what do you think?

   - Not important
   - Not important nor important (neutral)
   - Important

Dental implants (restoration):
B. Based on round 1 questionnaire, a majority of the expert panel members reported it is important that students complete a written assessment at the end of the preclinical course in
Dental Implants (restoration) (52%), Based on the overall group response, what do you think?

   - Not important
   - Not important nor important (neutral)
   - Important

- Comment:

39. How important is it that students complete an oral/ viva voce assessment at the end of the preclinical course in?

Complete dentures:
A. Based on round 1 questionnaire, expert panel members reported that students complete an oral/ viva voce assessment at the end of the preclinical course in complete dentures is not
important (43%) and important (30%). Based on the overall group response, what do you think?

   - Not important
   - Not important nor important (neutral)
   - Important

Removable partial dentures:

B. Based on round 1 questionnaire, expert panel members reported that students complete an oral/ viva voce assessment at the end of the preclinical course in removable partial dentures is not important (39%) and important (39%). Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

Fixed prosthodontics:

C. Based on round 1 questionnaire, expert panel members reported that students complete an oral/ viva voce assessment at the end of the preclinical course in fixed prosthodontics is not important (39%) and important (39%). Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

Dental implants (surgical placement):

D. Based on round 1 questionnaire, expert panel members reported that students complete an oral/ viva voce assessment at the end of the preclinical course in dental implants (surgical placement) is not important (48%). Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

Dental implants (restoration):

E. Based on round 1 questionnaire, expert panel members reported that students complete an oral/ viva voce assessment at the end of the preclinical course in dental implants (restoration) is not important (48%). Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

- Comment:

40. Who should be responsible for assessing students’ work and competence during the preclinical sessions?

Prosthodontics disciplines	Professor	Consultant	Senior lecturer	Lecturer	GDP (part-time lecturer	Technician
A. Based on round 1 questionnaire, the most common response the expert panel members reported is that Senior lecturers (30%) should be responsible for assessing students’ work and competence during the complete dentures preclinical sessions, what do you think?						
B. Based on round 1 questionnaire, the most common response the expert panel members reported is that Professors (26%) or Senior lecturers (26%) should be responsible for assessing students’ work and competence during the removable partial dentures preclinical sessions, what do you think?						
C. Based on round 1 questionnaire, the most common response the expert panel members reported is that Senior lecturers (30%) should be responsible for assessing students’ work and competence during the fixed prosthodontics preclinical sessions, what do you think?						
D. Based on round 1 questionnaire, the most common response the expert panel members reported is that Senior lecturers (35%) should be responsible for assessing students’ work and competence during the dental implants preclinical sessions, what do you think?						

- Comment:

41. What is the best method to achieve consistency in assessment during the hands-on/ practical skills sessions? (when more than one assessor/examiner is assessing/marking same student).

Prosthodontics disciplines	Follow guidelines/ criteria set-up by the department	Regular teachers meeting	Staff training	Using digital software	Left to individual teachers discretion	Other (write in comment)

				(e.g.: Liftupp)		
A. Based on round 1 questionnaire, a majority of the expert panel members reported that the best method to achieve consistency in assessment during complete dentures hands-on/ practical skills sessions is Follow guidelines/criteria setup by the department (61%). Based on the overall group response, what do you think?						
B. Based on round 1 questionnaire, a majority of the expert panel members reported that the best method to achieve consistency in assessment during removable partial dentures hands-on/ practical skills sessions is Follow guidelines/criteria setup by the department (56%). Based on the overall group response, what do you think?						
C. Based on round 1 questionnaire, a majority of the expert panel members reported that the best method to achieve consistency in assessment during fixed prosthodontics hands-on/ practical skills sessions is Follow guidelines/criteria setup by the department (52%). Based on the overall group response, what do you think?						
D. Based on round 1 questionnaire, a majority of the expert panel members reported that the best method to achieve consistency in assessment during dental implants hands-on/ practical skills sessions is Follow guidelines/criteria setup by the department (56%). Based on						

the overall group response, what do you think?						

- Comment:

42. What is the best progression path if a student fails the assessment?

Prosthodontics disciplines	Nothing/ student progresses to clinical treatment	Reduced grade in module (student still progresses to clinical module)	Required to re-sit (student still progresses to clinical module)	Cannot undertake clinical procedures until passing a re-sit
Based on round 1 questionnaire, a majority of the expert panel members reported that the best progression path if a student fails the assessment in preclinical removable partial dentures course is not to undertake clinical procedures until passing a re-sit (65%). Based on the overall group response, what do you think?				

- Comment:

Section 4: Clinical teaching trends:

43. Assuming your programme is 5 years, during which year of study should students commence clinical treatment of the following patient groups? *(if you have a 4 year programme, then the first year of your programme should correspond to Year 2 in the table)*

Prosthodontics disciplines	Year 1	Year 2	Year 3	Year 4	Year 5
A. Based on round 1 questionnaire, a majority of the expert panel members reported that a dedicated clinical course for complete denture is commenced during year 3 (56%). Based on the overall group response, what do you think?					
B. Based on round 1 questionnaire, a majority of the expert panel members reported that a dedicated clinical course for removable partial dentures is commenced during year 3 (56%). Based on the overall group response, what do you think?					
C. Based on round 1 questionnaire, the most common responses expert panel members reported that a dedicated clinical course for fixed prosthodontics is commenced during year 3 (43%) or year 4 (48%). Based on the overall group response, what do you think?					
D. Based on round 1 questionnaire, a majority of the expert panel members reported that a dedicated clinical course for dental implants is commenced					

during year 4 (52%). Based on the overall group response, what do you think?					

- Comment:

44. What would be the best staff: student ratio during the clinical sessions?

Prosthodontics disciplines	<1:3	1:3-1:5	1:6-1:9	1:10-1:13	1:14-1:17	>1:18
A. Based on round 1 questionnaire, expert panel members reported that the best staff: student ratio during the clinical sessions of complete dentures course is 1:3-1:5 (52%) or 1:6-1-9 (48%). Based on the overall group response, what do you think?						
B. Based on round 1 questionnaire, expert panel members reported that the best staff: student ratio during the clinical sessions of removable partial dentures course is 1:3-1:5 (52%) or 1:6 1-9 (48%). Based on the overall group response, what do you think?						
C. Based on round 1 questionnaire, expert panel members reported that the best staff: student ratio during the clinical sessions of fixed prosthodontics course is 1:3-1:5 (65%). Based on the overall group response, what do you think?						
D. Based on round 1 questionnaire, expert panel members reported that the best staff: student ratio during the clinical sessions of dental implants course is 1:3-1:5 (61%). Based on the overall group response, what do you think?						

- Comment:

45. Is it important to have a paired teaching (i.e. students working in pairs together: one operating/ one assisting)?

Prosthodontics disciplines	No	Some experience in a limited number of cases	Majority experience for most cases	Essential at all times
A. Based on round 1 questionnaire, expert panel members reported that to have paired teaching during complete dentures clinical sessions is important in some experience in a limited number of				

cases (43%). Based on the overall group response, what do you think?				
B. Based on round 1 questionnaire, expert panel members reported that to have paired teaching during removable partial dentures clinical sessions is important in some experience in a limited number of cases (52%). Based on the overall group response, what do you think?				
C. Based on round 1 questionnaire, expert panel members reported that to have paired teaching during fixed prosthodontics clinical sessions is important in some experience in a limited number of cases (35%). Based on the overall group response, what do you think?				
D. Based on round 1 questionnaire, expert panel members reported that to have paired teaching during dental implants clinical sessions is important in some experience in a limited number of cases (39%) or Essential at all times (30%). Based on the overall group response, what do you think?				

- Comment:

46. Who would be most suitable to supervise students during the clinical sessions?

Prosthodontics disciplines	Professor	Consultant	Senior lecturer	Lecturer	GDP (part-time lecturer	Technician
A. Based on round 1 questionnaire, expert panel members reported the most suitable professionals to supervise students during complete dentures clinical sessions course are professor (22%), senior lecturer (22%) or lecturer (22%). Who of them do you think is the most suitable?						
B. Based on round 1 questionnaire, expert panel members reported the most suitable professionals to supervise students during removable partial dentures clinical sessions course are professor (22%) or senior lecturer (22%). Who of them do you think is the most suitable?						

C. Based on round 1 questionnaire, expert panel members reported the most suitable professionals to supervise students during fixed prosthodontics clinical sessions course are professor (26%) or senior lecturer (22%). Who of them do you think is the most suitable?						
D. Based on round 1 questionnaire, expert panel members reported the most suitable professionals to supervise students during dental implants clinical sessions course are consultant (35%) or professor (26%). Who of them do you think is the most suitable?						

- Comment:

47. How many units of prosthesis are the best to be required to complete before graduation?

Prosthodontics disciplines	0-2	3-6	7-10	10-13	>13
A. Based on round 1 questionnaire, expert panel members reported that the best number of units of complete dentures to be required to complete before graduation are 3-6 (48%). Based on the overall group response, what do you think?					
B. Based on round 1 questionnaire, expert panel members reported that the best number of units of removable partial dentures to be required to complete before graduation are 3-6 (61%). Based on the overall group response, what do you think?					
C. Based on round 1 questionnaire, expert panel members reported that the best number of units of bridges to be required to complete before graduation are 3-6 (43%). Based on the overall group response, what do you think?					
D. Based on round 1 questionnaire, expert panel members reported that the best number of units of single crowns to be required to complete before graduation are 3-6 (39%). Based on the overall group response, what do you think?					

E. Based on round 1 questionnaire, expert panel members reported that the best number of units of dental implants restorations to be required to complete before graduation are 0-2 (56%). Based on the overall group response, what do you think?					

- Comment:

48. How important is it that students gain experience in digital workflow (e.g. intra-oral scanning and fitting lab work manufactured using 3-d printing, etc)?

Complete dentures:
A. Based on round 1 questionnaire, expert panel members reported it is not important nor important (neutral) that students gain experience in digital workflow in complete dentures (48%). Based on the overall group response, what do you think?
- o Not important
- o Not important nor important (neutral)
- o Important

Removable partial dentures:
B. Based on round 1 questionnaire, expert panel members reported it is neutral that students gain experience in digital workflow in removable partial dentures (52%). Based on the overall group response, what do you think?
- o Not important
- o Not important nor important (neutral)
- o Important

Dental implants (surgical placement):
C. Based on round 1 questionnaire, expert panel members reported it is important that students gain experience in digital workflow in dental implants surgical placement (48%). Based on the overall group response, what do you think?
- o Not important
- o Not important nor important (neutral)
- o Important

Dental implants (restoration):
D. Based on round 1 questionnaire, expert panel members reported it is important that students gain experience in digital workflow in dental implants restorations (48%). Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

- Comment:

49. How important is it that students gain experience in completing the production/ laboratory work for their own cases?

Complete dentures:

A. Based on round 1 questionnaire, expert panel members reported it is important that students gain experience in completing the production/ laboratory work for their own cases in complete dentures (52%). Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

Removable partial dentures:

B. Based on round 1 questionnaire, expert panel members reported it is important that students gain experience in completing the production/ laboratory work for their own cases in removable partial dentures (48%). Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

Fixed prosthodontics:

C. Based on round 1 questionnaire, expert panel members reported it is important that students gain experience in completing the production/ laboratory work for their own cases in fixed prosthodontics (48%). Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

Dental implants (surgical placement):

D. Based on round 1 questionnaire, expert panel members reported it is important that students gain experience in completing the production/ laboratory work for their own cases in dental implant surgical placement (39%). Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

Dental implants (restoration):

E. Based on round 1 questionnaire, expert panel members reported it is not important that students gain experience in completing the production/ laboratory work for their own cases in dental implant restorations (43%). Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

- Comment:

<u>Section 5: Clinical assessment trends</u>

50. How important are each of the following in determining a student's suitability/ competence for graduation:

Number of treatments (targets/ requirements) completed:

A. Based on round 1 questionnaire, expert panel members reported that the number of treatments (targets/ requirements) completed is not important nor important (neutral) (48%) or important (39%) in determining a student's suitability/ competence for graduation. Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

Grades achieved in clinical sessions:

B. Based on round 1 questionnaire, expert panel members reported that Grades achieved in clinical sessions is important (52%) in determining a student's suitability/ competence for graduation. Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

Criterion referenced assessed exercises:

Completion of an end-of-programme clinical exercise (e.g. crown prep, occlusal registration for dentures):

C. Based on round 1 questionnaire, expert panel members reported that Completion of an end-of-programme clinical exercise is important (65%) in determining a student's suitability/ competence for graduation. Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

Viva voce:

D. Based on round 1 questionnaire, expert panel members reported that Viva voce is important (61%) in determining a student's suitability/ competence for graduation. Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

- Comment:

51. How important are criterion referenced assessed exercises in each of the following?

Surgical placement:

A. Based on round 1 questionnaire, expert panel members reported that criterion referenced assessed exercises in dental implants surgical placement is not important (39%) or important (35%). Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

Restoration:

B. Based on round 1 questionnaire, expert panel members reported that criterion referenced assessed exercises in dental implants restorations is important (61%). Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

Master impression:

C. Based on round 1 questionnaire, expert panel members reported that criterion referenced assessed exercises in dental implants master impression is important (61%). Based on the overall group response, would you like to change your previous answer?

- Not important
- Not important nor important (neutral)
- Important

Abutment selection:

D. Based on round 1 questionnaire, expert panel members reported that criterion referenced assessed exercises in dental implants abutment selection is important (56%). Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

Fitting:

E. Based on round 1 questionnaire, expert panel members reported that criterion referenced assessed exercises in dental implants fitting is important (52%). Based on the overall group response, what do you think?

- Not important
- Not important nor important (neutral)
- Important

- Comment:

52. Who should be responsible to assess students' work and competence during the clinical sessions?

Prosthodontics disciplines	Professor	Consultan t	Senior lecturer	Lecturer	GDP (part-time lecturer	Technicia n

A. Based on round 1 questionnaire, expert panel members reported that Professors (26%), Senior lecturers (22%) or Lecturers (22%) should be responsible for assessing students' work and competence during the complete dentures clinical sessions. Based on the overall group response, what do you think?						
B. Based on round 1 questionnaire, expert panel members reported that Professor (26%) or Senior lecturer (22%) should be responsible for assessing students' work and competence during the removable partial dentures clinical sessions. Based on the overall group response, what do you think?						
C. Based on round 1 questionnaire, expert panel members reported that Professor (26%) or Senior lecturer (26%) should be responsible for assessing students' work and competence during the fixed prosthodontics clinical sessions. Based on the overall group response, what do you think?						
D. Based on round 1 questionnaire, expert panel members reported that Consultant (30%) or Professor (26%) should be responsible for assessing students' work and competence during the dental implants clinical sessions. Based on the overall group response, what do you think?						

- Comment:

53. What is the best method to achieve consistency in assessment during clinical sessions?

Prosthodontics disciplines	Follow guidelines / criteria set-up by the department	Regular teachers meeting	Staff training	Using digital software (e.g.: Liftupp)	Left to individual teachers discretion	Other (write in comment)
Based on round 1 questionnaire, expert panel members reported that the best method to achieve consistency in assessment during dental implants clinical sessions is Follow guidelines/criteria set-up by the department (65%). Based on the overall group response, what do you think?						

- Comment:

54. Should a final assessment/ examination before graduation be set for students?

Prosthodontics disciplines	Yes	No
A. Based on round 1 questionnaire, expert panel members reported that a final assessment/examination in complete dentures course is to be set for students before graduation (56%). Based on the overall group response, what do you think?		
B. Based on round 1 questionnaire, expert panel members reported that a final assessment/examination in dental implants course is not to be set for students before graduation (61%). Based on the overall group response, what do you think?		

- Comment:

55. What is/are the best method to assess students' clinical competence before graduation?

	Overall grades in the module	Completion of the clinical requirements	Competency or final clinical exam	Written examination	day-to-day assessments (Continuous assessment)	Portfolio	Other (write in comment)
A. Based on round 1 questionnaire, expert panel members reported that day-to-day assessments (continuous assessment) is the best method to assess students' clinical competence in complete dentures before graduation (52%). Based on the overall group response, what do you think?							
B. Based on round 1 questionnaire, expert panel members reported that day-to-day assessments (continuous assessment) is the best method to assess students' clinical competence in removable partial dentures before graduation (52%). Based on the overall group response, what do you think?							
C. Based on round 1 questionnaire, expert panel members reported that day-to-day assessments (continuous assessment) is the best method to assess students' clinical competence in fixed prosthodontics before graduation (52%). Based on the overall group response, what do you think?							
D. Based on round 1 questionnaire, expert panel members reported that day-to-day assessments (continuous assessment) is the best method to assess students' clinical competence in dental implants before graduation (43%). Based on the overall group response, what do you think?							

- Comment:

56. In your opinion, what is the minimum competence level that undergraduate dental students should have at graduation in? (e.g. list the skills that student should minimally have at graduation).

- **Complete dentures:**

A. Be able to diagnose and formulate treatment plan for fully-edentulous patients.
   - Agree
   - Disagree

B. Have the knowledge of complete dentures preparation and construction.
   - Agree
   - Disagree

C. Be able to perform all the clinical steps that used to construct conventional and interim complete dentures.
   - Agree
   - Disagree

D. Complete all preclinical exercises and fabricating a number of clinical cases (2-3 cases).
   - Agree
   - Disagree

E. Be able to perform ideal final impression, proper centric relation registration, knowledge in denture occlusion and handling post-insertion complications (e.g. perform relining and rebasing procedures).
   - Agree
   - Disagree

F. Fabricate non-complex complete dentures in cases from start to finish
   - Agree
   - Disagree

G. Be able to treat patients with dentures and achieve patient satisfaction
   - Agree
   - Disagree

- **Removable partial dentures:**

  A. Be able to diagnose and formulate treatment plan for partially-edentulous patients.
     - Agree
     - Disagree

  B. Have the knowledge of removable partial dentures preparation and construction.
     - Agree
     - Disagree

C. Be able to generate removable partial denture designs for various partially edentulous cases and evaluate the aesthetics and occlusion of the removable partial dentures.
   - Agree
   - Disagree

D. Be able to rehabilitate cases using Cobalt-Chromium and acrylic based dentures, free-end saddles and anterior saddles.
   - Agree
   - Disagree

E. Complete all preclinical exercises and fabricating a number of clinical cases (3-8 cases).
   - Agree
   - Disagree

F. Be able to assess patients, tooth preparations, primary and definitive impressions, review partial dentures and solve problem.
   - Agree
   - Disagree

G. Be able to design and make non-complex Co-Cr and acrylic RPDs cases from start to finish.
   - Agree
   - Disagree

H. Know how to survey and select proper design, ideal tooth preparation, ideal final impression, proper bite registration, knowledge in denture occlusion and handling post-insertion complications.
   - Agree
   - Disagree

- **Fixed prosthodontics:**

A. Be able to diagnose and formulate treatment planning of fixed prostheses and successfully manage clinical fixed prosthodontics cases.
   - Agree
   - Disagree

B. Have the knowledge of all aspects of fixed prostheses preparation and construction.
   - Agree
   - Disagree

C. Be able to rehabilitate a range of cases using crowns, resin-retained bridges and conventional bridges.
   - Agree
   - Disagree

D. Practice different types of tooth preparations of abutments of fixed prostheses and practicing with different types of prosthetic/restorative materials.
   - Agree
   - Disagree

E. Be able to produce biologically compatible and aesthetically and functionally acceptable
provisional crowns and safely manipulate soft tissues during impression making for prepared tooth/teeth.
   - Agree
   - Disagree

F. Be able to utilize inter-occlusal records and articulators for mounting clinical cases.
   - Agree
   - Disagree

G. Have the knowledge and good experience in preparation and manufacturing veneer, single crown (porcelain/metal/porcelain only), resin-retained bridges, conventional bridges and cantilever bridges.
   - Agree
   - Disagree

H. Be able to assess, tooth/teeth preparation, preform primary and definitive impressions, review final restoration and solve problem.
   - Agree
   - Disagree

I. Competently complete all preclinical exercises and a number of clinical cases (6-15 units).
   - Agree
   - Disagree

J. Be able to perform crown or bridge abutments preparation clinically, impression, temporization and fitting final restoration.
   - Agree
   - Disagree

K. Be able to treat patients with fixed prostheses and achieve patient satisfaction.
   - Agree
   - Disagree

- **Dental implants:**

A. Only have a theoretical understanding of how implants work.
   - Agree
   - Disagree

B. Be able to perform treatment plan and restore missing tooth/teeth with dental implant prostheses (removable or fixed prostheses).
   - Agree
   - Disagree

C. Have a thorough knowledge in implant parts for simple implant restorations (such as single implant supported crowns), impression techniques and their indications, fabrication of radiographic and surgical stints.
   - Agree
   - Disagree

D. Have the knowledge of all aspects of dental implants restoration and surgical sequence, indications and limitations.
   - Agree
   - Disagree

E. Be able to select patient, preform case assessment and surgical treatment planning of a single tooth cases.
   - Agree
   - Disagree

F. Be able to perform impression and fit screw retained crown.
   - Agree
   - Disagree

G. Have competently completed all preclinical exercises and a number of clinical cases (2-3 cases).
   - Agree
   - Disagree

H. Be able to treat patients with Dental implants and achieve patient satisfaction.
   - Agree
   - Disagree

I. Minimum competence in dental implants is not needed for graduation but desirable
   - Agree
   - Disagree

Thank you for your time

Delphi Round 3 Questionnaire

Section 1: Demographic information:

- Name of institute you work in:

Section 2: Preclinical teaching trends

Please tick/ select the best answer to the following questions/statements. Comments can be given under each question/statement.

57. How important is it that students have a dedicated preclinical course in?

- Based on round 2 questionnaire, most of the experts panel (50%) reported that a dedicated preclinical course for dental implants(surgical placement) is not important nor important (neutral). Do you agree?
  - I agree
  - I do not agree
- Comment:

58. Assuming your programme is 5 years, during which year of study should students commence preclinical course of the following? *(if you have a 4 year programme, then the first year of your programme should correspond to Year 2 in the table)*

	I agree	I do not agree
A. Based on round 2 questionnaire, most of the expert panel members reported that a dedicated preclinical course for complete denture should be commenced during year 3 (55.5%). Do you agree?		
B. Based on round 2 questionnaire, a majority of the expert panel members reported that a dedicated preclinical course for fixed prosthodontics should be commenced during year 3 (61.1%). Do you agree?		

- Comment:

59. What range of hours of hands-on/ practical skills will be suitable/the best during the preclinical course?

	I agree	I do not agree
A. Based on round 2 questionnaire, a majority of expert panel members reported that hours of Hands-on/ practical skills would be suitable/the best during the preclinical complete dentures course are 20-30 hours (61.1%). Do you agree?		
B. Based on round 2 questionnaire, a majority of expert panel members reported that hours of Hands-on/ practical skills would be suitable/the best during the preclinical removable partial dentures course are 20-30 hours (67%). Do you agree?		
C. Based on round 2 questionnaire, a majority of expert panel members reported that hours of Hands-on/ practical skills would be suitable/the best during the preclinical fixed prosthodontics course are 40-50 hours (67%). Do you agree?		
D. Based on round 2 questionnaire, a majority of the expert panel members reported that hours of Hands-on/ practical skills would be suitable/the best during the preclinical dental implants course are <10 hours (67%). Do you agree?		

- Comment:

60. Who would be the most suitable to direct the preclinical courses?

	I agree	I do not agree
A. Based on round 2 questionnaire, a majority of expert panel members reported most suitable director of the preclinical complete dentures course are senior lecturer (67%). Do you agree?		
B. Based on round 2 questionnaire, a majority expert panel members reported most suitable director of the preclinical removable partial dentures course are senior lecturer (67%). Do you agree?		
C. Based on round 2 questionnaire, most of expert panel members reported most suitable director of the preclinical dental		

implants course are senior lecturer (55.5%). Do you agree?		

- Comment:

61. Who would be suitable to supervise students during the hands-on/ practical skills sessions?

	I agree	I do not agree
A. Based on round 2 questionnaire, most of expert panel members reported the most suitable professional to supervise students during hands-on of preclinical complete dentures course are senior lecturer (50%). Do you agree?		
B. Based on round 2 questionnaire, a majority of expert panel members reported the most suitable professional to supervise students during hands-on of preclinical removable partial dentures course are senior lecturer (67%). Do you agree?		
C. Based on round 2 questionnaire, a majority of expert panel members reported the most suitable professional to supervise students during hands-on of preclinical fixed prosthodontics course are senior lecturer (67%). Do you agree?		
D. Based on round 1 questionnaire, a majority of expert panel members reported the most suitable professional to supervise students during hands-on of preclinical dental implants course are senior lecturer (67%). Do you agree?		

- Comment:

<u>Section 3: Preclinical assessment trends</u>

62. How important is it that students gain experience in each of the following preclinical practical exercises?

Removable partial dentures:

A. Based on round 2 questionnaire, most of the expert panel members reported that students gain experience in Altered cast impression technique during preclinical removable partial dentures course is not important nor important (neutral) (55.5%).Do you agree?

- I agree
- I do not agree

Dental implants:

B. Based on round 1 questionnaire, most of the expert panel members reported that students gain experience in Fabrication of surgical stent during preclinical dental implants dentures course is important (50%), Do you agree?

- I agree
- I do not agree

- Comment:

63. How important is it that students complete a practical assessment at the end of the preclinical course in?

Dental implants (surgical placement):

A. Based on round 2 questionnaire, a majority of the expert panel members (61.1%) reported it is not important that students complete a practical assessment at the end of the preclinical course in Dental Implants (surgical placement). Do you agree?

- I agree
- I do not agree

Dental implants (restoration):

B. Based on round 2 questionnaire, a majority of the expert panel members (61.1%) reported it is important that students complete a practical assessment

at the end of the preclinical course in Dental Implants (restoration). Do you agree?
- I agree
- I do not agree

- Comment:

64. How important is it that students complete a written assessment at the end of the preclinical course in?

Dental implants (surgical placement):

A. Based on round 2 questionnaire, most of the expert panel members reported that students complete a written assessment at the end of the preclinical course in Dental Implants (surgical placement) is not important nor important (neutral) (55.5%). Do you agree?
- I agree
- I do not agree

Dental implants (restoration):

B. Based on round 2 questionnaire, most of the expert panel members reported that students complete a written assessment at the end of the preclinical course in Dental Implants(restoration) is important (55.5%). Do you agree?
- I agree
- I do not agree

- Comment:

65. How important is it that students complete an oral/ viva voce assessment at the end of the preclinical course in?

Complete dentures:

A. Based on round 2 questionnaire, most of expert panel members reported that students complete an oral/ viva voce assessment at the end of the preclinical course in complete dentures is not important (50%). Do you agree?
- I agree
- I do not agree

Removable partial dentures:

B. Based on round 2 questionnaire, the most common response of expert panel members reported that students complete an oral/ viva voce assessment at the end of the preclinical course in removable partial dentures is not important (44.4%). Do you agree?

- I agree
- I do not agree

Fixed prosthodontics:

C. Based on round 2 questionnaire, the most common response of expert panel members reported that students complete an oral/ viva voce assessment at the end of the preclinical course in fixed prosthodontics is not important (44.4%). Do you agree?

- I agree
- I do not agree

Dental implants (restoration):

D. Based on round 2 questionnaire, a majority of expert panel members reported that students complete an oral/ viva voce assessment at the end of the preclinical course in dental implants (restoration) is not important (61.1%). Do you agree?

- I agree
- I do not agree

- Comment:

66. Who should be responsible for assessing students' work and competence during the preclinical sessions?

	I agree	I do not agree
A. Based on round 2 questionnaire, the most common response the expert panel members reported that Senior lecturers (67%)should be responsible for assessing students' work and competence during the complete dentures preclinical sessions. Do you agree?		
B. Based on round 2 questionnaire, the most common response the expert panel members reported that Senior lecturers (67%)should be responsible for assessing students' work and competence during the removable partial dentures preclinical sessions. Do you agree?		

C. Based on round 2 questionnaire, the most common response the expert panel members reported that Senior lecturers (67%)should be responsible for assessing students' work and competence during the fixed prosthodontics preclinical sessions. Do you agree?		
D. Based on round 2 questionnaire, the most common response the expert panel members reported that Senior lecturers (67%)should be responsible for assessing students' work and competence during the dental implants preclinical sessions. Do you agree?		

- Comment:

Section 4: Clinical teaching trends:

67. Assuming your programme is 5 years, during which year of study should students commence clinical treatment of the following patient groups? *(if you have a 4 year programme, then the first year of your programme should correspond to Year 2 in the table)*

	Year 1	Year 2	Year 3	Year 4	Year 5
A. Based on round 2 questionnaire, the most common responses expert panel members reported that a dedicated clinical course for fixed prosthodontics is commenced during year 3 (55.5%) or year 4 (50%). Based on the overall group response, what do you think?					

- Comment:

68. What would be the best staff: student ratio during the clinical sessions?

	I agree	I do not agree
A. Based on round 2 questionnaire, a majority of expert panel members reported that the best staff: student ratio during the clinical sessions of complete dentures course is 1:6-1-9(61.1%). Do you agree?		
B. Based on round 2 questionnaire, most of expert panel members reported that the best staff: student ratio during the clinical sessions of removable partial dentures course is 1:6-1-9(55.5%). Do you agree?		
C. Based on round 2 questionnaire, a majority of expert panel members		

reported that the best staff: student ratio during the clinical sessions of fixed prosthodontics course is 1:3-1:5(61.1%). Do you agree?		
D. Based on round 2 questionnaire, a majority of expert panel members reported that the best staff: student ratio during the clinical sessions of dental implants course is 1:3-1:5 (67%). Do you agree?		

- Comment:

69. Is it important to have a paired teaching (i.e. students working in pairs together: one operating/ one assisting)?

	I agree	I do not agree
A. Based on round 1 questionnaire, a majority of expert panel members reported that to have paired teaching during complete dentures clinical sessions is important in some experience in a limited number of cases (61.1%). Do you agree?		
B. Based on round 1 questionnaire, a majority of expert panel members reported that to have paired teaching during removable partial dentures clinical sessions is important in some experience in a limited number of cases (61.1%). Do you agree?		
C. Based on round 1 questionnaire, a majority of expert panel members reported that to have paired teaching during fixed prosthodontics clinical sessions is important in some experience in a limited number of cases (61.1%). Do you agree?		
D. Based on round 1 questionnaire, most of expert panel members reported that to have paired teaching during dental implants clinical sessions is important in some experience in a limited number of cases (55.5%). Do you agree?		

- Comment:

70. Who would be most suitable to supervise students during the clinical sessions?

	I agree	I do not agree

A. Based on round 2 questionnaire, a majority of expert panel members reported the most suitable professional to supervise students during complete dentures clinical sessions course are senior lecturer (61.1%). Do you agree?		
B. Based on round 2 questionnaire, most of expert panel members reported the most suitable professional to supervise students during removable partial dentures clinical sessions course are senior lecturer (55.5%). Do you agree?		
C. Based on round 2 questionnaire, a majority of expert panel members reported the most suitable professional to supervise students during fixed prosthodontics clinical sessions course are senior lecturer (61.1%). Do you agree?		
D. Based on round 2 questionnaire, a majority of expert panel members reported the most suitable professional to supervise students during dental implants clinical sessions course are senior lecturer (67%). Do you agree?		

- Comment:

71. How important is it that students gain experience in digital workflow (e.g. intra-oral scanning and fitting lab work manufactured using 3-d printing, etc)?

	I agree	I do not agree
A. Based on round 2 questionnaire, a majority of expert panel members reported it is not important nor important (neutral) that students gain experience in digital workflow in complete dentures (61.1%). Do you agree?		
B. Based on round 2 questionnaire, a majority of expert panel members reported it is not important nor important (neutral) that students gain experience in digital workflow in removable partial dentures (67%). Do you agree?		
C. Based on round 2 questionnaire, a majority of expert panel members reported it is important that students gain experience in digital workflow in dental		

implants surgical placement (67%).Do you agree?		
D. Based on round 2 questionnaire, a majority of expert panel members reported it is important that students gain experience in digital workflow in dental implants restorations (67%). Do you agree?		
E. Based on round 1 questionnaire, expert panel members reported that the best number of units of dental implants restorations to be required to complete before graduation are 0-2 (56%). Based on the overall group response, what do you think?		

- Comment:

72. How important is it that students gain experience in completing the production/ laboratory work for their own cases?

Complete dentures:

A. Based on round 2 questionnaire, a majority of expert panel members reported it is important that students gain experience in completing the production/ laboratory work for their own cases in complete dentures (67%). Do you agree?

- ○ I agree
- ○ I do not agree

Removable partial dentures:

B. Based on round 2 questionnaire, most of expert panel members reported it is important that students gain experience in completing the production/ laboratory work for their own cases in removable partial dentures (55.5%). Do you agree?

- ○ I agree
- ○ I do not agree

Fixed prosthodontics:

C. Based on round 2 questionnaire, a majority of expert panel members reported it is important that students gain experience in completing the

production/ laboratory work for their own cases in fixed prosthodontics (61.1%). Do you agree?
- I agree
- I do not agree

Dental implants (surgical placement):

D. Based on round 2 questionnaire, most of expert panel members reported it is not important nor important (neutral) that students gain experience in completing the production/laboratory work for their own cases in dental implant surgical placement (39%). Do you agree?
- I agree
- I do not agree

Dental implants (restoration):

E. Based on round 2 questionnaire, most of expert panel members reported it not important that students gain experience in completing the production/ laboratory work for their own cases in dental implant restorations (44.4%). Do you agree?
- I agree
- I do not agree

- Comment:

Section 5: Clinical assessment trends

73. How important are each of the following in determining a student's suitability/ competence for graduation:

Number of treatments (targets/ requirements) completed:

A. Based on round 2 questionnaire, most of expert panel members reported that the number of treatments (targets/requirements) completed is important (55.5%) in determining a student's suitability/ competence for graduation. Do you agree?
- I agree
- I do not agree

Viva voce:

B. Based on round 2 questionnaire, a majority of expert panel members reported that Viva voce is important (61.1%) in determining a student's suitability/ competence for graduation. Do you agree?
- I agree
- I do not agree

- Comment:

74. How important are criterion referenced assessed exercises in each of the following?

Dental implants surgical placement:

A. Based on round 2 questionnaire, a majority of expert panel members reported that criterion referenced assessed exercises in dental implants surgical placement is not important (67%) .Do you agree?

- I agree
- I do not agree

Dental implants restoration:

B. Based on round 2 questionnaire, most of expert panel members reported that criterion referenced assessed exercises in dental implants restorations is important (50%). Do you agree?

- I agree
- I do not agree

Dental implants master impression:

C. Based on round 2 questionnaire, most of expert panel members reported that criterion referenced assessed exercises in dental implants master impression is important (50%). Do you agree?

- I agree
- I do not agree

Dental implants abutment selection:

D. Based on round 2 questionnaire, most of expert panel members reported that criterion referenced assessed exercises in dental implants abutment selection is important (44.4%). Do you agree?

- I agree
- I do not agree

Dental implants fitting:

E. Based on round 2 questionnaire, most of expert panel members reported that criterion referenced assessed exercises in dental implants fitting is important (55.5%). Do you agree?

- I agree
- I do not agree

- Comment:

75. Who should be responsible to assess students' work and competence during the clinical sessions?

	I agree	I do not agree
A. Based on round 2 questionnaire, a majority of expert panel members reported that Senior lecturers (61.1%) should be responsible for assessing students' work and competence during the complete dentures clinical sessions. Do you agree?		
B. Based on round 2 questionnaire, most of expert panel members reported that Senior lecturer (50%) should be responsible for assessing students' work and competence during the removable partial dentures clinical sessions. Do you agree?		
C. Based on round 2 questionnaire, most of expert panel members reported that Senior lecturer (55.5%) should be responsible for assessing students' work and competence during the fixed prosthodontics clinical sessions. Do you agree?		
D. Based on round 2 questionnaire, most of expert panel members reported that Senior lecturer (50%) should be responsible for assessing students' work and competence during the dental implants clinical sessions. Do you agree?		

- Comment:

76. Should a final assessment/ examination before graduation be set for students?

	I agree	I do not agree
Based on round 2 questionnaire, most of expert panel members reported that a final assessment/examination in dental implants course is not to be set for students before graduation (55.5%). Do you agree?		

- Comment:

77. In your opinion, what is the minimum competence level that undergraduate dental students should have at graduation in? (e.g. list the skills that student should minimally have at graduation).

Dental implants:

A. Based on round 2 questionnaire, a majority of experts panel believed that students should not be able to select patient, preform case assessment and surgical treatment planning of a single tooth cases at graduation (61.1%). Do you agree?

- I agree
- I do not agree

B. Based on round 2 questionnaire, a majority of experts panel believed that students should not have to competently completed all preclinical exercises and a number of clinical cases (2-3 cases) at graduation (67%). Do you agree?

- I agree
- I do not agree

C. Based on round 2 questionnaire, a majority of experts panel believed that students should not be able to treat patients with Dental implants and achieve patient satisfaction (67%). Do you agree?

- I agree
- I do not agree

Thank you for your time.

Appendix 10: The study information leaflet, the consent statement and the interview topic guide of the Qualitative Study of Senior Academics' Perceptions in Undergraduate Prosthodontics Teaching and Assessment

Study information and Interviews Topic Guide

This is a qualitative study aims to invite a number of academic experts in prosthodontics from different geographical areas. You are eligible to participate in this study if you are an academic or specialist in prosthodontics/ restorative dentistry and involved in prosthodontics curriculum teaching and assessment. A semi-structured one-to-one interview will be used for data collection (approximately 15-20 minutes), and participants will be asked for their opinion on specific topics that have not reached consensus during a Delphi survey and about their experiences in teaching and assessments of prosthodontics curriculum in general. They will also be asked about the criteria they use to ensure students' competency at graduation.

The interview topic guide:

At the beginning the interviewee will be asked to introduce himself/herself (Demographic characteristics: name, title and job role, name of the institute and years of undergraduate teaching experience).

Questions that had not reached consensus:

Q1: In your opinion, who would be suitable to supervise students during the hands-on/ practical skills sessions in **complete dentures, removable partial dentures and dental implants courses**?

Q2: In your opinion, how important is it that students complete an oral/ viva voce assessment at the end of the preclinical course in **complete dentures**?

Q3: In your opinion, during which year of study should students commence dedicated clinical course for **fixed prosthodontics (crowns and bridges)**?

Q4: In your opinion, who would be suitable to supervise students during the clinical sessions of **complete dentures**, **removable partial dentures** and **dental implants**?

Q5: In your opinion, how important is it that students gain experience in completing the production/ laboratory work for their own cases in **removable partial dentures course?**

Q6: In your opinion, how important are criterion referenced assessed exercises in **dental implants abutment** selection? (Grading students against a set of prespecified and standardised exercises)

Q7: In your opinion, who would be suitable to be responsible for assessing students' work and competence during the **removable partial dentures** clinical sessions?

Q8: In your opinion, should a final assessment/examination in **dental implants course** be set for students before graduation?

Q9: In your opinion, should students competently complete all preclinical exercises and a number of clinical cases (2-3 cases) during **dental implants** course as a minimum competence level that undergraduate dental students should have at graduation?

Consent statement

- Your participation in this study is voluntary, and you are free to withdraw your participation at any time.
- The interview will be held virtually on MS Teams and Zoom Platform in place where the privacy of the participants will be ensured to avoid any breach or interruption.
- The interview will be audio recoded and transcribed via MS Teams or Zoom Platform auto transcription.
- The interview audio record will be deleted after the interviewer ensures that the transcription has no faults or missing data.
- The interview will last for approximately 15-20 minutes.
- All information you provide will be confidential and your anonymity will be protected throughout the study and all related outputs.
- Anonymised data will be stored on the UCC OneDrive system and subsequently the UCC server. The UCC Research Data Store set up by

Professor Christopher Lynch (UCC consultant and PhD supervisor) and only accessed from encrypted and password-protected computers and will NOT be shared via cloud services or USBs).

- The data collected (transcripts and data analysis) will be stored for a minimum of ten years (as required in the UCC Code of Research Conduct), during this time the data may be used in subsequent studies.
- Consent is implied by indicating your intention to participate via replying to the invitation email and a verbal consent will be recorded at the beginning of the interview.
- Your participation would be of great value as the information collected in this study via the interview will contribute to a PhD thesis, research publications, conference presentations, and/or research reports.
- The information you provide will benefit in the teaching of prosthodontics in Dental Schools in the future.
- All results, when published, will be treated in an anonymous manner.
- This study has been approved by the Social Research Ethics Committee of University College Cork. There are no risks associated with participating in this study.
- If you have any questions regarding the study or your participation, please do not hesitate to contact me: 118222110@umail.ucc.ie.