Improving students' learning and performance in pre-clinical endodontics

THE UNIVERSITY of ADELAIDE

School of Dentistry

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List of abbreviations

AIC	Akaike Information Criterion
BDS	Bachelor of Dental Surgery
BFT	Balanced Force Technique
CF	Cognitive Failure
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
CMP	Conscious Motor Processing
COM1	Comparative group (Study 1)
COM2	Comparative group (Study 2)
DRe	Decision Reinvestment
DRu	Decision Rumination
DSRS	Decision-Specific Reinvestment Scale
EFA	Exploratory Factor Analysis
E ful	Errorful
E less	Error less
GFI	Goodness-of-Fit Index
GO	Guided-observation
HR	Heart Rate
IO	Instructed-observation
ISAT	Imperial Stress Assessment Tool
MSC	Movement Self-Consciousness
MSRS	Movement-Specific Reinvestment Scale
N0°	Narrow straight canal block
N20°	Narrow 20° curved canal block
NiTi	Nickel-titanium
OO	Observation-only
PrSC	Private Self-Consciousness
PSS	Perceived Stress Scale
PuSC	Public Self-Consciousness
RH	Rehearsal
RMSEA	Root Mean Square Error of Approximation
RS	Reinvestment Scale
SRMR	Standardised Root Mean-squared Residual
STAI	State-Trait Anxiety Inventory
W0°	Wide straight canal block
W20°	Wide 20° curved canal block

Abstract

There has been limited use of contemporary learning theories or available evidence when designing activities to develop fine motor skills in dentistry. Recent evidence from non-dental studies concerning levels of performance following fine motor skill learning highlights the negative impact of reinvestment, i.e. conscious monitoring and control of movements when learning, particularly during the early stages of learning. Learning implicitly so that minimal conscious involvement is required (e.g. approaches that minimise errors or involve observation with physical guidance), has been shown to limit the effect of reinvestment on subsequent performance. This leads to positive and sustained outcomes, even under multi-tasking or stressful conditions, in comparison to commonly used explicit approaches (e.g. approaches that involve error production or observation with instructions) (Maxwell et al., 2001; Poolton et al., 2011).

Outcomes of learning implicitly are important in dentistry because working under stressful conditions (e.g. physiological or psychological) is a consistent characteristic, either during undergraduate study or in practice. However, there are no published data about this approach for learning dental skills. The aim of this research was to evaluate the effect of learning approaches, consistent with implicit or explicit learning, on the acquisition of endodontic hand instrumentation skills among dental students. It was hypothesised that learning implicitly (e.g. by limiting errors or observation with guidance) would result in minimal decrement in performance under pressured or stressful conditions. In contrast, it was expected that learning explicitly (e.g. through increasing errors or observation with instructions and observation alone)

would lead to a reduction in performance under pressured or stressful conditions. It was also aimed to investigate the impact of reinvestment on performance of the dental students. It was hypothesised that individuals with a high propensity for conscious monitoring during root canal preparation would not perform as well as low reinvesters, as a consequence of allocating working memory resources to monitoring and controlling their movements.

Participants were volunteer dental students from the University of Adelaide, with no previous endodontic work or learning experiences. These students were randomly assigned to the experimental groups. Other volunteer dental students who had completed the normal pre-clinical learning activities provided comparative performance data.

Participants performed fundamental root-canal hand instrumentation tasks during learning (experimental groups: 1.5-2h; comparative groups: 15-20h) and testing phases (0.5-1h). During learning, participants in the experimental groups prepared standardised canals with different canal diameters and curvatures using the balanced force technique. Learning methods in the experimental groups involved minimising (errorless: n=21) or maximising errors (errorful: n=21) in Study 1, or guided-observation (n=23), instructed-observation (n=23), or observation-only (n=13) in Study 2. Participants in Study 1 and Study 2 completed the three previously published reinvestment surveys related to propensity to reinvest. These were used to evaluate participants' focus of attention behaviours on learning and performance in general.

To test performance levels after the learning phases, all participants prepared the distal canal on a plastic tooth (Test 1), then completed the same task under multi-tasking condition (Test 2), with the observation groups completing Test 1 again but under stressful conditions (Test 3). Performance was assessed by preparation accuracy, completion time, procedural errors, and reported rules. For accuracy and time, repeated measures ANOVA and post-hoc analyses were used to assess differences within and between groups, while procedural errors were analysed using Wilcoxon Rank Sum Test and Kruskal-Wallis Test. Differences in the number of reported rules between the groups were assessed by an unpaired t-tests for Study 1 and a one way ANOVA and post-hoc analyses for Study 2.

Performance by the experimental groups was similar during learning. When tested, accuracy of preparation and completion time in the errorless and comparative groups did not change significantly under multi-tasking conditions ($p>0.05$), whereas, learners who learnt with errors showed a significant deterioration in preparation accuracy when multi-tasking ($p< 0.05$). Participants' reported significantly increased stress levels in all observation groups for all tests ($p< 0.05$). However, preparation accuracy did not differ significantly within or between the experimental observation and comparative groups ($p> 0.05$). The errorful and instructed-observation learning groups reported significantly more 'root canal instrumentation rules' than the errorless, guided-observation and observation-only groups. Correlation analyses of data from the Reinvestment Scale (RS), the Movement-specific Reinvestment Scale (MSRS), and the Decision- Specific Reinvestment Scale (DSRS) showed significant association between the three reinvestment surveys. However, no significant differences for the three reinvestment surveys were found between experimental and comparative groups in Study 1 and 2. Furthermore, no significant differences in accuracy of canal preparation or completion times were found between 'low' and ‘high’ reinvesters based on a median split for the primary task, under multi-tasking, or under stressful conditions.

Findings from Study 1 provide the first evidence that learning endodontic skills implicitly, i.e. under conditions that limit errors, resulted in stable performance when multi-tasking. This may be explained by reduced use of working memory for error management when learning. However, the learning strategies adopted when learning by observation with guidance were not consistent with implicit learning approaches. This conclusion is supported by the high number of errors produced during learning trials on plastic blocks and the apparent low level of accuracy of performance during transfer tests. This finding highlights difficulties associated with designing approaches that are consistent with learning implicitly in the real world.

The apparently low impact of reinvestment on performance of participants in Study 1 and 2 may be explained by the small number of low and high reinvesters in both studies and the variable level of complexity in the instructions provided. Propensity to reinvest is suggested to be dependent on performance context and task attentional demands. The fine motor learning context in endodontics and the complexity of dental tasks are likely to be different to those encountered in sports or in surgery, which might explain the variable impact of reinvestment on performance. Further research of learning other skills by dental students is needed, including testing different implicit learning paradigms and investigating the role that the reinvestment might play when learning endodontic skills. These studies should lead to better outcomes, especially during multi-tasking and under stressful environments.

Thesis declaration

Name: **Mohamed Yahya El-Kishawi** Program: **PhD in Dentistry**

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