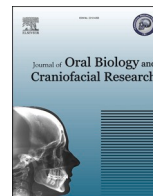




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# Developing an instructional module of ‘digital dentistry’ for undergraduate prosthodontics curriculum

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## ABSTRACT

**Purpose:** To prepare a module on ‘Digital Dentistry’, which can be used to sensitize dental undergraduate students during their final year Prosthodontics curriculum. **Methods:** Ethical approval (167/Ethics/2022) was taken from the Institution before starting the study. Need assessment was achieved using focused group discussion (Online Zoom meeting) of various stakeholders of the Department of Prosthodontics of the institution. A preliminary module content was prepared in google questionnaire form after thorough literature review by the research team and final content was developed using modified Delphi technique in 3 questionnaire rounds with the help of 27 experts.

**Result:** Thematic analysis of Need Assessment focussed group discussion led to the emergence of both theoretical and practical aspect of learning in digital dentistry. The final module was developed with the process followed in modified Delphi technique.

**Conclusion:** Within the limitations of the study the module of Digital dentistry was developed which can be implemented in most of the dental institutes depending on the resources and available infrastructure.

## 1. Introduction

With the changing time, introduction of new concepts and technologies have resulted in requirement of innovative course content. The thrust in the new regulations has led to an outcome driven educational curriculum according to current global trends. A very fine example of this is shifting from teaching amalgam to composite in restoration and fixed partial dentures to introducing dental implants for replacement of teeth. Dentistry seems to be evolved in digitalization with time and it is known from the literature that digital dentistry can help improve the quality of patient care and pedagogical methodologies.<sup>1</sup> A dental school that relies heavily on teaching traditional restorative procedures may particularly face many challenges to embrace new technology.<sup>2</sup> One of the biggest challenges in digital education is the practice of continuous adaptation and adjustment with the developments in technology and applying those to dental practice.<sup>3</sup> In a study done by Schlenz et al., a positive perspective was noted among students after implementation of digital dentistry in the preclinical curriculum.<sup>4</sup>

With the evolve of computer-aided design/computer-aided manufacturing (CAD/CAM), digitalization is an expanding field in dentistry now.<sup>5</sup> In a study done by Schweyen et al., a tendency was found that students using CAD/CAM technology prepared more teeth

than their fellow students who did not use CAD/CAM technology.<sup>6</sup> Many types of digital technologies are being practiced in dental education that include, web-based knowledge transfer and e-learning, digital surface mapping, dental simulator motor skills, intraoral scanning, digital radiography, tooth preparation, virtual and augmented reality and surveys related to the penetration and acceptance of digital education.<sup>1,7–10</sup>

In India, education of dental students is still solely focused on conventional teaching methods including traditional laboratory techniques such as waxing, casting, finishing, and tooth preparation exercises on the phantom head. There is a need to prepare a curriculum on Digital dentistry to make our undergraduate students sensitised with digital practice. For preparing a curriculum, Delphi/modified Delphi techniques are reliable methods and have been used to facilitate group transformation of opinion into a common consensus using iterative multistage design.<sup>11,12</sup> With the above background, present project on “Developing an Instructional Module of ‘Digital Dentistry’ for Undergraduate Prosthodontics Curriculum” has been systematically carried out using Modified Delphi technique, with the aim to create awareness among our undergraduate students with digital technology in dentistry.

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## 2. Methods

Ethical approval (167/Ethics/2022) was taken from the Institution before starting the study. Need assessment was taken using focused group discussion (FGD) by online Zoom meeting of various stakeholders of the Department of Prosthodontics of the institution. A total of 20 Participants from the aforementioned stakeholders (4 faculty, 4 Interns, 4 undergraduate students, 4 Postgraduate Students and 4 alumni) participated in the FGD. Primary author of this article moderated the Zoom meeting. It was taken care to record this meeting online as well as offline by one of the co-author, who manually recorded all participant's view. The lead questions asked were - rationale of developing Digital dentistry curriculum, the problems while implementing the module, advantages and limitations of digital dentistry. All the participants were given chance to put their views in 40 min online meeting. The responses of participants were coded and analyzed.

A preliminary module content was prepared in google questionnaire form by the research team after thorough literature review. The research team consisted of all 3 contributing authors, who were having more than 15 years of undergraduate prosthodontics teaching experience. For final content development of module, modified Delphi technique was used in 3 questionnaire rounds. In Round 1, scoring of content item was collected along with additional opinions from the participants. In round 2, focus was given on additional comments regarding the content and structure and round 3, content and structure were summarized to get final opinion of the selected senior experts.

The online questionnaires were sent to the participants' email addresses. Almost 1 month duration was provided to each round. In case of nonresponse to the questionnaires, 2 reminders were sent to the participant in the gap of 1 week via email/phone call/short message services (SMS). After that prompt, any non-responders were dropped from the study and no longer considered a potential source of data. After the completion of each round, the core team analyzed the data and the questions were modified for the next rounds. Participants' names and institutions were coded to ensure confidentiality and anonymity. All data collection was conducted between April and September 2022.

### 3. Delphi rounds-

#### 3.1. First Delphi round

After thorough literature review, contents of the module were prepared by the research team, as questionnaire in the Google form. 30 experts having more than 5 years of clinical/Academic experience were contacted for their willingness to participation in April 2022 and amongst them 27 participants responded. The questionnaire was divided in 7 sections- 1st section included 9 demographic questions related to their identity, age, designation and degree of involvement in digital practice. Sections 2, 3 and 4 (24 content specific) were related to content of the module and were divided in subheadings along with one free response question in each section. Experts had to select contents sub-heading from 1 to 5 on linear scale. (Where 5 was the most preferred and 1 was the least preferred choice) and had to provide their opinion/addition/deletion of any content in free response question. Section 5 was related to structure of the module where experts had to select preferable teaching learning methodology, total no of hours for module and assessment tools. In this section again a free answer based question was there for expert view/addition/deletion/modification of the content. In the section 6 experts were asked about 'Digital dentistry as skill course' their view of including this module as skill course in preclinical/clinical Prosthodontics. In the section 7, a question was asked regarding their view for any other suggestions for improvement of the Module preparation.

After the responses were received further questions were modified according to the responses/feedbacks achieved for the round 2.

#### 3.2. Second Delphi round

Modified questionnaire was sent back to same group of experts to obtain their opinion with attached instructions. This round included 5 sections (26 content specific) in which 1st section was related to demographic with short profile, 2nd, 3rd, 4th sections related to contents and 5th section was related to structure of the module. 2nd section titled, 'Introduction' had 12 content specific questions. 3rd section titled, 'Diagnosis and Treatment Planning' had 6 content specific sub-heading and 4th section included 'Computer aided designing/Computer-aided manufacturing' as heading and 8 subheading. Questions receiving more than 70% responses<sup>13</sup> were now added as contents with few addition and modifications in this section. 5th section was related with structure of the module. All 4 sections included 1 free answer question at the end to receive expert's opinion.

#### 3.3. Third Delphi round

It was divided in 2 sections- 1st being demographic and second with contents and structure of whole module. According to the responses received in round 2, the content of the module were modified and further summarized. The summary was sent to 6 senior specialists having more than 15 years of experience to get the final consensus.

## 4. Result

Thematic analysis of Need Assessment focussed group discussion led to the emergence of two major aspects of learning in digital dentistry-theoretical and practical aspect. Fig. 1 shows a fishbone diagram depicting the reasons for not adopting the module in the current time.

Table 1 shows the demographic profile of the participants. Table 2 shows percentage agreement response (experts rated the questions 4 or 5 were included as nominator) of the participants for the content specific questions.

Fig. 2 shows the overview of Delphi rounds, how the process was conducted and how the module was developed.

## 5. Discussion

Depending on local resources and demands, the implementation of digital technologies in dental curricula has now reached globally at varying levels of penetration.<sup>1</sup> In United states, regarding digital denture technology, a study revealed that approximately 50% of post-graduate prosthodontic programs included aspects of this technology in their programs while only 12% of undergraduate programs included this technology in their curriculum.<sup>3</sup> However in 2021 'American College of Prosthodontists' have prepared a curriculum on Digital Dentistry for predoctoral and advanced courses on Prosthodontics.<sup>14</sup> In India, though few institutions have adopted digitalization depending on their infrastructure, no literature have been found yet. Therefore, there is a need to develop a module on Digital dentistry, which can be further implemented in various institutions.

Need assessment is the first step required for developing a curriculum.<sup>15</sup> FGD (Online Zoom meeting) of 20 participants revealed that both theoretical and practical aspects are required while teaching digital dentistry to undergraduate students and they supported the fact that digital learning should not be limited to theoretical learning. Many of the participants agreed that lack of infrastructure and lack of awareness are major limitation for its implementation. Participants also discussed the advantage of digital dentistry i.e. reduced treatment time with digitalization, patient and clinician comfort, improved communication, helps in overcoming the conventional technique's shortcomings, improved record maintenance and helps in adopting a holistic approach of treatment.

The present project, was conducted in 3 rounds as done in modified Delphi technique for developing the module. The Delphi technique is a

Fishbone diagram showing the reasons for not adopting the module in the current time.

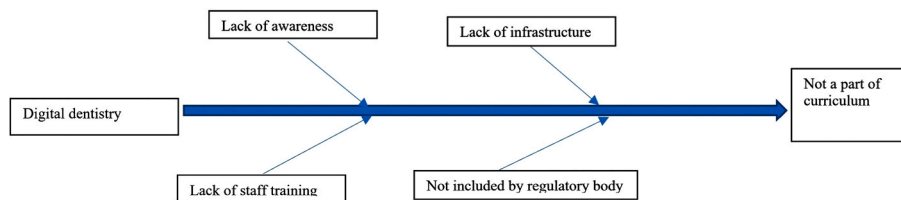


Fig. 1. Fishbone diagram showing the reasons for not adopting the module in the current time.

**Table 1**  
Demographic profile of the experts.

Participant code	Gender	Age	Qualification	Current designation	Academic/clinical Experience (in years)	Use of Digital Technology in practice(1-5)
E1	male	43	BDS	Private Practice	23	3
E2	male	46	BDS	Private practice	22	5
E3	male	41	BDS	Private practice	10	2
E4	male	38	MDS	Associate Professor	10	2
E5	male	42	MDS	Professor	16	3
E6	Female	38	BDS	Private practice	12	2
E7	male	39	BDS	Private practice	10	5
E8	Female	35	MDS	Reader	8	5
E9	male	43	MDS	Professor	19	5
E10	Female	50	MDS	Professor and Head	21	4
E11	male	37	BDS	Private practice	12	3
E12	Female	45	MDS	Professor	18	2
E13	male	42	MDS	Professor	12	5
E14	male	51	MDS	professor	20	5
E15	Female	45	MDS	Professor	20	5
E16	Female	40	MDS	Assist prof	13	4
E17	male	50	MDS	Professor	20	3
E18	Female	43	MDS	Prof and HOD	15	2
E19	Female	42	MDS	Professor	14	4
E20	male	48	MDS	Professor	17	2
E21	male	45	MDS	Professor	16	1
E22	Female	38	MDS	Asstt Professor	5	2
E23	male	55	MDS	Professor and Head	30	5
E24	Female	50	MDS	Asstt.professor	22	3
E25	male	59	MDS	Prof and HOD	30	5
E26	male	45	MDS	Professor	17	4
E27	male	47	MDS	Professor	23	5

well-recognized consensus method, which is used to determine the extent of agreement on an issue. This process involves formation of a template, used for further rating, which is generally built on either a literature review or pre-existing data. A panel of experts provide their views in a series of ‘rounds’ for identification, clarification, refining the data and finally to achieve a common consensus.<sup>16</sup> As the process is done remotely, findings are usually unbiased as individuals can express their opinion without being influenced by others. Similar to Delphi method, the modified Delphi method is a used to achieve uniform consensus within a group and it involves agreeing to a research question followed by initial literature search to develop a questionnaire. After multiple iterative rounds of questionnaires, feedback is provided to participants between rounds and consequently a summary of the findings is developed.<sup>11,12</sup> Anonymity, iteration, statistical group response and controlled feedback are key feature of this method.<sup>17,18</sup> The benefits of this method included larger number of potential participants, filling of questionnaire remotely and anonymity in the expert panel group which further avoid undue influence between participants in decision making.<sup>19</sup>

Thorough preparation is critical to ensure the validity and accuracy of a Delphi study.<sup>20</sup> After a thorough literature search, a tentative module was prepared in questionnaire form which was divided in 7

sections depending upon the content. 30 Experts were asked about their willingness to be the part of the study, among which 27 accepted and responded the questionnaire. Among 27, 21 participants were also involved in academics along with practice. As the present module of digital dentistry was related to Bachelor of Dental Surgery (BDS) curriculum, 6 BDS practitioners actively involved for more than 5 years in digital dentistry during their clinical practice, were also included among the experts. The common goal behind using experts was to increase the qualitative value and strength of developed recommendations or consensus.<sup>17</sup>

Fig. 2 shows the process of development of the module. In round one 24 content items were presented in 2nd, 3rd and 4th sections. According to the responses/feedbacks achieved, the content items were further modified in all 3 sections, which led to 23 items in final round. For teaching learning method didactic lectures, online/offline videos, demonstration by faculty, Seminar/workshops and online/offline study materials were suggested initially by the core team. Visit to a dental lab to show digital dentistry and its application and hands-on activity on models were added after getting expert’s opinion, which were further added in final consensus. Post lecture assignments, feedbacks, Multiple choice questions(MCQs)/Quizzes, Hands-on on models, viva –voce and Essay/short answer type questions were included as assessment method

**Table 2**

Percentage agreement response of the participants for the content specific questions in Delphi Round-1.

Sr no	Items	Percentage agreement* (Mean ± Std dev)
<b>Introduction of Digital dentistry</b>		
1	Digital soft wares available for Record maintenance	85 (4.40 ± 0.84)
2	Patient interaction tools for patient education and motivation	93 (4.63 ± 0.74)
3	Intraoral scan available	70 (3.85 ± 1.41)
4	Digital learning in education	93 (4.63 ± 0.63)
5	Computer-aided design (CAD) computer-aided manufacturing (CAM) systems-	78 (4.15 ± 1.08)
6	Digital tools helpful in research	81 (4.26 ± 0.86)
7	Tools available for Practice management	89 (4.37 ± 0.79)
8	Digital Investigations tools	81 (4.37 ± 0.93)
9	Difference between real and virtual patient	70 (3.71 ± 1.20)
10	Digital tools to be used for various restorations	78 (4.05 ± 0.95)
11	Advantages/disadvantages of digital dentistry	85 (4.48 ± 0.85)
<b>Diagnosis and Treatment Planning</b>		
1	Transfer of records	93 (4.42 ± 0.64)
2	Optical impressions	89 (4.52 ± 0.70)
3	Digital Radiography	93 (4.86 ± 0.72)
4	Digital smile design	85 (4.33 ± 0.89)
5	Manufacturing devices(CAD/CAM), helpful in treatment planning	89 (4.38 ± 0.89)
<b>Computer aided designing/Computer-aided manufacturing (CAD/CAM)</b>		
1	Digital scanning or digital photography	96 (4.66 ± 0.67)
2	Smile designing	93 (4.57 ± 0.74)
3	Use of CAD/CAM in Intraoral restorations	81 (4.48 ± 0.89)
4	Use of CAD/CAM in Implants positioning	70 (4.24 ± 1.10)
5	Use of CAD/CAM in fabricating Prosthesis	81 (4.33 ± 1.04)
6	Use of CAD/CAM in Occlusal analysis	78 (4.10 ± 1.13)
7	Use of CAD/CAM in Virtual articulators	85 (4.10 ± 0.95)
8	Subtractive and additive manufacturing technique	89 (4.33 ± 0.80)

for the module.

In round 2, a common consensus was found regarding the content of the module, teaching -learning methods and assessments methods however regarding duration of the project, there was response rate of 1:1(7-8 h: 14-15 h), which again needed to be addressed in the 3rd round and according to the responses achieved from senior panellists 14-15 h duration was included in the final module. This duration suggests that Digital Dentistry can be added as Value added course in undergraduate dental education. This leads to a significant finding in the present study.

The present module of digital dentistry have been proposed for BDS students with the objective to introduce and make them aware with digital dentistry. There are certain strengths of this study- Firstly, the study had a 90% response rate (27 out of 30 experts). For achieving this, a strategy was used in the study to maintain the participation by sending extra prompts with specific reminder content.<sup>21</sup> Secondly, by using modified Delphi Technique with a series of questionnaires, helped us in achieving the consensus of expert opinion and this whole process helped in avoiding problems occurring from influence of few powerful participants and group pressures.<sup>19</sup> Thirdly The module was flexible enough to be adopted by other dental institutions depending upon their infrastructure, manpower and support. Depending on the available institutional infrastructure, there is a scope for revision of the module structure. It can alternatively be implemented in various institution as value added course.

It has been noticed that there is no uniform standards in dental education with regard to the application of digital tools. Such standards are essential to ensure uniformity in teaching-learning, which is particularly important for an international exchange.<sup>1</sup> Literature suggest that intraoral scanning and digital impression techniques can be introduced early in the dental curriculum to help the students aware with ongoing development in the computer-assisted technologies used in oral rehabilitative procedures.<sup>22,23</sup>

However any change in curriculum requires internal as well as external motivation at faculty level, institution level, managerial level and regulatory body level. Future research work should focus on implementation of digital dentistry as curriculum based on availability or resources for the undergraduates and also to explicit the learning outcomes of dental students and clinical outcomes in patients that are the endpoints of the educational training. Institutions are now accredited according to their academic performances and with time the best dental institution might be ranked according to their digital infrastructure combined with the level of innovation of the teaching faculty. Thus, Digitalization offers the potential to revolutionize the entire field of dental education.

## 6. Conclusion

Within the limitations of the study, the module of Digital dentistry was developed which can be implemented in most of the dental institutes depending on the resources and available infrastructure. Course integration with digital technology and the clinical workflow will

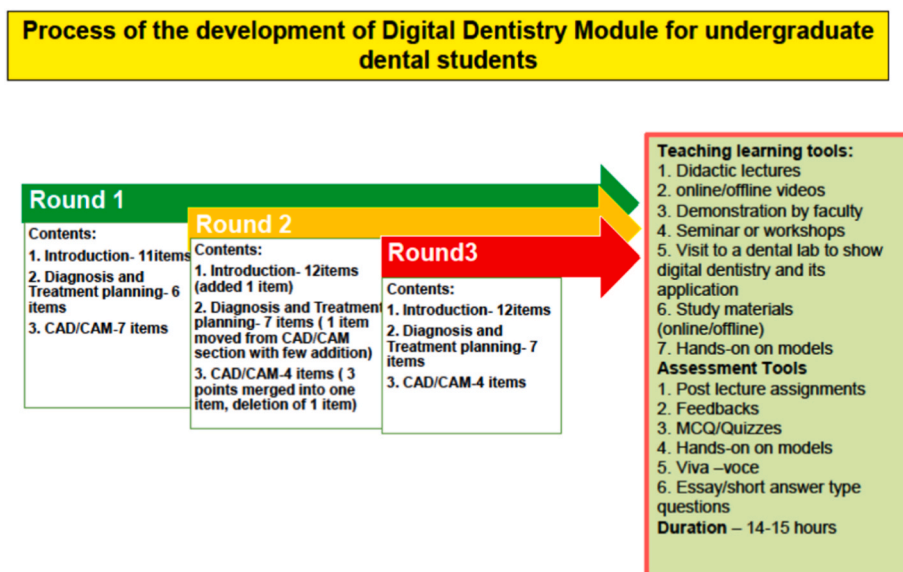


Fig. 2. Process of the development of Digital Dentistry Module for undergraduate dental students.

further provide graduates with the knowledge, skills, and experiences to become competent in providing patient care.

#### Declaration of generative AI and AI-assisted technologies in the writing process

NA.

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