ORIGINAL ARTICLE

Levels and Predictors of Digital Literacy Skills Among Dental Students: A Multi-institutional Study in Malaysia

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ABSTRACT

Introduction: The greatest challenge in dental education is the need to adapt consistently and adjust to the advancement of digital dentistry and its application in dental practice. Thus, the scarcity of digital literacy (DL) levels among Malaysian dental students must be addressed to identify areas in dental education that need improvement. **Materials and methods:** Online self-administered questionnaires were distributed to 668 Malaysian dental students that have been proportionately sampled. A total of 501 (75% response rate) dental students from 11 dental schools completed the validated questionnaire. The mean score of the DL level was analysed with the p-value set at 0.05. **Results:** The majority of Malaysian dental students reported high skill levels in 'uploading documents online' (95.21%), 'sending and receiving e-mails' (94.61%), and 'using different social media platforms' (92.41%). Overall, the mean score of the dental students' DL level was considered to be in the 'moderate' range with a mean score of 31.13 (SD ± 4.95). After adjusting the relevant confounders, multiple linear regression predicted that dental students from public dental schools positively influence the DL level (p= 0.026). **Conclusion:** Malaysian dental students possess a moderate level of DL skills. Current dental education and training need to prioritize efforts to increase DL levels among undergraduates. This data presents an opportunity for policymakers and educators to modify the current educational method to advance students' current learning methods.
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INTRODUCTION

Digital literacy (DL) is the ability to use information and communication technologies to find, evaluate, create, and communicate information, requiring cognitive and technical skills (1). Initially described by Gilster (1997), DL encompasses understanding and utilising data in diverse formats via computers and networked mediums (2). DL is a theoretically multidimensional concept, warranting exploration concerning dimensions such as age and gender, which bear significance (3). DL constitutes a crucial skill set for students' educational advancement amidst dynamic global transformations (4).

A digitally literate individual exhibits quick adaptability to emerging technologies, grasps new means of communication, and possesses awareness, attitude, and proficiency in identifying, accessing, managing, integrating, evaluating, analysing, and synthesising digital resources. This empowers them to construct new knowledge, create media expressions, and effectively communicate with others. A study by Ng (2012) proposed DL model identified three primary literacy domains that existed: technical, cognitive, and socioemotional (5). In the Malaysian context, the implications of new digital technologies for redefining content and literacy, particularly among Malaysian youths and students, have yet to be fully explored. Consequently, educators and students must reconsider what literacy means in today's digital world (6). In contemporary literacy research, it is essential not to define DL as merely a technical skill narrowly. Such an approach could overlook the interconnectedness of online activities with broader social and cultural issues (7).

In the local setting, there is a growing concern among stakeholders, particularly academicians, regarding digital literacy, which has become increasingly prominent in recent times (8). In 2024, the Malaysian government recently mandated that all government

servants undergo an online digital literacy assessment across ministries. This initiative aligns with the Malaysia Digital Economy Blueprint (MyDigital), launched in 2021, to set the nation's digital economic direction and lay the groundwork for advancing digital initiatives across government, public, and business clusters (9). It aims to achieve the government's aspiration of 100% competence in DL among civil servants by 2025.

In the dental profession, future dentists will be required to utilise more computers and digital skills significantly than today's dental practitioners in their daily practice. Appropriate use of contemporary technologies will allow for a higher quality of care while increasing efficiency and productivity. Patients will profit from these beneficial advancements simultaneously (10).

DL should become a prerequisite ability for future health professionals to facilitate the application and exploit the potential of digital technology to promote health, digital health literacy, and digital skills. Dental education and curriculum in the twenty-first century need to promote higher levels of DL, and both educators and dental students need to learn knowledge and technology in dentistry (11). Thus, the objectives of this study are:
1. To determine the DL skill levels among Malaysian dental students
2. To predict DL skill levels among Malaysian dental students based on their sociodemographic profiles.

MATERIALS AND METHODS

Study Population

This study involved all undergraduate students in 13 dental schools across Malaysia, comprising six public and seven private universities. Figure 1 provides an overview of the geographical distribution of these 13 dental schools throughout Peninsular Malaysia. In 2021, the total number of undergraduate dental students in Malaysia was N= 3573, with public universities accounting for n= 1651 (46.21%) of the total and private universities constituting n= 1922 (53.69%).

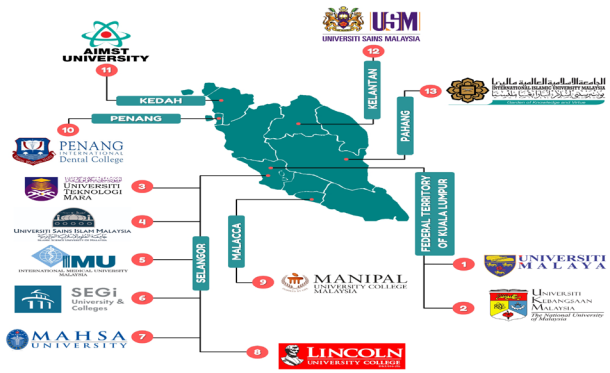

Figure 1: Dental Schools in Malaysia.

Sample Size Calculation

The required calculated sample size for this study with a confidence level of 95% and a margin of error of 4% is 514. A non-response rate of 30% was included to project the final minimum sample size of n= 668. This study employed a multistage probability stratified random sampling method, as illustrated in Figure 2. The first stratification was divided proportionately by the university sectors: public (46.21%, n= 309) and private (53.79%, n= 359) over the total enrolment of dental students in Malaysia. Next, dental students were stratified proportionately into the gender of male and female dentists at 1:4, considering the current ratio of male to female dentists in Malaysia (12).

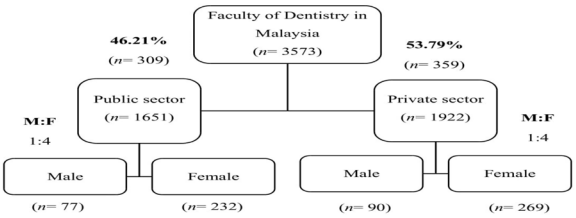

Figure 2: Flowchart shows a multistage probability with proportionate stratified random sampling technique for the study.

Realiability of the study tool

The measurement tool utilised was a structured and validated set of questionnaires used in an African study by Baro et al., (2019) (13). A pilot study was then conducted to assess the reliability of each section of the questionnaire. A total of 44 dental graduates awaiting posting (GAP) dental students were included from local public universities (n= 35), and private universities (n= 9) participated in evaluating the reliability of the questionnaire. No changes were applied, considering the internal consistency of the questionnaire was acceptable using Cronbach's alpha index ($\alpha = 0.70$).

Data collection

A separate brief introduction email was submitted to the respective Deans' email and their faculty of dentistry official email addresses. The email consisted of a brief introduction and study description, a summary of research methods, a description of participants and the basis of their selection, recruiting procedures and documents, a copy of written informed consent forms, a link for the questionnaire, the plan for maintaining the confidentiality of records, and the data collection protocol. After obtaining approval from the Deans of dental faculties across Malaysia, data collection for the study commenced. Contact information, including email addresses, phone numbers, student IDs, and genders of dental students, was obtained through respective university liaison officers. A regular communication was maintained to coordinate the research process.

To maintain anonymity of study participants during data collection, only student IDs and emails were provided without disclosing their names. A total of 668 dental students were identified through randomisation using simple random sampling in Microsoft Excel 2021 based on their student identification numbers (IDs) and genders across the 11 dental schools. After randomisation, the researcher contacted these participants using contact information obtained from their universities, primarily emails and phone numbers. Participants were emailed and contacted individually to complete the online questionnaire on Google Forms over one month from June 1st to June 30th, 2022. The questionnaire link on Google Forms was distributed anonymously to participants. Due to compliance with the Malaysian Personal Data Protection Act 2010, which restricted access to student emails and phone numbers at private universities, the researcher coordinated with university personnel or representatives to facilitate distribution and reminders for questionnaire completion. Weekly reminders were sent to both students and university contacts to encourage participation.

Data analysis

The descriptive data on demographic profiles and the DL level were analysed by calculating frequencies and percentages for categorical variables and mean and standard deviation (SD) for continuous variables.

In order to determine the association between independent and dependent variables, a total mean score of DL level was calculated by a visual binning method in IBM SPSS 28.0.0.0 as shown in Table I. Visual binning is an alternative recoding procedure that allows the researcher to recode a quantitative variable into a discrete category by numbering it into bins, groups, or cases (14). In this study, the dependent variables of the DL skill level were analysed as ordinal variables. The categorisation consisted of determining two cut points with an equal number of cases in each bin using the total scores of the level of DL skills (14, 15). Thus, three categories of DL skill levels were generated: low, moderate, high.

Table I: Total Mean Score of DL Interpretations

B-Level of DL Skills	Total Mean Score
Low	≤ 29.00
Moderate	29.01 – 32.99
High	≥ 33.00

For the multivariate analyses, simple and multiple linear and logistic regression were employed to determine the predictor(s) contributing to the level of DL skills among the study respondents. Odds ratios and 95% confidence interval were computed. P-value < 0.05 is considered significant for the final analysis.

Ethical clearance

This study was approved by the UiTM Faculty of Dentistry Research Ethics Committee (FRC) in March 2022 Research Ethics Committee (REC) [FRC/01/2022 (HE/6/13)].

RESULTS

Respondents' Demographic Profiles

The total respondents were 501 from 668 (75%) dental students. Only 501 of the 519 samples were willing to participate in the final survey. Most respondents (77.64%) were female dental students, Malays (72.06%), studying in a public institution (58.8%), and were in their Clinical Years (64.67%).

DL Skills Level Among Respondents

Table II shows a descriptive analysis of the respondents' DL skills level. Most of the dental students reported having moderate skills in database search skills, n= 224 (44.71%) and metadata development skills, n= 264 (52.69%), applying new technologies, n= 219 (43.71%) and website development skills, n= 201 (40.12%). The respondents reported that most have a high level of digitalisation skills, n= 238 (47.50 %), sending and receiving emails, n= 307 (61.28%), uploading documents, n= 324 (64.67%), and skills in using different social media, n= 242 (48.30%). However, the findings show that most dental students have difficulty developing website skills (M= 2.19, SD= 0.88). In general, it can be concluded that almost all Malaysian dental students' DL level is at a moderate level (M= 31.13, SD= 4.95).

Table II: Distribution of the level of DL skills possessed by the participants by items

No.	B Level of DL Skills	Low		Moderate		High		Very High		Mean (SD)
		n	%	*n*	%	*n*	%	*n*	%	
1.	Database search skills	31	6.19	224	44.71	222	44.31	24	4.79	2.48 (0.69)
2.	Metadata development skills	57	11.38	264	52.69	165	32.93	15	2.99	2.28 (0.70)
3.	Digitalisation skills	42	8.38	184	36.73	238	47.50	37	7.39	2.54 (0.75)
4.	Sending and receiving e-mails	2	0.40	25	4.99	167	33.33	307	61.28	3.55 (0.61)
5.	Uploading documents to online platforms	1	0.20	23	4.59	153	30.54	324	64.67	3.60 (0.59)
6.	Skills in using different social media	1	0.20	37	7.39	221	44.11	242	48.30	3.41 (0.63)

CONTINUE

Table II: Distribution of the level of DL skills possessed by the participants by items. (CONT.)

No.	B Level of DL Skills	Low		Moderate		High		Very High		Mean (SD)
		n	%	*n*	%	*n*	%	*n*	%	
7.	Digital development skills	27	5.39	178	35.53	235	46.91	61	12.18	2.66 (0.76)
8.	Applying new technologies into dental services	26	5.19	219	43.71	206	41.12	50	9.98	2.56 (0.74)
9.	Website development skills	121	24.15	201	40.12	144	28.74	35	6.99	2.19 (0.88)
10.	Ability to create different file formats (Pdf, gif, bitmap, jpg)	7	1.40	95	18.96	210	41.92	189	37.72	3.16 (0.77)
11.	Ability to use open-source software	54	10.78	141	28.14	200	39.92	106	21.16	2.71 (0.92)

SD= Standard deviation

Predictors of the Level of DL Skills on Sociodemographic Profiles

In the multiple linear regression test, Table III shows a linear relationship between the level of DL skills and the university sector, p= 0.026. From the analysis, it has been shown that if the respondent is from a private university, the level of DL skills is decreased by 1.10 (95% CI: -2.06, -0.13), p= 0.026.

Table III: Simple and multiple linear regression for the level of DL skills between independent variables.

B-Level of DL Skills		SLR[a]			MLR[b**]		
		cβ (95% CI)	t[a]	p-value	aβ (95% CI)	t[b]	p-value
Age (R^2= 0.914)		-0.23 (-0.50, 0.02)	-1.85	0.064			
Gender (R^2= 0.911)	Female	-0.61 (-1.74, 0.51)	-1.07	0.283			
	Male (ref)	-	-	-	-	-	-
Ethnicity (R^2= 0.973)	Chinese	-1.17 (-2.34, >0.00)	-1.96	0.050			
	Indian	-0.420 (-2.33, 1.49)	-0.43	0.666			

CONTINUE

Table III: Simple and multiple linear regression for the level of DL skills between independent variables. (CONT.)

B-Level of DL Skills		SLR[a]			MLR[b**]		
		cβ (95% CI)	t[a]	p-value	aβ (95% CI)	t[b]	p-value
Ethnicity (R^2= 0.973)	Others	-0.859 (-3.25, 1.53)	-0.71	0.481			
	Malay (ref)	-	-	-	-	-	-
Study Class (R^2= 0.967)	Preclinical	0.85 (-0.01, 1.80)	1.76	0.078			
	Clinical (ref)	-	-	-			
Year of Study (R^2= 0.934)	Year 1	1.27 (-0.12, 2.66)	1.80	0.072			
	Year 2	0.041 (-1.38, 1.46)	0.06	0.955			
	Year 3	0.003 (-1.45, 1.45)	>0.00	0.997			
	Year 4	-0.536 (-1.94, 0.86)	-0.75	0.452			
	Year 5 (ref)	-	-	-	-	-	-
University Sector (R^2= 0.955)	Private	-0.99 (-1.96, -0.03)	-2.02	0.044[*a]	-1.10 (-2.06, -0.13)	-2.24	0.026[*b]
	Public (ref)	-	-	-	-	-	-

a – Simple Linear Regression, b - Multiple Linear Regression
[*]Statistically significant at $p < 0.05$
[**]Stepwise method applied
[b]ANOVA test (p=0.005)
[b]Adjusted R^2 for model summary is 0.956
[b]Multicollinearity and interaction terms were checked and not found

From the above output, the regression equation is:
Level of DL skills = 30.67 [Moderate] SOC (-1.10) Private university

DISCUSSION

This study found that Malaysian dental students reported having moderate database search skills, which contrasts with the findings of Saxena et al., (2017) among Indian dental students (16) and another study among Finnish dental students (17). A similar local study also found that undergraduate dental students rated their database search skills as mediocre or poor (17). However, a different study with different populations of African librarians discovered that most of their respondents reported having high database search skills among librarians (13). These findings varied as librarians routinely engage with databases to assist patrons, conduct research, and

manage information resources, leading to a higher proficiency in these skills. On the other hand, dental students may use database search skills less frequently and primarily for academic purposes, limiting their opportunities to develop high-level expertise. Database search skills are crucial for the dental profession, particularly in the context of evidence-based dentistry (EBD). EBD relies on locating, appraising, and applying the best available evidence to clinical decision-making (18). Proficient database search skills enable dental professionals to identify relevant research studies, clinical guidelines, and systematic reviews that inform patient care. Without solid search skills, dental students and practitioners may struggle to access high-quality evidence, potentially impacting the quality of care they provide. A study among Iranian dental students found that commonly used information sources by dental students were not evidence-based (19). Therefore, more effort should be put into teaching basic information retrieval skills and EBD in dental curricula to ensure that future dental professionals are well-equipped to provide high-quality, evidence-based care. Users must understand and have strategies for locating information through online databases and must be aware of and validate the information found (20, 21).

This research found that most dental students reported moderate metadata development skills due to the nature of handling metadata development requiring a higher and more advanced level of skills in information and communications technologies (ICT), which most dental students do not possess (22). Dental education primarily focuses on theoretical knowledge and clinical practice related to oral health rather than comprehensive ICT or metadata development training. This educational emphasis may result in a lack of exposure to and familiarity with the complexities of metadata handling. Dental students, who often do not receive specialised training in these areas during their education, may therefore, perceive their skills in metadata development as moderate due to limited practical experience and training. The rapid evolution of ICT tools and techniques necessitates ongoing learning and adaptation, which may not be fully integrated into dental curricula. As a result, students may not have had sufficient opportunities to acquire or refine their metadata development skills within the context of their academic training.

Most Malaysian dental students reported high levels of digitalisation skills. Digitalisation skills are essential for healthcare professionals as there will likely be fewer incidents of patient injury and fewer issues with documentation, saving time in the workplace, streamlining processes and expediting communication (23). Proficiency in digital skills among healthcare professionals can improve patient safety and operational efficiency. For example, digital tools such as electronic health records (EHRs) help ensure accurate and accessible patient information, reducing the likelihood of medical errors like incorrect medication administration or missed allergies. Digital systems also facilitate quicker access to patient histories and diagnostic information, enabling faster decision-making during emergencies. Furthermore, adopting the opportunities that are brought by digital technology enables dental personnel to navigate the new digital environment in dentistry confidently while acquiring new skills (24, 25).

Many dental students reported they possess high DL skills in sending and receiving emails and uploading documents. While these basic skills are essential for effective communication and administrative efficiency, they represent only a fraction of the DL competencies needed in modern dentistry. Proficiency in email communication is crucial for the dental profession as it ensures efficient communication with colleagues, professors, and patients. As email and other electronic communication methods become more prevalent, it is crucial for dental schools to integrate curriculum that equips graduates with effective electronic communication strategies tailored for patient interactions (26). It facilitates the timely exchange of important information, appointment scheduling, and collaboration on academic and clinical projects. The American Medical Association has issued guidelines on email communication for healthcare personnels, highlighting essential behaviors like safeguarding patients' protected health information, maintaining accurate records, and using professional language, reflecting the evolving norms in healthcare communication (26, 27). In Malaysia, it would be beneficial for healthcare institutions, including dental schools, to adopt similar guidelines for email communication. Additionally, sending and receiving documents electronically streamlines administrative tasks, enhances record-keeping, and supports a more organised and productive work environment. Developing these basic digital skills is foundational for more advanced competencies required in modern dental practice. Dentists who dedicate time to effective communication with their patients and colleagues will likely experience improved interpersonal relationships and a more satisfying professional life (28).

Nearly all Malaysian dental students have very high skill levels in using different social media. This result agrees with a study in Malaysia by Kamar Affendy et al (2020) and colleagues that the pattern of social media behaviour is evidently similar, and most students utilise different forms of social media in their daily lives (29). The term Dentistry 4.0 coincides with Industry 4.0, in which the traditional methods of manufacturing and information are made more precise to enhance process efficiency by using automation and advanced computer technologies (30). This could be due to the common practice among dentists in Dentistry 4.0, specifically, who have opted for social media platforms as the main sources of communication with their patients and as tools to promote their practice. Most dentists use

it to share deals, news, updates, network, exchange knowledge through blogs, and monitor patient feedback, specifically reviews left by patients who have visited their clinics on social media (31). In contrast, Rajan et al., (2011) did not share this finding; almost 87 % of the surveyed dentists did not believe in using social media to acquire more patients and share information (32).

Most respondents rated their website development skills as moderate. They agreed with the study by Baro (2019), Ayoku & Okafo (2015) (13, 33), which could be due to the academic requirements of dental students, which do not include website development in Malaysia. Mastering soft and hard skills that include good clinical, interpersonal, technical, and business practices can help dentists care for their patients and colleagues while growing their business (34). Therefore, there is a clear need for training and education in various aspects of information and communications technology (ICT) within dental teams, not only at the undergraduate level but also throughout the professional development of each dental team member. By integrating ICT training into dental education and continuous professional development, dental professionals can enhance their practice management, patient care outcomes, and overall professional satisfaction.

Generally, it can be concluded that almost all Malaysian dental students' DL levels are at moderate levels. In contrast, a study among Danish nursing students showed that their DL level tended to be higher (35), and a study in Vietnam also indicates that the students have a good knowledge of DL and a positive attitude toward ICT (36). Despite this, attention is required to develop interventions and academic training programs that can improve ICT and digital skills (37, 38).

This study found that the university sector was a statistically significant predictor of the level of DL skills. It is predicted that the level of DL skills will decrease if dental students are from private universities. However, the results conflicted with a study done in Jordan by Tabieh and colleagues, where in their study, the private sector workers have better DL skills than their public sector peers (39). These differences might occur due to different populations in different countries using different tools studied to determine the level of DL. This research has also considered and adjusted other confounders in the analysis. In this study, a favourable result observed in the public dental school could be entirely due to the standard of the infrastructure and support of more established public universities in Malaysia compared to private dental schools. Simultaneously, these results are consistent with Hosseini's (2018) study, where workers in the private sector were keener to possess and employ digital skills to maintain and advance their work, while those public sector workers are more confident in job security and do not feel the need to develop in the digital field (40).

This study faces several notable limitations that warrant consideration. Firstly, the reliance on self-reported data from surveys introduces potential biases, particularly recall bias, which may affect the accuracy of reported DL skills mong Malaysian dental students. Their subjective interpretations or memory lapses could influence participants' responses, potentially skewing the findings. Secondly, the study encountered challenges related to non-response bias in its quantitative phase. Differences between respondents and non-respondents could undermine the sample's representativeness, impacting the generalizability of results to the broader population of dental students in Malaysia. Despite efforts to mitigate this through reminder emails, the effectiveness was limited by administrative complexities and uneven access to official student emails across participating institutions. Furthermore, the study's sampling method, designed for representativeness through multistage proportionate stratified random sampling, required extensive administrative coordination and compliance with data protection regulations like the Personal Data Protection Act (PDPA) 2010. These factors collectively highlight the need for cautious interpretation of the study's findings and suggest avenues for future research to address these methodological challenges effectively.

Despite these limitations, this study addressed several methodological delimitations to enhance its robustness and reliability. Firstly, a low margin of error of 4% at a 95% confidence level was maintained through rigorous sampling methods, ensuring higher confidence in the survey results' representativeness for the targeted population of Malaysian dental students. The questionnaire's validity was upheld by using instruments previously validated in relevant studies from Africa and America. Internal consistency of the questionnaire was ensured through a reliability test using Cronbach's alpha during a pilot study, indicating strong inter-item reliability. Probability sampling, specifically multistage proportionate stratified random sampling, was employed to select a representative sample from various university sectors and genders, enhancing the study's generalizability. Advanced statistical analyses were conducted to elucidate relationships between variables, further bolstering the study's robustness. Lastly, efforts to maintain a high response rate, including multiple reminders via student emails, aimed to mitigate potential non-response bias and ensure comprehensive data collection. These methodological considerations strengthened the study's validity and reliability, offering robustness, replicability, and valuable insights into digital literacy among Malaysian dental students.

CONCLUSION

Generally, it can be concluded that Malaysian dental students' DL level is moderate. DL is evolving in all aspects, including its definition, competence areas, and research advancement concerning digital dentistry. As

a developing country, Malaysia also focuses on digital competence in many areas, including education, which has become essential in producing employable and competent graduates. Similarly, current dental education and training need to prioritise efforts that increase the levels of DL among undergraduates. This data presents an opportunity for policymakers and educators to identify areas that need improvement and adjustment, enabling students to adapt to the current digital learning environment and promote a higher DL.

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