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Assessment of Digital Dentistry Knowledge and Practices Among Dental Students at King Faisal University, Saudi Arabia

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Background: Digital dental (DD) technologies need to be developed for dental use because of the prominent position that these technologies have recently acquired. This 21-item online questionnaire-based study aimed to assess the understanding of DD methods in 120 undergraduate dental students at King Faisal University, Saudi Arabia (SA).

Material/Methods: Electronic surveys were sent to 123 dental students at different study phases (basic, preclinical, and clinical). Dental students were requested to answer the questionnaires in accordance with their knowledge, observations, particular experiences, and DD practice. Data were analyzed using descriptive statistics, which involved numerical values and ratios. Then, the associations among study level, knowledge, practice, and study phases were analyzed using chi-square and Fisher's exact tests.

Results: Completed questionnaires were returned by 120 students. The chi-square test showed significant differences in relation to questions "Do you have any previous knowledge of DD?", "The field that uses DD the most is...", "Does DD provide more precise results than conventional dentistry?", and "Do you know about CAD/CAM?", with *P* values of 0.006, 0.000, 0.018, and 0.002, respectively. Students at clinical phase exhibited significantly higher levels of knowledge than those at the preclinical phase ($P<0.01$). With regard to DD practice, 73.3% of students expressed a negative viewpoint, 82.5% stated that DD is essential for the future, and half said that practicing DD will result in improvements in patient satisfaction, time consumed, and level of predictability.

Conclusions: Students at basic, preclinical, and clinical phases had good knowledge on DD and were motivated to practice it in future in their workplaces.

Keywords: Dentistry • General Practice, Dental • Perception

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Introduction

Digital dentistry (DD) has become popular in recent years, and it now plays a critical role in the advancement of dentistry. It also plays an increasingly important part in driving innovation and shaping students' experiences in today's dental education [1]. The computer has become a part of dentistry and provides more accurate, efficient, and quick treatment to patients compared with traditional dentistry [2,3]. It offers convenience by reducing chairside time and appointment visits and providing an economical treatment [4]. Similarly, it helps reduce the workload of dentists and laboratory technicians so that more patients can be treated. DD data can be stored in computer hardware through an oral scan [5].

Computer-aided design and computer-aided manufacturing (CAD/CAM) is the most frequently used DD [6]. It is a strategy for the future and has opened new paths in dental medicine and dental technology. The modern methods of CAD/CAM are constantly moving in new directions to provide innovative products and systems with the highest quality standards [6,7]. With their help, perfect clinical restorations can be achieved with high biocompatibility, no secondary reactions, excellent esthetics, and improved cooperation between dentists and dental laboratories [6-8].

Traditional laboratory techniques, such as waxing, casting, finishing, and tooth preparation exercises on a phantom head, are still used in most universities to educate dental students at basic and preclinical levels. The challenge is to implement new DD technologies, such as computer-aided learning, without disregarding the importance of manual skills training in dental treatment [9]. The advantage of DD technologies over conventional procedures is the former's accuracy in reproducing details [9,10]. DD technologies have a smooth, flexible workflow and reduce costs and working time [11,12]. With current equipment, radiography has changed from 2D to 3D, and intraoral scanning is used as an alternative of conventional impression systems, prosthetics, and implant software. Milling machines and 3D printers are employed to quickly create esthetic and precise restorations [13], thus increasing efficiency and patient satisfaction [14].

Surveys have been conducted in various countries to assess the knowledge and practice of DD across the globe. In a 2016 survey performed in the UK, 55.6% of the respondents did not use DD because of its high cost [15]. In the Netherlands, DD use is high, especially among practice owners [16]. In India, a study among dental practitioners found that 96.7% of practitioners are aware of CAD/CAM technology in dentistry, and 87% believe that lack of knowledge, not high cost, is the major shortcoming of CAD/CAM [17]. Another study concluded that 74% of undergraduate students are unaware of the materials used to fabricate CAD/CAM prostheses [18]. In Egypt, the market for DD has grown considerably, especially in private dental practice, even though the majority of dentists are working in the governmental sector [19].

Local studies in Saudi Arabia (SA) have shown that the majority of individuals (98.5%) believe that DD improves the quality of dentistry and will ultimately replace traditional dental facilities [20,21]. Madfa et al studied the level of knowledge among preclinical, clinical, and intern students at the College of Dentistry, Hail University, and concluded that DD knowledge gradually increases with the study level [22]. Radwan et al reported that clinical trials and hands-on training courses can help overcome barriers to adoption of new DD [23].

In SA, Alfallaj et al found that only 65.4% of local dental schools integrate DD into their undergraduate curricula [24]. Internationally and in other SA dental colleges, a systematic review concluded that digital technology tools and applications are now prevalent in daily dental medicine and care. At present, digital dental education encompasses several areas of teaching interests, including Web-based knowledge assignment and specific technologies such as digital surface mapping, dental simulator motor skills including intraoral scanner, and digital radiography [25]. A 2024 study by Aldowah et al concluded that dental undergraduate students had limited knowledge about artificial intelligence (AI) as DD, and this type of DD must apply additional effort to prepare students for the era of AI as DD [26]

In 2016, King Faisal University (KFU) launched a 6-year undergraduate Bachelor of Dental Science (BDS) program that consists of 3 study phases. The first phase is the basic studying phase, which covers basic subjects with a minimum number of credit hours; it is usually for the first 2-year program. The preclinical phase is implemented during the third and fourth years, and the clinical phase is the final 2 years of the program and has the largest number of credit hours among the 3 phases. Since the launch of the program, 9 student cohorts have been enrolled, and 3 cohorts of graduates have been produced over 3 years [27]. Only a few courses are conducted on DD during the undergraduate program at different phases. The teaching modules are a lecture-based instruction for basic phase and a mixture of individual and inquiry-based learning in preclinical and clinical phases.

Given the importance of DD for future practice, DD has been studied by various scholars. Research on the use of DD among SA dental students needs to be conducted to thoroughly recognize the current situation, address the knowledge gap in this vital field, and offer a basis for future research. Scientific investigation is also necessary to help academicians assess the present situation, adjust curricula appropriately, and enhance

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future developments in this crucial field [22]. Therefore, this 21-item online questionnaire-based study aimed to evaluate the understanding of digital dentistry methods in 120 undergraduate dental students at King Faisal Complex, SA.

Material and Methods

The study was performed in accordance with the principles of the Helsinki Declaration [28] and was approved by the Institutional Ethics Review Board Committee of the College of Dentistry, KFU, SA (KFU-REC-2022-NOV-ETHICS353).

Study Design, Setting, and Population

A cross-sectional, Web-based online questionnaire study was performed among dental students in the basic, preclinical, and clinical phases of their education through an e-survey using Google Forms between November and December 2022. All regular students (2nd-6th year or basic–clinical) at the time the research was conducted were involved. A total of 123 questionnaires were sent to the regular students (the total number of students in the different studying phases). Aside from age and study section, the questionnaire had 3 other parts.

Study Tools and Data Collection

A 21-item closed-question questionnaire that included the study phase was adopted from previous local [20-24] and global studies [15-18,29] published recently with some modifications. The survey questionnaire was translated into Arabic with the assistance of a native Arabic speaker; later, the forms of questions were exposed to forward and backward translation into English [30,31]. The questionnaire's validity was judged by a panel of 10 subject-matter experts. Reliability was established by conducting a test–retest among 12 volunteer participants. The kappa value was 0.85, which indicated high reliability. The test–retest was followed by pilot testing among 12 volunteers who were asked to answer the questionnaire and provide feedback on its content, clarity, and brevity. Squared boxes were provided, and students from different study phases had to select a single option for each question. A student could only respond to the questionnaire once, and all questions needed to be answered. The answers were directly documented through Google Forms. Informed consent was asked for in the Google Form, and the questionnaire copies were sent through WhatsApp.

Questionnaire Parts

An English version of a Web-based, self-administrated survey separated into 3 parts was circulated. The questionnaire comprised a brief clarification of the aim of the study, the process of data gathering, and closed-ended queries. The first part of the questionnaire involved questions about age and study phase (basic, preclinical, clinical). The second part consisted of 14 questions on overall knowledge and awareness of DD. The last part of the questionnaire comprised 5 questions related to the practice of DD. Feedback was entirely anonymous to ensure confidentiality, and a consent form was enclosed with the questionnaire.

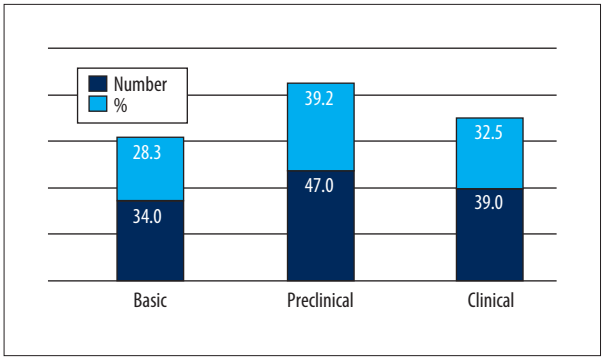

Figure 1. Distribution of participants on the basis of study phase.

Statical Analysis

The collected information was analyzed using the statistical software R version 4.2.2 (R Foundation for Statistical Computing) and Microsoft Excel. Categorical variables were signified by frequency and ratio. Chi-square and Fisher's exact tests were used to check the association between categorical variables. *P* values less than or equal to 0.05 indicated statistical significance.

Results

Participants Characteristics

Out of the 123 questionnaires sent to all students in different study phases, 120 were sent back with answers; the overall response rate was 97%. The number (percentage) of students was 34 (28.3%), 47 (39.2%), and 39 (32.5%) for basic, preclinical, and clinical phases, respectively (**Figure 1**). The dental students' ages were 19-24 years, with a mean age and standard deviation of 21.19±3.662 years.

Participant's Understanding and Awareness of Digital Dentistry

Table 1 presents the responses of the students in relation to knowledge and awareness of DD in their school. Two-thirds of the students responded positively to the questions "How skillful are you with computers?" and "Do you have any previous

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Table 1. Responses of the participants regarding their knowledge and awareness of digital dentistry.

Variable	Answer	N (%)
How skillful are you with computers?	Very good	43 (35.8)
	Good	75 (62.5)
	Non	2 (1.7)
Do you have any previous knowledge on digital dentistry?	Yes	76 (63.3)
	No	44 (36.7)
The field that uses digital dentistry the most is...	General dentistry	31 (25.8)
	Periodontics	5 (4.2)
	Prosthodontics	39 (32.5)
	Maxillofacial surgery	11 (9.2)
	Orthodontics	22 (18.3)
	Endodontology/restorative dentistry	12 (10.0)
Does digital dentistry provide more precise results than conventional dentistry?	Yes	110 (91.7)
	No	10 (8.3)
How much do you think digital dentistry improves work efficiency in the dental laboratory?	A lot	97 (80.8)
	Some	23 (19.2)
	Very little	00 (0.0)
Has digital dentistry replaced traditional dentistry?	Yes	101 (84.2)
	No	19 (15.8)
Does your curriculum include a course on Digital Dentistry?	Yes	18 (15.0)
	No	88 (73.3)
	I don't know	14 (11.7)
Are there any dental schools that teach digital dentistry in their BDS curriculum in Saudi Arabia?	Most of them	12 (10.0)
	A few	69 (57.5)
	None	39 (32.5(
Do you think that the widespread implementation of digital technologies will have a negative effect on the number of employees in dental laboratories?	Yes	104 (86.7)
	No	16 (13.3)
How do you know about digital dentistry?	Friends	18 (15.2)
	College	27 (22.2)
	Media	51 (42.5)
	Textbooks	14 (11.7)
	Conferences and workshops	10 (8.3)
Does digital dentistry require skills and training?	Yes	89 (74.2)
	No	31 (25.8)

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Table 1 continued. Responses of the participants regarding their knowledge and awareness of digital dentistry.

Variable	Answer	N (%)
What materials can be processed using dental technology?	Ceramic	71 (59.2)
	Polymers	12 (10.0)
	Alloys/metals	10 (8.3)
	All of the above	16 (13.3)
	I don't know	8 (6.7)
Did you know about CAD/CAM?	Yes	97 (80.8)
	No	23 (19.2)
Did you know about 3D?	Yes	24 (20.0)
	No	96 (80.0)

Table 2. Responses of the participants regarding their practice of digital dentistry.

Variable	Answer	N (%)
Do you monitor the development of digital dentistry?	Yes	57 (47.5)
	No	63 (52.5)
Is digital dentistry the future of dentistry?	Yes	99 (82.5)
	No	21 (17.5)
Do you practice digital dentistry?	Yes	32 (26.7)
	No	88 (73.3)
Will the practice of digital dentistry will improve related factors?	Patient satisfaction	14 (11.7)
	Time consumed	21 (17.5)
	Level of predictability of outcome	22 (18.3)
	More than one	63 (52.5)
Do you think the quality of patient care will decline if digital dentistry is used?	Yes, absolutely	28 (23.3)
	To some extent	46 (38.3)
	Not at all	46 (38.3)

knowledge of DD?" A large percentage of the respondents (32.5%) stated that prosthodontic specialty is the most common among all topics in DD. The questions "How much do you think DD improves work efficiency in the dental laboratory?", "Has DD replaced traditional dentistry?", and "Do you think that the widespread implementation of digital technologies will have a negative effect on the number of employees in dental laboratories?" elicited the answers "a lot" and "yes" from 97 (80.8%), 101 (84.2), and 104 (86.7) students, respectively.

The question "Does DD require skills and training?" The response rate for this question was less than for the overall responses (89, 74.2%). "Does DD provide more precise results than conventional dentistry?" Dental ceramic was the most utilized and processed material (71, 59.2%) in dental technology in comparison with other dental materials, followed by polymers (12, 10%) and different alloys and metals (10, 8.3%). Most of the respondents (96, 80%) did not know about 3D DD, and nearly the same number and percentage of respondents were familiar with CAD/CAM technology (**Table 1**).

Understanding of Participants Regarding Their Practice of Digital Dentistry

With regard to the practice of DD among the 120 participants, as shown in **Table 2**, most of the respondents (88, 73.3%) did not practice DD, but most of them (99, 82.5%) said that DD is the future of dentistry. More than half of the participants stated that practicing DD will result in improvements in all factors, such as patient satisfaction, time consumed, and level of predictability.

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Table 3. Responses of the participants about the influence of study level on digital dentistry knowledge (chi-square or Fisher's exact test).

Variable	Response	Basic N (%)	Preclinical N (%)	Clinical N (%)	P value
How skillful are you with computers?	Very good	10 (29.4)	19 (40.4)	14 (35.9)	0.372[b]
	Good	24 (70.6)	28 (59.6)	23 (59.0)	
	No	0 (0.0)	0 (0.0)	2 (5.1)	
Do you have any previous knowledge on digital dentistry?	Yes	16 (47.1)	28 (59.6)	32 (82.1)	0.006[a]*
	No	18 (52.9)	19 (40.4)	7 (17.9)	
The field that uses digital dentistry the most is...	General dentistry	10 (29.4)	18 (38.3)	3 (7.7)	0.000a*
	Periodontics	3 (8.8)	0 (0.0)	2 (5.1)	
	Prosthodontics	5 (14.7)	19 (40.4)	15 (38.5)	
	Maxillofacial surgery	3 (8.8)	7 (14.9)	1 (2.6)	
	Orthodontics	9 (26.5)	3 (6.4)	10 (25.6)	
	Endodontology/ restorative dentistry	4 (11.8)	0 (0.0)	8 (20.5)	
Does digital dentistry provide more precise results than conventional dentistry?	Yes	28 (82.4)	43 (91.5)	39 (100.0)	0.018[a]*
	No	6 (17.6)	4 (8.5)	0 (0.0)	
How much do you think digital dentistry improves the work efficiency in dental laboratories?	A lot	27 (79.4)	36 (76.6)	34 (87.2)	0.455[a]
	Some	7 (20.6)	11 (23.4)	5 (12.8)	
	Very little	0 (0.0)	0 (0.0)	0 (0.0)	
Has digital dentistry replaced traditional dentistry?	Yes	29 (85.3)	37 (78.7)	35 (89.7)	0.381[a]
	No	5 (14.7)	10 (21.3)	4 (10.3)	
Does your curriculum include a course on Digital Dentistry?	Yes	10 (29.4)	19 (40.4)	14 (35.9)	0.336[b]
	No	24 (70.6)	28 (59.6)	23 (59.0)	
	I don't know	0 (0.0)	0 (0.0)	2 (5.1)	
Are there any dental schools that teach digital dentistry in their BDS curriculum in Saudi Arabia?	Most of them	1 (2.9)	7 (14.9)	4 (10.3)	0.256[b]
	A few	24 (70.6)	25 (53.2)	20 (51.3)	
	None	9 (26.5)	15 (31.9)	15 (38.5)	
Do you think that the widespread implementation of digital technologies will have a negative effect on the number of employees in dental laboratories?	Yes	34 (100.0)	38 (80.9)	32 (82.1)	0.011[b]*
	No	0 (0.0)	9 (19.1)	7 (17.9)	
How do you know about digital dentistry?	Friends	2 (5.9)	9 (19.1)	7 (17.9)	0.067[b]
	College	10 (29.4)	14 (29.8)	3 (7.7)	
	Media	13 (38.2)	18 (38.3)	20 (51.3)	
	Textbooks	5 (14.7)	5 (10.6)	4 (10.3)	
	Conferences and workshops	4 (11.8)	1 (2.1)	5 (12.8)	

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Table 3 continued. Responses of the participants about the influence of study level on digital dentistry knowledge (chi-square or Fisher's exact test).

Variable	Response	Basic N (%)	Preclinical N (%)	Clinical N (%)	P value
Does digital dentistry require skills and training?	Yes	20 (58.8)	37 (78.7)	32 (82.1)	0.063[a]
	No	14 (41.2)	10 (21.3)	7 (17.9)	
What materials can be processed using dental technology?	Ceramic	21 (61.8)	24 (51.1)	26 (66.7)	0.000[b]*
	Polymers	6 (17.6)	4 (8.5)	2 (5.1)	
	Alloys/metals	3 (8.8)	8 (17.0)	2 (5.1)	
	All of the above	4 (11.8)	11 (23.4)	1 (2.6)	
	I don't know	0 (0.0)	0 (0.0)	8 (20.5)	
Did you know about CAD/CAM?	Yes	25 (73.5)	34 (72.3)	38 (97.4)	0.002[a]*
	No	9 (26.5)	13 (27.7)	1 (2.6)	
Did you know about 3D?	Yes	8 (23.5)	11 (23.4)	5 (12.8)	0.405[a]
	No	26 (76.5)	36(76.6)	34 (87.2)	

[a] Pearson's chi-square test; [b] Fisher's exact test; * significant differences at p≤0.05.

Association Between DD Awareness and Knowledge and Study Level

Table 3 shows the correlation of the knowledge parameter to DD and students in different study phases. The clinical-phase students recorded the largest numbers and percentages of responses to the questions/statements "Do you have any previous knowledge of DD?" (32, 82.1%), "Prosthodontic specialty is the field that uses DD the most" (15, 38.5%), "Does DD provide more precise results than conventional dentistry?" (39, 100%), and "Ceramic is the most common material that can be processed using DD" (26, 66.7%).

The chi-square test showed significant differences in relation to the questions "Do you have any previous knowledge about DD?", "The field that uses DD the most is...", "Does DD provide more precise results than conventional dentistry?", and "Do you know about CAD/CAM?", which had *P* values of 0.006, 0.000, 0.018, and 0.002, respectively (**Table 3**). Fisher's exact test showed a significant difference in relation to the questions "Do you think that the widespread implementation of digital technologies will have a negative effect on the number of employees in dental laboratories?" and "What materials can be processed using dental technology?", which had *P* values of 0.011 and 0.000, respectively (**Table 3**).

Association Between Practice of Participants and Study Level

In relation to the practice of DD, the chi-square test showed no significant differences in the responses of the students at different study levels to the questions "Do you monitor the development of digital dentistry?", "Is the digital dentistry the future of dentistry?", "Do you practice DD?", "Will the practice of digital dentistry improve related factors", and "Do you think the quality of patient care will decline when DD is used?", which had *P* values of 0.403, 0.126, 0.155, 0.403, and 0.359, respectively (**Table 4**).

Association Between Digital Dentistry Improvement and Clinical Practice Among Study Levels

The students at different study levels accounted for the highest percentage of the positive responses to the statement that DD results in improvements in patient satisfaction, time consumed, and level of predictability of outcomes, with 61.7%, 50.0%, and 43.6% for preclinical, clinical, and basic students, respectively. Most of them stated that the quality of patient care will decline during the use of DD; the number (percentage) of students who answered "yes," "to some extent," and "no" was 28 (23.3%), 46 (38.3%), and 46 (38.3%), respectively (**Figure 2**). Moreover, with regard to knowledge about DD, most of the students answered that prosthodontics is the field that uses DD the most; the preclinical, clinical, and basic students produced response rates of 40.4%, 38.5%, and 14.7%, respectively. Additionally, the students believed that dental ceramic is the most suitable material to be processed by DD, with response rates of 66.7%, 61.8%, and 51.1% from the clinical, basic, and preclinical students, respectively (**Figure 2**).

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Table 4. Responses of the participants about the influence of study level on digital dentistry practice.

Variable	Response	Basic N (%)	Preclinical N (%)	Clinical N (%)	P value
Do you monitor the development of digital dentistry?	Yes	19 (55.9)	19 (40.4)	19 (48.7)	0.403[a]
	No	15 (44.1)	28 (59.6)	20 (51.3)	
Is digital dentistry the future of dentistry?	Yes	27 (79.4)	36 (76.6)	36 (92.3)	0.126[a]
	No	7 (20.6)	11 (23.4)	3 (7.7)	
Do you practice digital dentistry?	Yes	5 (14.7)	14 (29.8)	13 (33.3)	0.155[a]
	No	29 (85.3)	33 (70.2)	26 (66.7)	
Will the practice of digital dentistry improve related factors?	Patient satisfaction	7 (20.6)	5 (10.6)	2 (5.1)	0.403[a]
	Time consumed	4 (11.8)	8 (17.0)	9 (23.1)	
	Level of predictability of outcomes	6 (17.6)	5 (10.6)	11 (28.2)	
	More than one	17 (50.0)	29 (61.7)	17 (43.6)	
Do you think the quality of patient care will decline if digital dentistry is used?	Yes, absolutely	5 (14.7)	12 (25.5)	11 (28.2)	0.359[a]
	To some extent	13 (38.2)	21 (44.7)	12 (30.8)	
	Not at all	16 (47.1)	14 (29.8)	16 (41.0)	

[a] Pearson's chi-square test.

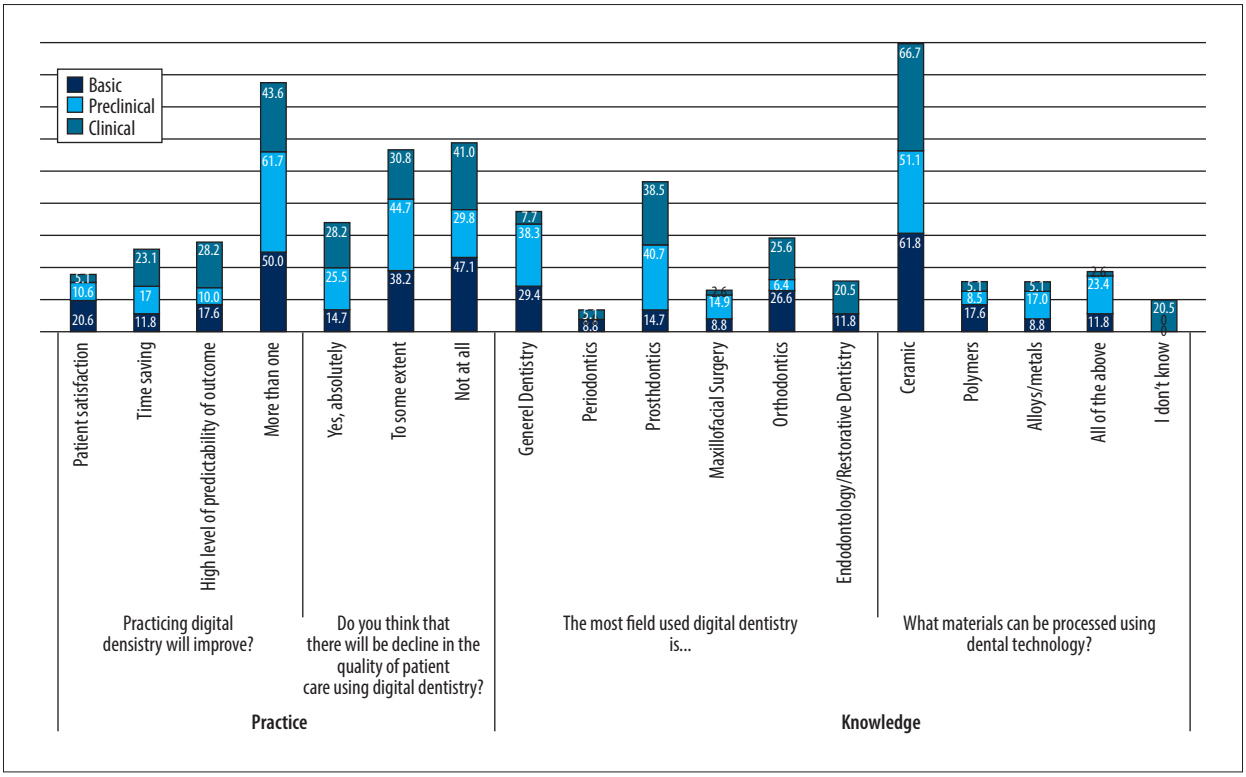

Figure 2. How digital dentistry improves clinical practice and knowledge among students at different study levels.

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Discussion

Enhancing students' views about DD from the perspective of dental educators is necessary for students to be involved in DD after graduation. The use of DD throughout dental measures, together with relevant experiences in using recent equipment, good information, and ample training time, can help students develop favorable attitudes toward the use of DD. Doing so might increase the adoption of this technology [20]. The objective of this study was to evaluate the knowledge and practice of dental students at basic, preclinical, and clinical study phases at the College of Dentistry, King Faisal Complex, SA, regarding the application of DD.

The students in this study showed a favorable perception of DD at all study levels (basic, preclinical, and clinical), but the value for the clinical-phase students was slightly higher than those of students in the other phases. The overall results revealed that the students have ample knowledge, and they are ready to use DD in their future practice, although most of them do not practice DD yet. Our overall results vary from those of previous local studies [20,22,23] that showed that students at the clinical level use DD more than basic or preclinical students. This could be possibly because these previous studies compared undergraduate students. This result also disagrees with those of some international studies [16,32] because those studies conducted surveys among dental practitioners and graduate students, whereas the present study was conducted among undergraduate students only.

Since digital simulation systems have previously been involved in dental curricula for undergraduate students in several countries, dental students should have some knowledge and awareness of these technologies, including digital microscopes, virtual pathology slides, digital X-ray images, and DD skill training machines [22]. The most common prosthesis students fabricate via CAD/CAM is single crowns [24]. However, dental schools encounter issues in the integration of DD into their regular curricula [20]. Most of the students (80%) at different study levels in the current study had a high percentage of knowledge about CAD/CAM, and this result is in agreement with those of many previous local studies [20,22] and international studies. For example, a Romanian study conducted by Diaconu-Popa revealed that dental students theoretically know about CAD-CAM [33]. Meanwhile, knowledge of CAD/CAM is limited to preclinical dental students in Pakistan [34], dental students in India [18], and general practitioners in Egypt, where 47.3% of participants have moderate knowledge [29].

In the current study, 63.3% of students had knowledge of DD, and most of them answered positively to the related questions. This result is unsurprising and agrees with those of prior research that identified time as a critical topic for dental program administrators due to the extreme amount of information distributed to students [35]. The students in the current study had a favorable attitude toward DD, a result that agrees with prior research [36,37] on different subjects that used DD during their study. Students are well motivated to gain knowledge about different types of DD and to use DD during their study or in their practice after graduation.

In the current study, with regard to the questions pertaining to DD knowledge, 42.5% said that they knew about DD from media, and only 22.2% found out about DD in college. This finding is in contrast to those of Ibrahim et al and Madfa et al, who reported that 91% of students know about DD in college [20,22] and those of Radwan et al, who reported that most dentists find out about DD from their courses and workshops [23]. This variation is likely due to the fact that these previous studies were conducted on practicing dentists with various specialties. Aldowah et al reported that most (77.6%) AI information accessed by Saudi undergraduate students came from social media [26].

Knowledge of CAD/CAM was slightly higher (72.3%) among students in this study than reported by previous studies of preclinical dental students [34] and from the results of Mhanni et al, who reported that only 35% of undergraduate students have seen a CAD/CAM unit [38]. Diaconu-Popa found that all students have theoretical knowledge about the digital technology CAD/CAM [33]. These results emphasize the importance of sending different messages through different media platforms and the need for conferences and seminars in colleges, cities, and countries.

The current study showed that students think that prosthodontics is the field that uses DD the most, and the specialty that uses DD the least is periodontitis. This finding totally agrees with results recently published by Aldowah et al, reporting 33.9% and 6.7% for the same specialty [26], but disagrees with those of many previous studies [24,39,40] that reported DD is mostly implemented in digital radiography, 2D digital radiography, and cone beam computed tomography, and implemented the least in the digital manufacturing of completely removable dentures. This difference can be explained by the fact that these previous surveys were conducted among general practitioners and graduated dentists who were practicing dentistry in private clinics, whereas the current study was conducted among dental students only.

Students are immersed in DD, so they are characteristically excited about practicing the technology in their forthcoming jobs [41,42]. However, no studies on students' actual practice of DD have been published in SA. The current study revealed that 52.5% of the participants at the basic, preclinical, and clinical phases stated that using DD improves patient satisfaction by 11.7% and time consumption by 17.5%. This finding varies from that of Madfa et al [22], who found 94.3%. Moreover, practicing DD improves the quality of clinical practice.

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Most previous studies were conducted on practicing dentists and intern students, so their practice results are higher than the current results because most of the participants in the current research were basic and preclinical students. The current study also showed that most students think that DD requires skills and training and believe that DD is of better quality than traditional dentistry and could replace the latter. This finding is consistent with results obtained from other colleges in SA [20,22].

The current study found that most students think that DD is the future of dentistry, although only less than one-third of the students practice DD. This situation can be explained by the fact that most of the students are still enrolled in the BDS program. This result does not agree with those of Madfa et al, who reported that most students use DD. Notably, their study included respondents from high study levels, such as preclinical–clinical and interns [22]. With regard to the practice of DD, the present study found no significant differences between students' levels, and this finding is consistent with those of previous local studies conducted recently on preclinical, clinical, and dental interns [20,22].

Dental students [43] and dentists [44] should utilize DD to improve their educational experience and future career. DD has gained in popularity not only among dental educators but also among behavioral, social, and educational professionals [16,32,33]. In the current study, the students had a favorable attitude about practicing DD at all study levels (basic, preclinical, and clinical), but most of them did not practice DD yet. This result varies from those of other studies [20,22], which showed that almost 87% of dental students use DD. This variation may be explained by the fact that these previous studies were conducted on students at high study levels. Dental students use different types of DD during their training, and emphasizing the value of using DD influences their willingness to use and practice it in the future. Consequently, future attempts to advance DD education should focus on elements associated with students' behavioral intentions [20].

Overall, DD has advantages in several dental disciplines. Its digital dental workflow contributes to increased safety, reduces the length and number of dental appointments, entails minimally invasive surgical procedures, and decreases the contact between basic and preclinical dental laboratories and clinical practicing subjects. Moreover, as DD develops it may replace some other topics in the curriculum. One of the problems is that students may prefer to connect with DD rather than patients, staff, and colleagues; in this case, their ability to engage patients may diminish. An additional topic of interest is the possible lack of manual dexterity of dental students, which may hinder their ability to conduct dental services using analog methods at the required competency levels [44]. Understanding educational methodologies is critical to maximizing educational effectiveness as learning methods and tools advance [45]. However, dental schools encounter several issues in the integration of DD into their regular curricula [20].

Future narrow-focus, reliable, validated studies that explore the application of certain DD technologies might enhance the current curricula in different BDS programs. Follow-up observational and survey studies are highly recommended to observe the future integration of DD into Saudi dental schools' curricula and compare SA's dental schools with other leading dental schools worldwide. In addition, a demonstrative sample of students at different study levels from each local dental school could be used in an investigation to determine the effectiveness of incorporating DD into curricula and measure student satisfaction and confidence in undertaking DD as digital workflow [24].

This study is a first to highlight the importance, knowledge, and practice of digital dentistry among dental college students, and the inclusion of such courses in BDS programs. Further studies in similar dental and other medical fields should be conducted. One of the limitations of this study is that the questionnaire did not include all types of dental technology, such as intraoral scanners and recently developed 3D machines. Moreover, the study examined only 1 dental college, and dental technicians were excluded because they are a basic partner in the field of DD.

Conclusions

The following conclusions were obtained.

- The students (basic, preclinical, and clinical) had good knowledge of DD and were motivated to practice it in the future in their workplaces, although most of them had not practiced it yet. The students at all study phases reported that DD is better than traditional methods in various dental procedures.
- A strong relationship was found between students' knowledge and level of study and the use of DD in their training.
- Most students reported that DD helps improve the practice of dentistry and is more time- and effort-saving than traditional methods. However, the students stressed the need for further training to increase skills in this aspect.
- The inclusion of DD in the curriculum of undergraduate dental students in the BDS program is beneficial for the dental profession because it can enhance the competency of qualified dentists.

Department and Institution Where Work Was Done

This work was carried out at the College of Dentistry, King Faisal University, Hofuf, Saudi Arabia.

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Declaration of Figures' Authenticity

All figures submitted have been created by the authors, who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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