

Development of Psychomotor Skills in Dentistry Based on Motor Learning Principles: A Review

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ABSTRACT

Aim: This review aims to recapitulate the available literature for skill development, instruction, and evaluation of the dental and dental hygiene preclinical students.

Background: The attainment of psychomotor skills is a crucial competence in dental education. The dental profession demands high precision and skill that require the development of cognition, distinctive abilities, and motivation, which influence motor performance. Practical instructions and knowledge for dental instrumentation necessitate the association of knowledge of motor skills with excellent motor skills attainment. Dental trainees need small, unequivocal steps that outline production. Preceding any task, the skill needed for the task should be projected precisely by the learner. Appropriate and detailed feedback from the trainer to the trainee contributes to learning and evolving.

Review results: This review reveals that learning of dexterity accretion should ingress both the aspects of psychomotor skills, that is the motor performance and motor learning, to obtain data that can be used to support skill learning.

Conclusion: To gain a better understanding of the accretion of cognitive content in operative dentistry, and differences in dental performance, more research should focus on factors such as the learning environment, including the type and sequence of learning activities. There is a critical need for staff development for the laboratory tutors who develop positive learning environment and provide students with effective feedback.

Clinical significance: This review highlights the importance of preclinical exercises in dentistry and how it enhances the psychomotor skills of students making them better clinicians in future. Reforms are needed in dentistry for improvement in learning atmosphere, proper arrangement of learning activities, and staff development for the laboratory tutors.

Keywords: Grade point average, Motor learning theories, Perceptual aptitude test, Preclinical exercises, Psychomotor skills.

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INTRODUCTION

Dentistry, like other medical and paramedical professions, requires a high level of clinical skills that necessitates broad usage of cognitive, affective, and psychomotor domains of learning.¹

The learning and acquisition of psychomotor skills are highly crucial for a successful dental professional.² Dental programs demand high accuracy encompassing irrevocable surgical work. The students need to cultivate these skills during their beginning years of the program before delivering real patient care.

The application of motor skills in dental procedures requires the utilization of knowledge and cognition in coordination with the eye, finger, and hand movements. These movements may involve procedures using a range of instruments while performing carving in the preclinical lab, activating hand scalers in periodontal treatment, preparing a cavity, or crown-cutting procedures.³

Moreover, dentistry is a field wherein there are always innovations and inclusions of newer technologies and materials for which the dentist should be continuously developing their motor skills.⁴

Psychomotor abilities can be characterized as those that require the subject to have the ability to synchronize sensorial data and strong motor coordination so as to play out a decided errand.⁵ According to Rose and Christina, these skills are involved in controlling muscles signaled by the brain and motor neural pathways resulting in steadfast movement.⁶

This article aims to understand the learning methods in preclinical activities, followed by a review of how psychomotor skills are acquired and applied for developing a relationship between ability, performance, and motivation.

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LEARNING METHODS IN PRECLINICAL ACTIVITIES

In a dental curriculum, students develop their psychomotor skills by working in preclinical laboratories as a part of the curriculum.

Because of the multifaceted nature of aptitudes required, novice apprentices invest a lot of energy and time creating and practicing these abilities through their preclinical exercises. Exercises extend from the utilization of customary benchtop tasks, including manikins to high innovation gadgets, e.g., computer-generated virtual reality test systems.^{7,8} In preclinical exercises, the students are required to use their theoretical knowledge, preparing them to deal with a wide range of case scenarios on simulation to meet similar clinical situations. They also learn to develop spatial abilities and reasoning abilities to gauge their motor skills. Other skills that are refined in preclinical activities are indirect visualization, cavity depth assessment, accessibility, and self-positioning.⁹

With the incredible advancement in the field of simulation, the students have preclinical experience close to reality. The lifelike manikins and simulators place the student in an objective setting similar to the actual patient encounter in the clinic, for example, utilization of indirect vision with the help of a mouth mirror while operating in posterior maxillary teeth and retracting the soft tissues.

The performance of the students is monitored by the faculty and simulators who provide feedback to students concerning the structure and measurements of their cavity preparations. Wierinck et al. reported that computer-based simulation approaches are very promising in dentistry in surgical skill training.⁸ By the opinion of Bradley et al. and Okuda et al., there have been doubts whether these test systems could improve learning abilities in preclinical settings and empower the pupils to apply these aptitudes in patient treatment and care.¹⁰⁻¹³ One of the hindrances with the utilization of test systems is the constrained incorporation of concepts of skill growth and improvement in the plan of learning exercises, which is essential for novice students. Few authors like Quinn et al. still believe that the conventional laboratory method has value in enhancing the interactions with the instructors and aids in acquiring critical feedback.¹⁴

MOTOR PERFORMANCE AND MOTOR LEARNING PERSPECTIVES IN THE DEVELOPMENT OF PSYCHOMOTOR SKILLS

Historians like Mc Geoch, Irion, and Adams provided detailed reviews of motor learning research in the past century. Early experimental investigations of motor learning were concerned with real-world skills and the problems associated with their acquisition, retention, and transfer. Disinterest in motor learning research continued through the end of the century. However, the relevance of motor learning to other disciplines such as health, paramedical field, sports skills, surgical skills, the skill acquisition theories laid up by Adams et al., and schema theory by Schmidt et al. have revitalized motor learning.^{15,16}

Motor performance alludes to the unequivocal physical activities or the results of a task. To illustrate, while assessing the performance of motor skills in the field of cavity cutting and preparation, the evaluators mostly focus the final cavity preparation. Accordingly, there is no data about the dental students' aptitudes utilized during the cavity preparation, which thus restrains the kind of response that can be given. Conversely, motor learning alludes to the capacity of an individual to comprehend the procedures and results expected, prompting everlasting changes in their presentation according to Schmidt et al.¹⁷ Motor learning is the process by which the capability for skilled motor control becomes represented in memory. Motor learning is most often associated

with the field directed at understanding the acquisition of skill with practice or experience.^{16,17}

Acquiring data from studies and implementing them on skill learning is essential. Presently, according to Tedesco et al., dental education programs mostly evaluate the psychomotor skills concerning outcome-based motor performances, without being assessed for learning processes for psychomotor skills development.¹⁸

METHODS OF EVALUATION OF PERFORMANCE

Evaluation of motor performance in various professions been an essential aspect of the curriculum in recent studies. Many instruments are used in various professions such as time, hand movement, final merchandise rating, agendas, and masterclass worldwide appraisals according to Hamstra et al.¹⁹ Conferring to De Andrés et al. and Heintze et al., in dentistry, motor evaluation, by and large, has been assessed utilizing the final product rating, e.g., scores for cavity preparation, restoration, and ranks for clinical and practical examination.^{5,20}

In general, instructor valuation methods apply to the awarding of grades. According to Cook and Beckman, the significant point here is assurance of the cogency and consistency of assessment instruments used for practical presentations, which has an impact on analyzing the results in such studies.²¹ In dentistry, assessment instruments with validity and reliability are inadequate in general in the view of Gillet et al. and De Andrés et al.^{5,22}

Beckman et al. showed that five foundations of cogency confirmation have been described with reference to medical education. These foundations include the content, feedback process, internal structure, affiliation with different factors, and outcomes. According to them, cogency is centered more around providing proof to help important interpretations as opposed to concentrating on the property of the evaluation tool itself. All things considered, past investigations have not generously tended to these perspectives, and this will hamper the effectiveness of the reported outcomes.²³

Haynes et al. reported that this might end in overrepresentation or underrepresentation of some of the features of the hypothesis of interest, such as the manual skills of the students. Due to limitations in previous studies conducted on dental training, in the domain of psychomotor expertise development and inadequate utilization of skill learning theories, the emphasis was on only one perception for the research on psychomotor skills, that is, motor skills and inadequate exploration of the cogency of tool used.²⁴

Researchers suggest several possible methods to evaluate the performance of a learner. They are classified as post-acquisition tests, retention tests, and transfer tests. Post-acquisition tests improve learning, and they measure performance immediately after the teaching and practicing of a new skill. These are valid methods to measure a change in performance. Still, the drawback is because of the immediacy of testing, caution in interpreting the performance must be exercised, as it is the reflection of a temporary situation. Its association should not be with concomitant enduring change related to learning.

Retention test measures the performance during which a rest period is present between the last practiced skill and the retention test. The rest period is usually a few hours or days. This rest period eliminates the temporary effects of the practiced skill and measures learning that indicates the permanent changes. With transfer tests, the ability of the learner to adapt the newly learned procedural

skill to a different situation is tested, for instance, practicing like tasks under a time constraint in an innovative setting regularly at the time-point interval to skill acquisition phase. The reason for transfer tests is that the adaptability of a learner to a variety of circumstances increases with the degree of learning.²⁵ This indicates that in a state where there is a failure in learning but momentary progress in performance on a post-acquisition test, a person might either have the minimal skill or completely unable to adjust to the technique in a novel circumstance.

On the contrary, a skilled person who has acquired genuine learning will be able to adapt the procedural skills to new demands.

RELATIONSHIP BETWEEN ABILITY, PERFORMANCE, AND MOTIVATION

The field of dentistry requires acquiring psychomotor skills as a critical competence, and it is seen that an individual's innate abilities greatly influence motor performance and motivation.⁴ Innate ability is the necessary aptitude associated with an individual while performing a task.¹⁷

As indicated by the hypothesis of skill acquisition, there are three critical abilities needed in various phases of dexterity accretion.²⁶ First, the cognitive phase is required to comprehend the strategies and methods related to a specific assignment. Besides, the associative stage, perceptual speed capacity is needed to find the best method to accomplish the task.²⁷ Third, in the autonomous stage, performance is overwhelmed by a student's psychomotor ability, with less dependence on their cognitive ability.²⁸

Keehner et al. proved that the relationship between ability and motor performances has been reported in many studies in various fields of surgery, indicating the close association between cognition and performance in surgical simulation, proposing that for the acquisition of particular skills, it is essential to have a specific ability.²⁹ This also implies those dental graduates who have a high level of propensity that is required in dentistry ought to likewise exhibit a significant level of dental psychomotor performance. Based on the scores obtained in the ability tests like grade point average (GPA), visual-spatial ability test, and perceptual aptitude test (PAT) have been used in predicting performance in dental preclinical operative sessions.¹⁷ According to Boyle and Santelli,³⁰ Walcott et al.,³¹ and Gansky et al.,³² it has been noticed in dentistry that college GPA is not related to performance in preclinical courses, and grades are not considered to straightforwardly mirror the learning parameters required in dexterity accretion. Grade point average denotes a broad measurement of an aptitude of obtaining basic knowledge, suggesting to test cognitive ability concerning obtaining evidence regarding which factors are necessary for the achievement of psychomotor skills in dentistry.

Several studies have scrutinized the predictive value of a visual-spatial ability test, namely, the PAT, concerning dental performance in preclinical operative courses conferring to Gansky et al.,³² Kramer,³³ and Oudshoorn.³⁴ In any case, the outcomes have been conflicting. A few investigations have indicated that the estimations of relapse coefficients of absolute PAT scores in anticipating dental performance are low. A positive relationship was found between the outcomes in a preclinical course and grades on a spatial capacity test. In this study, the spatial capacity was estimated by requesting that examinees envision a three-dimensional article when given different two-dimensional perspectives. The absence of steady outcomes in past investigations may be because of an absence of clear homogenization of theory in the selection of ability

tests.^{20,32} The research has concentrated on recognizing the viability of different cognitive and manual adeptness tests in predicting dental performance.^{35,36} There are no particular test scores to gauge success in dental programs, since studies performed earlier delivered a wide range of results with no conclusions. These inconsistencies are related to the partial, unambiguous use of the perilous theories, e.g., skill acquisition theory, to the study designs used. It is proved that while cognitive capacity, explicitly the visual-spatial ability, related to the performance by dental understudies on a new mind-boggling surgical task, there was no relationship between visual-spatial ability and operational execution for advanced students and specialists. It was suggested that ability and performance are prejudiced by practice and experience.³⁷

Another study reported the correlation of innate ability with performance differences in initial phases of learning. However, they concluded that with repeated performance of the same task, the differences in performance result were reduced.²⁹

Motivation is the vital aspect of learning motor skills.³⁸ It is related to consequent learning results, particularly when another learning model is familiarized to the students.³⁹ Motivation is the internal effort allocated to tasks, and it influences the ability and performance and thereby increasing skill acquisition.⁴⁰ The motivation of an individual has a significant influence on motor performance.

According to a few experts like Langan-Fox et al., individuals showing high motivation are likely to attain a high level of performance.⁴¹ According to the motivation theory, abstract psychological exertion is a powerful construct affected by different components, including goal orientation, goal-setting, and self-regulatory processes.⁴²⁻⁴⁴ The goal-setting stage includes goals and decisions that will be given to different undertakings, and this is affected by factors, for example, task intricacy and self-viability. Among people who set targets for themselves, those with great self-efficiency are more probable to fix higher targets than those with less self-efficiency.⁴⁵ Self-regulatory processes enable people to contrast real performance and the ideal objective, bringing about an alteration in the subjective effort due to the amount of motivation provided to accomplish the ideal objective according to Yeo et al.⁴⁴

Motivational determinants have been accounted for ability-performance interactions, with less motivation bringing about low degrees of performance among people with low- and high-performance ability.⁴² In disparity, with high motivation, unpredictability in ability tends to decree performance. Despite the significant role of impetus and effort in accomplishing high-quality motor performance in dentistry, the subject related to motor performance or motor learning has not been explored adequately. Thus, it can be advised that future research should focus on important facets such as the learning atmosphere, which includes the type and arrangement of learning activities. There is a perilous need of staff development for the laboratory tutors who develop positive learning environment and provide students with effective feedback to enhance the process of learning.

CONCLUSION

This review reveals that research on skill acquisition ought to evaluate both the aspects of psychomotor skills, that is, the motor performance and motor learning, to get data that can be utilized to help skill learning. Be that as it may, dental education research, for the most part, investigates psychomotor aptitudes as far as motor

performance outcomes results, with a constrained evaluation of the learning processes for psychomotor skills improvement.

The majority of studies have inspected the impact of cognitive ability and psychomotor ability on cavity preparation exercises, with weak positive associations for the association between perceptual speed ability and performance in operative dentistry. It looks like up till now, ability tests in dentistry were used without first authenticating them based on theory. To get more knowledge about the attainment of psychomotor skills in operative dentistry, and the differences in dental tasks performance, we advise that research should focus on aspects such as improvement in learning atmosphere, including the type and arrangement of learning activities and staff development for the laboratory tutors.

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