Original Article

Evaluation of Dental Students' Learning Skill Throughout Repeated Practicing in Recording Preliminary Impressions: An Experimental Study

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Abstract

Objective: This study aims to assess whether repeated attempts at taking alginate impressions improve the manual skills of dental students by measuring the error percentage of each preliminary impression and comparing these percentages across multiple trials to evaluate skill progression.

Methods: Twenty dental students from the fifth-year stage were selected randomly to participate in the study. Each student took five alginate impressions after receiving a demonstration that included audio and video presentations to reinforce previously acquired knowledge. Error areas were highlighted using a red pen and then identified and quantified using Adobe Photoshop. Error areas have been deliberately identified to calculate the accuracy of each impression. The null hypothesis was that there would be no significant variation in the error percentages of preliminary impressions across the students' trials.

Results: The study's results revealed an improvement in the students' manual skills in taking impressions after repeated trials. Even though the fifth trial had the lowest median error percentage, the difference in group means was not statistically significant.

Conclusions: Repeated impression-taking improves dental students' manual skills, lowering error percentages in subsequent trials. Furthermore, the use of digital technologies in dental education facilities breaks skill acquisition down into more straightforward steps to detect and correct the errors.

Keywords: *Primary impression; Dental education; Dental Photography; Error area.*

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Introduction

Undergraduate dental students often face challenges acquiring theoretical and practical knowledge within a limited timeframe. It is essential for students to not only grasp fundamental concepts but also develop practical skills to provide effective patient care. This necessitates integrating theoretical knowledge with practical abilities and demonstrating continuous performance improvement[1]. Assessing technical skills in dentistry remains relatively new due to challenges in maintaining validity, objectivity, and fairness. However, technical proficiency and knowledge and attitude are crucial for dental procedures. Dental students develop these skills in two phases: preclinical simulated clinical activities and clinical activities performed on patients, as outlined in their Bachelor of Dental Surgery (BDS) curriculum. Enhancing training and learning strategies is vital, and evidence-based approaches should support these strategies[2,3].

Previous studies have only briefly discussed the structure and purpose of preclinical and clinical dentistry learning activities. Additionally, the factors that influence motor skill performance in dentistry have not been comprehensively studied, highlighting the need for further research to identify the best methods for promoting students' acquisition of hand skills and ensuring adequate training for dental procedures[4].

The digital revolution's impact has also extended to dentistry, introducing modern technologies such as digital photography, 3D intraoral scanners, and cone beam computed tomography (CBCT). This trend toward digitization has influenced various dental specialties, including oral and maxillofacial pathology, prosthodontics, implant dentistry, and oral public health, leading to an increase in computer-generated data[5,6]. Despite advancements in digital impression techniques and cast production, traditional clinical-laboratory methods remain in use due to the feasibility of materials and instruments and their lower cost. In prosthetic dentistry, creating accurate and dimensionally stable impressions is essential for producing well-fitting indirect restorations, which are crucial for the success and longevity of treatments[7]. Various factors, such as room temperature, tray type, impression technique, and material handling, have been discussed in relation to improving the accuracy of impressions[8]. Moreover, the repetition of impression-taking may enhance handling skills and improve the accuracy of subsequent impressions[9]. A wide range of impression materials is used for fixed and removable denture impressions, including silicones, polyether, polysulfide, and alginate impression materials. Alginate, an elastic irreversible hydrocolloid, is widely used in indirect restorations due to its low cost, ease of handling, and ability to capture detailed impressions even in the presence of undercuts. Despite its dimensional instability, which requires immediate pouring, alginate remains a commonly used material in dentistry, particularly for preliminary impressions[10].

In modern dental practice, digital photography has become an essential tool. It is widely used for record-keeping, pre- and post-treatment assessments, case documentation, scientific publications, legal protection, and professional marketing. Digital images, stored as computerized files, are integral to many aspects of dental practice and education[11-13]This study aims to evaluate the competency-based learning of dental students in recording preliminary impressions with alginate material and integrate this with modern digital technology. Specifically, the study will analyze the students' performance through digital photography, examining their progress over consecutive trials using descriptive and inferential statistical analysis of the recorded error areas.

Materials and methods

Ethical Approval

The Ethics Committee of the College of Dentistry of University of Sulaimani approved this study on November 5, 2023, no. 213/23.

Sample Selection

A subset of 20 fifth-year dental students from the College of Dentistry at the University of Sulaimani were selected randomly to participate in this study. This group was chosen to represent the broader student body, providing a focused sample for evaluating specific instructional methodologies and their impact on clinical skill acquisition.

Student Preparation

To ensure the students were adequately prepared, an interactive session was held between the participants and the instructors[14]. The goal of this session was to refresh and reinforce previously acquired knowledge related to dental impression procedures. The instructors facilitated a comprehensive review, encouraging active student engagement and discussion. Following this, a detailed live demonstration of the impression-taking process was conducted. The demonstration was performed live and recorded, with audio and video synchronized for future reference. This recording was designed to serve as a learning tool for the students, allowing them to revisit the procedure and clarify any uncertainties that might arise during their practice[15].

In addition to the demonstration, the session included a thorough exhibition of common errors that may occur during the impression recording process. These potential mistakes were carefully analyzed, and the instructors provided guidelines on effectively addressing and amending such errors[16]. Strategies for coping with these challenges in clinical settings were also discussed to enhance the students' practical skills.

In the second phase of the instructional process, a real-time, live demonstration of the impression procedure was conducted. This hands-on demonstration allowed students to observe the precise techniques in a clinical context, bridging the gap between theoretical knowledge and practical application.

Practical Application

Upon completing the instructional and demonstration phases, the students applied their newly reinforced knowledge practically. Each student had taken five dental impressions on the upper arch of a fully dentate volunteer within the same day. As recapped from the meeting sessions, the patient was seated upright with their head supported to minimize movement and enhance comfort. The student operator typically stands to the patient's side, ensuring proper visibility and access to the oral cavity. An appropriately sized impression tray is selected by ensuring it adequately covers the dental arch while allowing uniform material distribution. Before mixing, the alginate powder is agitated to prevent clumping, then measured and mixed with water manually according to the manufacturer's instructions using a spatula and rubber bowl. The mixture is blended to a smooth, homogeneous consistency and promptly loaded into the tray. Once positioned in the patient's mouth, the tray is held firmly in place until the material sets, after which the impression is carefully removed and inspected for accuracy. This immediate application of skills allowed for a direct evaluation of their learning, offering both the students and instructors insight into the effectiveness of the teaching methods and the students' grasp of the impression-taking process.

Evaluation of Impression Errors

The students' performance in recording preliminary impressions was evaluated through a structured observational process. This assessment involved three instructors who utilized explicit criteria and standardized rating scales that had been previously agreed upon. These criteria were designed to capture the essential aspects of the impression-taking procedure, ensuring a consistent and objective evaluation of student performance.

The instructors assessed each impression within 12 minutes[15]. The primary defects considered in this study were voids, air bubbles, and/or insufficiently recorded flanges and frena within the alginate impression material, as these are critical errors that can compromise the quality of dental impressions.

In addition to the immediate evaluation, photographic techniques further documented the impressions. Each impression was placed in a controlled mini studio, with lighting and positioning carefully arranged to capture clear and accurate images. A digital single-lens reflex (DSLR) camera (Canon 800D equipped with a Canon 18-55 mm lens) was used to photograph the impressions. The camera was set to an aperture of 1/125, a focal length of 20 mm, and an International Organization of Standardization (ISO) sensitivity of 100, ensuring high-quality images that could be used for detailed analysis and further reference[17].

Calculation of Impression Error Percentage (IEP)

The error percentages were defined as the proportion of the impression that contained defects relative to the total impression area. To systematically determine these errors, three instructors independently evaluated each impression using standardized criteria which covered all necessary anatomical landmarks, including vestibular areas, the teeth, palatal vault, rugae area, and frena. The impressions were visually inspected, and defects were marked with a red pen for easier identification. The alginate impressions were photographed in a controlled mini studio using a DSLR camera (Canon 800D) with an 18–55 mm lens and a ring flash. To ensure consistency in image capture, the camera was positioned at a fixed vertical distance of 25 cm from the impression surface. The camera settings included an aperture of 1/125, a focal length of 20 mm, and an ISO sensitivity of 100 to ensure high-quality image capture.

The error percentages were calculated using Adobe Photoshop 2024, a digital image processing software that allowed precise area selection and measurement. The first step involved determining the total impression area by selecting the entire impression surface in pixels per inch, as shown in Figure 1. This selection provided the total area measurement, which served as the denominator for the percentage calculation. Afterward, the defective regions (previously marked by instructors) were isolated within the image, as shown in Figure 2. These areas were selected using Photoshop's area selection tool, and their pixel values were recorded. To calculate the error percentage, the study used the formula:

Error Percentage= (Defective Area/ Total Impression Area) × 100

This formula was applied to each impression, ensuring consistency across all five trials. The error percentages were then recorded for each student and subjected to statistical analysis. Since the data followed a non-normal distribution, the Kruskal-Walli's test was used to compare error percentages across different trials

The percentage of the error was then calculated by dividing the area of the defect by the total impression area, and the result was multiplied by 100 to obtain the percentage of the defective area relative to the overall impression. This procedure was repeated for every student's five trials, ensuring consistency and accuracy in the error measurement process.

Statistical Analysis

Descriptive and inferential statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS) version 22 (IBM Corp., Armonk, NY).

Descriptive statistics were used to summarize the characteristics of the data set, including measures of central tendency and dispersion. Inferential analysis was performed to assess the normality of the variables using the Shapiro-Wilk test. As the data followed a non-normal distribution, the Kruskal-Wallis test was applied for group comparisons, as shown in (Table 1).

Results

Results were reported as means and standard deviations (M ±SD), medians (Md), minimum, maximum and interquartile range, as shown in (Table 2). Data was entered twice to ensure accuracy and reliability, and thoroughly checked for errors and plausibility. The Shapiro-Wilk test revealed non-parametric data, prompting using the Kruskal-Wallis test for group comparisons. The significance threshold was set at $p < 0.05$. The findings indicated that students' impression-taking skills improved with repeated practice in recording alginate impressions. Notably, the fifth group exhibited the lowest median error percentage. However, the difference in mean error percentages across groups was not statistically significant, as illustrated in (Table 2).

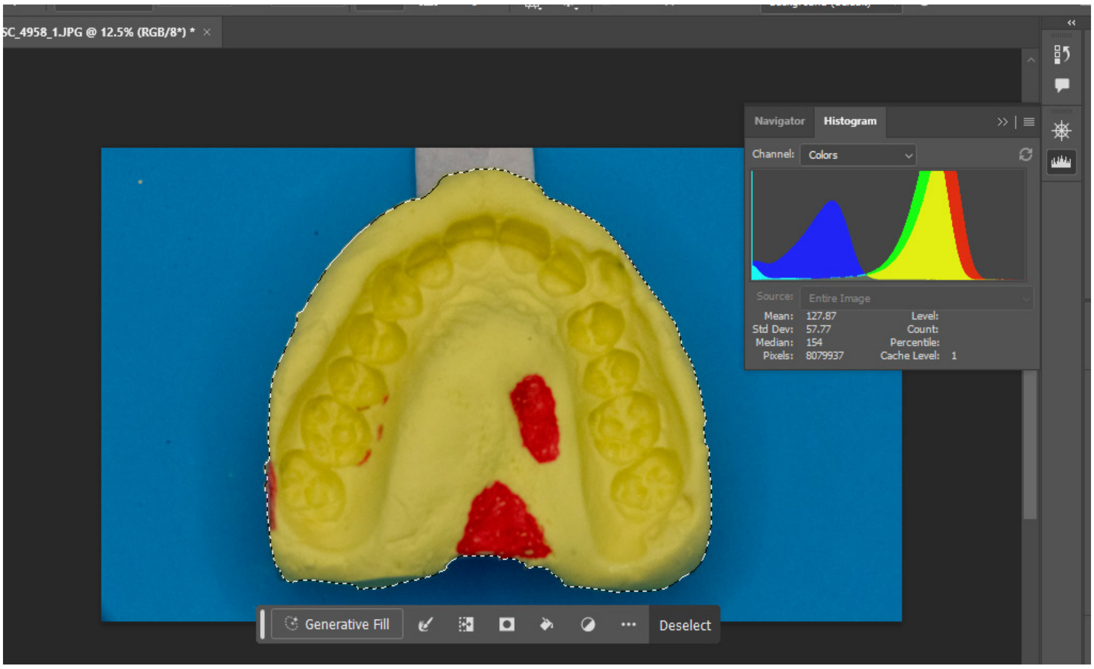

Figure 1: Total impression area shown in pixels per inch.

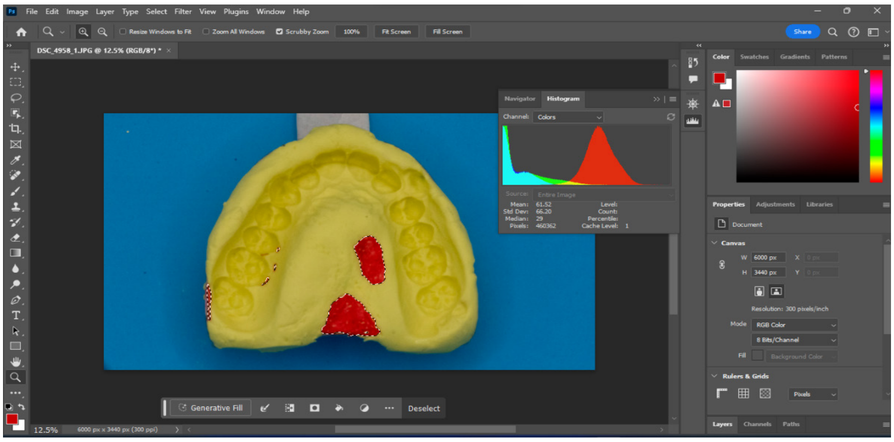

Figure 2: The impression's defect area shown in

Table 1: Normality Test Results for Kolmogorov-Smirnov and Shapiro-Wilk tests.

	Kolmogorov-Smirnov			Shapiro-Wilk		
Groups	**Statistic**	**df**	**Statistic**	**Statistic**	**df**	**Sig.**
IT 1	.297	10	.013	.712	10	.001
IT 2	.151	10	.200	.927	10	.420
IT 3	.242	10	.101	.852	10	.061
IT 4	.134	10	.200	.939	10	.539
IT 5	.283	10	.022	.741	10	.003

Table 2: Summary of Descriptive Statistics (Means, Standard Deviations, Medians, Ranges, and IQR, as well as independent samples of the Kruskal-Wallis test).

Groups	Mean ± SD	Median (MD)	Minimum	Maximum	Interquartile Range	Independent samples Kruskal-Wallis test F-Value
IT*1	6.2915 ±7.2023	3.2069	1.4475	23.8048	6.8495	
IT2	3.4570 ±1.7520	3.6743	0.8260	5.6976	3.4534	
IT3	5.1702 ±3.9983	3.8422	0.7400	12.7600	5.2749	0.938
IT4	3.7843 ±2.2691	3.6791	1.0140	7.8099	3.6486	
IT5	4.9369 ±4.9208	3.0534	0.8111	14.0300	5.5566	

* **df:** degree of freedom

****IT:** Impression trial group

Discussion

Impression materials have been used to replicate the teeth and surrounding oral structures by producing a dental impression filled with dental plaster to construct a dental cast. This process enables the fabrication of a three-dimensional and precise reproduction of the mouth, facilitating dental procedures even when the patient is not present[18]. Dental models facilitate dentists in conducting more accurate diagnoses and treatment plans by allowing for detailed visualization and examination of teeth from perspectives that are challenging to observe within the patient's oral cavity. Dental casts enable the implementation of specific treatments, such as removable and fixed prostheses. The accuracy of the impression material in recording tissue details determines the final fit of the restoration or prosthesis[19]. During the pre-clinical years of dental education, lectures have typically been the primary focal point. The didactic lecture has conventionally functioned as the principal method of imparting knowledge from instructors to students. However, this approach has faced numerous challenges, prompting the implementation of modern pedagogical strategies[20]. White et al. argue that the planning and execution of didactic lectures as a form of active learning for students are insufficient, leading to a passive learning experience that does not effectively promote collaborative learning. Students are increasingly showing a lack of enthusiasm for engaging in educational activities outside of the classroom[21].

Taylor asserts that to achieve effective learning through participation in practical tasks, it is essential to prioritize self-investment and attain objectives that encompass all aspects of a person's being. Taylor argues that this technique highlights the importance of maintaining a non-authoritarian presence during the process to provide a safe and non-defensive environment for students.[22] This enables individuals to acquire knowledge not because of the instructor's demand, but due to their necessity to accomplish their goal.

In this study we explored a subgroup of dental students' learning experiences in the clinical environment of the prosthodontic department. Learning approaches constitute cognitive, affective, and psychosocial behaviours that are relatively stable indicators of how learners perceive, interact with, and respond to the learning environment. They involve instructional strategies that allow individuals to acquire knowledge most efficiently. Students combine what they already know with what is being taught to form their interpretations[23]. As a result, deep learning is considered the most favored learning approach in higher education. Although the statistical results did not indicate a significant outcome initially, following the presentation of the results, a pattern of expected behavior emerged among the participants. We observed a discernible increase in impression accuracy from the first to the last (fifth trial), indicating a positive relationship between clinical training and motivation with clinical skills improvement. At the fifth trial, the error percentage began to decrease. This aligns with the behavior of students who adopt a deep approach to learning[24, 25]. The students are characterized by their concentrated focus on the task and intrinsic motivation to engage actively with the material. A relevant concept is trial-error teaching, where students can make and learn from mistakes. This method transforms errors into valuable learning opportunities. Over multiple trials, students refine their understanding, as reducing error rates suggests growing mastery of the subject matter[24]. This approach helps students develop resilience and encourages more profound engagement with the content. The goal is to understand the impression-taking procedure thoroughly, and they often derive personal satisfaction that leads to deeper comprehension from their study. Our findings corroborate earlier research demonstrating that mental training enhances motor learning and performance. Thus, mental training can be coupled with physical training to facilitate the acquisition of technical abilities[26-30].

Nevertheless, these findings contrast with other research which found that mental training improves execution more than no training at all[31-33]. Manual skill is not an aptitude, according to Giuliani et al.[34], although it can be significantly enhanced with practice. They demonstrated how manual ability improved dramatically among pupils who were able to complete the entire phantom course training. The findings of two additional investigations in 2019 and 2021 show the same results[35],[36]. Additionally, studies by Lugassy and Luck found that exercise is a good way to develop and enhance manual dexterity[35,37]. These findings agree with our results, even though all of the previous studies were performed on models (phantom and models).

This study has several limitations that should be considered. Firstly, the small sample size didn't represent all dental students. Additionally, there was limited availability in the student groups' timeframe in the undergraduate prosthodontic department clinics. Another significant limitation was patient cooperation and fatigue, which could have affected the accuracy of impressions over repeated trials. Furthermore, the study did not account for psychological stress, prior manual dexterity, or individual learning preferences, which could have influenced student performance.

Biases may have also played a role in influencing the study outcomes. Observer bias is a concern, as the evaluation of impression errors was conducted by instructors, and despite standardized criteria, subjective judgment could have influenced results. Additionally, the Hawthorne effect may have been present, wherein students altered their behavior due to the awareness of being observed, potentially affecting their performance. Furthermore, differences in individual learning curves were not accounted for, meaning some students may have improved faster than others, creating variability in the data. Another possible bias is the fatigue and boredom effect, as repetitive practice over multiple trials may have caused some students to lose motivation, leading to inconsistent performance across trials. In addition to these limitations and biases, potential errors may have affected the results. Measurement errors could have occurred due to the reliance on Adobe Photoshop to calculate impression error percentages, as manual selection of defect areas may introduce variability.

Conclusion

Based on the results of this clinical trial, it can be concluded that repeated practice in impression-taking notably enhances dental students' proficiency, as evidenced by a reduction in error percentages over successive trials. The fifth group's demonstration of the lowest, albeit not statistically significant, median error percentage, indicates that practice improves individuals' skills; however, variations among students persist. These findings emphasize the value of incorporating practical, hands-on training in dental education to build competency in impression-taking, alongside implementing modern, student-centered pedagogical strategies that foster active and self-directed learning. Additionally, the study underscores the effectiveness of digital assessment tools, such as digital photography and software analysis, in providing objective and precise evaluations of student performance, thereby improving feedback quality and tracking skill progression over time. The role of repetition and immediate feedback is also highlighted as essential for skill acquisition; thus, educational frameworks that integrate frequent practice and constructive feedback are recommended to support more profound learning and substantial skill enhancement.

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