Motor Skill Learning

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Motor skill learning requires the control and integration of a range of stimuli and responses to be able to perform the desired motor task. How can we explain, support, or predict how people learn these skills? Several learning theories have been developed to explain how learning motor skills occurs and what stimulates individuals to learn and change.

motor skills learning theories dentistry self-consciousness working memory

1. Introduction

Many contemporary theories of motor skill learning identified the importance of cognitive processes during motor skill acquisition, particularly in the initial stages of learning. The initial stage of motor skill learning (i.e., cognitive stage/declarative stage) involves cognitive processing of verbal/visual instructions related to the task and rehearsal of the task in working memory. This cognitive processing facilitates the interpretation of the instructions required to perform the task.

2. Understanding Motor Skill Learning as Related to Dentistry

Procedural and cognitive skills are essential abilities for clinical dental practice. Students learn these skills during simulated clinical activities designed to ensure that they achieve a satisfactory level prior to proceeding to direct patient care. These simulated activities have associated high costs in terms of staffing and facilities [1][2][3]. To optimize learning in these settings, the design of relevant learning activities needs to be informed by theory and based on evidence.

However, there has only been limited research conducted in relation to the design of the most effective and efficient methods for learning the complex cognitive and fine motor skills required for patient care in dentistry [1][4][5][6]. Similarly, there are few publications discussing the rationale and design of simulation and clinical endodontic learning activities [7][8][9].

Other than investigation of the design and diameter of hand file handles and the effect of the fit of gloves on performance [10][11][12], there has been limited use of learning theories to explicitly inform the design of simulation and clinical dental learning activities [6][13][14][15].

In dentistry, understanding relevant learning theories is essential for dental educators to be able to design effective learning activities, with a clear rationale that supports their dental students' learning. Below, we will discuss five key theories that have relevance to learning procedural skills and declarative knowledge in dentistry. Specifically, these are Schema theory, Cognitive Load theory, OPTIMAL theory of motor learning, the Novice-Expert continuum and deliberate practice principles, and Reinvestment theory (Table 2).

Table 2. Summary of motor learning theories relevant to dentistry.

Theory	Description	Points in Favor	Points Against
1. Schema Theory [16]	Motor learning involves ongoing processes that update the recall and recognition of proprioceptive information from limbs and fingers. The response parameters (e.g., speed and force) are specified according to stored knowledge of the results.	- Commonly used theory. - Used to explain procedural skill development.	- No longer valid for understanding motor skill learning. - Unable to describe learning through observation. - Unable to explain the role of augmented feedback.
2. The OPTIMAL theory of motor learning [17]	Focuses on discovering the correct instructional approach to support motivation and direction of motor learning to the desired outcome of the motor task.	- Supports simplifying movement instructions. - Positive impact on instructional design. - Reduces the load on the working memory.	- Limited evidence addressing complex fine motor skill learning.
3. Cognitive Load Theory [18]	Based on the assumption that cognitive system is limited as working memory can only store and process a small amount of information for a few seconds.	- Knowledge build up by combining simple elements can result in development of more complex results. -	- Lacks conceptual clarity and validity of instrument used. - Lack generalizability in different contexts. -

Theory	Description	Points in Favor	Points Against
		Reduces the load on working memory. - Positive impact on instructional design.	Uses self-reported survey to measure cognitive loads.
4. Novice-Expert continuum and deliberate practice principles [19]	Development of expert motor performance depends on continuous deliberate practice improved by trial-and-error learning and supported by appropriate supervision.	- Supports gradual buildup and improvement of motor skills. - Supports safe and low risk buildup of competency.	- Does not address individual’s cognitive, attentional and perceptual abilities. - Requires a long deliberate practice to achieve expert level.
5. Reinvestment Theory [20]	Based on the distinction between individual’s movement self-consciousness features related to movement processing and decision making.	- Commonly used theory. - Implicit learning reduces the load on the working memory. - Supports simplifying movement instructions. - Implicit learning maintains robust performance under multi-tasking and stressful conditions.	- Limited evidence addressing complex fine motor skill learning. - Lack of consensus related to the role of observational learning as an implicit learning approach. - Uses self-reported survey to measure the level of reinvestment.

There is limited evidence regarding fine motor skill learning in dentistry, particularly in endodontics. It has been shown that learning implicitly when carrying out a motor skill may limit the effect of self-focus and self-regulation on subsequent performance.

Stressors related to dental students’ transferring from simulation to clinical settings can result in deterioration of performance. It is suggested that learning implicitly in the simulation stage can reduce disruptions in performance when moving to clinical settings. Therefore, further investigation of effective methods for learning fine dental motor skills is indicated, using conditions that result in robust performance, even under multi-tasking or stressful conditions.

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