Biomaterials Journal
http://www.biomatj.com
Online ISSN: 2812-5045

Type of the Paper (Editorial letter)

The Printed Promise: From Innovation to Validation

Rasha M. Abdelraouf [1*]

[1] ***Biomaterials Department, Faculty of Dentistry, Cairo University, Cairo 11553, Egypt.***
* Corresponding author e-mail: rasha.abdelraouf@dentistry.cu.edu.eg

Citation: *Rasha M. Abdelraouf. The Printed Promise: From Innovation to Validation. Biomat. J., 4 (2), 1 – 3 (2025).*

https://doi.org/10.5281/znodo.5829408

Received: 11 September 2025

Accepted: 12 September 2025

Published: 15 September 2025

Abstract: This editorial addresses the rapid integration of 3D printing (additive manufacturing) into restorative dentistry, highlighting a critical gap between technological enthusiasm and the supporting scientific evidence. The letter issues three primary calls to action for the dental community: 1) To prioritize long-term, in vivo clinical trials over purely laboratory-based (in vitro) studies; 2) To establish standardized, transparent protocols for printing and post-processing to ensure consistent and reliable outcomes; and 3) To accelerate the development of a new generation of high-performance, biocompatible materials that can rival conventional options. Ultimately, the editorial argues that for 3D-printed restorations to fulfill their transformative potential, the dental community must commit to a foundation of robust clinical evidence, collaborative standardization, and focused material innovation.

Keywords: 3D Printing; Digital Dentistry; Clinical Evidence; Standardization.

Introduction

The advent of additive manufacturing, or 3D printing, in dentistry represents one of the most significant paradigm shifts of our generation. The ability to rapidly fabricate customized crowns, dentures, and surgical guides with remarkable precision promises to democratize digital dentistry, potentially reducing costs and chair time while enhancing patient outcomes. We have moved beyond the initial phase of novelty and are now firmly in an era of clinical application. The enthusiasm is palpable in our journals and at our conferences.

But have we allowed our enthusiasm to outpace our evidence? As we stand at this critical juncture, it is imperative that we, as a community of clinicians, researchers, and manufacturers, temper our excitement with scientific rigor. The long-term success of 3D-printed restorations depends not on the speed of the printer, but on the quality of the evidence supporting their use (1).

Therefore, this editorial issues a set of recommendations and requests to guide the next phase of innovation in this exciting field.

The majority of published literature on 3D-printed restorative materials consists of *in vitro* studies. While essential, lab-based metrics for flexural strength, wear, and color stability do not fully replicate the complex, dynamic oral environment. We strongly urge researchers and funding bodies to prioritize and sup-

port longitudinal, multi-center, *in vivo* clinical trials. We need robust data on the performance of these restorations at 5, 10, and 15 years. Questions regarding marginal integrity, chipping rates, biocompatibility, and long-term esthetics can only be answered by observing these materials in the mouths of our patients over time (2).

A significant challenge hindering the comparison of study results is the variability in printing and post-processing protocols. The type of printer, layer thickness, curing unit, and even the washing solvent can dramatically alter the final properties of a restoration. We call upon manufacturers to provide greater transparency and detailed, validated protocols for their systems. Furthermore, we request that all researchers explicitly detail every step of their manufacturing workflow in their publications. A collaborative effort between academia and industry to establish standardized testing parameters, similar to ISO standards for traditional materials, is urgently needed (3).

Current 3D-printable dental resins, while impressive, still fall short of the proven durability and biocompatibility of materials like zirconia or lithium disilicate. Concerns about residual monomers, long-term water sorption, and mechanical strength under cyclic loading remain valid. We challenge material scientists to look beyond simply modifying existing resins. We need a new generation of printable materials designed from the ground up for permanent dental applications. The focus should be on enhancing biocompatibility, increasing fracture toughness, and ensuring color stability that rivals our best conventional materials. The development of printable ceramics and advanced polymer-infiltrated ceramic networks should be a top priority (4).

The promise of 3D printing is not just in replicating what we can already do, but in enabling what was previously impossible. Let us commit to building this future on a foundation of robust evidence, collaborative standards, and relentless innovation. The integrity of our profession and the well-being of our patients depend on it.

References

1. Dewan H. Clinical Effectiveness of 3D-Milled and 3D-Printed Zirconia Prosthesis—A Systematic Review and Meta-Analysis. Vol. 8, Biomimetics. 2023.

2. Alharbi S, Alshabib A, Algamaiah H, Aldosari M, Alayad A. Influence of Post-Printing Polymerization Time on Flexural Strength and Microhardness of 3D Printed Resin Composite. Coatings [Internet]. 2025;15(2). Available from: https://www.mdpi.com/2079-6412/15/2/230

3. Donmez MB, Okutan Y. Marginal gap and fracture resistance of implant-supported 3D-printed definitive composite crowns: An in vitro study. J Dent. 2022;124.

4. Khanlar LN, Rios AS, Tahmaseb A, Zandinejad A. Additive manufacturing of zirconia ceramic and its application in clinical dentistry: A review. Vol. 9, Dentistry Journal. 2021.

Biomaterials Journal
http://www.biomatj.com
Online ISSN: 2812-5045

Type of the Paper (Mini-Review)

AI-Powered Revolution in Dental Material Design: A Mini-Review

Tamer M. Hamdy [1,*]

Citation: Tamer M. Hamdy. AI-Powered Revolution in Dental Material Design: A Mini-Review. *Biomat. J., 4 (2),4 – 7 (2025).*

https://doi.org/10.5281/znodo.5829408

Received: 10 September 2025
Accepted: 12 September 2025
Published: 15 September 2025

[1] Restorative and Dental Materials Department, Oral and Dental Research Institute, National Research Centre (NRC), Giza, Dokki, 12622, Egypt
* Corresponding author e-mail: dr_tamer_hamdy@yahoo.com

Abstract: The development of dental materials is transitioning from traditional, empirical trial-and-error methods to a more efficient, data-driven paradigm powered by Artificial Intelligence (AI). This review summarizes the impact of AI and Machine Learning (ML) on the design, prediction, and discovery of novel dental materials. A primary application is the use of ML models to accurately predict the mechanical, physical, and biocompatible properties of new material formulations, such as composites and ceramics, based on their composition. This predictive power enables the rapid *in silico* screening and optimization of materials. Furthermore, advanced generative AI models facilitate "inverse design," proposing novel compositions to meet specific, predefined performance criteria. While the primary challenge remains the need for large, high-quality datasets, AI is fundamentally accelerating the innovation cycle. It is poised to become an indispensable tool for engineering the next generation of safer, more durable, and effective dental materials.

Keywords: Artificial Intelligence; dental materials; material design; predictive modeling.

The development of dental materials has traditionally been an empirical process, relying heavily on incremental modifications and laborious trial-and-error laboratory testing. This conventional approach is often slow, costly, and limited in its ability to explore the vast landscape of possible material compositions. The advent of Artificial Intelligence (AI) and Machine Learning (ML) has introduced a paradigm shift, moving the field towards a data-driven, predictive, and accelerated "inverse design" approach. Instead of asking "what are the properties of this material?," researchers can now ask, "what material composition will give me these desired properties?" This mini-review outlines the recent impact of AI on the design and discovery of dental materials.

Predictive Modeling of Material Properties

One of the most impactful applications of AI in dental materials is the prediction of key performance properties. By training ML models on existing datasets from literature and experiments, researchers can build robust algorithms that accurately forecast the behavior of new, untested materials.

Machine learning models, such as Artificial Neural Networks (ANNs), Support Vector Machines (SVMs), and Random Forests, are being successfully employed to predict a range of critical properties in dental composites and ceramics. For instance, models can correlate the composition of a composite resin (e.g., filler type, size, loading, and silane coupling agent) with its mechanical characteristics like flexural strength, wear resistance, and polymerization shrinkage [1]. A recent study demonstrated that different ML models could excel at predicting specific outcomes; a k-nearest neighbors (KNN) model was

superior for predicting flexural modulus, while a Decision Tree model was best for flexural strength and volumetric shrinkage [2]. This predictive power allows for the rapid *in silico* screening of thousands of potential formulations, identifying only the most promising candidates for physical synthesis and testing, thereby saving significant time and resources.

Formulation Optimization and Inverse Design

Beyond prediction, AI is enabling the optimization of material formulations. Genetic algorithms and other optimization techniques can explore a multi-dimensional design space to pinpoint ideal compositions that balance competing properties, such as achieving high strength without compromising aesthetics or biocompatibility.

AI-Powered Revolution in Dental Material Design: A Mini-Review
Introduction

The development of dental materials has traditionally been an empirical process, relying heavily on incremental modifications and laborious trial-and-error laboratory testing. This conventional approach is often slow, costly, and limited in its ability to explore the vast landscape of possible material compositions. The advent of Artificial Intelligence (AI) and Machine Learning (ML) has introduced a paradigm shift, moving the field towards a data-driven, predictive, and accelerated "inverse design" approach. Instead of asking "what are the properties of this material?" researchers can now ask, "what material composition will give me these desired properties?" This mini review outlines the recent impact of AI on the design and discovery of dental materials.

Predictive Modeling of Material Properties

One of the most impactful applications of AI in dental materials is the prediction of key performance properties. By training ML models on existing datasets from literature and experiments, researchers can build robust algorithms that accurately forecast the behavior of new, untested materials.

Machine learning models, such as Artificial Neural Networks (ANNs), Support Vector Machines (SVMs), and Random Forests, are being successfully employed to predict a range of critical properties in dental composites and ceramics. For instance, models can correlate the composition of a composite resin (e.g., filler type, size, loading, and silane coupling agent) with its mechanical characteristics like flexural strength, wear resistance, and polymerization shrinkage [3]. A recent study demonstrated that different ML models could excel at predicting specific outcomes; a k-nearest neighbors (KNN) model was superior for predicting flexural modulus, while a Decision Tree model was best for flexural strength and volumetric shrinkage [2]. This predictive power allows for the rapid *in silico* screening of thousands of potential formulations, identifying only the most promising candidates for physical synthesis and testing, thereby saving significant time and resources.

Formulation Optimization and Inverse Design

Beyond prediction, AI is enabling the optimization of material formulations. Genetic algorithms and other optimization techniques can explore a multi-dimensional design space to pinpoint ideal compositions that balance competing properties, such as achieving high strength without compromising aesthetics or biocompatibility.

In the realm of dental ceramics, AI has been used to optimize processing parameters to maximize hardness and fracture toughness. By feeding experimental data on sintering temperatures, times, and additive contents into an AI model, researchers can identify the optimal conditions to produce a ceramic with superior mechanical properties [4].

More advanced generative AI models are beginning to facilitate true inverse design. These models, including Generative Adversarial Networks (GANs) and Variational Autoencoders (VAEs), can learn the underlying relationships between material structure and function. Given a set of target properties—for example, a specific translucency, radiopacity, and strength for a new CAD/CAM block—a generative model can propose novel material compositions that are likely to meet those criteria [5].

Challenges and Future Outlook

Despite the immense potential, several challenges remain. The primary hurdle is the need for large, high-quality, and standardized datasets. The performance of any AI model is fundamentally limited by the data on which it is trained. The dental materials field currently suffers from fragmented data reported in varying formats across thousands of publications. The creation of centralized, open-access databases is crucial for advancing AI-driven design [6].

Furthermore, the "black box" nature of some complex AI models can be a barrier to understanding the underlying physical principles. Future research will likely focus on developing more interpretable AI to provide not just predictions, but also scientific insights into material behavior.

Conclusion

Artificial intelligence is rapidly transforming dental material science from an art of incremental innovation to a science of predictive design. By enabling the rapid prediction of properties, optimization of formulations, and discovery of novel compositions, AI is accelerating the development of the next generation of safer, more durable, and more effective dental materials. As data availability improves and algorithms become more sophisticated, AI will become an indispensable tool in the quest to engineer ideal materials for oral rehabilitation.

Refernces

[1] *J. A. Cruz and D. S. Wishart, "Applications of machine learning in cancer prediction and prognosis," Cancer Informatics, vol. 2. pp. 59–77, 2006. doi: 10.1177/117693510600200030.*

[2] *B. Lael, "What Are We Learning about Artificial Intelligence in Financial Services?," J. Mater. Process. Technol., vol. 1, no. 1, pp. 1–8, 2018, [Online]. Available: http://dx.doi.org/10.1016/j.cirp.2016.06.001%0Ahttp://dx.doi.org/10.1016/j.powtec.2016.12.055%0Ahttps://doi.org/10.1016/j.ijfatigue.2019.02.006%0Ahttps://doi.org/10.1016/j.matlet.2019.04.024%0Ahttps://doi.org/10.1016/j.matlet.2019.127252%0Ahttp://dx.doi.o*

[3] *A. Suryawanshi and N. Behera, "Prediction of wear of dental composite materials using machine learning algorithms," Comput. Methods Biomech. Biomed. Engin., vol. 27, no. 3, pp. 400–410, 2024, doi: 10.1080/10255842.2023.2187671.*

[4] *H. Ghayour, M. Abdellahi, and M. Bahmanpour, "Artificial intelligence and ceramic tools: Experimental study, modeling and optimizing," Ceram. Int., vol. 41, no. 10, pp. 13470–13479, 2015, doi: 10.1016/j.ceramint.2015.07.138.*

[5] *J. H. Song, J. H. Lee, N. Kim, and K. Min, "Artificial Intelligence in the Design of Innovative Metamaterials: A Comprehensive Review," International Journal of Precision Engineering and Manufacturing, vol. 25, no. 1. pp. 225–244, 2024. doi: 10.1007/s12541-023-00857-w.*

[6] *Y. K. Huang, L. P. Hsu, and Y. C. Chang, "Artificial intelligence in clinical dentistry: The potentially negative impacts and future actions," Journal of Dental Sciences, vol. 17, no. 4. pp. 1817–1818, 2022. doi: 10.1016/j.jds.2022.07.013.*

[7] *M. Bhushan, S. Tyagi, M. Nigam, A. Choudary, N. Khurana, and V. Dwivedi, "Bioactive Materials: A Short Review," J Orofac Res, vol. 5, no. 4, pp. 138–141, 2015, doi: 10.5005/jp-journals-10026-1198.*

Biomaterials Journal
http://www.biomatj.com
Online ISSN: 2812-5045

Type of the Paper (Research Article)

Assessing and Reporting Student Satisfaction with Prosthetic Dentistry Teaching and Curriculum in the Faculty of Dentistry, University of Benghazi

Salima Aoun [1*], Nora Adem [1], and Fatimah Faheem Mohammed [1]

Citation: *Salima Aoun, Nora Adem , and Fatimah Faheem Mohammed . Assessing and Reporting Student Satisfaction with Prosthetic Dentistry Teaching and Curriculum in the Faculty of Dentistry, University of Benghazi. Biomat. J., 4 (2), 8 – 26 (2025).*

https://doi.org/10.5281/znodo.5829408

Received: 20 Augaust 2025
Accepted: 12 September 2025
Published: 15 Sebtember 2025

[1] Fixed Prosthodontic Department, Faculty of Dentistry, University of Benghazi, Libya

* Corresponding author e-mail: Nora.adem@uob.edu.ly

Abstract:

Background: The evaluation of student satisfaction is essential for the quality assurance and continuous improvement of dental education programs. Student feedback offers crucial insights for enhancing training curricula to ensure that future dentists are equipped with the necessary competence for safe clinical practice. This study was designed to assess student perceptions of preclinical fixed prosthodontics training to identify strengths and areas for improvement. **Aim:** The objective of this study was to assess the satisfaction levels of undergraduate dental students regarding their preclinical training and educational experience in fixed prosthodontics at the Faculty of Dentistry, University of Benghazi, Libya. **Methods:** A cross-sectional, questionnaire-based study was conducted with 146 senior undergraduate dental students. An online survey composed of 22 questions was distributed, covering seven areas: socio-demographic factors, learning objectives, course materials, content relevance, instructor knowledge, instructor delivery, and facilities. Data were analyzed using descriptive statistics, including mean scores and the coefficient of variation, to gauge overall opinion and the level of agreement. **Results:** Most of the 146 participants were female (76%) and second-year students (74.7%). The overall perception of the course was neutral to positive, with mean scores for all survey questions ranging from 2.7 to 3.7. Strengths included the instructor's knowledge, which 43.2% of students rated as "good," and the usefulness of course materials, rated as "useful" by 40.4%. The highest level of disagreement was noted for the instructor's engagement and enthusiasm (coefficient of variation = 18.9). A significant area of concern was the teaching facilities, with 37.7% of students giving a "neutral" response and 23.3% rating them as "unsuitable".**Conclusion:** The study highlights the instructor's knowledge as a significant strength

of the fixed prosthodontics course. However, it also identifies a critical need for improvement in the quality of teaching facilities and the learning environment to enhance the student experience. The findings were consistent with similar studies conducted in other countries and different dental specialties.

Keywords: *Student satisfaction, prosthetic dentistry, teaching and curriculum, Libya*.

1. Introduction

Dental schools offer a diverse range of subjects in their undergraduate programs, beginning with foundational sciences and progressing to more specialized clinical topics. One of the key areas of focus is Prosthodontics, which is described as "the dental specialty that involves diagnosing, planning treatment, rehabilitating, and maintaining the oral function, comfort, appearance, and health of patients dealing with issues related to missing or inadequate teeth or oral and maxillofacial tissues, using biocompatible materials". This field encompasses four main disciplines: Complete Dentures (CD), Removable Partial Dentures (RPD), Fixed Prosthodontics (FP), and Dental Implants (DI) (1).

Dental professionalism is absolutely vital for anyone practicing dentistry today. It's not just about having the right skills; it's also about embodying the right personal qualities. That's why dental education programs need to incorporate both formative assessments, which help students grow professionally, and summative assessments, which determine if they've met the necessary standards. There's a wealth of evidence and agreement among experts that assessment is key to the success of any educational program. Research indicates that various assessment methods can greatly influence how students grasp and engage with their learning. For dental students, it's essential to gain the knowledge, skills, and attitudes that will make them competent and independent practitioners by the time they graduate (2).

To maintain high standards and encourage ongoing improvement, every training program must undergo regular evaluations. In other words, consistent evaluation is crucial for quality assurance and further enhancement of the program. Higher education institutions are increasingly paying attention to how students respond to their learning experiences. This initial evaluation should be a fundamental part of every training program, as it helps pinpoint areas that need improvement and sets the stage for more in-depth evaluations. Students' feedback offers valuable insights into whether effective learning is taking place.

Generally, their satisfaction and attitudes toward the training program serve as key indicators of their overall reactions. The undergraduate dental curriculum is designed to prepare graduates for real-world practice. Its main objective is to align with students' career aspirations and help shape their professional identities. Additionally, the program aims to equip students with the skills they need for job applications (3).

One of the key ways to evaluate an educational system is by gathering feedback from students, who truly feel the impact of the teaching throughout their courses . Since students are the primary beneficiaries of the educational system, assessing their satisfaction is crucial for understanding the quality of education. Research indicates that many dental school programs currently fall short of helping students achieve their set educational objectives. Therefore, it's essential to continuously assess the current state of education, pinpointing both its strengths and weaknesses to ensure effective clinical training (4,5).

The significance of this study lies in monitoring how students react to their learning experiences. This feedback can help enhance and further develop training programs. Additionally, by evaluating student training, we can lay the groundwork for more advanced assessments, as these reactions indicate whether effective learning is taking place. Thus, it is crucial to provide future dentists with high-quality instruction in order to ensure patient safety. Furthermore, dentistry school exams must to be designed to evaluate undergraduates in relation to all necessary learning objectives. They ought to be created to assess the degree of knowledge, behavior, or skill acquisition of students. Students' primary focus and motivation to participate in the learning process is typically assessments. In order for dental graduates to become certified to practice independently, it is advised that "assessment processes should be rigorous, appropriate, and reliable" (6). The aim of the current study is to assess the professional preclinical training and the levels of student satisfaction with their educational experience for fixed prosthodontics amoong undergraduate dental students in Faculty of Dentistry, University of Benghazi, Libya.

2. Material and method:

Ethics statement

The Institutional Ethical Committee approval was held from the Scientific Research Ethics Committee (SREC) of the Faculty of Dentistry, University of Benghazi (Approval No.#0222). Participants were informed about the study objectives and provided their informed consent.

Study design and setting

A cross-sectional questionnaire-based study was carried out among senior undergraduate 2nd-year dental students who have begun laboratory training on plastic teeth as part of the fixed prosthodontic curriculum in Faculty of Dentistry, University of Benghazi, Libya.

Questionnaire details

A survey was made using Google Forms and sent to the senior undergraduate dental students Faculty of Dentistry, University of Benghazi, Libya through email and social media platforms like WhatsApp. The online survey form had required questions to make sure no incomplete answers were allowed. The responses were collected, and the data was automatically added to an Excel sheet by Google Forms. An online survey is created and sent to 146 male and female students to fill out. Data was collected using a survey consisting of 22 questions that cover seven areas: socio-demographic factors, learning objectives, course materials, content relevance, instructor knowledge, instructor delivery, and the facility and environment. Questionnaire distributed by electronic link written in English was distributed to all the participants and the response received by E-mail. The nclusion criteria of research subjects were: dental school, fixed prosthodontics department, undergraduate students. While, the exclusion criteria of research subjects were; final year students,Internship, postgraduate student, general practitioner and specialists.

Statistical analysis

After the responses are collected, the data was analyzed using descriptive analysis using Statistical Package for Social Sciences (SPSS, IBM, Chicago, USA) 16.0 statistical software.

This study analyzed opinions from a survey. The responses were rated on a scale of 1 to 5, where 1 was given to the least negative as very unclear, not aligned, not effective at all, very inadequate,…etc. and 5 represented a positive one as very clear, fully aligned, very effective, very adequate….etc.

The study assessed the prevailing opinion for each questionnaire by comparing the calculated mean to a specific range-based scale. For instance, a mean between 1 and 1.79 indicated the least negative opinion (e.g., "very unclear"), while a mean of 4.2 to 5 signified the most positive ("very clear"). This method was applied to all comparable answers. Additionally, the coefficient of variation (standard deviation divided by the mean, multiplied by 100) was computed for each question's responses. This metric was used to rank the questions based on the level of agreement, with lower coefficients indicating more consensus and higher coefficients indicating more disagreement.

3. Results:

Table 1 and figure 1 represent the categorization of participants according to their gender, age, and academic years. Table 2 represents the percentage of the responses of the participants to the questions of the survey. Figures 2-18 are illustrating charts for the survey questions.

Table 1: Socio-Demographic Information of Participants.

Description	Response	Percentage
A) Gender	- Male	24 %
	- Female	76%
B) Age	- 21 Years	3.5%
	- 22 Years	43.8%
	- ≥ 23 Years	52.7%
C) Academic Year	- First year	0%
	- Second year	74.7%
	- Third year	12.3%
	- Fourth year	11%
	- Fifth year	2%
D) Are you pursuing any additional degrees or certifications alongside your dental program?	- Yes	56.2%
	- No	43.8%

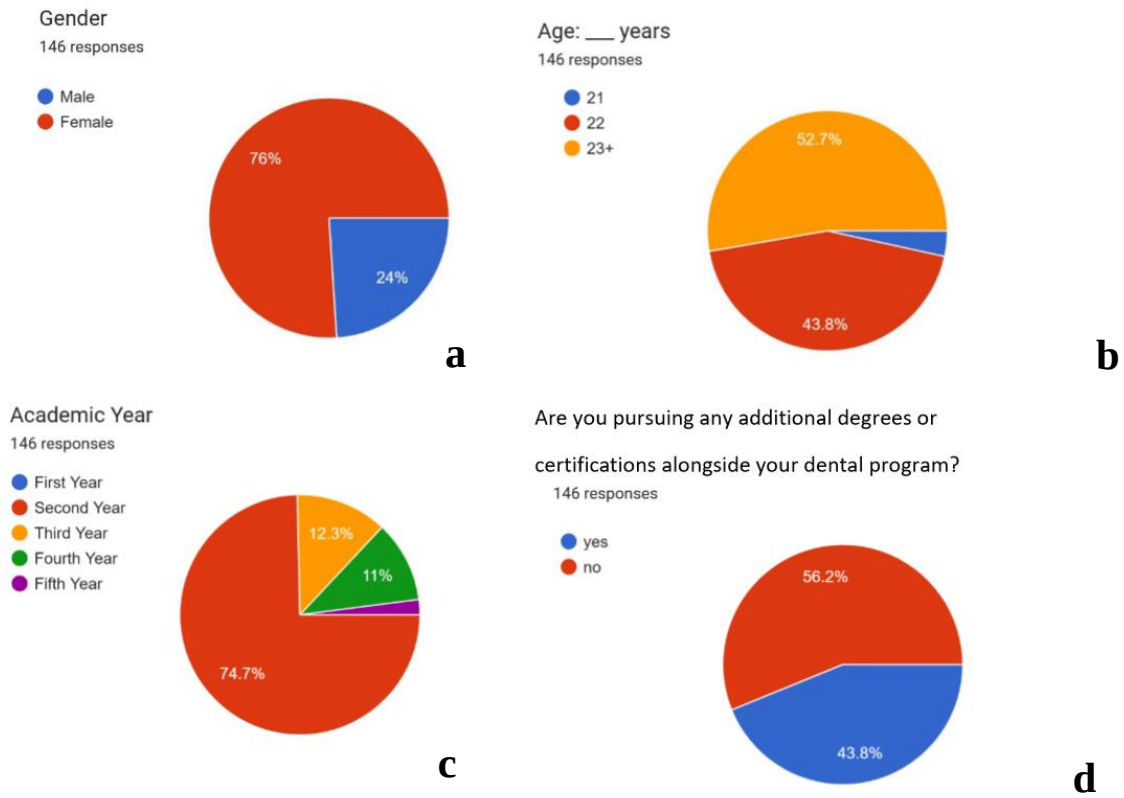

Figure 1: Charts of Participants' Categorization according to a) Gender b) Age c) Academic year d) additional degrees or certifications alongside your dental program.

Since all the mean values ranged between 2.7 and 3.7, this means that the majority of answers were either neutral or the positive grade after the neutral, Table 2.

According to the calculated coefficient of variation, the answers could be ranked from the most agreeable (least coefficient of variation) to the least agreeable (highest coefficient of variation). The answers to the question "Accessibility

of supplementary resources (e.g., online materials, videos)" were the most agreeable (the lowest coefficient of variation = 10.8), while the answers to the question "Instructor's engagement and enthusiasm during lectures" were the least agreeable (the highest coefficient of variation = 18.9).

Table 2: Responses, Percentages of the Learning Objectives Questionnaire.

Survey Question Number	Responses	Percentage	Mean	S.D.	Coefficient of Variation
Q1: The clarity of stated learning objectives	- Very Unclear - Unclear - Neutral - Clear - Very Clear	4.8% 11.6% 42.5% 32.9% 8.2%	3.3	0.5	16.3
Q2: The alignment of learning objectives with course content	- Not Aligned - Partially Aligned - Neutral - Aligned - Fully Aligned	5% 16.4% 39% 34.2% 5%	3.2	0.5	16.6
Q3: How effectively did the learning objectives help you understand the scope of the course?	- Not Effective at All - Slightly Effective - Neutral - Effective - Very Effective	6.9% 21.2% 27.4% 34.2% 10.3%	3.2	0.4	13.6

Table 3: Responses, Percentages of the Course Materials Questionnaire.

Survey Question Number	Responses	Percentage	Mean	S.D.	Coefficient of Variation
Q1: Adequacy and relevance of course materials (e.g., textbooks, handouts).	- Very Inadequate - Inadequate - Neutral - Adequate - Very Adequate	7.5% 15.1% 37% 32.9% 7.5%	3.2	0.5	15.3
Q2: Accessibility of supplementary resources (e.g., online materials, videos).	Very Inaccessible - Inaccessible - Neutral - Accessible - Very Accessible	8.9% 21.9% 30.1% 26% 13%	3.1	0.3	10.8
Q3: How useful were the provided course materials in aiding your understanding of the subject matter?	- Not Useful at All - Slightly Useful - Neutral - Useful - Very Useful	6.2% 13% 26.7% 40.4% 13.7%	3.4	0.5	15.7

Table 4: Responses, Percentages of the Content Relevance Questionnaire.

Survey Question Number	Responses	Percentage	Mean	S.D.	Coefficient of Variation
Q1: The relevance of course content to real-world practice	- Not Relevant - Partially Relevant - Neutral - Relevant - Highly Relevant	7.5% 19.2% 35.6% 32.9% 4.8%	3.1	0.5	15.8
Q2: How well did the course content prepare you for real-world applications in fixed prosthodontics?	- Not Well at All - Slightly Well - Neutral - Well - Very Well	10.3% 22.6% 27.4% 30.8% 8.9%	3.1	0.4	12.6
Q3: How engaging was the course content in maintaining your interest throughout the course?	- Not Engaging at All - Slightly Engaging - Neutral - Engaging - Very Engaging	11% 16.4% 28.1% 36.3% 8.2%	3.1	0.5	15.1

Table 5: Responses, Percentages of the Instructor Questionnaire.

Survey Question Number	Responses	Percentage	Mean	S.D.	Coefficient of Variation
Q1: Instructor's knowledge of the subject matter	- Very Poor - Poor - Neutral - Good - Very Good	3.3% 6.2% 28.1% 43.2% 19.2%	3.7	0.6	16.8
Q2: Instructor's ability to explain concepts effectively	- Very Ineffective - Ineffective - Neutral - Effective - Very Effective	6.8% 9.6% 35.6% 34.2% 13.7%	3.4	0.5	14.7
Q3: How approachable and supportive was the instructor in addressing your questions or concerns?	- Not Approachable or Supportive - Slightly Approachable or Supportive - Neutral - Approachable and Supportive - Very Approachable and Supportive	8.9% 19.9% 30.1% 30.8% 10.3%	3.1	0.4	12.7

Table 6: Responses, Percentages of the Instructor Delivery and Style Questionnaire.

Survey Question Number	Responses	Percentage	Mean	S.D.	Coefficient of Variation
Q1: Instructor's engagement and enthusiasm during lectures	- Very Low - Low - Neutral - High - Very High	4.8% 17.1% 48.6% 22.6% 6.8%	2.8	0.5	18.9
Q2: Clarity and organization of the instructor's delivery	- Very Disorganized - Disorganized - Neutral - Organized - Very Organized	7.5% 8.9% 41.8% 35.6% 6.2%	3.7	0.7	18.3
Q3: How well did the instructor's teaching style facilitate your learning experience?	- Hindered Learning - Slightly Hindered Learning - Neutral - Facilitated Learning - Highly Facilitated Learning	8.9% 14.4% 35.6% 32.9% 8.2%	3.2	0.5	14.9

Table 7: Responses, Percentages of the Facility and Environment Questionnaire.

Survey Question Number	Responses	Percentage	Mean	S.D.	Coefficient of Variation
Q1: Suitability and adequacy of teaching facilities (e.g., classrooms, labs).	- Very Unsuitable - Unsuitable - Neutral - Suitable - Very Suitable	15.1% 23.3% 37.7% 21.2% 2.7%	2.7	0.4	14.3
Q2: Overall comfort and conducive learning environment	- Very Uncomfortable - Uncomfortable - Neutral - Comfortable - Very Comfortable	14.4% 23.3% 36.3% 25.3% 0.7%	2.7	0.4	15.8
Q3: How conducive was the learning environment to your overall learning experience?	- Highly Not Conducive - Not Conducive - Neutral - Conducive - Very Conducive	4.8% 15.1% 54.8% 15.1% 10.3%	3.1	0.5	17.5

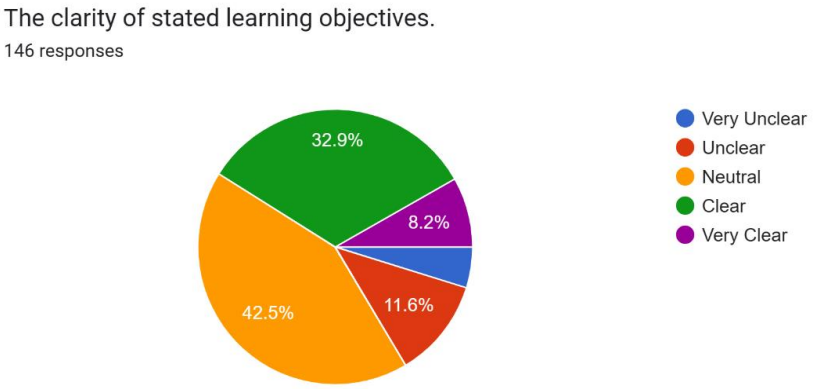

Figure 2: Chart illustrating the clarity of stated learning objectives.

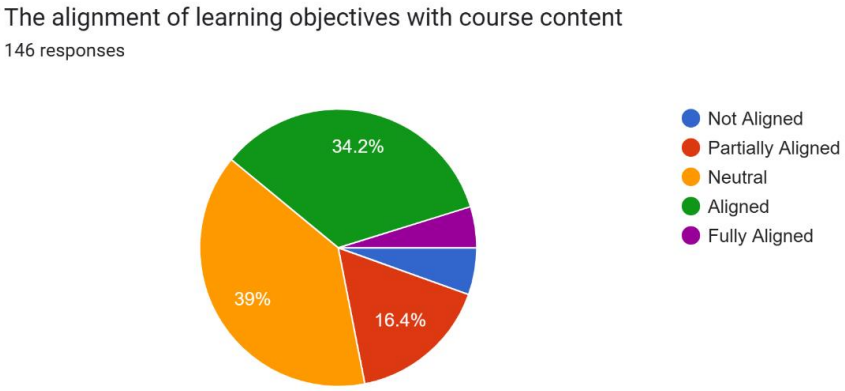

Figure 3: Chart illustrating the alignment of learning objectives with course content.

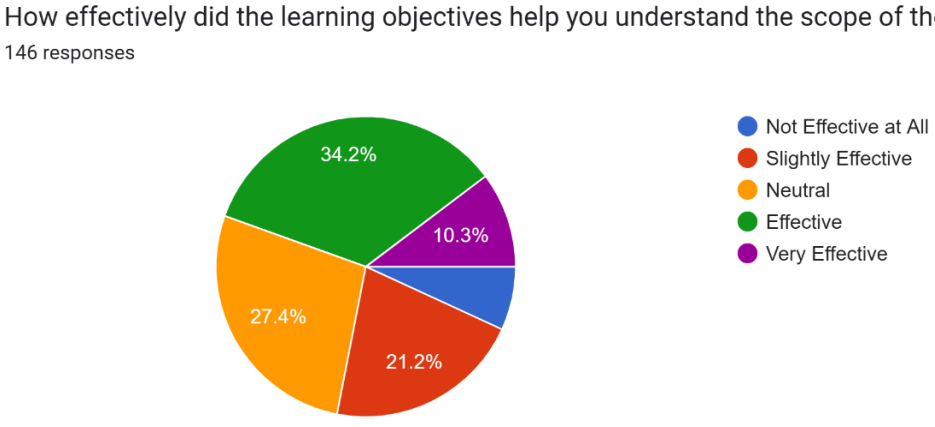

Figure 4: Chart illustrating how effectively did the learning objectives help you understand the scope of the course.

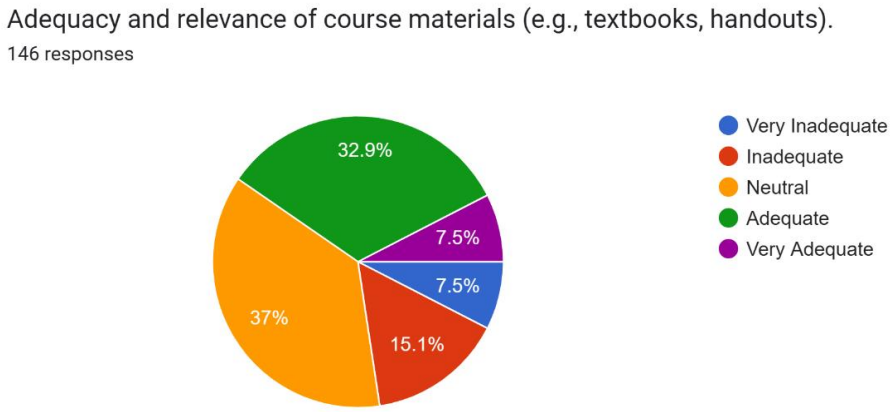

Figure 5: Chart illustrating the adequacy and relevance of course materials (e.g., textbooks, handouts).

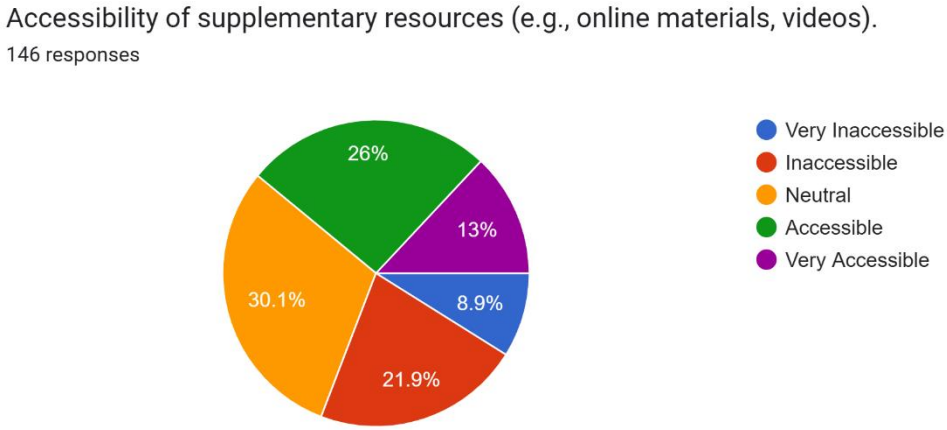

Figure 6: Chart illustrating the accessibility of supplementary resources (e.g., online materials, videos).

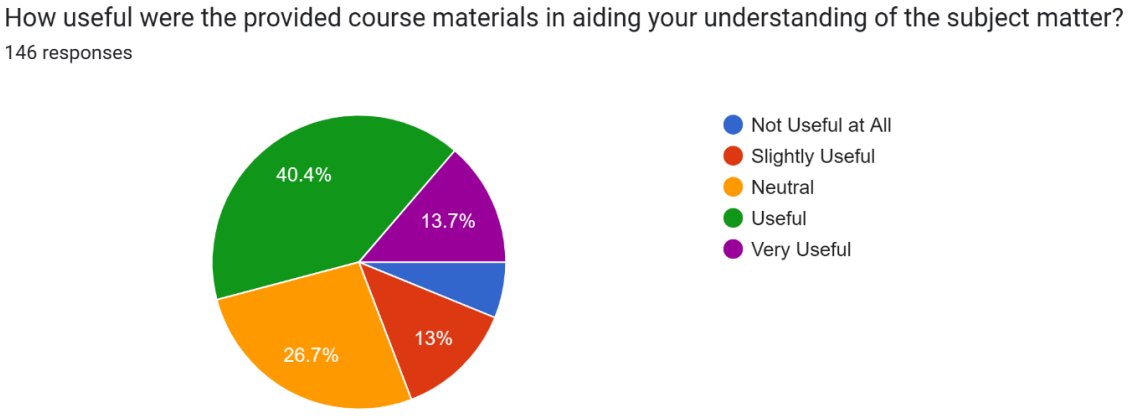

Figure 7: Chart illustrating how useful were the provided course materials in aiding your understanding of the subject matter.

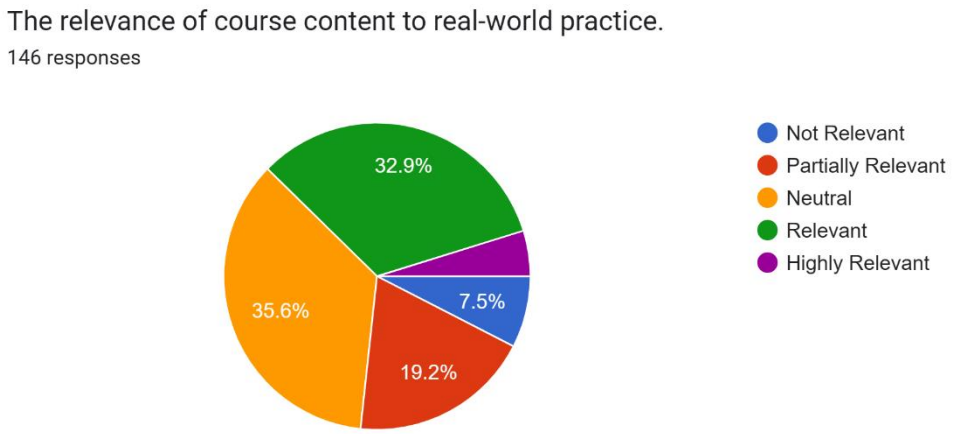

Figure 8: Chart illustrating the relevance of course content to real-world practice.

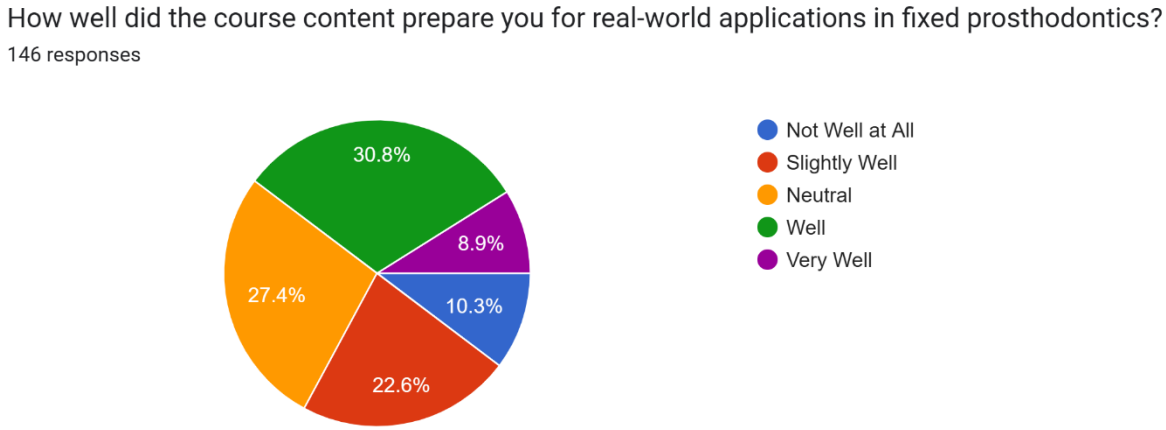

Figure 9: Chart illustrating how well did the course content prepare you for real-world applications in fixed prosthodontics.

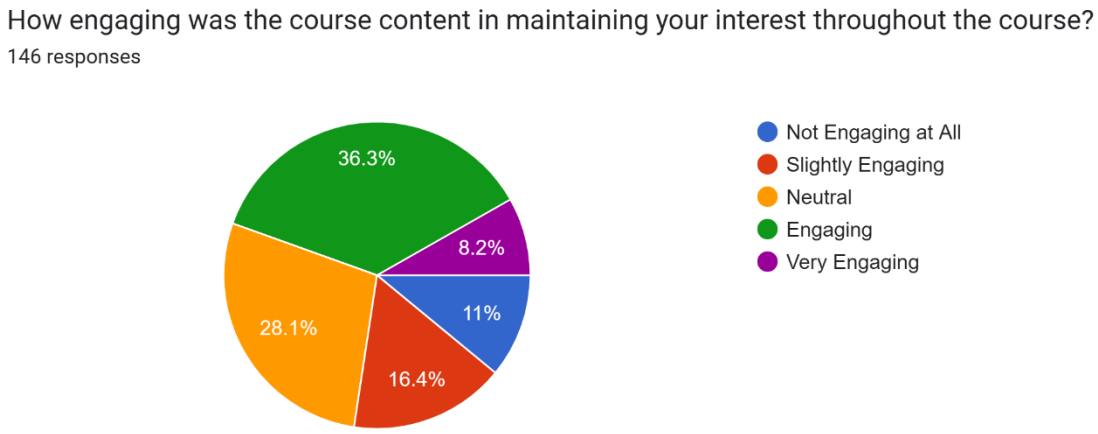

Figure 10: Chart illustrating how engaging was the course content in maintaining your interest throughout the course.

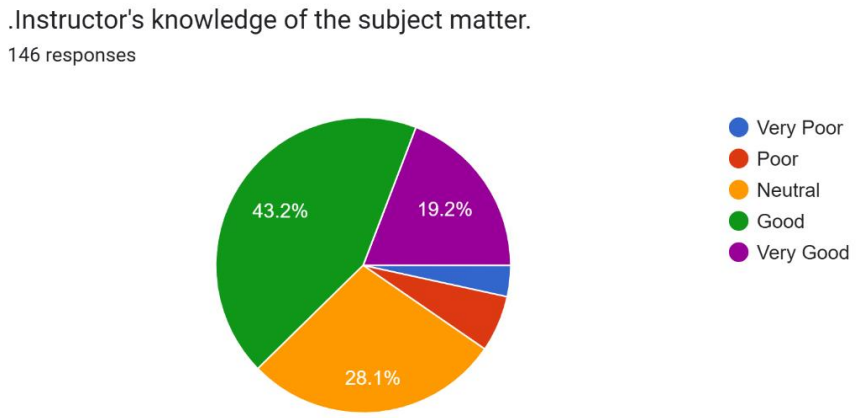

Figure 11: Chart illustrating the instructor's knowledge of the subject matter.

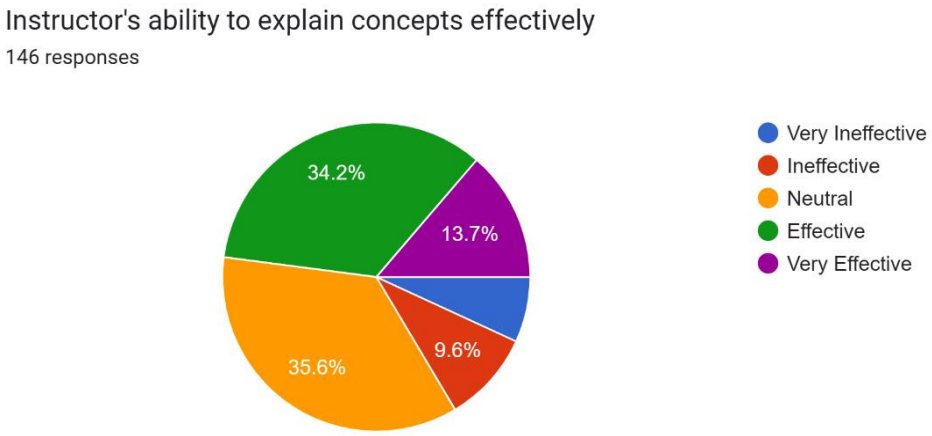

Figure 11: Chart illustrating instructor's ability to explain concepts effectively.

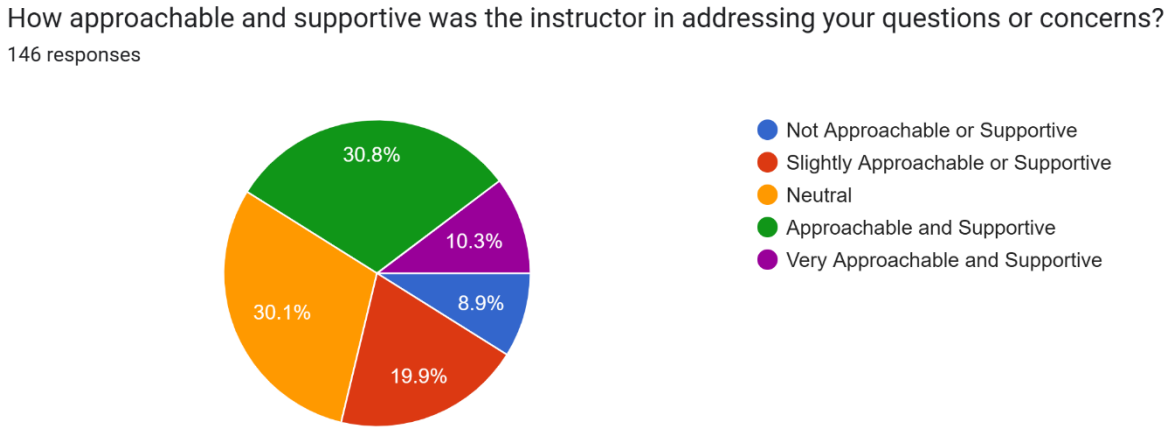

Figure 12: Chart illustrating how approachable and supportive was the instructor in addressing your questions or concerns.

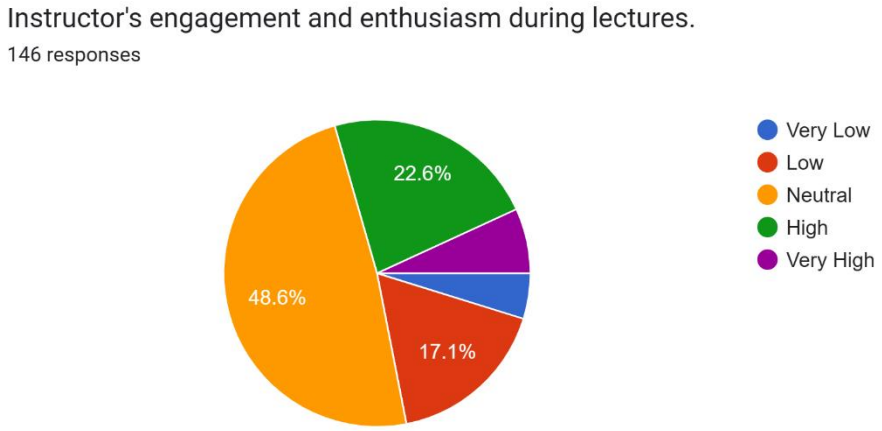

Figure 13: Chart illustrating the instructor's engagement and enthusiasm during lectures.

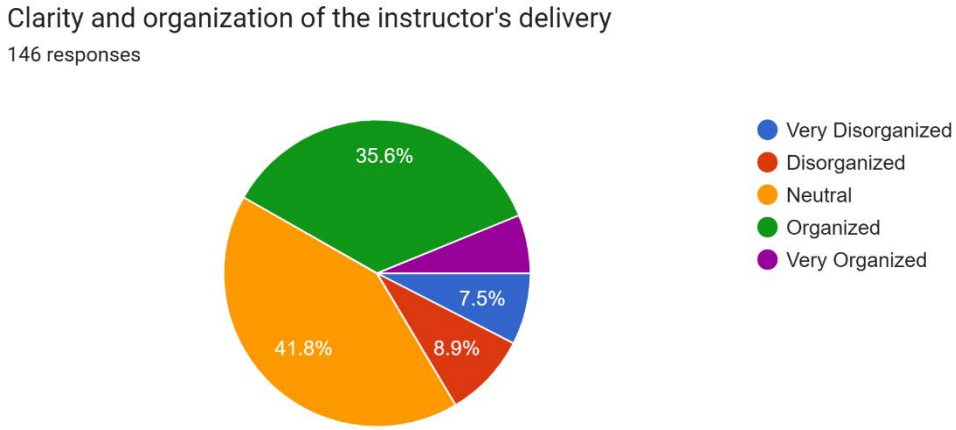

Figure 14: Chart illustrating the clarity and organization of the instructor's delivery.

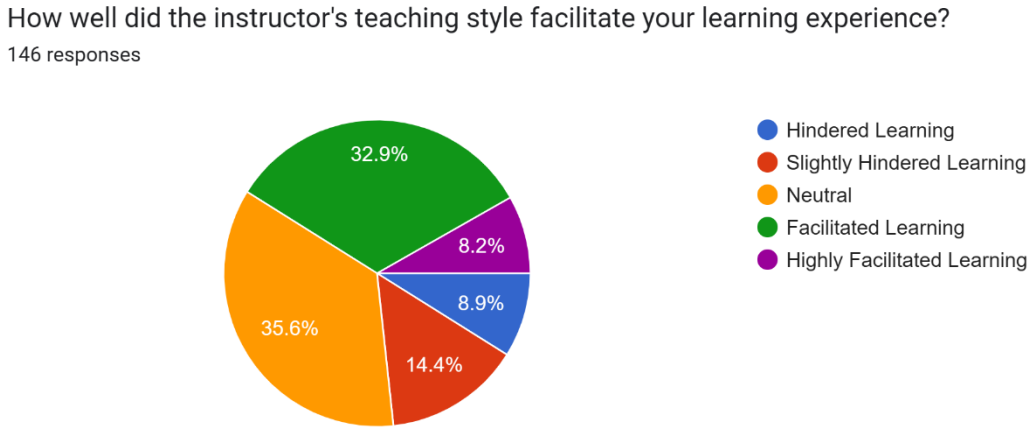

Figure 15: Chart illustrating how well did the instructor's teaching style facilitate your learning experience.

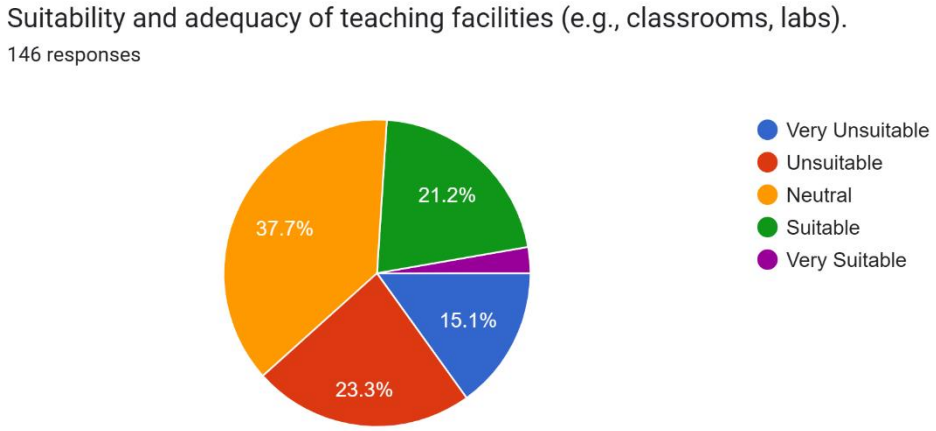

Figure 16: Chart illustrating the suitability and adequacy of teaching facilities (e.g., classrooms, labs).

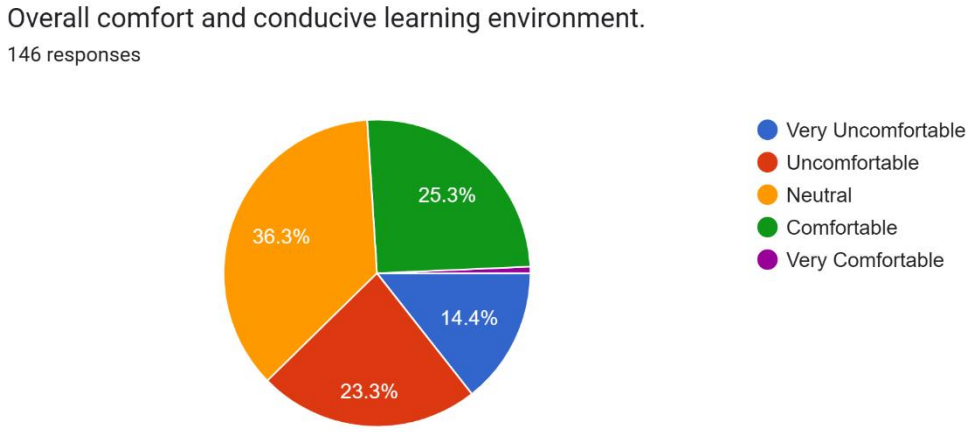

Figure 17: Chart illustrating the overall comfort and conducive learning environment.

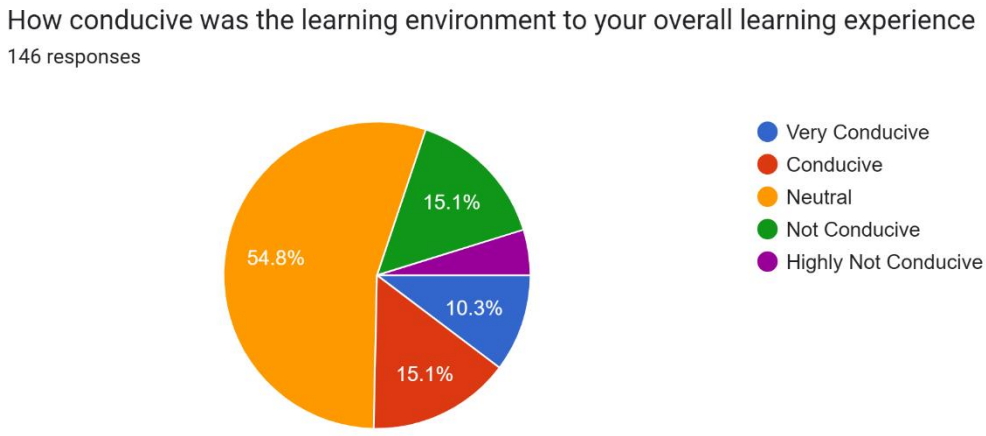

Figure 18: Chart illustrating How conducive was the learning environment to your overall learning experience.

4. Discussion:

This study rigorously evaluated undergraduate student satisfaction with preclinical fixed prosthodontics training at the University of Benghazi's Faculty of Dentistry. Recognizing student feedback as an invaluable tool for gauging educational efficacy, the research explored key factors influencing learner experiences. A pivotal element was the instructor's role; prior studies consistently show that an instructor's expertise, communication skills, and approachability are primary determinants of student satisfaction. This study's findings corroborate this, demonstrating a strong link between positive student experiences and effective, nurturing faculty interactions (7).

Furthermore, the learning environment and facilities were identified as crucial. A supportive, well-equipped setting significantly boosts student motivation, whereas challenges like inadequate laboratory resources, overcrowding, or outdated equipment can lower satisfaction. Addressing these infrastructural issues is essential for enhancing the program's effectiveness (8).

In conclusion, this research underscores the critical need for ongoing evaluation and progressive curriculum development. Key strategies for improvement include clarifying learning objectives, ensuring access to contemporary resources, and cultivating strong faculty-student relationships. Aligning the curriculum with real-world clinical practice is also vital for bolstering students' confidence and readiness for clinical training. The findings, derived from student survey data, offer valuable insights into the course's strengths and weaknesses in its design, content, and delivery, providing a roadmap for future enhancements (9,10).

The study's findings, based on a survey of 146 participants, offer insights into several aspects of the educational experience in a dental program. The demographic information reveals that a majority of the respondents were female (76%) and over 22 years old, with the largest group being 22 years old (43.8%). A significant portion of the participants (74.7%) were in their second academic year, and over half (56.2%) were pursuing additional degrees or certifications alongside their dental program.

The analysis of the survey questions, which included various themes such as learning objectives, course materials, content relevance, instructors, and facilities, indicates an overall positive to neutral perception among the students. The mean scores for all questions ranged from 2.7 to 3.7, suggesting that the majority of responses fell within the "neutral" or "positive" categories.

Students generally found the learning objectives to be clear and aligned with the course content, with 32.9% of respondents rating clarity as "clear" and 34.2% seeing alignment as "aligned". The effectiveness of objectives in helping students understand the course scope was also rated positively, with 34.2% finding them "effective". Similarly, students rated the usefulness and relevance of course materials highly, with 40.4% finding them "useful" and 32.9% rating them as "adequate".

Instructor effectiveness was rated favorably across several metrics. A large percentage of participants, 43.2%, rated the instructor's knowledge as "good," and 34.2% considered their ability to explain concepts "effective". The relevance of the course content to real-world practice was also seen positively, with 32.9% of students rating it as "relevant". However, the instructor's engagement and enthusiasm during lectures had a high coefficient of variation (18.9), indicating a wider range of opinions on this aspect. This question had the highest coefficient of variation among all survey questions, suggesting it was the least agreeable point for students. Conversely, the accessibility of supplementary resources was the most agreeable aspect, with the lowest coefficient of variation (10.8). This aligns with earlier studies about instructor effectiveness, as it generally provides a wide range of opinions reflecting the different attitudes of the students (11,12).

While the overall results are positive, some areas could be improved. The highest percentage of "Neutral" responses appeared for the question about the suitability of teaching facilities (37.7%), and a significant percentage of students found them "unsuitable" (23.3%). This suggests that the physical learning environment could be a potential concern for many students. Additionally, although the instructor's knowledge and ability to explain concepts were rated well, the varied responses regarding their enthusiasm and engagement during lectures suggest that teaching delivery styles could be a focus for future development to ensure a more consistent and positive experience for all students (13).

The results of our research align with similar studies in other countries and dental fields (14–19). Furthermore, the findings reveal a spectrum of satisfaction across crucial areas: learning objectives, course materials, content relevance, instructor performance, teaching methods, and the overall learning environment. This diversity of feedback not only highlights the strengths of the program but also indicates specific areas ripe for improvement within the curriculum. Aligning with previous research (20), our study confirms that student satisfaction is closely linked to clear learning objectives, adequate resources, and a supportive teaching atmosphere. When these key factors are well established, students are more inclined to express higher levels of

engagement and preparedness for their clinical endeavors. Conversely, a lack of resources or ambiguous expectations can undermine learning outcomes and lead to dissatisfaction. Moreover, the relevance of course content to real-world clinical applications emerged as a crucial factor. Research by Manogue et al. (21) indicates that the degree to which preclinical training mirrors actual clinical practice significantly shapes students' confidence and competence as they transition to clinical years. Disparities between theoretical knowledge and practical application can cause students to perceive their training as less effective, despite strong teaching quality (22).

One limitation of this study is its heavy reliance on self-reported questionnaires, which may introduce biases in responses. Furthermore, as the findings are confined to a single institution, they may lack generalizability to other dental schools. Future research should consider incorporating qualitative methods, such as interviews or focus groups, to gain richer insights into students' perceptions. Expanding the evaluation to encompass clinical training years would also facilitate a more comprehensive understanding of the curriculum's effectiveness.

In conclusion, the survey results provide valuable insights into the strengths and weaknesses of the fixed prosthodontics course. The instructors' knowledge and effectiveness were rated positively, which is a major strength. However, the survey also reveals significant areas for improvement, particularly regarding the alignment of learning objectives, accessibility of supplementary materials, and most importantly, the quality and suitability of the teaching facilities and learning environment. Addressing these issues would likely lead to a more effective and satisfactory learning experience for dental students. Future studies could explore the specific reasons behind the negative feedback on facilities and compare the perceptions of students across different academic years to identify any evolving trends.

Refernces:

1. Khalaf K Al, Moore C, McKenna G, Da Mata C, Lynch CD. Undergraduate teaching and assessment methods in prosthodontics curriculum: An international Delphi survey. J Dent [Internet]. 2022 Aug;123:104207. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0300571222002639

2. Manogue M, Brown G, Foster H. Clinical assessment of dental students: values and practices of teachers in restorative dentistry. Med Educ. 2001 Apr;35(4):364–70.

3. Zijlstra-Shaw S, Roberts T, Robinson PG. Evaluation of an assessment system for professionalism amongst dental students. Eur J Dent Educ. 2017;

4. Henzi D, Davis E, Jasinevicius R, Hendricson W. In the Students' Own Words: What Are the Strengths and Weaknesses of the Dental School Curriculum? J Dent Educ. 2007;

5. Plasschaert AJM, Lindh C, McLoughlin J, Manogue M, Murtomaa H, Nattestad A, et al. Curriculum structure and the European credit transfer system for European dental schools: Part I. Eur J Dent Educ. 2006;

6. Taylor CL, Grey N, Satterthwaite JD. Assessing the Clinical Skills of Dental Students: A Review of the Literature. J Educ Learn. 2013;

7. Wang X. Exploring positive teacher-student relationships: the synergy of teacher mindfulness and emotional intelligence. Front Psychol. 2023;14.

8. Savolainen T. A safe learning environment from the perspective of Laurea University of applied sciences safety, security and risk management students and staff. Heliyon. 2023;9(3).

9. Theile CW. Strengths and Weaknesses of the Current Dental Hygiene Educational System. J Dent Educ. 2017;81(9).

10. Ciocan LT, Pantea M, Vasilescu VG, Țâncu AM, Sfeatcu R, Didilescu AC, et al. Evaluation of Undergraduate Dental Students' Opinions on the Use of Digital Versus Conventional Design in Prosthodontics. Vol. 13, Dentistry Journal. 2025.

11. Sharka R, Alghamdi M, Almarghlani A, Abed H, Alluqmani S, Alhazmi R, et al. Exploring Factors Contributing to Effective Teaching in Dental Clinical Settings: Perceptions of Dental Students. Dent J. Switzerland; 2025 Feb;13(2).

12. Nimmo A, Mitchell GS, Echeto L, Ojha AK. Effect of Dental Students as Instructors on Preclinical Performance in Prosthodontics. J Dent Educ. 2008;72(12):1488–92.

13. Hattar S, AlHadidi A, Altarawneh S, Abu-Ghazaleh S, Hammad M. Dental Student Perspectives of a Comprehensive-Based Teaching Methodology: A Confidence, Effectiveness, and Challenge Report. Int J Dent [Internet]. 2020 Aug 28;2020:1–6. Available from: https://www.hindawi.com/journals/ijd/2020/8842008/

14. El Shimy S, Hamza M, Essam-ElDin W. STAFF MEMBERS' PERCEPTION TOWARDS CURRICULUM REFORM: IS THERE A DIFFERENCE BETWEEN GOVERNMENTAL AND NON-GOVERNMENTAL DENTAL SCHOOLS IN ALEXANDRIA, EGYPT. Alexandria Dent J. 2016;41(1):55–65.

15. Wolf A, Pricop-Jeckstad M, Botzenhart U, Gredes T. Assessment of Dental Student Satisfaction after Internships in Collaborative Dental Practices in Saxony—A Retrospective Questionnaire Analysis. Dent J. 2024;12(1).

16. Soltani E, Amiri SM, Moradi A. Evaluation of Dentistry Students' Satisfaction Rate with Educational Services at Kermanshah University of Medical Sciences, Iran (2015 – 16). Educ Res Med Sci. 2018;7(1).

17. Alqarni MA. Assessing dental students' professional satisfaction with operative dentistry teaching and curriculum: A study in Saudi Arabia. Med (United States). 2021;100(25):E26459.

18. Acar NK, Sahin N, Celikel P. Comparison of students' satisfaction levels in different dentistry faculties in Türkiye. BMC Med Educ [Internet]. 2025;25(1):1064. Available from: https://doi.org/10.1186/s12909-025-07677-8

19. Smail Y, Dursun E, Ciers J-Y, Taleb C, Nardari C, Keosouvanh N, et al. Students' perceptions of knowledge reinforcement on indirect prosthetic dental material choices by a translational approach. J Dent Educ. United States; 2025 Apr;89(4):514–22.

20. Abendaño ART, Quimada RT, Coloquit LMP. The Effectiveness and Utilization of Social Media as Academic Medium in the UNC College of Education. Int J Res Educ. 2022;2(2):142–54.

21. Manogue M, Mcloughlin J, Christersson C, Delap E, Lindh C, Schoonheim-Klein M, et al. Curriculum structure, content, learning and assessment in European undergraduate dental education - update 2010. Eur J Dent Educ. 2011;15(3):133–41.

22. Setyowati RN, Nurhasan, Sarmini, Herianto E. Multicultural Education in Indonesia as a Function of Curriculum Development Strategies, Students' Cultural Competencies and Globalization. Przestrz Spoleczna. 2022;23(2):114–36.