Dental students' approach to the formulation of a diagnosis and treatment plan during their periodontal training: Examining the effect of didactic and clinical experiences from a mixed methods perspective.

by

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Abstract

Periodontitis is a multifactorial infectious disease, whereby the interplay of bacterial load, host immunoinflammatory response, environmental and local risk factors interact and shape its progression. Competent diagnosis of differing forms of periodontitis is based on decision-making schemes and utilization of clinical parameters which allow for the recording, monitoring and treatment of periodontitis.

This mixed methods study evaluated third and fourth-year dental students' competence and confidence in rendering periodontal care and explored the reasons students put forth for their suboptimal performance in periodontal education. A survey was used to assess participant competence and confidence in questions regarding medical history, periodontal examination, treatment, diagnosis and maintenance ascription. The survey was first circulated amongst ten periodontists to establish the gold standard responses to the questions. This survey was then administered to third and fourth-year dental students at the University of Alberta in the Fall and Winter 2017/2018.

The survey had 52 respondents. The students performed well on diagnostic parameters and instrument selection, modestly on medical history intake and periodontal examination and poorly on maintenance schedule ascription. In general, fourth year dental students performed better than their third-year counterparts. Students were less confident as questions were more periodontal care detailed. The students' academic year did not predict correct diagnostic response for the diagnostic cases. Aggressive periodontitis was identified <50% of the time. No correlation was found between confidence and correct responses.

To assess the reasons for student suboptimal performance and challenges they faced, thematic analysis was employed to analyze eleven students' interviews. Themes derived from the

qualitative analysis referred to the reasons that students stated when accounting for their suboptimal performance in periodontal care. These themes were related to pre-clinical and clinical learning of periodontics. Pre-clinical themes included, relevant periodontal content insufficiently covered, relevant periodontal content inadequately delivered and insufficient simulation of clinical skills. The clinical themes focused on instructor inconsistencies, fragmentation of treatment rendering, and mismatch between patient complexity and student readiness. Within the qualitative research, the students noted some consequences the shortcoming they faced had for their periodontal education. The study conducted allowed for exploration of areas in which the undergraduate periodontics curriculum would benefit from making changes and highlighted areas. Ultimately it is concluded that there are shortcomings in the periodontal education of undergraduate dental students. These problems are present in both the didactic and clinical components of their education. In order to counter these issues and help students be proficient in periodontology, considerations for instructor calibration, cohesion between didactic and clinical education, patient focused treatment and importance of integrative feedback should be considered.

Preface

This thesis is the original work of Amirsalar Mofidi. Our research project, received research ethics approval from the University of Alberta's Research Ethics Board entitled "Students' approach to the formulation of a diagnosis and treatment plan during their periodontal training: Examining the effect of didactic and clinical experiences from a mixed methods perspective."; No: Pro00071317" (Appendix A).

My role included manuscript writing and literature review. Drs. Monica Gibson and Liran Levin were my supervisor and co-supervisor.

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Chapter One: Background

This chapter will review what periodontal disease is as an entity. Secondly, highlight the etiology, risk factors, consequences, and preventive measures for periodontal diseases. Considerations regarding the importance of periodontal diseases in oral health care will be discussed. It will explore relevant competencies students should develop from their education, and lastly examine the literature with regard to periodontal education and preparedness of clinicians and dental students for providing periodontal care.

Periodontal Disease

Periodontitis is a multifactorial infectious disease, whereby the interplay of bacterial load, host immunoinflammatory response, environmental and local risk factors interact and shape its progression (Tonneti et al., 2018). Primarily, this disease progresses silently with no overt symptomology or perceptible signs, as such, its detection is purely contingent on a clinician whom is well versed in its early recognition and diagnosis. Competent diagnosis of differing forms of periodontitis is based on decision-making schemes and utilization of clinical parameters which allow for the recording, monitoring and treatment of periodontitis (Tonneti et al., 2018).

Prevalence

Periodontitis is the second most prevalent disease of the human oral cavity. Epidemiological studies in the past have estimated that periodontitis afflicts half the adult population (Eke et al., 2012). The prevalence of the disease increases with age, low socioeconomic status, current smoking, and lowered education (Eke et al., 2012). Specifically, the Canadian Health Measure Survey (2010) identified that 16% of the population has moderate

periodontal disease, and another 4% present with severe disease (Canadian Health Measure Survey, 2010). Similar to the findings of the United States, this survey reveals age and smoking to be two factors significantly associated with increased chances of periodontal disease. In Canada, lower socioeconomic status individuals are two times more likely to present with gingival inflammation (25% vs 48%) (Canadian Health Measure Survey, 2010).

Periodontal Diagnostic Classification Systems

An adequate classification scheme is a fundamental requirement for the description of a disease entity, possible pathogenesis, treatment and associated conditions. Classification schemes also allow clinicians to converse with one another and for research to be conducted under an agreed upon interpretation of what the disease entails.

Periodontal classifications have historically attempted to do this. As scientific advances mount and better understanding of pathogenesis of periodontal diseases develop, the older classification systems would require to be updated (Tonneti et al., 2018). Surrounding the time of this research, the periodontal community was on the verge of publishing a new classification system.

The former classification system whereby the vast majority of north American dental schools relied upon was that of Armitage 1999 (Armitage, 1999). It is beyond the scope of this introductory section to discuss the exact depth of the classification; however, a succinct description will be provided. The 1999 classification system divided periodontal diseases into gingivitis (with its many variations), periodontitis (chronic vs aggressive) and a series of sub diagnoses which ultimately had effects on periodontal apparatus. Chronic periodontitis was graded via a mild, moderate and severe pending on the amount of supporting tissue loss.

Meanwhile, aggressive periodontitis was extent based with the number of teeth presenting with loss of support being the main descriptor for localized and more generalized forms of it. Armitage noted aggressive periodontitis as a separate entity, with its primary features making disease diagnosis pathognomonic for a clinician (Armitage 1999; Lang et al., 1999).

A new classification system was released in the summer of 2018. This system was used to align and update the diagnostic scheme to that of the current understanding. Specifically, the new classification focused on the inclusion of peri-implant diseases alongside periodontal diseases (Caton et al., 2018). However, this new system, does not consider aggressive periodontitis as a separate periodontal entity. A two-part staging and grading are utilized to define periodontitis. The staging focuses on severity and ultimate complexity of management of disease, whereas grading considers the rate of progression, systemic modifying factors and likely outcome of treatment response (Caton et al., 2018).

Consequences

Periodontal diseases have many adverse consequences. Signs, symptoms and outcomes may include bleeding red gums, gum recession, mobility, pain, abscesses and oral infections which negatively affect patients' oral health and quality of life (Tonetti et al., 2015, Herrera et al., 2018). Periodontal disease progresses via initial gingival inflammation, as bacterial burden surpasses the defences of the periodontium, soft tissue and bone loss ensue. Ultimately, periodontal disease left unchallenged will lead to tooth loss with possible deleterious effects on systemic health. In the past decades much attention of the periodontal community has been directed towards various systemic diseases associated with periodontal conditions. The two most

notable and well documented are diabetes and cardiovascular disease ((Sanz et al., 2018, Borgnakke et al., 2013). For diabetes, there is moderate evidence that the relationship may be bidirectional in nature, with glycemic control having an effect on periodontal bone loss, and conversely, extent of periodontal disease expressing an influence on glycemic control (Sanz et al., 2018). Other systemic diseases correlations are still in their infancy in terms of association. However, there is currently some evidence regarding the association of periodontal disease and adverse pregnancy outcomes, rheumatoid arthritis, chronic obstructive pulmonary disease, kidney diseases, cognitive impairments and many others (Scannapieco et al., 1998, Sanz & Kornman, 2013, Kshirsagar et al., 2005, de Pablo et al., 2009, Chen et al., 2017).

Biological determinants& Modifiers of Periodontal Health

It is estimated that approximately 80% of periodontal disease risk is attributable to that of genetic factors (Grossi et al., 1994). Concordance rates amongst monozygotic twins for periodontal disease manifestation is approximately 50% (Michalowicz et al., 2000). This highlights the importance of adequate familial history taking. It is possible that the risk of periodontal disease is transferred from parents to children. This would imply that an acquired imprint on the human genome may traverse generations, and is becoming a large focus of periodontal research (Bird, 2007 ; Baroos & Offenbacher 2009). However, currently, there lays controversy in the true effect of epigenetic control on the periodontal risk and more studies are exploring this topic (Lindhe, 2015).

The two most commonly attributed risk factors to periodontal disease are diabetes and smoking (Sanz et al., 2018, Tomar & Asma, 2000). Periodontal disease may have a bidirectional effect on diabetic patients, with poor periodontal status affecting glycemic control (Sanz et al.,

2018). Poor glycemic control may in turn exacerbate periodontal breakdown and increase the speed of disease progression (Chappele et al., 2013). Previous studies have attempted to assess the efficacy of periodontal therapy on the reduction of hemoglobin A1C, the hallmark metric of diabetic control. A recent meta-analysis noted that a mean reduction of 0.36% in the hemoglobin A1C is possible post periodontal therapy of diabetic patients (Engebretson & Kocher, 2013). This is a significant value for consideration as this reduction equates to the supplementation of a second line pharmacological antidiabetic medication (Engebretson & Kocher, 2013).

Tobacco smoke contains a slew of different chemicals which have adverse systemic and oral outcomes. Significantly increased odds risks of periodontal breakdown in individuals that are smokers has been noted (Tomar & Asma, 2000). A dose and duration dependent outcome can be anticipated from individuals that continue the habit, with increased dose and duration having more negative consequences for patients (Chaffee et al., 2016). Smoking's negative outcomes on the periodontal apparatus are multifactorial. Studies have demonstrated that bacterial acquisition, colonization, aggregation and increased keystone pathogens are associated with smokers (Kubota et al., 2011, Brook, 2011). Smokers are at decreased capacity to heal subsequent to both forms of surgical and non-surgical therapy (Johnston, 2007). Smoking has negative outcomes on the innate and adaptive immune system (Matthews et al., 2012).

Many other chronic systemic inflammatory diseases have been regarded as risk modifiers of periodontal disease. Obesity is considered a chronic metabolic disease with a multitude of comorbidities (cardiovascular diseases, type II diabetes, hypertension) (Martinez-herrera et al., 2017). Even though the mechanism for obesity induced increased periodontal risk has to date not been elucidated, the relationship between periodontal disease and obesity is evident across the

literature. A recent systematic review concluded that there is unequivocal evidence suggesting an association between the two chronic inflammatory diseases (Martinez-Herrera et al., 2017).

Stress has been noted as a modifier of periodontal disease. Chronic stress can have a negative impact on the inception and treatment of periodontal disease (Gunepin et al., 2018). The periodontal influence of stress has been speculated to be as a result of direct downregulation of immune surveillance and indirectly via stress induced behaviors which may result in partaking in smoking and oral hygiene neglect (Gunepin et al., 2018). It is interesting to note that a specific form of periodontal diseases, necrotizing periodontal disease, has been historically referred to as "periodontal emotional stress syndrome" (DeMarco, 1976).

Since periodontal diseases (gingivitis and periodontitis) are both considered diseases of microbial origin, adequate oral hygiene is essential in the prevention and progression of periodontal disease (Loe, 1973; Chapple et al., 2015; Figuero et al., 2017). As time elapses from last oral hygiene measure, food particles and dental plaque become calcified into calculus (Loe, 1973). The hallmark studies of Loe et al., (1965) and (1986), demonstrated that tea laborers without oral hygiene and professional cleanings succumbed to periodontal disease. The vast majority of these individuals lost a significant amount of attachment around their teeth, albeit, the dentition of a small minority was spared from the effects of plaque and calculus (Loe, 1986). This is owed to the differing susceptibility of the individual. Numerous systematic reviews have assessed the efficacy of different toothbrushes, dentifrices and chemotherapeutics in reductions of plaque around the dentition (Needleman et al., 2015; Salzer et al., 2015). Most conclude substantial reductions in plaque and gingival inflammation (Chapple et al., 2015; Needleman et al., 2015). Thus, it may be argued that since plaque and biofilm are the underlying causative

agent for periodontal diseases their control is imperative in minimizing onset and progression of disease (Chapple et al., 2015).

History taking and Clinical Examination

Clinical history taking would consider the many factors that are important during assessment of a periodontal patient. These include underlying medical conditions, medications, social habits, familial history and previous dental care. Clinical examinations would include a thorough assessment of the head and neck region, hard and soft tissues in the mouth, oral cancer screens as well as specific periodontal parameters as outlined by the American Academy of Periodontology. These include, periodontal charting, radiographic interpretation, assessing for signs of inflammation, oral hygiene measures and other patient reported complaints important to oral health (Pihlstrom, 2001).

Prevention and Treatment

Since periodontitis is a multifactorial disease, adept familial, dental, social and medical history taking is imperative in the pre-examination stage. As well, assessment of predisposing risk factors is a crucial step as an antecedent to examination (Sweeting et al., 2008). This allows a clinician to address possible modifier of periodontal disease preceding initial therapy. As a conduit for a correct diagnosis, a thorough clinical examination is carried out to discern the diagnostic class of periodontitis presenting (Sweeting et al., 2008). Although, noticing disease is a step in the right direction, the responsibility of the primary care provider is to deem a suitable treatment modality, how to carry out this treatment and the important realization that if the severity of the case surpasses the clinical expertise of the practitioner then an appropriate referral

must be made (Cobb et al., 2002). Therapy usually consists of debridement of the oral cavity from bacteria and debris to allow for healing of the soft and hard tissues to occur. A re-evaluation stage is employed at a 4-6-week stage to ascertain how much healing has occurred (Sweeting et al., 2008). At this juncture the clinician may decide disease has remitted or is progressing and may require additional intervention possibly with the introduction of regenerative or surgical approaches. The fundamental pillar in the eradication and remittance of disease and often the most neglected aspect of periodontal treatment is maintenance (Supportive Periodontal Therapy) (Cohen, 2003). Maintenance is defined as future periodontal care provided to gauge success of therapy, ensure bacterial load are kept low, interception when disease recurs and allow reinforcement to the patient for upkeeping oral hygiene habits (Cohen, 2003) Thus, formulating an appropriate maintenance schedule for future therapies and examination is strongly related to proficient treatment of periodontitis.

Oral hygiene measures:

Consistent oral hygiene measures have historically been the method of choice to counter the outcomes of periodontal disease. Periodontal tissue stability can be maintained via adequate oral hygiene routines, and this has been demonstrated from large cohort studies (Axelsson et al., 2004). Persistent inflammation and bleeding of the gums are deemed to be periodontal risk factors and increase the chance of disease progression (Lang et al., 2009). Poor oral hygiene measures may increase the risk of periodontitis by two to five-fold (Lertpimonchai et al., 2017). Brushing and flossing render significant reductions in bleeding on probing, an objective parameter for inflammation by approximately 35-67%(Graves et al., 1989). A large systematic review by Slot and colleagues in 2012 demonstrated that self-performed oral hygiene measures

are successful in reducing half of the bacterial plaque build-up in the oral cavity from baseline. There is some conflicting evidence regarding the most effective method of brushing, electric versus manual toothbrushes and duration of brushing. However, one thing is apparent, there is no universal ideal toothbrush that exists for all patients, the ultimate choice is predicated on the effectiveness the patient demonstrates with their toothbrush of choice (Jepsen, 1998).

Professional cleanings (Non-surgical pocket and root instrumentation):

Plaque and calculus are strongly associated with the initiation and progression of periodontal disease (Cobb, 2002). There is a question in the efficacy of how well root surfaces can be debrided of calculus and plaque, especially when attachment loss is progressed (Caffese et al., 1986; Sherman et al., 1990). As depth of pockets and attachment loss increases, the chances of effective debridement decreases. In light of these clinical limitations with adequate debridement, systematic reviews investigating non-surgical therapy outcomes provide conclusive evidence that instrumentation of roots leads to effective reductions in probing depths and periodontal apparatus loss (Lang et al., 2008; Eberhard et al., 2008).

Control of risk factors:

As previously mentioned, smoking is a significant risk factor in the development of periodontal diseases. Effective discussions with patients regarding smoking cessation can help patients reduce the risk to their periodontal apparatus. It is documented that current smokers and former smokers differ in their periodontal risk, as well former smokers who have abstained for >11 years enjoy the same risk profile as individuals that have never smoker(Tomar & Asma, 2000).

Secondly, diabetic glycemic control is imperative in reducing the risk to the periodontal apparatus. A prudent clinician would inquire about the patient's glycemic control and ensure the patient recognizes the relationship. This would aid the patient in reducing their periodontal risk, and by treating periodontal disease may improve glycemic control by a modest degree(Sanz et al., 2018, Eke et al., 2012).

Clinical Reasoning in Dental Education

A proficient dental clinician is required to employ various faculties in order to render care to a patient. There is a non-declarative interplay between reasoning, knowledge, patient's presentation and past experiences that help shape the care one provides (Khatami et al., 2012). In dentistry however, there is a lack of a fundamental framework that captures this multidimensional reasoning (Khatami et al., 2012). Primarily the frameworks for clinical reasoning are derived from medical literature, however, their translation to dental education is meagre (Khatami et al., 2012).

The hypothetico-deductive model has been proposed as a method that clinicians utilize clinical information (patient presentation) to generate hypotheses (Elstein et al., 2008). From there the clinician validates the strength of their hypothesis by interpreting how well it can explain the clinical presentation, thus, employing an inductive approach to provide care (Elstein et al., 2008). It has been suggested that the inductive ("data driven") versus deductive "backward" reasoning is related to level of expertise. Groen and Patel (1988) suggested that more novice clinicians tend to apply more deductive reasoning to arrive at diagnoses and treatments, whereas experienced clinicians were more likely to be data driven and use an inductive approach. This has been corroborated by research in dentistry (Higg & Loftus, 2008).

The dual processing theory is another cognitive framework that has gained attention in both medical and dental literature (Khatami et al., 2012). In this construct, a clinician may first employ schemas and pattern recognition whereby they compare the current presentation to previous experiences, in the second part of this dual process, an analytical approach is undertaken much like that of the hypothetico-deductive approach to render care (Khatami et al., 2012). It is anticipated if the clinician has previously come across an individual with similar presentation, then the script matches their previous schemas and they would pursue treatment that has gained them success in the past. However, if a patient's condition presents with an atypical presentation then the analytical path must be undertaken to provide treatment and diagnose, as this script does not exist in the repertoire of the clinician (Khatami et al., 2012).

Due to the shortcoming and limited applicability of previous frameworks, Khatami and colleagues (2012) have provided a strong conceptual framework that attempts to capture clinical reasoning students utilize in dentistry. This model is cyclical, and frames the dentist, the patient as well as the health care environment as important features in the decision-making process for students. Students initially follow a ritualistic approach to ascertain medical, social, dental and clinical data. From there, once a chief complaint has been established, a combination of deductive and inductive reasoning would be employed to arrive at hypotheses. Khatami and colleagues (2012) noted that students with less experience were more likely to employ deductive methods especially when signs and symptoms of a disease were common across many diseases. Pattern recognition through knowledge of diseases helps students recognize specific diseases. A decision analysis is employed as a last step once the problems are identified, options provided to patients and decision regarding treating.

Reasoning strategies identified by Khatami and colleagues (2012) included scientific, conditional, narrative, ethical, pragmatic, collaborative, and part-whole reasoning. Scientific reasoning in their construct closely resembles the hypothetico-deductive processes of reasoning. Conditional reasoning allows students to consider what would likely occur in the future should a disease not be addressed. Collaborative reasoning includes the involvement of the patient in the decision-making process in order to ascertain their desires and feasibility of proposed treatment. Ethical reasoning in this framework considers decisions based on patient autonomy and limits the students set with relation to the patient's autonomy. Pragmatic reasoning was identified as a method of reasoning that helps students when clinical problems relate to social and economic aspects of providing treatment. Part-whole reasoning encompasses the various reasoning strategies identified used in unison to address more complicated and larger context of problems, alternatively put, from focus on a specific problem to an overall patient centered treatment.

Khatami and colleagues (2012) construct can summarize dental students' tools for reasoning as follows. Diagnostic processes involve both analytical and nonanalytical based on the presentation of the problem. From there, past knowledge and experiences, patient and dentist values and beliefs help identify and prioritize problems. Implementation of the part-whole reasoning strategies allows for global and localized treatment while keeping biopsychosocial determinants of treatment in mind (Khatami et al., 2012). The conceptual model of clinical reasoning as depicted by Khatami and colleagues (2011) is included in figure 1.

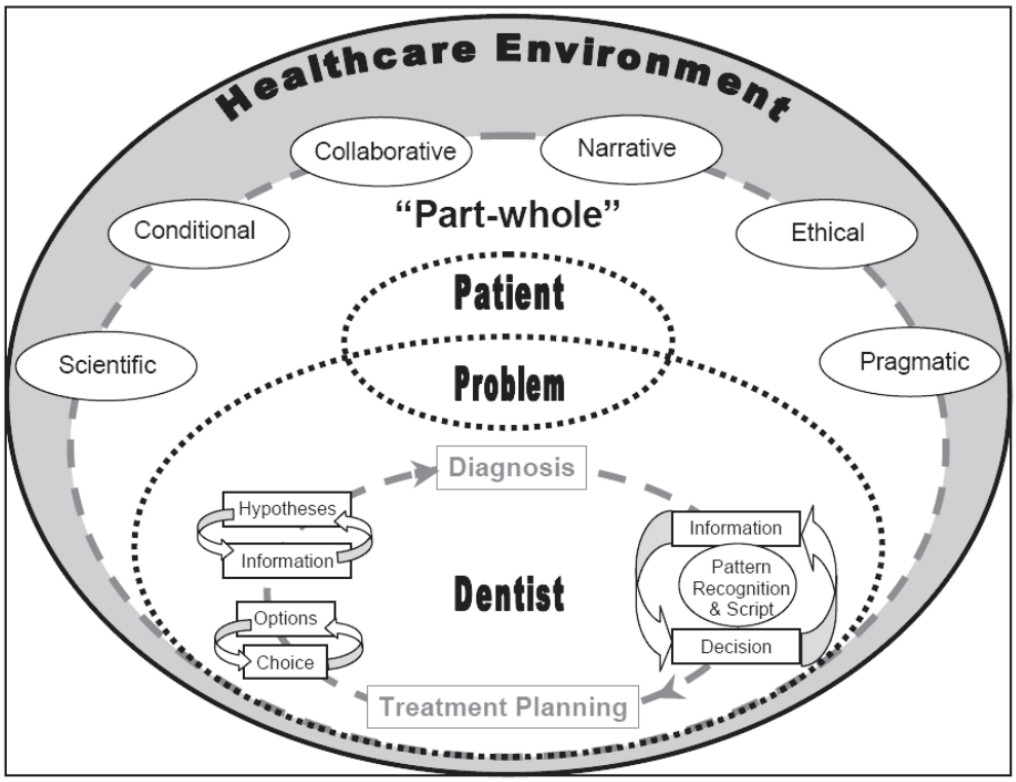


Figure 1. Framework for clinical reasoning in dentistry

Cognitive learning theories

Within the scope of health education and specifically dental education, it is agreed that recognition of facts and sole proficiency of technical skills are no longer the only predictors of success (Albino et al., 2008). Not only are students required to understand the basis of disease and its recognition and treatment, they need to be able to employ critical thinking and problem solving in order to achieve this task. Many educational institutions end goal is to determine the competence of individuals in situational settings that mimic their lifelong healthcare setting (Albino et al., 2008). There are various models that have investigated knowledge acquisition, these include the Miller 1990 model, the problem based learning model and the cognitive apprenticeship model proposed by Collins 1989. A brief description of the teaching and learning style will be given.

Miller Model

The Miller model considers a gradual progression through a hierarchical pyramid as the student becomes more autonomous and reaches their goal of becoming a self-sufficient clinician. In the Miller model competence is judged for students initially based on knowing, this is the general stage of knowledge acquisition typified by understanding the basics and competence judged via multiple choice questions (Albino et al., 2008). With time it is anticipated the student has acquired skills for knowing how to apply the earlier knowledge within a clinical context, in other words they now know how to proceed. For the aforementioned stage, the didactic to clinical knowledge transferal is gauged via more deeper understanding and solving cases. As the student progresses, they now are required to combine the know, the know how into clinical capability of show how. These competencies are assessed via simulatory preclinical tests and standardized patients/OSCE. Lastly, the student is anticipated to have arrived at the does and the peak of the pyramid, an area where they are now competent in combining all previous stages and are en-route to self-sufficiency.

Problem based Learning

Problem based learning has been derived from cognitive psychology and serves as the basis for holistic dental care (Rohlin et al., 2011). Problem based learning shifts learning objectives of learning onto students, they indeed will be required to reflect on integrated questions in their learning and conveying peer wisdom is strongly advocated as a learning process (Bergmann et al., 2017). Thus, the joint effort in order to come to a resolution of a proposed problem itself serves as the learning experience. Furthermore, in this model, peer teaching can help students whom have less knowledge to be caught up to that of their peer

educators (Bergmann et al., 2017). Proponents of PBL try to minimize lecture dominant educational means, even though it can be agreed that for the certain purposes this form of education is superior. For example if students require answers to questions, an adept instructor is one that can convey knowledge, however, when students require to be internally motivated to seek answers and learn strategies for this form of knowledge acquisition it can be argued that PBL is better suited model for education (Bergmann et al., 2017). There are proponents and opponents of this educational method, albeit, the literature notes that students whom graduate from PBL dominant curricula are more accepting of uncertainty, are more collaborative and lastly, are better communicators with their peers during their clinical tenure (Bergmann et al., 2017)

Cognitive apprenticeship model

The cognitive apprenticeship model focuses not only on declarative skills required to achieve competence but also considers non-declarative skills which is referred to as meta-cognition (Collins et al., 1989). The model supposes that the interaction amongst a dentist and student is relatively similar to that of an apprentice and skill master (Collins et al., 1989) This model was proposed to curtail some of the disconnect which exists as a result of knowledge application in actual clinical settings. The premise is that a trained expert in knowledge transferal should also be able to handover the non-declarative information which they consider in making decisions and treatment (Collins et al, 1989). Thus, if an individual will be able to make the cognitive processes visible to the students this allows for better learning opportunities. This is crucial in dental education and clinical practice, as myriad of different conditions and situations may arise when a student is practicing dentistry, as such, a one size fits all approach cannot be

assumed to be sufficient in handling the variety of cases. Therefore, introspection into the underlying considerations are more important than handling a specific task as this knowledge would serve the multitude of differing clinical scenarios.

Periodontal Education

Dental education requires students to be proficient in the understanding of basic and oral sciences as well as possessing clinical competencies to render treatment to their patients (Sanz & Meyle, 2010). Thus, one of the main goals of dental education is that of ensuring clinical readiness of future dental graduates (Palatta et al., 2017). The European workshop on periodontal education highlighted some of the minimum criteria they note students should achieve in their dental training with regard to periodontal education. Without the inclusion of non-didactic criteria such as interpersonal communication, ethical value and professionalism, these criteria can be summarized by the following (Sanz & Meyle, 2010):

Knowledge and information handling with critical thinking

Competency in understanding the etiology, systemic correlates, microbial pathogenesis, risk factors associated with periodontal diseases, social factors influence on periodontal health and lastly genetic and familial links (Sanz & Meyle, 2010).

Diagnosis and treatment planning

Sanz and Meyele (2010) also noted the importance of a clinician that is competent in diagnosis and decisions making and implementation of available data to arrive at the correct treatment options (Sanz & Meyle, 2010).

Establishment of periodontal health

As a last part of the competencies acquired by the student's education is that of managing gingivitis, mild to moderate forms of periodontal disease, acute periodontal conditions and mild oral mucosal diseases. Thus, students should be adept at discussions of smoking cessation, mechanical therapy of the oral cavity, and prescription of medications and medicaments to counter periodontal disease (Sanz & Meyle, 2010). As well, ascription of maintenance schedules and following patients are highlighted as an important competency required for graduates.

Clinician performance in periodontal care

Periodontology is an area where the lack of preparedness of students and graduates is apparent. Darby and colleagues found that approximately one third of the surveyed general dentists lacked confidence in treating advanced periodontitis and more than half were not confident in rendering treatment for aggressive periodontal cases. Even though, in this study, a significant portion (80%) of the sampled population felt confident in treating basic forms of periodontal disease, many of the dentists requested further education in periodontal care (Darby et al., 2005). It is important to note that periodontal referral rates are declining, in addition, when such referrals are made, they are often individuals with more severe and advanced periodontal disease (Lee et al., 2009, Cobb et al., 2003, Zemanovich et al., 2006). In this context, periodontal dental education has a critical role to play as in the near future, general dentists are expected to be the sole providers of care to patients with low to moderate severity of periodontal disease (McGuire & Scheyer, 2003). Evidently, as disease severity progresses, treatment options diminish, thereby invasiveness, complexity and cost increase. This highlights the importance of competent periodontal training for the future generation of dentists exiting dental schools.

Student performance in periodontal care

Studies comparing the performance of dental students and calibrated instructors have reported poor student performances in relation to diagnosis and management of periodontal diseases (Lane et al., 2015, John et al., 2013). For example, in a study with dental students from three dental schools, Lane and colleagues (2015) found that student clinical performances in periodontics were modest across schools and grade point average. Some of the proposed reasons previously investigating this outcome have been attributed to shortcomings of the student's dental education (Lee et al., 2009) as well as lack of calibrations amongst instructors (Lane et al., 2015).

Further, research suggests that a sizeable number of dental students may not be satisfied with their periodontal performance. Chandrasekaran and colleagues (2017) reported that only 36.9% of four-year students rated their periodontal care as adequate (Chandrasekaran et al., 2017). In this study, students attributed their inadequate performance to several factors, including factors related to students (e.g., student oversight), school (e.g., limited operator session) and patient related factors (e.g., scheduling compliance).

Gaps of knowledge in previous studies assessing student performance

Previous research on student performances in periodontics has been quantitative by nature and has relied on closed ended questions and discrete categories of responses to assess student performances. Using single choice answers does not allow for a 'rich narrative' of student views of their performances, including their perceived level of readiness and the factors they attribute to their sub-optimal performance (John et al., 2013). Additionally, employing discrete categorical answers may lead to artificial responses, as typically treatment and diagnosis do not

adhere to strict categorical domains (John et al., 2013). Research on student performances in periodontics has also adopted a general approach so that areas where students experience more difficulties remain to be elucidated. To date, no study has explored student reasons for sub-optimal performances when providing periodontal care to patients in school clinics. Qualitative research approaches are well suited to provide insights into issues that negatively affect students' performance, based on which actionable changes can be implemented to improve their periodontal education.

Objectives

The objectives of our mixed-method study were to *(i)* determine the areas in which third- and fourth-year dental students' were less competent and confident in providing periodontal care with investigation of academic years, and *(ii)* explore the reasons that students attributed to their sub-optimal performance.

Research Questions

- What areas do third and fourth-year students lack confidence and competence in providing periodontal care and does academic year render a difference?
- What factors do students consider for their suboptimal performance in rendering periodontal care?

Chapter Two: Methods

In this chapter the methods undertaken to assess the students' performance in periodontal care will be discussed. As well the methodology used to explore students' views and the reasons that negatively affect their ability to properly provide this care.

Study Design

Our study followed a sequential explanatory mixed methods design in which quantitative data were collected and analyzed, this informed the collection and analysis of the qualitative data to further explain the main qualitative findings (Creswel, 2009). Ethics approval was attained from the University of Alberta research board, No: Pro00071317 (Appendix A)

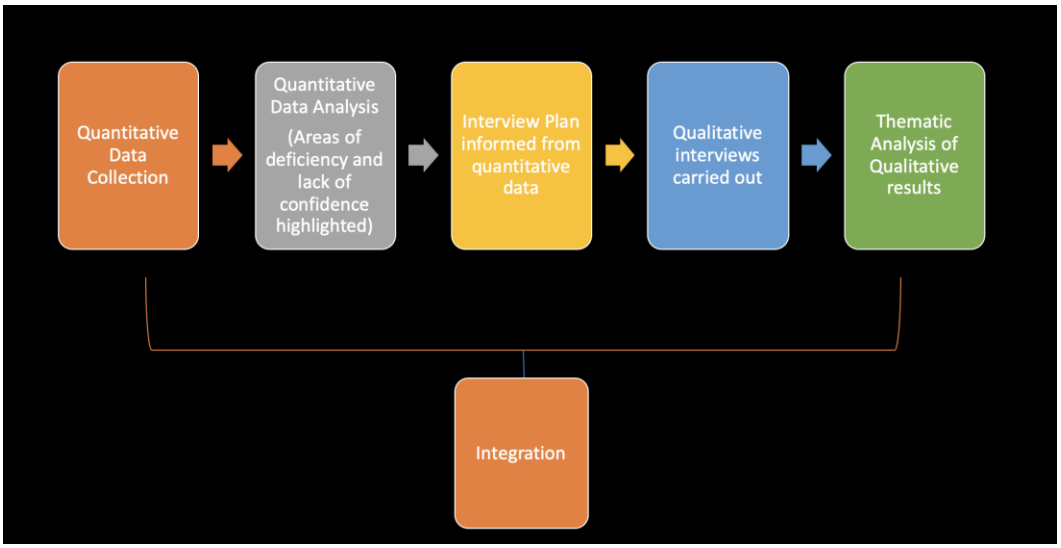


Figure 2. ***Mixed methods design***

Participants

Participants of the study were third- and fourth-year dental students in the School of Dentistry at the University of Alberta during the years of 2017-2018. An expert panel comprised of ten periodontists practicing in Edmonton, Alberta, both in academic and private practice, were used to define the 'correct answers' (gold standard) to the questionnaire. This panel are responsible for the undergraduate students' didactic and clinical education at the University of Alberta. Expert panel use to decide gold standard answers is a method that has been used in determining correct responses in periodontal questionnaires (Williams et al., 2014, Lane et al., 2015). The use of expert panels to judge students' performances is important as students are likely to integrate their instructors' methods of reasoning (Lanning et al., 2013). Our survey was initially conducted on the participating periodontist in October 2017 and their responses analyzed for gold standard fabrication in Nov 2017. The survey was then rolled out to the third and fourth-year students in January 2018, analyzed and areas of deficiency highlighted in February 2018, interview dates set, all interviews were carried out in late March 2018 and April 2018. The remained of the studies analysis and integration were carried out throughout the years of 2019-2020.

Figure 3. Timeline of study

Periodontal Education at the University of Alberta

The cohort whom participated in this research project dental curriculum is as follows: In the first years the students partook in the preventative course with emphasis on periodontal disease prevention. In the second year the students focused on periodontal education. At the same time the students had an opportunity to practice clinical data gathering and examinations in partners on one another. In their third year, their periodontal education focuses on clinical treatment of periodontal disease with a mix of clinical problem-solving cases and traditional lecture-based learning. During their third year, the dental students concurrent with their clinical periodontal education are responsible for providing care to patients in the clinics. In their fourth year, the students partake in short duration sessions of periodontal seminars, where exposure regarding more advanced therapies of periodontics is considered (lasers, soft tissue grafting and surgeries). The vast majority of the dental student's education prior to the recent curriculum change was lecturer dominated.

Characteristics of Survey

A survey was developed to examine student skills in history taking, examination, diagnosis, treatment planning, and maintenance schedule prescription (Appendix B). The parameters assessed are the basic requirements for assessment of periodontal patients. They are explicitly indicated as precedents of patient care and important in continuing treatment and supportive periodontal therapy (Philstrom, 2008; Sweetings et al., 2008). Diagnostic cases were derived from the works of Lane et al., 2015. Furthermore, knowledge in these parameters that are assessed have been considered important in undergraduate dental curriculums and listed as competencies students must be proficient in upon graduation (Sanz & Meyele, 2018). The

assessment of students' performances relayed on unprompted free recall, which closely mimics the real clinical scenarios general practitioners faced in their daily practice. Individuals are required to recall information that they previously learned (Haist et al., 1992). Specifically, they have to retrieve information from their memories and then ensuring that once this information is retrieved, it is the factual answer to the case provided. By the contrary, recognition memory tests (cued recall) rely on picking information that is presumed to be most correct (Haist et al., 1992). Even though generally there is a correlation in aptitude between recall and recognition memory tests, the use of free recall is better suited for our study objectives (Bridgeman & Morgan, 1996). Furthermore, by allowing open ended questions, our questionnaire allows for application of multiple treatment modalities, combinatory diagnostics, and ability to convey information that is required for a specific question without the limitations of closed ended questions (John et al., 2013).

The following questions were used to elicit free recall analysis of the participants(Appendix B) .

1. What medical history questions are important to consider for a periodontal patient?
2. What constitutes a thorough periodontal exam?
3. How do you come to a diagnosis for gingival and periodontal diseases?
4. What are the chief tools of your preference for scaling and root planing?
5. What are the chief considerations for estimating the recall interval in your patient?

The survey contains three diagnostic cases with presentations of clinical pictures, periodontal chartings, and radiographs for participants to come to a certain diagnosis. These cases match those of Lane and colleagues (2015). This study predated the release of the new diagnostic classification (AAP/EOP world workshop) and thus adheres to the previous diagnoses

falling under the Armitage 1999 classification. The correct diagnosis in these cases were defined by gold standard consensus as: Diagnosis 1: Gingivitis (plaque induced), Diagnosis 2: Generalized Severe Chronic Periodontitis Diagnosis 3: Localized Aggressive periodontitis. As a secondary feature of the questionnaire, a Likert scale ranging from (1=very confident to 5= not confident) was employed to assess participant confidence prior to each free recall question.

Quantitative Data Collection

The third- and fourth-year students were invited to participate in this research via e-mail with the survey being completed on Research Electronic Data Capture (REDCap software)(Harris et al., 2009). Information sheet along with studies intentions were shared with the students prior to participation (Appendix C)

Cosine Similarity index and script concordance

Script concordance was used to compare the gold standard script to that of the student's responses. The gold standard script was derived from the answers of the expert panel and most common responses were coded. The similarity in text was assessed via the inclusion of the cosine-similarity index (CSI). CSI allows for comparison of the respondent's semantic similarity in answers across the two academic years and compare that to the gold standard script. A word is positioned as a vector, the angle between two vectors corresponds to the numeric proximity of the words/text, this is followed by the interpretation of similarity done by numerical proximity to one (Singhal, 2001). The closer the respondent's value to one, the more similar the text response would be to the coded answers (Singhal, 2001).

Data analysis

The collected data was coded, including the respondents' school year (third vs fourth) and imported into SPSS for windows version 21. To deflate type I errors, a Bonferroni corrected measure of α/n pending on the number of recurrent tests was utilized for statistical analysis. The Kolmogorov–Smirnov test to assess the distribution of the data. As the data is not normally distributed, the use of non-parametric testing was required.

Mann-Whitney U-test for the median was used to assess the competence and treatment planning questions, and Bonferroni corrected alpha value = 0.00625 was utilized to compare the median difference in competence questions by academic years.

To analyse if confidence and competence were correlated, a linear regression model was employed five times, Bonferroni corrected $\alpha=0.01$. Lastly, a Chi square statistical test determined if correct diagnostic responses were based on academic year, $\alpha=0.0125$.

Qualitative Data Collection

Interview

All students who completed the survey were invited to participate in one-on-one interviews. Eleven students accepted to be interviewed. Semi-structured interviews were conducted in a conversational manner by S.M. Upon exploring the areas where students had difficulties with periodontal education, a meeting was conducted with a research methodologist and supervisor in order to fabricate an interview guide. The questions to be asked of participating students were formulated based on areas of deficiency and uncertainty. This interview was first piloted with a graduate student in the presence of a research methodologist to ensure the main interviewer was conducting the interview correctly and as a way to refine questions, improve

sequence of questions, and familiarize the main interviewer with the interview process prior to undertaking interviews with the students. Interviews lasted from 17 minutes to 33 minutes. Prior to every interview, the students were familiarized with the interview process and a consent form signed (Appendix D/E). Confidentiality and anonymity were discussed with participants. As the interviews focused on areas both academic years commonly had hardships with, it was the suggestion of the research methodologist to not collect interviews based on academic year. Furthermore, it was anticipated that the student's population was homogenous in nature, as such under the direction of the research methodologist additional demographics were not collected. It is important to note that previous studies did not highlight a difference amongst academic standing (Lane et al., 2015). The interviews focused on areas where students had difficulties in attaining similar responses to the gold standard and the reasons they provided for their suboptimal performance.

Interview Transcription

The audio-recorded interviews were transcribed verbatim. All personal identifiers were removed.

Transcript analysis and Thematic Analysis

Thematic analysis (TA) was used to analyze the interview data (Braun & Clarke, 2006). This analytical strategy is commonly used in applied sciences, including medical and dental education (Wong et al., 2019, McKenzie et al., 2019). Braun and Clarke describe a sequential step at performing thematic analysis. Braun and Clark (2013) suggested the use of a sample size of ten or more interviews for medium thematic analysis projects. Their process relies on thorough data extraction, coding of the data set, translation of these codes into potential themes

and eventual determination of hierarchical levels to themes. For adequate immersion in the data set, the transcripts were read and re-read to ensure familiarization with the content. Codes were assigned to relevant data segments and equal attention was devoted to all aspects of the transcript. Relevant extracts were collated. These collations were then turned into potential themes and sub-themes. Braun and Clark 2006 defined themes as important features of the data that help answer the research question. Our data set was managed using QSR's Nudist VIVO software (Version 12). Peer checking (discussing themes and sub-themes with other team members) was used to improve methodological rigor. At multiple stages during our analysis, the codes, themes and subthemes were discussed with the supervisory committee and the research methodologist aiding with the analysis. Also, to improve rigor, developed themes and sub-themes were checked against the entire data set to confirm they captured participants' perspectives of the study phenomenon. The written report strives to capture the relationships and order within themes. As well, written detail of the student's experiences is provided. A thematic map was used to represent the study findings, while illustrated quotes were selected to support data analysis.

Chapter Three: Results

In this chapter we will first discuss the results derived from the quantitative data. Secondly, we will show the results of our thematic analysis in a descriptive format.

Quantitative results

Assessing student competence

Overall, 18 fourth year dental students and 34 third year dental students participated in our survey. The Mann-Whitney test for differences in medians shows that the third- and fourth-year students differ in their response correctness in questions concerning periodontal examination, factors assessed for arriving at diagnosis, instrumentation during therapy and treatment rendering for periodontitis (Table 1). The fourth-year dental students significantly answered the questions about what constitutes a thorough periodontal examination better than their third-year counterparts with a median difference of .20 (0.17-0.29) p-value <0.00625 on the CSI. Conversely, the third-year dental students answered questions regarding arrival at periodontal diagnosis closer to that of the periodontists with a median difference of 0.03 (0.03-0.15) p-value = 0.001 on the CSI.

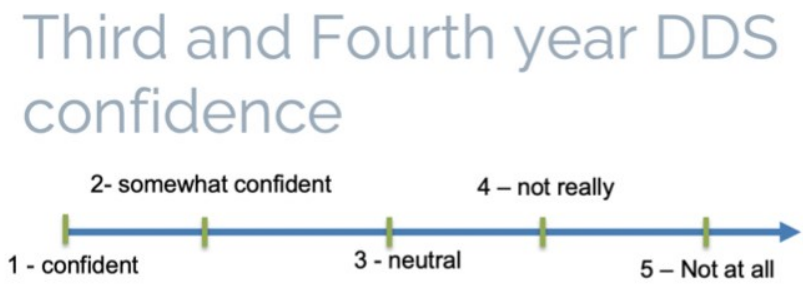
Lastly, the fourth-year dental students were more proficient in their tool selection in rendering initial therapy as compared to the third-year students with a difference of 0.08(0.04-0.09) p-value < 0.00625 on the CSI as well as coming up with a treatment plan regarding our chronic periodontitis case with a difference of 0.08(0-0.07) p-value < 0.00625. The students did not differ on questions regarding medical history intake, setting up recall intervals or treatment planning cases with regard to gingivitis and aggressive periodontitis cases.

Table 1. Median Differences between fourth- and third-year students on the CSI with surveyed periodontists

Table 1. Median Differences between fourth- and third-year students on the CSI with surveyed periodontists				
	Fourth year students (Median CSI)	Third year students (Median CSI)	Difference amongst academic years	
Medical History	0.63 (0.54-0.71)	0.58 (0.54-0.62)	0.05 (0-0.09) p-value = 0.041	
Periodontal examination	**0.65 (0.62-0.69)**	**0.45 (0.39-0.52)**	**.20 (0.17-0.29) * p-value < 0.001**	**4th year students > 3rd year**
Diagnosis	**0.86 (0.83-0.88)**	**0.89 (0.68-0.91)**	**0.03 (0.03-0.15) * p-value = 0.0001**	**3rd > 4th year**
Tool preference (Rendering periodontal treatment)	**0.87 (0.81-0.93)**	**0.79 (0.75-0.840)**	**0.08(0.04-0.09) * p-value = 0.001**	**4th > 3rd year**
Recall Intervals	0.3 (0.18-0.41)	0.19 (0.14-0.25)	0.11(0.04-0.16) p-value = 0.200	
Treatment plan 1	0.3 (0.24-0.42)	0.42 (0.34-0.49)	0.1 (0.07-0.1) p-value = 0.09	
Treatment plan 2	**0.4(0.25-0.53)**	**0.32(0.25-0.4)**	**0.08(0-0.07) * p-value = 0.0001**	**4th > 3rd year**
Treatment plan 3	0.18(0.11-0.24)	0.25(0.18-0.32)	0.07(0.07-0.08) p-value = 0.382	

Assessing student confidence

In order to assess the student confidence, we used a descriptive analysis of the mean likert scores (Table 2). The likert scores are reflective of students being fairly confident in ascertaining a correct medical history prudent to periodontal care and in general carrying out clinical examinations for periodontal patients. However, a reduction in confidence is apparent as questions are geared towards diagnosing, rendering periodontal treatment and following these patients for care in the future.



Area	Fourth year (Likert mean)	Third year (Likert Mean)
Medical history	1.3	1.8
Clinical Examination	1.6	1.9
Diagnosis	1.9	2.3
Rendering periodontal treatment	2.2	2.1
Recall Assignment	2.4	2.4

Table 2. Descriptive Likert Scale - Third and fourth-year student confidence on different competence questions

Diagnostic correctness by year

The chi-square analysis was employed to analyze if a student's academic year, permitted for a higher proportion of correct responses in the diagnostic questions. No significant differences were noted amongst year of study and correct diagnostic response rate, p-value > 0.0125. Table 3 depicts the correct response rate by academic year.

Diagnostic correctness by academic year and case		
Correct Diagnosis	**Fourth year**	**Third Year**
Gingivitis	66%	47%
Generalized Severe Chronic Periodontitis	50%	79%
Localized Aggressive Periodontitis	50%	44%

Table 3. Diagnostic correctness per academic year and diagnosis

Confidence and competence correlation

A linear regression model along with scatter plots was employed as a method to ascertain if confidence in a particular question will predict competence, no statistical significance was noted ($p>0.01$). A sample representation is provided depicting Likert (confidence) and periodontal examination parameter (competence) by academic year, and as noted there was no correlation amongst the confidence and competence.

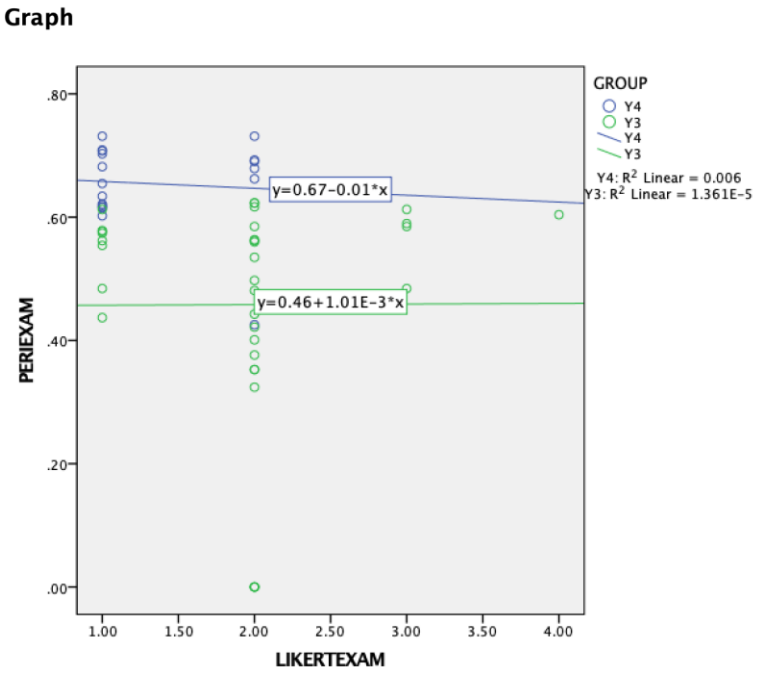
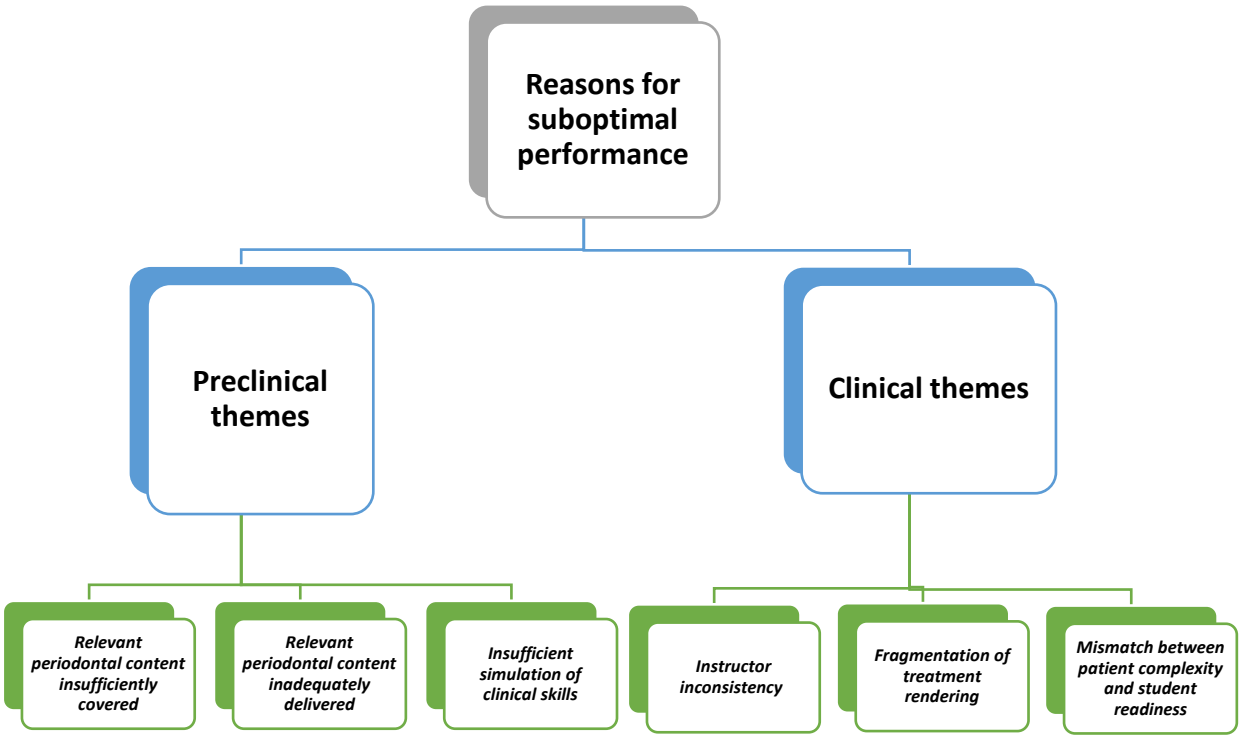


Figure 4. Graph depicting relationship between Likert score and periodontal examination CSI by academic year.

Qualitative results

Themes derived from the qualitative analysis referred to the reasons that students stated when accounting for their suboptimal performance in periodontal care. These themes were related to pre-clinical and clinical learning of periodontics (Figure 1)

Figure 5. Thematic Map of Analysis



Preclinical themes

Relevant periodontal content insufficiently covered

Students consistently highlighted the insufficient coverage of relevant content in their preclinical training as a reason for their struggles to provide proper periodontal care to patients. Students felt unprepared in relation to several issues. These included risk management for periodontal diseases, diagnosis of periodontal conditions, as well as clinical parameters to diagnose conditions and treatment options, especially surgical procedures. Although students reported they had a good understanding of the risk factors that negatively affect the periodontal status of patients, they mentioned that their preparation to manage those factors was insufficient. As one student pointed out, "*I encourage them to quit smoking and explain the risk factors and how it's making their periodontal disease worse, but we don't really have any tools or resources here at the school for them, and we never really get taught how to do smoking cessation with patients*".

Similarly, students regarded their preclinical education on diagnosis and clinical parameters important to render periodontal treatment to patients as insufficient. As one student indicated, *"so [the new instructor] did a really good job of kind of "reviewing" how to diagnose and kind of function in clinic since we weren't really taught a lot of the clinically relevant day to day things before that."* According to students, this knowledge gap limited their ability to provide adequate treatment. Preclinical teaching of treatment options past initial therapy was also seen as insufficient. Students reported that they were unfamiliar with treatment options for patients that were unresponsive to initial therapy. They also had difficulties determining when a referral to a periodontist was necessary. As one student commented, "*So it's kind of like if I saw someone in perio, I wouldn't know what they need done and I would just send them to a*

periodontist because I just don't know what they need done, what procedures they need- when to do what procedure and what case, you know." Students acknowledged that as future general dentists, they did not need to know how to perform surgical procedures; however, they wanted to be well-informed about surgical options to properly refer patients for specialized periodontal care and be able to educate their patients regarding the treatment options. One student comment clearly illustrated students' interest in being properly informed, "*Like I don't expect to be taught (surgery) that as a general dentist, but it would be nice to see it so I know like what it is and like if my patient needs it, and who they can go see if my patient needs it, you know*".

Students mentioned that these knowledge gaps not only affected the quality of periodontal care they provide to patients, but also their dental education, especially when taking advanced periodontal courses and board exams. The following comments illustrated these two perceived consequences, *"And because they [the instructor] has to start from the very beginning with even just the bacteria that cause periodontal disease, we don't really get into any of the advance perio stuff in our advanced perio course"* and "*I think most of us recognized studying for boards that perio was our weakest area, and most of us started studying with perio, like that was our first priority."*

Relevant periodontal content inadequately delivered

Along with covering the periodontal content insufficiently, students mentioned that this content was not properly taught, which also affected their clinical and educational performances later on in the program. Teaching-related issues that students highlighted included poor structure of the content covered and the learning of complex periodontal topics prior to an understanding of basic concepts. One student noted, "*We go sit in a class and we learn nothing. There's no slides, there's no real information being passed down. It's basically just like, this research*

article … Like, before we even know what attached gingiva is, before any of like that, we're talking about like these advanced like studies into like chronic perio and like the bacterial subtypes." Students reflected that these teaching issues negatively affected their learning (e.g. creating confusion), interest in periodontics, and the value attributed to the topics covered, although they now recognize their clinical relevance. In this regard, one student commented *"It was one of those classes, well, I'll be honest with you, at some point, you say I'm not even going to go anymore because I'm not learning anything",* and another stated, "*I didn't find it very useful. But I felt the class was a waste of my time…now I realized just how important it was to keep up with the research in dentistry, because all the time there's always something new coming out and you always have to be learning.*"

Insufficient simulation of clinical skills

Students' lack of preparation for periodontal care was also attributed to the insufficient practice of periodontal procedures in the simulation laboratory. The practice of these procedures was regarded as more limited than the practice of other clinical procedures in the same setting. Further, students indicated that the lack of practice prevented them from receiving feedback from instructors, which they considered critically important to the development of psychomotor clinical skills. As one student argued, "*So like in any part of dentistry we've had competencies, practical competencies. We've had practical competencies in operative, fixed, pretty much even in dentures, and then we would finish the competency in SimLab, and now we are allowed to treat in clinic. That didn't happen in perio, so perio didn't actually give us that option to … someone to give us feedback on: Hey are you doing this right*?"

Clinical themes

Instructor inconsistency

Several students mentioned instructor inconsistencies as a reason for their suboptimal performances in periodontal care as they created confusion about what was right or wrong when providing care to patients. Inconsistency was viewed as contradicting opinions about conditions and courses of actions. Students reported inconsistencies regrading diagnosis, including risk assessments. One student voiced, "*periodontists on staff a lot of them see it different ways. So, you get some individuals that think it's moderate, some individuals that might think it might be aggressive at one region, and some people that think that this might be just a varying form of gingivitis*…". Similarly, inconsistencies were observed in relation to treatment rendering. As another student noted, "*And everyone had like a different rule on how many units of root planning we can do every time*." Instructor inconsistencies were still present at the final stage of maintenance ascription. As one student pointed out, "*To be honest I mostly ask the instructor, because again we get different views all the time. There does not seem to be any consensus on how you set it up [maintenance], aside from very, very severe cases, then obviously you need the three month [recall]*".

Inconsistencies were observed between clinical instructors. As one student commented, "*Yeah, because it changes depending on the periodontist you see that day, because I've had people come in for a complete exam that were high-risk because they have a lot of attachment loss and the periodontist says, you know what, this person is actually low-risk, there's not a lot here*". Inconsistencies between didactic and clinical instructors were also reported. One student stated, "*so there's been numerous instances like that that occur in clinic, because there seems to*

be very little consensus over how the [preclinical] instructions actually teach us and how they [clinical instructors] evaluate and use the same terms versus how we were taught".

Additionally, students commented that these inconsistencies had a positive or negative impact on their learning experiences depending on the instructor. As a student stated, *"when I do actually get the time with them, I learned a lot from them. So, yeah, I guess it depends on which instructor you get, too. Very selective."* and *"And sometimes they do, and sometimes the instructors do a good job of like, okay, here's a spot, feel this, and then they have you feel it, which I enjoy that, like I want to feel it."*

Fragmentation in treatment rendering

The inability to assess treatment outcomes was described as another factor that negatively affected student performances. Students regarded treatment (re)evaluation as critically important to ascertain the quality of their performances. According to students, the inability to assess treatment outcomes was mainly due to patients not coming back to the clinic and the prolonged time lag between care delivery and re-evaluation of treatment outcomes. Comments that illustrate these views included, *"I'm hoping my patients will be coming in for me to see, but at the moment no. I have not been able to really follow up and actually there's just been one … One patient that I've had out of seven or eight that I've been able to see"* and *"So I don't know if that defeats the purpose of the re-evaluation, but I find myself doing the re-evaluation and sometimes going back to initial therapy, and I don't know if that's because initial therapy didn't work or if that was because we didn't have the re-evaluation soon enough"*.

Mismatch between patient complexity and student readiness

The students noted that the assignment of patients with complex treatment requirements at the inception of their clinical tenure became problematic for them. Specifically, they indicated that in some instances they did not provide proper treatment simply because they were not fully prepared to manage complex cases. As one indicated, "*And so then we get to clinic and see these high-risk cases: One, we're like not prepared to treat them; we don't have that much experience because our technique is terrible*."

Chapter Four: Discussion

This research aimed to examine third- and fourth-year dental students' confidence, competence, and areas of deficiencies regarding periodontal care (diagnosis, treatment planning, and maintenance phase) as well as self-reported reasons for sub-optimal performance. The works of John and colleagues and Lane and colleagues (2015) demonstrated that variations exist in the student's responses. In the present study, besides diagnosis and treatment planning, clinical parameters that students were having difficulties with were also examined.

The results reveal that the students experience dissonance regarding diagnosis and rendering treatment. The student's confidence decreases in these two categories; however, their competence is high. This may suggest that even though a student knows what features and parameters are necessary, they are not experiencing self-efficacy. It is imperative to highlight that true competence (knowledge and/or skill) does not necessarily coincide with the belief of competence, which we refer to as confidence (Woolliscroft et al., 1993). An individual may possess the necessary clinical skills and knowledge; however, they may lack confidence in carrying out a particular task. This would define an individual that has low self-efficacy

(Bandura, 1982, Gilmour et al., 2016). The converse may also exist, an individual that lacks competence whom is overly confident, and this may translate to a false sense of clinical security (Gilmour et al., 2016). In the interest of patient care, the ideal development would be students and clinicians whom there is precise self-assessment of their knowledge and skill (Gilmour et al., 2016).

Throughout the qualitative analysis, students voiced concerns regarding diagnosis and rendering treatment. The question within the survey required students to understand the instrumentation necessary for treatment rendering. As well, students needed to recognize the diagnostic parameters required to come to a correct diagnosis. However, as their interviews elucidate, even though the students understand instrumentation, they are not confident in their technique and therapy outcomes. This lack of confidence is rational as scaling and root planning besides general understanding of instrument selection will require development of dexterity and tactile proficiency (Deeb et al., 2019). Consequently, it is not surprising that students had a greater number of self-assessments prior to being examined on this competency in one study (Deeb et al., 2019). This can be corroborated by the student's in this study stating that lack of confidence was stemming from inadequate demonstration of the technique during preclinical and clinical education. With regard to diagnosis, the students iterated the shortcomings of diagnostic reasoning in their preclinical education and this is further evident from their inability to judge correct diagnoses on our three diagnostics cases with high accuracy.

The students discuss the lack of adequate understanding and management of risk factors. Competence in risk factor identification and management is a fundamental aspect of rendering periodontal care. Understanding appropriate risk factors also increases the chance that a clinician will refer a patient to a specialist (Williams et al., 2014). Numerous studies in the past have

highlighted that periodontal referral rates are declining, and when they are made, they are late stage disease (Cobb, 2003; Lee et al., 2009;, Dockter et al., 2006). Previous studies have sought to assess student knowledge of risk factors important to periodontal disease. Friesen and colleagues (2014) noted that students in the third and fourth year accurately identified three of the potential six periodontal risk factors with 50% accuracy, demonstrating a modest level of understanding with regard to potential risk factors. Similarly, Willaim and colleagues (2014) noted that only (60-65%) of their students noted uncontrolled diabetes mellitus as a risk factor. With the use of qualitative research, the students in our study voiced their concerns on their knowledge and management risk factors can be corroborated from the literature. Moreover, even though, appropriate risk factor identification is a step in the right direction, this does not translate into adequate management of the risk factor. This was one of the conclusions of our qualitative research highlighted, without knowledge of how to manage, a clinician may still not have the necessary skills to make a difference for a patient. Thus, an important area of focus for revamping the periodontal education would be on that emphasizes the importance of recognizing risk factors, appropriate management strategies and the timely referral should the risk factors be uncontrollable at the level of treating clinician.

In general, it was anticipated that the fourth-year students would perform better than their third-year counterparts (Lane et al., 2015). This is in line with the findings of previous studies in which senior students attained better responses (Lane et al., 2015; Friesen et al., 2014). Surprisingly, our third-year achieved a better match to the gold standard on the diagnostic parameters. This may be attributed to the recency effect, as the third-year students have been exposed to the diagnostic classification more recently than their fourth-year counterparts during their third-year periodontal class.

This study highlights that for both academic years, the confidence of the students decreases as competence questions focus on periodontal care. However, the students felt relatively confident in medical history intake and periodontal examination for both academic years. Similarly, previous studies found that their participating students polled were generally comfortable with history taking and examinations (Gilmour et al., 2016; Patel et al, 2014). For example, in one study, students' average confidence in periodontal examination was 4.91 on a 5-point likert scale (Gilmour et al., 2016). Albeit, it must be noted that the students in our study attained lower confidence as compared to the aforementioned study. In general, the third-year students were less confident than their fourth-year counterparts, likely due to the higher exposure to patient care of fourth-year students. An over inflation of confidence in skills deemed important for clinical practice could also explain such difference (Greenwood et al., 1993), especially among students exiting their program. This over inflation is important as researchers at the School of Dentistry in Cardiff showed that, approximately 80% of their students felt unprepared for clinical work, and more than half relied heavily on supervisor intervention during their clinical training, yet confidence may be reported as high (Gilmour et al., 2016).

We note that the students in the survey did not differ across the diagnostic correctness they attained. Albeit, descriptively we noted that especially for the chronic periodontitis case, the third-year students achieved higher concordance with that of the gold standard, even though statistical significance was not reached. We reiterate that the third-year students were closer in time to the education of specific diagnostic characteristics. John and colleagues (2013) also suggested that their fourth-year students attained better diagnostic response rates than their third-year counterparts, this corroborates our findings for our gingivitis and aggressive periodontitis case. It is worth noting the poor diagnostic correctness (<50%) for the aggressive periodontitis

case. Aggressive periodontitis is a very specific form of periodontal disease, with parameters of young age, location/type of bone loss, absence of risk factors, which make its presentation relatively pathognomonic (Lang et al., 1999). Similarly, Lane and colleagues found that only 49% of third year and 56% of fourth year students properly diagnosed aggressive periodontal case. Providing students with further opportunities to discuss clinical cases may improve their diagnostic skills. For example, case-based learning or peer-assisted learning may help student develop the skills and confidence they need to diagnose varying forms of periodontal diseases (Hunt et al., 2019).

A fundamental theme that was central to the student's reasons for suboptimal performance was that of inconsistencies underlying their education. The American Academy of Periodontology workshop on predoctoral educators in 2014 highlighted inconsistencies as an issue in periodontal education and published a workshop on the importance of faculty calibration (AAP, 2014). It has been suggested that inconsistencies in clinical reasoning may stem from lack of knowledge and erroneous interpretation(Friedman et al., 1998). As well, in the medical literature, inconsistencies may arise from thoroughness in investigating the obtained clinical data and personal bias on behalf of the clinician(Bader & Shugars, 1995). Marlow and colleagues (2018) argued that due to the subjective nature of many features of periodontal disease, a certain degree of inconsistency may be present. Although total removal of clinician inconsistency may not be possible, instructor calibration may help address this issue. John and colleagues (2013) and Lane and colleague (2015) found that consensus training may help reduce inconsistencies in diagnosis and treatment planning, which would translate for better agreement amongst clinicians and students in periodontal education. The work of Orsini and colleagues (1999) on location of the articular disc with respect to the condyles also demonstrated that calibration training

improves instructor agreement. Our qualitative data show that students' concerns about instructor inconsistences were not limited to diagnosis and treatment planning. This highlights the important of qualitative methods to identify the full scope of areas in which inconsistencies may arise and their perceived consequences for students and patients. Thus, an important consideration for the education of our dental students is increasing the number of times calibration sessions occur for the periodontal faculty in order to assure students are learning the same way, day after day, from the many faculty members responsible for their education.

Our students perceived the fragmentation of periodontal care as a factor that negatively influenced their performance. Fragmentation of care can be described as a difficulty or lapse in providing continuity of care. Similarly, Chanderskersan and colleagues (2017) found that student's dissatisfaction with periodontal care to patients partially stemmed from inability to gauge their patient's response to treatment. The reasoning for fragmentation as described by the students could be attributed to a lack of adequate clinical sessions by 20%, and due to competing priorities expressed by 18% of the students. Furthermore, patient related factors such as scheduling compliance (62%) were noted. Our students reported similar reasons for their malperformance in periodontal care. Patients' compliance to prescribed maintenance schedules and appointments is crucial in preventing incidence and recurrence of disease, hence due to dropout or untimely patient returns, the students may not benefit from visualizing the success of their treatment (Renvert & Persson, 2004). Teaching models focused on procedural requirements employ methods to ensure students meet a certain number of cases for graduation (Park et al., 2011). This form of education is criticized mainly due to its emphasis on student focused treatment to meet requirements, rather than providing patient centered care, which may be deleterious to the learning environment for the dental student (Formicola, 1991). For example,

studies investigating differences in risk factor identification and referrals, have concluded that in general, dental hygiene students perform better on these tasks (Williams et al., 2014). The suggested reasoning for this is from the way the disciplines are taught patient care, with the focus of hygiene programs being on identification of patients in need of periodontal care, whereas, dental students are less attentive to the periodontal status of individuals and more restorative care driven (Williams et al., 2014). Case completion curriculum may serve to aid in reducing competing priorities as Park and colleagues (2011) suggested and centres on more complete care for the patient. As for patient compliance, automated services for schedule reminders, and incentivizing appointment upkeep may be methods to counter poor patient compliance (Chanderskersan et al., 2017). For example, University of Rochester noted a 4% decline in missed appointments by patients after the implementation of reminders (Almog et al., 2003).

Repetition of a procedure may increase confidence and competence(Gilmour et al., 2016). However, research has questioned the efficacy of repeated experiences without adequate structure (Choudhry et al., 2005). Our students voiced concerns regarding the amount of preclinical simulation of periodontal skills as well as consistency of its structure during clinical sessions. Our students also attributed their sub-optimal performance to inadequate feedback from instructors. Feedback is an important part of dental education and focus of much educational research (Molloy 2010). Feedback allows for a bridge in the gap of what the students understand and what ought to be learnt, mainly due to the disconnect that exists between didactic education and clinical components of patient care (Black and Wiliam 1998; Deeb et al., 2019). Effective feedback is considered more than a one-way transferal of information, from instructor to student. Rodriguez-Gomez and colleagues (2015) argued for a feedforward mechanism where communication allows for students to monitor and regulate their learning experiences. Student

reported efficacy of feedback as a means of learning has been documented by Ebbeling and colleagues (2018) and is a theme our students discuss. Besides, positive feedback may also serve to increase student confidence (Deeb et al., 2019). As of recent, there is an emphasis on the need for integrative feedback and self-assessment, this entails that students assign themselves a score based on their knowledge and performance, which later is discussed with the grading of an instructor (Deeb et al., 2019). Self-assessment can align a student's judgment of their skills and allow for better development of self-insight (Tuncer et al., 2015). Approximately 90% of students regarded self-assessment as a useful tool in increasing their performance on clinical competencies (Deeb et al., 2019). Therefore, implementation of self-assessment methods for clinical sessions is a logical option to increase student performance.

In our study, students raised concerns about the quality of their early didactic education in periodontics. Students in their early dental education are required to understand a great deal of basic sciences along with dental education and be able to link the two in a clinical setting. Struwig and colleagues (2016) found that volume and complexity of subject pose a great burden to students understanding. Furthermore, information dense lectures tend to undermine meaningful learning (Palatta et al., 2017). This is concerning since 59% of dental education is led by instructors and does not foster critical thinking (Behar-Horenstein et al., 2000). In this passive learning environment students may feel disconnected and overwhelmed(Miller et al., 2002). This may also lead to lack of interest in the content area and eventually poor performance as our study suggests. The applicability of didactic knowledge to clinical scenarios is a fundamental goal that the Commission of National Dental Examinations seeks to assess on board examinations, yet, extrapolation of knowledge into clinical practice may be lacking (Williams et al., 2014). An additional factor our students commented on was the negative impact that

discussing and being required to carry out complex tasks before gaining the necessary knowledge to understand basic principles has on their learning, confidence and treatment. Miller's pyramid is one of the common ways medical and dental students are thought to transition through education (Miller, 1990). The sequential steps through this pyramid are that a student first knows the basics of the task (didactic knowledge), then knows how to perform a certain task (simulation practice), from their they can demonstrate this task (in simulation), and lastly, does this task on a patient (Miller, 1990). It would be logical to assume that if a student does not progressively move on through these stages, they can be faced with challenges. This is important, because dental education contrary to that of medical education, requires their students to carry out many different procedures that are complex and irreversible under minimal supervision early on in their career (Bennet et al., 2010).

Limitations and Future Directions:

Our study was conducted between late 2017 and early 2018. At this time period, we obtained differing response rates amongst the two academic years. Further, for neither academic year did we have full class participation. Additionally, the data collection was done at single time point, thus, not allowing investigation into the changes in perception and performance as experience increased. A future direction of the study could be one that investigates students at two time points, particularly examining if increasing experiences change students' performance and perception. Furthermore, we note that the results of our study are derived from a single institution and from a single cohort of students. Hence the external generalization of our results is limited, especially since every dental school may possess differing curricula and the dental students' perceptions and challenges may vary pending on the school they attend. Undertaking

this research in other Canadian schools will provide insight into challenges that may be present in other schools, all together this would deliver a comprehensive account of how dental education with regard to periodontics can be shaped to be suitable for honing the confidence and competence of future clinicians. As discussed with the advent of the new classification system, it would be interesting to investigate the results of a similar study. A new study can explore if the introduction of a more structured classification system removes some of the diagnostic dilemmas that students face.

An important future direction for periodontal educational research is one that focuses on the knowledge of peri-implant diseases alongside periodontal disease. To the best of the authors knowledge, no educational research has thus far investigated students' knowledge on peri-implant diseases. In the current dental arena, it is imperative that graduating clinicians are familiarized with implant related diseases. Dental implants are now widely utilized and accepted to replace missing teeth. At times, hasty judgements are made in the replacement of teeth that in the past traditional periodontal therapy may have retained (Cosgarea et al., 2019). Implant popularity is owed to its tremendous success recognized in a multitude of studies since the early 1980's (Cosgarea et al., 2019). Implants were erroneously considered invulnerable to periodontal disease, however, the first reports of peri-implantitis were published in 1987 and showed features of infectious disease mimicking that of periodontitis (Mombelli et al., 1987). The prevalence of peri-implantitis has been estimated to range between 14-30%, and its gingival equivalent (peri-mucositis) to be 50-80% (Derks and Tomasi, 2015). Although, both periodontitis and peri-implant diseases share risk factors, there are idiosyncrasies present (Schwarz et al., 2018). Even if a general dental practitioner themselves does not place or restore implants, it is highly likely that they will have patients with implants in their practice. Therefore, it is important for

clinicians to be cognizant of peri-implant diseases, its clinical signs, risk factors and radiographic features. Interceptive efforts are crucial to counter early disease presentation, and if clinicians do not feel comfortable appropriate referrals should be made in a timely fashion. Implant therapy is mainstream and graduating clinicians will be required to assess peri-implant health.

Despite the limitations discussed, our study had some strengths, namely the large participation of students (~65%), the mixed–methods approach, the rich insight into 11 students' perceptions as to the challenges they faced in their undergraduate periodontal curriculum. Furthermore, we were able to assess the confidence of the students, alongside the use of a free recall open ended questions.

Conclusions

This research project aimed to identify areas in which dental students were less competent and confident in during periodontal care and education and to depict a narrative of student's reasons for suboptimal performance in periodontics. The qualitative and quantitative analysis revealed that students faced difficulties with periodontal education and care. The implementation of a mixed methods approach allowed the research to highlight areas of student reported shortcomings in periodontal education for the first time. Re-evaluation of students at different time points, across multiple schools, with a focus on the new classification system and peri-implant diseases should be implemented as a future goal of the research. Ultimately it is concluded that there are shortcomings in the periodontal education of undergraduate dental students. These problems are present in both the didactic and clinical components of their education. In order to counter these issues and help students be proficient in periodontology,

considerations for instructor calibration, cohesion between didactic and clinical education, patient focused treatment and importance of integrative feedback should be considered.

References

Albino, J. E. N., Young, S. K., Neumann, L. M., Kramer, G. A., Andrieu, S. C., Henson, L., . . . Hendricson, W. D. (2008). Assessing dental students' competence: Best practice recommendations in the performance assessment literature and investigation of current practices in predoctoral dental education. *Journal of Dental Education, 72*(12), 1405-1435. 10.1002/j.0022-0337.2008.72.12.tb04620.x

Almog, D., Devries, J., Borrelli, J., & Kopycka-Kedzierawski, D. (2003). The reduction of broken appointment rates through an automated appointment confirmation system. Journal of dental education, 67, 1016-1022.

Armitage, G. C. (2000). Development of a classification system for periodontal diseases and conditions. Northwest dentistry, 79(6), 31-35. Retrieved from http://europepmc.org/abstract/MED/11413609

Axelsson, P., Nyström, B., & Lindhe, J. (2004). The long-term effect of a plaque control program on tooth mortality, caries and periodontal disease in adults. Journal of Clinical Periodontology, 31(9), 749-757. doi:10.1111/j.1600-051X.2004.00563.x

Bader JD and Shugars DA (1995). Variation in dentists' clinical decisions. *Journal of public health dentistry* **55**: 181-188.

Bandura, Albert (1982). "Self-efficacy mechanism in human agency". A*merican Psychologist.* **37** (2): 122–147.

Barros, S. P., & Offenbacher, S. (2009). Epigenetics: Connecting Environment and Genotype to Phenotype and Disease. Journal of Dental Research, 88(5), 400-408. doi:10.1177/0022034509335868

Behar-Horenstein LS, Dolan TA, Courts FJ and Mitchell GS (2000). Cultivating critical thinking in the clinical learning environment. *Journal of Dental Education* **64**: 610-615.

Bennett, J., Freeman, A., Coombes, L., Kay, L., & RickettS, C. (2010). Adaptation of medical progress testing to a dental setting. Medical Teacher, 32(6), 500-502. doi:10.3109/0142159X.2010.486057

Bergmann, H., Walker, J., Dalrymple, K. R., & Shuler, C. F. (2017). Dental faculty members' pedagogic beliefs and curriculum aims in Problem-Based learning: An exploratory study. Journal of Dental Education, 81(8), 937-947. 10.21815/JDE.017.046

Bird, A. (2007). Perceptions of epigenetics. Nature, 447(7143), 396-398. doi:10.1038/nature05913

Black P, Wiliam D. (1998). Assessment and classroom learning. *Assessment in Education: Principles, Policy & Practice*. **5**:7–74.

Borgnakke WS, Ylostalo PV, Taylor GW and Genco RJ (2013). Effect of periodontal disease on diabetes: systematic review of epidemiologic observational evidence. *J Periodontol* **84**: S135-52.

Braun V and Clarke V (2006). Using thematic analysis in psychology. *Qualitative research in psychology* **3**: 77-101.

Bridgeman B and Morgan R (1996). Success in college for students with discrepancies between performance on multiple-choice and essay tests. *Journal of Educational Psychology* **88**: 333.

Brook, I. (2011). The Impact of Smoking on Oral and Nasopharyngeal Bacterial Flora. Journal of Dental Research, 90(6), 704-710. doi:10.1177/0022034510391794

Caffesse, R. G., Sweeney, P. L., & Smith, B. A. (1986). Scaling and root planing with and without periodontal flap surgery. Journal of Clinical Periodontology, 13(3), 205-210. doi:10.1111/j.1600-051X.1986.tb01461.x

Caton, J. G., Armitage, G., Berglundh, T., Chapple, I. L. C., Jepsen, S., Kornman, K. S., . . . Tonetti, M. S. (2018). A new classification scheme for periodontal and peri-implant diseases and conditions - Introduction and key changes from the 1999 classification. J Periodontol, 89 Suppl 1, S1-S8. doi:10.1002/JPER.18-0157

Chaffee, B. W., Couch, E. T., & Ryder, M. I. (2016). The tobacco-using periodontal patient: role of the dental practitioner in tobacco cessation and periodontal disease management. Periodontology 2000, 71(1), 52-64. doi:10.1111/prd.12120

Chandrasekaran S, Powell C, De la Rosa L, Mittal A and Johnson L (2017). Dental Students' Reflections on Quality of Periodontal Care in Dental School Clinics. *J Dent Educ* **81**: 14-21.

Chapple, I. L., Van der Weijden, F., Doerfer, C., Herrera, D., Shapira, L., Polak, D., Madianos, P., Louropoulou, A., Machtei, E., Donos, N., Greenwell, H., Van Winkelhoff, A. J., Eren Kuru, B., Arweiler, N., Teughels, W., Aimetti, M., Molina, A., Montero, E. & Graziani, F. (2015) Primary prevention of periodontitis: managing gingivitis. Journal of Clinical Periodontology 42 (Suppl 16), S71–S76.

Chapple, I. L. C., Genco, R., & workshop, w. g. o. t. j. E. A. (2013). Diabetes and periodontal diseases: consensus report of the Joint EFP/AAP Workshop on Periodontitis and Systemic Diseases. Journal of Clinical Periodontology, 40(s14), S106-S112. doi:10.1111/jcpe.12077

Chen CK, Wu YT and Chang YC (2017). Association between chronic periodontitis and the risk of Alzheimer's disease: a retrospective, population-based, matched-cohort study. *Alzheimers Res Ther* **9**: 56.

Choudhry NK, Fletcher RH and Soumerai SB (2005). Systematic review: the relationship between clinical experience and quality of health care. *Annals of Internal medicine* **142**: 260-273.

Cobb CM (2002). Clinical significance of non-surgical periodontal therapy: an evidence-based perspective of scaling and root planing. *J Clin Periodontol* **29 Suppl 2**: 6-16.

Cobb CM, Carrara A, El-Annan E, Youngblood LA, Becker BE, Becker W, Oxford GE and Williams KB (2003). Periodontal referral patterns, 1980 versus 2000: a preliminary study. *J Periodontol* **74**: 1470-4.

Collins, A., Brown, J. S., & Newman, S. (1989). Cognitive apprenticeship: teaching the craft of reading, writing and mathematics. In L. Resnick (Ed.), Knowing, learning and instruction: essays in honor of Robert Glaser (pp. 453-494). Hillsdale, NJ: Lawrence Erlbaum

COSGAREA, R., SCULEAN, A., SHIBLI, J. A., & SALVI, G. E. (2019). Prevalence of peri-implant diseases a critical review on the current evidence. Brazilian Oral Research, 33. Retrieved from http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1806-83242019000200400&nrm=iso

Creswel JW (2009). Research design: Qualitative, quantitative, and mixed methods approaches. *Los angeles: University of Nebraska–Lincoln*.

Darby IB, Angkasa F, Duong C, Ho D, Legudi S, Pham K and Welsh A (2005). Factors influencing the diagnosis and treatment of periodontal disease by dental practitioners in Victoria. *Aust Dent J* **50**: 37-41.

De Marco, T. J. (1976). Periodontal Emotional Stress Syndrome. Journal of Periodontology, 47(2), 67-68. doi:10.1902/jop.1976.47.2.67

de Pablo P, Chapple IL, Buckley CD and Dietrich T (2009). Periodontitis in systemic rheumatic diseases. *Nat Rev Rheumatol* **5**: 218-24.

Derks, J., Schaller, D., Håkansson, J., Wennström, J. L., Tomasi, C., & Berglundh, T. (2016). Effectiveness of Implant Therapy Analyzed in a Swedish Population:Prevalence of Peri-implantitis. Journal of Dental Research, 95(1), 43-49. doi:10.1177/0022034515608832

Dockter, K. M., Williams, K. B., Bray, K. S., & Cobb, C. M. (2006). Relationship between prereferral periodontal care and periodontal status at time of referral. Journal of Periodontology, 77(10), 1708-1716.

Ebbeling S, Adam L, Meldrum A, Rich AM, McLean AJ, Aitken W. 2018. Oral health and dental students' perceptions of their clinical learning environment: A focus group study. *Journal of Dental Education.* **82**:1036–1042.

Eberhard, J., Jepsen, S., Jervøe-Storm, P. M., Needleman, I., & Worthington, H. V. (2008). Full-mouth disinfection for the treatment of adult chronic periodontitis. Cochrane Database of Systematic Reviews(1). doi:10.1002/14651858.CD004622.pub2

Eke PI, Dye BA, Wei L, Thornton-Evans GO and Genco RJ (2012). Prevalence of periodontitis in adults in the United States: 2009 and 2010. *J Dent Res* **91**: 914-20.

Elstein AS, Schwartz A. Clinical reasoning in medicine. In: Higgs J, Jones MA, Loftus S, Christensen N, eds. Clinical reasoning in the health professions. Oxford: Butterworth-Heinemann, 2008:223–34.

Engebretson, S., & Kocher, T. (2013). Evidence that periodontal treatment improves diabetes outcomes: a systematic review and meta-analysis. Journal of Clinical Periodontology, 40(s14), S153-S163. doi:10.1111/jcpe.12084

Friedman M, Connell K, Olthoff A, Sinacore J and Bordage G (1998). Medical student errors in making a diagnosis. *Academic medicine: journal of the Association of American Medical Colleges* **73**: S19.

Friesen LR, Walker MP, Kisling RE, Liu Y and Williams KB (2014). Knowledge of risk factors and the periodontal disease-systemic link in dental students' clinical decisions. *Journal of dental education* **78**: 1244-1251.

Formicola, A. J. (1991). The dental curriculum: the interplay of pragmatic necessities, national needs, and educational philosophies in shaping its future. Journal of dental education, 55(6), 358-364.

Gilmour A, Welply A, Cowpe J, Bullock AD and Jones RJ (2016). The undergraduate preparation of dentists: Confidence levels of final year dental students at the School of Dentistry in Cardiff. *British dental journal* **221**: 349.

Golob Deeb, J., Carrico, C., Laskin, D., & Koertge, T. (2019). Influence of Self-Assessment on Dental Students' Performance on Technical Assessments in Periodontics. Journal of dental education, 83. doi:10.21815/JDE.019.047

Graves RC, Disney JA and Stamm JW (1989). Comparative effectiveness of flossing and brushing in reducing interproximal bleeding. *J Periodontol* **60**: 243-7.

Groen GJ, Patel VL. The relationship between comprehension and reasoning in medical expertise. In: Chi M, Glaser R, Farr M, eds. The nature of expertise. Hillsdale, NJ: Lawrence Erlbaum and Associates, 1988:287–310.

Grossi SG, Zambon JJ, Ho AW, Koch G, Dunford RG, Machtei EE, Norderyd OM and Genco RJ (1994). Assessment of risk for periodontal disease. I. Risk indicators for attachment loss. *J Periodontol* **65**: 260-7.

Gunepin, M., Derache, F., Trousselard, M., Salsou, B., & Risso, J.-J. (2018). Impact of chronic stress on periodontal health. J Oral Med Oral Surg, 24(1), 44-50. Retrieved from https://doi.org/10.1051/mbcb/2017028

Haist F, Shimamura AP and Squire LR (1992). On the relationship between recall and recognition memory. *J Exp Psychol Learn Mem Cogn* **18**: 691-702.

Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N and Conde JG (2009). Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of biomedical informatics* **42**: 377-381.

Herrera D, Retamal-Valdes B, Alonso B and Feres M (2018). Acute periodontal lesions (periodontal abscesses and necrotizing periodontal diseases) and endo-periodontal lesions. *J Clin Periodontol* **45 Suppl 20**: S78-s94.

Higgs J, Loftus S. A place for new research direction in clinical reasoning in the health professions. In: Higgs J, Jones MA, Loftus S, Christensen N, eds. Clinical reasoning in the health professions. Oxford: Butterworth Heinemann, 2008:213–20.

Hunt T, Jones TA and Carney PA (2019). Peer-Assisted Learning in Dental Students' Patient Case Evaluations: An Assessment of Reciprocal Learning. *Journal of dental education*.

Jepsen, S. (1998). The role of manual toothbrushes in effective plaque control: advantages and limitations. . Paper presented at the Proceedings of the European Workshop on Mechanical Plaque Control, Chicago.

John V, Lee S-J, Prakasam S, Eckert GJ and Maupome G (2013). Consensus Training: An Effective Tool to Minimize Variations in Periodontal Diagnosis and Treatment Planning Among Dental Faculty and Students. *Journal of Dental Education* **77**: 1022-1032.

Khatami, S., MacEntee, M., Pratt, D. and Collins, J. (2012). Clinical Reasoning in Dentistry: A Conceptual Framework for Dental Education. Journal of Dental Education, 76(9), pp.1116-1128.

Kshirsagar AV, Moss KL, Elter JR, Beck JD, Offenbacher S and Falk RJ (2005). Periodontal disease is associated with renal insufficiency in the Atherosclerosis Risk In Communities (ARIC) study. *Am J Kidney Dis* **45**: 650-7.

Kubota, M., Tanno-Nakanishi, M., Yamada, S., Okuda, K., & Ishihara, K. (2011). Effect of smoking on subgingival microflora of patients with periodontitis in Japan. BMC Oral Health, 11(1), 1. doi:10.1186/1472-6831-11-1

Lane BA, Luepke P, Chaves E, Maupome G, Eckert GJ, Blanchard S and John V (2015). Assessment of the calibration of periodontal diagnosis and treatment planning among dental students at three dental schools. *J Dent Educ* **79**: 16-24.

Lang N, Bartold PM, Cullinan M, Jeffcoat M, Mombelli A, Murakami S, Page R, Papapanou P, Tonetti M and Van Dyke T (1999). Consensus report: aggressive periodontitis. *Annals of periodontology* **4**: 53-53.

Lang, N. P., Tan, W. C., Krähenmann, M. A., & Zwahlen, M. (2008). A systematic review of the effects of full-mouth debridement with and without antiseptics in patients with chronic periodontitis. Journal of Clinical Periodontology, 35(s8), 8-21. doi:10.1111/j.1600-051X.2008.01257.x

Leadbeatter D and Gao J (2018). Engaging Oral Health Students in Learning Basic Science Through Assessment That Weaves in Personal Experience. *Journal of dental education* **82**: 388-398.

Lee, J. H., Bennett, D. E., Richards, P. S., & Inglehart, M. R. (2009). Periodontal referral patterns of general dentists: lessons for dental education. Journal of dental education, 73(2), 199-210.

Lertpimonchai, A., Rattanasiri, S., Arj-Ong Vallibhakara, S., Attia, J., & Thakkinstian, A. (2017). The association between oral hygiene and periodontitis: a systematic review and meta-analysis. International Dental Journal, 67(6), 332-343. doi:10.1111/idj.12317

Lindhe, J. (2015). Clinical Periodontology and Implant Dentistry (6th edition ed.): Wiley-Blackwell.

Martinez-Herrera, M., Silvestre-Rangil, J., & Silvestre, F. J. (2017). Association between obesity and periodontal disease. A systematic review of epidemiological studies and

controlled clinical trials. Medicina oral, patologia oral y cirugia bucal, 22(6), e708-e715. doi:10.4317/medoral.21786

McGuire MK and Scheyer ET (2003). A referral-based periodontal practice–Yesterday, today, and tomorrow. *Journal of periodontology* **74**: 1542-1544.

McKenzie CT, Tilashalski K, Abou-Arraj R, Peterson DT and White ML (2019). Students' Evaluations of Simulations in Dentistry: A Multiple Cohort Study at a US Dental School. *Journal of Dental Education*: JDE. 019.121.

Michalowicz BS, Diehl SR, Gunsolley JC, Sparks BS, Brooks CN, Koertge TE, Califano JV, Burmeister JA and Schenkein HA (2000). Evidence of a substantial genetic basis for risk of adult periodontitis. *Journal of periodontology* **71**: 1699-1707.

Miller SA, Perrotti W, Silverthorn DU, Dalley AF and Rarey KE (2002). From college to clinic: reasoning over memorization is key for understanding anatomy. *The Anatomical Record: An Official Publication of the American Association of Anatomists* **269**: 69-80.

Miller, G. E. (1990). The assessment of clinical skills/competence/performance. Academic Medicine, 65(9), S63-67. Retrieved from https://journals.lww.com/academicmedicine/Fulltext/1990/09000/The_assessment_of_clinical.45.aspx

Molloy EK. 2010. The feedforward mechanism: a way forward in clinical learning? *Medical Education*. **44**:1157–1159.

Mombelli, A., van Oosten, M. A. C., Schürch Jr., E., & Lang, N. P. (1987). The microbiota associated with successful or failing osseointegrated titanium implants. Oral Microbiology and Immunology, 2(4), 145-151. doi:10.1111/j.1399-302X.1987.tb00298.x

Needleman, I., Nibali, L. & Di Iorio, A. (2015) Professional mechanical plaque removal for prevention of periodontal diseases in adults–systematic review update. Journal of Clinical Periodontology 42 (Suppl 16), S12–S35.

Palatta AM, Kassebaum DK, Gadbury-Amyot CC, Karimbux NY, Licari FW, Nadershahi NA, Walji MF, Stewart JC and Valachovic RW (2017). Change is here: ADEA CCI 2.0—a

learning community for the advancement of dental education. *Journal of Dental Education* **81**: 640-648.

Park SE, Timothé P, Nalliah R, Karimbux NY and Howell TH (2011). A case completion curriculum for clinical dental education: replacing numerical requirements with patient-based comprehensive care. *Journal of Dental Education* **75**: 1411-1416.

Patel J, Fox K, Grieveson B and Youngson CC (2006). Undergraduate training as preparation for vocational training in England: a survey of vocational dental practitioners' and their trainers' views. *British dental journal* **201**: 9.

Pihlstrom BL (2001). Periodontal risk assessment, diagnosis and treatment planning. *Periodontol 2000* **25**: 37-58.

Position Paper Periodontal Maintenance. (2003). Journal of Periodontology, 74(9), 1395-1401. doi:10.1902/jop.2003.74.9.1395

Renvert, S., & Persson, G. R. (2004). Supportive periodontal therapy. Periodontology 2000, 36(1), 179-195. doi:10.1111/j.1600-0757.2004.03680.x

Rohlin, M., & Mileman, P. A. (2000b). Decision analysis in dentistry—the last 30 years. Journal of Dentistry, 28(7), 453-468. 10.1016/S0300-5712(00)00027-0

Salzer, S., Slot, D. E., Van der Weijden, F. A. & Dorfer, C. E. (2015) Efficacy of inter-dental mechanical plaque control in managing gingivitis–a meta-review. Journal of Clinical Periodontology 42 (Suppl 16), S92–S105.

Sanz M and Kornman K (2013). Periodontitis and adverse pregnancy outcomes: consensus report of the Joint EFP/AAP Workshop on Periodontitis and Systemic Diseases. *J Clin Periodontol* **40 Suppl 14**: S164-9.

Sanz M and Meyle J (2010). Scope, competences, learning outcomes and methods of periodontal education within the undergraduate dental curriculum: a consensus report of the 1st European Workshop on Periodontal Education--position paper 2 and consensus view 2. *Eur J Dent Educ* **14 Suppl 1**: 25-33.

Sanz M, Ceriello A, Buysschaert M, Chapple I, Demmer RT, Graziani F, Herrera D, Jepsen S, Lione L, Madianos P, Mathur M, Montanya E, Shapira L, Tonetti M and Vegh D (2018). Scientific evidence on the links between periodontal diseases and diabetes: Consensus report and guidelines of the joint workshop on periodontal diseases and diabetes by the International diabetes Federation and the European Federation of Periodontology. *Diabetes Res Clin Pract* **137**: 231-241.

Scannapieco FA, Papandonatos GD and Dunford RG (1998). Associations between oral conditions and respiratory disease in a national sample survey population. *Ann Periodontol* **3**: 251-6.

Schwarz, F., Derks, J., Monje, A., & Wang, H.-L. (2018). Peri-implantitis. Journal of Periodontology, 89(S1), S267-S290. doi:10.1002/jper.16-0350

Sherman, P. R., Hutchens Jr., L. H., Jewson, L. G., Moriarty, J. M., Greco, G. W., & McFall Jr., W. T. (1990). The Effectiveness of Subgingival Scaling and Root Planing I. Clinical Detection of Residual Calculus. Journal of Periodontology, 61(1), 3-8. doi:10.1902/jop.1990.61.1.3

Singhal A (2001). Modern information retrieval: A brief overview. *IEEE Data Eng. Bull.* **24**: 35-43.

Slot, D., Wiggelinkhuizen, L., Rosema, N., & Van der Weijden, G. (2012). The efficacy of manual toothbrushes following a brushing exercise: a systematic review. International Journal of Dental Hygiene, 10(3), 187-197. doi:10.1111/j.1601-5037.2012.00557.x

Struwig MC, Beylefeld AA and Joubert G (2016). Reasons for suboptimal learning in medical microbiology. *Teaching in Higher Education* **21**: 590-609.

Summary Report on the Findings of the Oral Health Component of the Canadian Health Measures Survey 2007–2009 (978-1-100-15662-0). (2010). www.fptdwg.ca/English/e-documents.html Health Canada

Sweeting, L., Davis, K., & Cobb, C. (2008). Periodontal Treatment Protocol (PTP) for the general dental practice. Journal of dental hygiene : JDH / American Dental Hygienists' Association, 82 Suppl 3, 16-26.

Thumbigere-Math, V., Michalowicz, B. S., Hodges, J. S., Tsai, M. L., Swenson, K. K., Rockwell, L., & Gopalakrishnan, R. (2013). Periodontal Disease as a Risk Factor for Bisphosphonate-Related Osteonecrosis of the Jaw. Journal of Periodontology, 85(2), 226-233. doi:10.1902/jop.2013.130017

Tomar SL and Asma S (2000). Smoking-attributable periodontitis in the United States: findings from NHANES III. National Health and Nutrition Examination Survey. *J Periodontol* **71**: 743-51.

Tonetti MS, Eickholz P, Loos BG, Papapanou P, van der Velden U, Armitage G, Bouchard P, Deinzer R, Dietrich T, Hughes F, Kocher T, Lang NP, Lopez R, Needleman I, Newton T, Nibali L, Pretzl B, Ramseier C, Sanz-Sanchez I, Schlagenhauf U and Suvan JE (2015). Principles in prevention of periodontal diseases: Consensus report of group 1 of the 11th European Workshop on Periodontology on effective prevention of periodontal and peri-implant diseases. *J Clin Periodontol* **42 Suppl 16**: S5-11.

Tonetti, M. S., Greenwell, H., & Kornman, K. S. (2018). Staging and grading of periodontitis: Framework and proposal of a new classification and case definition. Journal of Periodontology, 89(S1), S159-S172. doi:10.1002/jper.18-0006

Troeltzsch, M., Cagna, D., Stähler, P., Probst, F., Kaeppler, G., Troeltzsch, M., . . . Otto, S. (2016). Clinical features of peri-implant medication-related osteonecrosis of the jaw: Is there an association to peri-implantitis? Journal of Cranio-Maxillofacial Surgery, 44(12), 1945-1951. doi:http://dx.doi.org/10.1016/j.jcms.2016.09.018

Tuncer, D., Arhun, N., Yamanel, K., Celik, C., & Dayangaç, B. (2015). Dental Students' Ability to Assess Their Performance in a Preclinical Restorative Course: Comparison of Students' and Faculty Members' Assessments. Journal of dental education, 79, 658-664.

Williams, K. B., Burgardt, G. J., Rapley, J. W., Bray, K. K., & Cobb, C. M. (2014). Referring periodontal patients: clinical decision making by dental and dental hygiene students. Journal of dental education, 78(3), 445-453

Wong G, Apthorpe HC, Ruiz K and Nanayakkara S (2019). A Tale of Two Teaching Methods: Students' Clinical Perspectives on Administering Dental Local Anesthetics. *Journal of dental education*.

Woolliscroft JO, TenHaken J, Smith J and Calhoun JG (1993). Medical students' clinical self-assessments: comparisons with external measures of performance and the students' self-assessments of overall performance and effort. *Academic Medicine*.

Zemanovich MR, Bogacki RE, Abbott DM, Maynard JG, Jr. and Lanning SK (2006). Demographic variables affecting patient referrals from general practice dentists to periodontists. *J Periodontol* **77**: 341-9.

Appendix

Appendix A – Research ethics board approval of study

Notification of Approval

Date:	August 2, 2017	
Study ID:	Pro00071317	
Principal Investigator:	Monica Gibson	
Study Title:	Students' approach to the formulation of a diagnosis and treatment plan during their periodontal training: Examining the effect of didactic and clinical experiences from a mixed methods perspective.	
Approval Expiry Date:	Wednesday, August 1, 2018	
Approved Consent Form:	Approval Date 8/2/2017 8/2/2017 8/2/2017	Approved Document Information Sheet - Periodontists Information Sheet - Students.doc Consent form - Interview.docx
Sponsor/Funding Agency:	University of Alberta Faculty of Medicine and Dentistry	FOMD

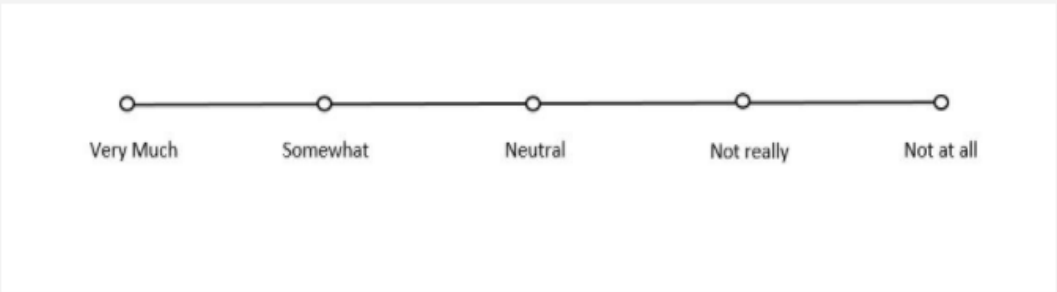
Thank you for submitting the above study to the Research Ethics Board 2. Your application has been reviewed and approved on behalf of the committee.

A renewal report must be submitted next year prior to the expiry of this approval if your study still requires ethics approval. If you do not renew on or before the renewal expiry date, you will have to re-submit an ethics application.

Approval by the Research Ethics Board does not encompass authorization to access the staff, students, facilities or resources of local institutions for the purposes of the research.

Appendix B –Survey

Please refer to this Likert scale for Questions [a)] 1-5.



1 a) Referring to the scale above that ranges from 1 - 5, how confident do you feel in taking a detailed medical history for a periodontal patient?

* must provide value

- 1- Very much
- 2- Somewhat
- 3- Neutral
- 4- Not really
- 5- Not at all

reset

1 b) In your opinion, what medical history questions are important to consider for a periodontal patient?

* must provide value

2 a) Referring to the scale above that ranges from 1 - 5, how confident do you feel in completing a thorough examination for a periodontal patient?

* must provide value

- ◯ 1- Very much
- ◯ 2- Somewhat
- ◯ 3- Neutral
- ◯ 4- Not really
- ◯ 5- Not at all

reset

2 b) In your opinion, what constitutes a thorough periodontal examination?

* must provide value

Expand

3 a) Referring to the scale above that ranges from 1 - 5, how confident do you feel in diagnosing a periodontal patient?

* must provide value

- ◯ 1- Very much
- ◯ 2- Somewhat
- ◯ 3- Neutral
- ◯ 4- Not really
- ◯ 5- Not at all

reset

3 b) How do you come to a diagnosis for gingival and periodontal diseases?

* must provide value

Expand

4 a) Referring to the scale above that ranges from 1 - 5, how confident do you feel in your ability to perform scaling and root planing?

* must provide value

- ◯ 1- Very much
- ◯ 2- Somewhat
- ◯ 3- Neutral
- ◯ 4- Not really
- ◯ 5- Not at all

reset

4 b) What are the chief tools of your preference for scaling and root planing? Why?

* must provide value

Expand

5 a) Referring to the scale above that ranges from 1 - 5, how confident do you feel in your ability to estimate the maintenance schedule for periodontal patients under your care?

* must provide value

- ◯ 1- Very much
- ◯ 2- Somewhat
- ◯ 3- Neutral
- ◯ 4- Not really
- ◯ 5- Not at all

reset

5 b) What are the chief considerations for estimating the recall interval in your patients?

* must provide value

Expand

Charting:
BUCCAL

	1.3	*1.2*	*1.1*	*2.1*	*2.2*	*2.3*
CAL	2 1 2	1 2 2	1 2 2	2 1 1	3 1 2	1 1 1
PD	1 1 2	1 1 1	1 2 2	1 1 1	2 1 1	1 1 1
GM	1 0 0	0 1 1	0 0 0	1 0 0	1 0 1	0 0 0

a) What is your best diagnosis with the information provided?

* must provide value

b) What would be your treatment plan for this case (not considering any financial barriers or patient motivation)?

* must provide value

Please see the lower anterior view-clinical photo, radiograph, and the charting to answer the following questions, assuming the rest of the mouth shows similar presentation. Case history: A 40-year-old Caucasian male in no apparent distress presented with a chief complaint of: "I have bleeding gums". Patient has a 10 pack-year smoking history and no significant medical history.

Charting:
LINGUAL

	4.3	4.2	4.1	3.1	3.2	3.3
CAL	6 3 6	6 3 8	7 2 5	6 2 4	5 1 5	6 3 5
PD	5 3 5	6 3 7	6 2 5	5 2 4	5 1 4	6 3 4
GM	1 0 1	0 0 1	1 0 0	1 0 0	0 0 1	0 0 1

a) What is your best diagnosis with the information provided?

* must provide value

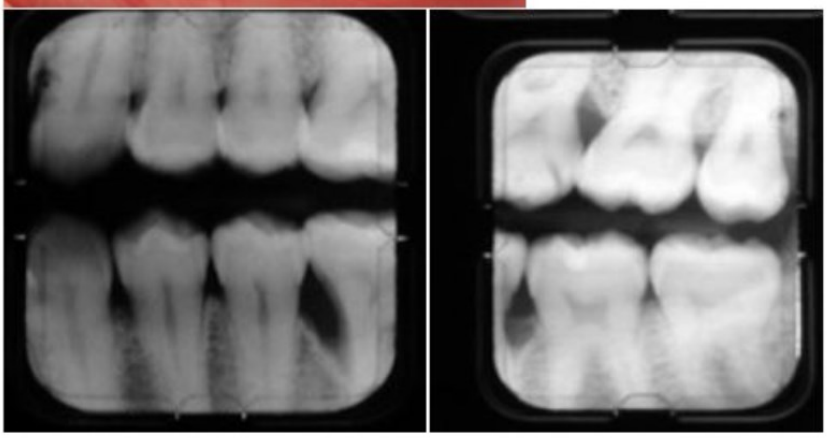
Expand

b) What would be your treatment plan for this case (not considering any financial barriers or patient motivation)?

* must provide value

Expand

Please see the lower left view-clinical photo, radiograph, and the charting to answer the following questions, assuming the rest of the mouth shows similar presentation. An 18-year-old African American male presented with a chief compliant of: "Bleeding gums on brushing and swollen gingiva in specific areas of the mouth."



Charting:
BUCCAL

	3.5	*3.6*	*3.7*
CAL	2 1 6	9 4 6	6 2 4
PD	2 1 5	7 3 6	5 2 3
GM	0 0 1	2 1 0	1 0 1

a) What is your best diagnosis with the information provided?

* must provide value

Expand

b) What would be your treatment plan for this case (not considering any financial barriers or patient motivation)?

* must provide value

Expand

Appendix C – Student Information sheet

Study Information Sheet

Project: Students' approach to the formulation of a diagnosis and treatment plan during their periodontal training: Examining the effect of didactic and clinical experiences from a mixed methods perspective.

Investigators: Dr. Monica Gibson, Dr. Liran Levin, Dr. Kari Rasmussen

Background:

You are invited to participate in a research study as part of an initiative to discover your perspectives on the formulation of periodontal diagnosis and treatment plans at the University of Alberta, School of Dentistry. You are integral to this study as you will be providing your perspective of how you would diagnose and treat Periodontitis. This study will help inform our faculty of the challenges dental students are facing when it comes to Periodontal training. This study will endeavor to ensure that future Periodontal courses prepare students effectively for clinical practice. Additionally, the findings of this study may be presented and published as part of our scholarly research in dental education.
Before you decide if you wish to take part, you need to understand why the research is being done and what it will involve for you. Please take the time necessary to read the following information, and ask your facilitator(s) if you have any questions.

Purpose:

Specifically, we hope to accomplish the following: to capture student perspectives their level of comfort and confidence in diagnosing, treating, and maintaining periodontal patients as well as clinical scenarios. This study will include two phases. Phase 1 will be an online anonymous survey, followed by phase 2 which includes interviews with students to capture their perspectives on their periodontal training, and any areas of training where students feel further emphasis and clarification is needed.

Participating in this study will involve:

This study will involve two phases, a survey followed by one-on-one interviews with a facilitator (see below for contact information of the facilitators within this project) who will be your point of contact with this study.

For **Phase 1**, all that is required is for you to participate in a single online survey that should take about 15 – 20 minutes to complete. These questions are not invasive, and, if you do not feel comfortable, you may choose not to answer a single question or not submit the survey. This survey will be online and at no time will your identity be captured in the completion and submission of the survey. Submission of the survey implies consent; data cannot be withdrawn once submitted.

For **Phase 2**, all that is required of you is to attend an interview and engage in dialogue with the interviewer while answering the questions. These questions will not be invasive, and, if you do not feel comfortable, you may decline to answer that question or end the interview. The interview will be no more than one hour in length. You may be contacted (with your permission) if clarification of a conversation or experience is required.

You may choose to participate in neither, one, or both of the phases of this study.

Possible Benefits:

Although you will not see a direct benefit within your current courses, your involvement in this study will inform our teaching and learning design and may subsequently affect future courses. You will be impacting future students in the School of Dentistry, and be setting the groundwork for the evolution of our learning environment.

Possible Risks:

There are no foreseeable risks involved in this study.

Confidentiality:

Although we will be collecting your name and contact information for the duration of the study (to be used for communication purposes only), your identity will be protected throughout the analysis and subsequent dissemination of this study. A pseudonym will be given to your interview after transcription to protect your data during analysis and dissemination.

Data (researchers' notes, audio recordings, transcripts, analysis) will be kept for five years (per University of Alberta guidelines). After this time period, all data collected will be deleted and disposed of according to the University's process for the shredding of confidential materials. All digital data will be stored on encrypted devices and stored in locked cabinets, hard copies will be also be stored in locked cabinets within the Educational Research and Scholarship Centre (ECHA, 11405 87 Avenue, Edmonton, Alberta, Canada T6G 1C9) in a secured office.

Voluntary Participation:

Your participation in this study is voluntary. If you choose not to participate, or withdraw from the study, your grades or academic status in the DDS program will not be affected in any way. **Two weeks** following your interview will be set as the last date that you may withdraw from the study for phase 2. There is no obligation on your part to continue and there is no penalty for withdrawing. Your related data (recordings, notes) can be destroyed and all references removed up to the point of data analysis.

Contact Names and Telephone Numbers:

If you have concerns about your rights as a study participant, you may contact the **Research Ethics Office** at (780) 492-2615. This office has no affiliation with the study investigators.

Please contact any of the individuals identified below if you have any questions or concerns:

Dr. Kari Rasmussen, PhD, MA
Educational Research Methodologist
Educational Research and Scholarship Centre
Phone: (780) 492-6469
Email: kwadding@ualberta.ca

Jacqueline Green
Research Assistant
Educational Research and Scholarship Centre
Phone: (780) 492-1330
Email: jgreen@ualberta.ca

Thank you for your participation! Your input is extremely valuable and appreciated!

Appendix D – Interview Consent

Title of Project: Students' approach to the formulation of a diagnosis and treatment plan during their periodontal training: Examining the effect of didactic and clinical experiences from a mixed methods perspective.

Investigator(s): Dr. Monica Gibson, Dr. Liran Levin, Dr. Kari Rasmussen
School of Dentistry, Faculty of Medicine & Dentistry, University of Alberta

Do you understand that you have been asked to participate in a research study?	Yes	No
Have you read and received a copy of the attached Information Sheet?	Yes	No
Do you understand the benefits and risks involved in taking part in this research study?	Yes	No
Have you had an opportunity to ask questions and discuss this study?	Yes	No
Has the issue of confidentiality been explained to you?	Yes	No
Do you understand that your participation is voluntary and that you may request to withdraw from this study until **two weeks** after your interview?	Yes	No
Do you agree to have your interview(s) audio-taped?	Yes	No

This study was explained to me by: _____

_____ _____ _____
Signature of Research Participant Date Printed Name

I believe that the person signing this form understands what is involved in the study

_____ _____
Signature of Investigator or Designee Date

Appendix E – Interview Questions

Students' approach to the formulation of a diagnosis and treatment plan during their periodontal training: Examining the effect of didactic and clinical experiences from a mixed methods perspective

This study examines the diagnosis and development of a treatment plan for periodontitis. This interview will capture your experiences and conceptions of this process from your perspective.

1. During your initial exam, if a patient presents with periodontal disease, how would you do a pre-assessment?
2. Think to when you undertake a diagnosis for periodontal disease and describe your process in arriving to your diagnosis for the patient.
    a. How confident do you feel when diagnosing periodontal disease?
3. When performing treatment do you feel confident in the selection of instruments?
4. How do you approach the creation of a follow-up schedule for your patients?
    a. How confident do you feel when creating a recall schedule?
5. How do you approach smoking cessation with periodontal patients?

I'm going to refer back to the 3rd case from the initial survey.

6. Can you look at the case and describe the decisions and considerations you would have in the diagnosis, treatment and maintenance of this case?