Learn-A-Prep II as a Predictor of Psychomotor Performance in a Restorative Dentistry Course

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Abstract: This investigation assessed whether early student performance with a dental handpiece on a didactic training aid known as the Learn-A-Prep II (LAP II) was predictive of performance on subsequent practical examinations in a preclinical restorative dentistry course. Eighty-one first-year students were given initial handpiece training and formative feedback using the LAP II and were then instructed to independently prepare four LAP II patterns within the pattern lines and at a specified depth. Performance on the LAP II was compared with the summative assessment on two subsequent amalgam preparation practical examinations given at the middle (Class II) and end (Complex) of the course. Pattern preparation within the lines did not significantly improve the likelihood of receiving an A or B on the Class II practical (p=0.53) or on the Complex practical (p=0.37). Students who had an acceptable depth on the LAP II were 3.73 times more likely to receive an A or B on the Class II practical than those students who did not have acceptable depth (p=0.03). Performance at an acceptable depth did not significantly improve the likelihood of receiving an A or B on the Complex practical (p=0.15). The LAP II may aid in identification of students who would benefit from early intervention with additional focused instruction.

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Dental students enter the preclinical phase of their operative dental training with a range of initial levels of psychomotor skill and rates of learning. Identification of students who require additional focused instruction often does not occur until after formative and summative assessments have been completed. For these students, mid-course evaluations and strategic educational interventions may be too late, resulting in overall course performance that falls below average or is failing. It is important that the summative assessment process augment student learning.[1] First-year dental students are highly motivated to learn operative dentistry as they see this as an important step toward fulfillment of professional goals. Poor course performance is discouraging for both students and faculty members and may reduce student motivation and increase stress during and following preclinical operative courses. Early identification of dental students with below average psychomotor skills and rates of learning may allow individual-specific intervention, resulting in improved progression toward competence in the preclinical environment.[2]

Preclinical course design should incorporate methods that foster progression through stages of competence such that the novice/beginner gradually transitions into a competent operator.[3] Novice learners require specific instructions with immediate and accurate instructor feedback and much practice/repetition.[4] A variety of lead-up activities have been developed to assist in early development of psychomotor skills for operative dentistry.[5] The Cavidrill (Vivadent, Schaan, Liechtenstein), which was essentially an easily handled acrylic block, was intended as a cost-effective substitute for acrylic teeth during the initial phase of preclinical training.[6] Students prepared specific patterns at various depths on the Cavidrill block as a means to develop hand-to-eye coordination and initial rotary instrument proficiency. The block utilized colors and/or material hardness to mimic enamel, dentin, and pulp tissue. The overall goal of the design was to foster understanding of movement through vertical and horizontal space by developing the ability to create precise three-dimensional preparations. Transparent grids that were positioned over the Cavidrill block

were developed to assist in standardized grading of various preparations.[7] A controlled study of the potential benefit of the Cavidrill as a training aid found no improvement in cavity preparation performance over more traditional learning of preparation techniques on acrylic teeth as assessed by average preclinical course midterm and final practical examination scores.[8] However, there has been no published study that correlated individual student performance on the Cavidrill with subsequent performance on course practical examinations to identify if initial training using the device resulted in a higher level of operator proficiency.

Although the Cavidrill is no longer available, the Whip Mix Corporation (Louisville, KY, USA) has developed a similar teaching aid known as the Learn-A-Prep II (LAP II, Figure 1). Similar to the Cavidrill, the LAP II utilizes material hardness and thickness variation to mimic enamel and dentin for the purposes of enhancing early tactile sense discrimination and awareness of approximate dental anatomic depth dimensions. Various enamel surface patterns are designed to provide opportunity for the development of fine motor skills as well as mimic the Class I, II, and V preparations. Additional patterns located along the LAP II edge allow for direct observation of preparation convergence/divergence and retentive groove placement potentially required as a retentive feature of Class II or V preparations. The Whip Mix Corporation reports that twenty-nine dental schools in North America (approximately 42 percent of the total) are currently using the LAP II as part of preclinical operative training (personal communication, Whip Mix representative). The patterns and layer thicknesses of the LAP II are designed based on the notion that there may be a benefit to initial handpiece motor skill development prior to attempted implementation of various preparation designs on plastic dentoform teeth, though this needs to be evaluated.[5,8]

The LAP II is currently being used at the beginning of the preclinical operative dentistry course at the University of North Carolina at Chapel Hill School of Dentistry. Students gain familiarity with handpiece operation prior to attempting various preparation techniques and discrimination exercises while removing simulated caries in plastic dentoform teeth.[9] The tendency to make errors during initial LAP II exercises may reveal a need for early intervention and individualized student instruction. Early instructional intervention may lead to better overall preclinical course performance and a higher level of preclinical

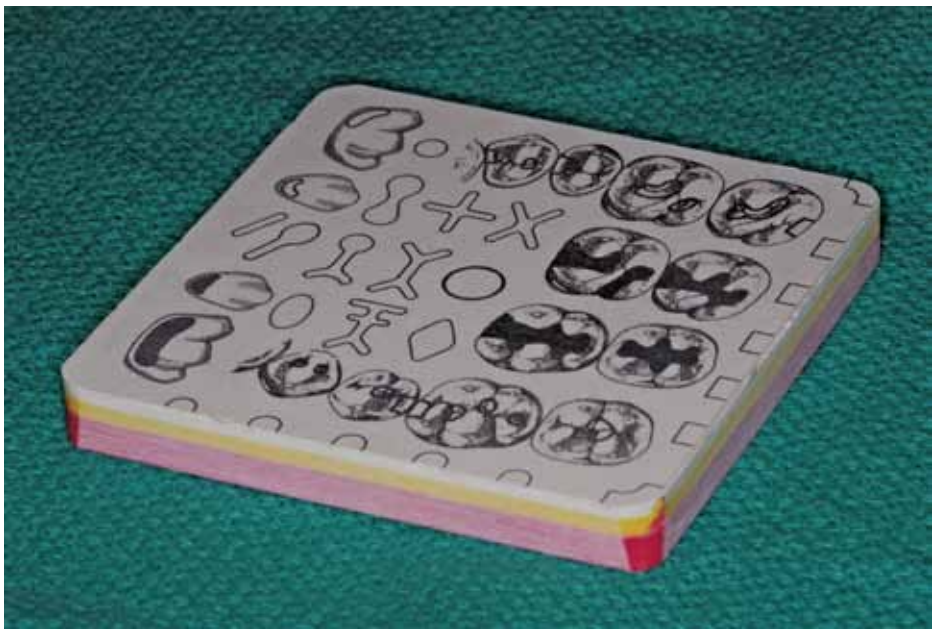

Figure 1. The Learn-A-Prep II (Whip Mix Corporation)

competence. The purpose of this investigation was to assess whether early performance on the LAP II was predictive of performance on subsequent practical examinations.

Materials and Methods

First-year dental students (n=81) participated in a fifteen-week preclinical operative dentistry course in the spring semester of 2009 that provided 49.5 hours of handpiece operating training/experience in a dental simulation laboratory (Table 1). At the beginning of the course, the students received 1.5 hours of instruction specific to dental handpiece use, and the LAP II was introduced. All students were given specific verbal instructions, with live demonstration, on the steps of LAP II pattern preparation. The students then prepared specific LAP II patterns under direct faculty supervision for practice exercises designed to allow the development of familiarity with the handpiece and feel of preparing the LAP II. Students were instructed to prepare the various shapes up to, but not into or beyond, the pattern outline and at a constant depth just through the artificial enamel and into the dentin (Figure 2).

The students self-evaluated the three patterns during the laboratory procedure, assessing their own ability to accomplish a uniform preparation at a specified depth precisely within the assigned patterns. The evaluation was a simple yes/no to the ability to control extension and depth. Immediate faculty feedback was provided. The students were then given a LAP II practical assignment that consisted of accomplishing four specific patterns following the exact same instructions for outline and depth (Figure 3). The LAP II practical assignment was assessed at the end of the course by a course director, who was blinded to student identification. The student's ability to accomplish the LAP II preparation exercise was assessed in two ways: 1) preparation within the pattern lines (yes/no) and 2) preparation at an acceptable depth (yes/no) (Figure 4).

After the completion of the LAP II training protocol and practical, the students began to accomplish specific preparations in plastic dentoform teeth (Table 1). New concepts of preparation design were introduced by demonstration and use of the LAP II before being performed on dentoform teeth. Each laboratory period provided for formative assessment of procedures accomplished on dentoform teeth using specific preparation criteria. The students

Table 1. Chronological order of preclinical operative course subject matter and timing of practicals with number of hours students worked with handpieces

Preclinical Operative Dentistry Laboratory Exercise	Hours
Dental handpiece introduction and LAP II lab exercise	1.5
LAP II: Practical Exercise	
Natural tooth sealant	0.5
Class I composite resin	6.5
Class I amalgam	4.5
LAP II: Indirect Vision	
Class II composite resin	7.0
LAP II: Class II Pattern	
Class II amalgam	5.0
LAPII: Class II Retention	
Practical Evaluation II: Class II Amalgam	
Pediatric dentistry procedures	10.0
LAP II: Class V Pattern	
Class V composite resin	1.0
LAP II: Class V Retention	
Class V amalgam	1.0
Class III composite resin	6.5
LAP II: Slot and Pin Placement	
Complex amalgam	6.0
Practical Evaluation IV: Complex Amalgam	

Note: Hours devoted to practical exercises/examinations and restorations are not included. Exercises where handpieces were not used in the course, e.g., restoration of pre-prepared Class IV preparations, are not included.

Figure 2. Shapes in initial practice exercises

Figure 3. LAP II practical assignment

devoted 23.5 hours of in-lab time to the development of handpiece skills prior to the practical that examined student ability to complete and assess a Class II preparation for amalgam. The students devoted another 24.5 hours of in-lab time prior to the practical that examined student ability to complete and assess a Complex preparation for amalgam.

Laboratory exercises and practical examinations were accomplished using a dentoform containing plastic teeth with simulated caries in anatomically correct locations (Dentoform [D85SDP-200 GUB], Class II Caries [A27A-46U], Complex Caries [A27A-46V], Kilgore International, Coldwater, MI, USA). Student performance on the Class II and Complex practicals was evaluated in comparison with an ideal preparation independently by two course directors who were also responsible for presenting course content. The course directors were blinded to the identity of the students. Students were given an overall A, B, C, or F summative assessment on each practical examination. Disagreements in summative feedback were discussed in light of overall course goals until consensus was reached.

An exact Mantel-Haenszel chi-square test was used to evaluate the bivariate relationships between each of the LAP II measures (pattern line and depth) and each of the practical grades. Given the importance of preclinical motor skills, the preclinical proficiency outcome for each of the practicals was designated as "desirable" if the student received a grade of A or B, while a C or F was considered "undesirable." A logistic regression was performed separately for the preclinical proficiency status for each practical with the LAP II measures as the explanatory variables. Level of significance was set at 0.05.

Results

Slightly more than half of the students participating in the course were male (53 percent). The average age was twenty-five years with a range of twenty-one to forty-four. All students completed the

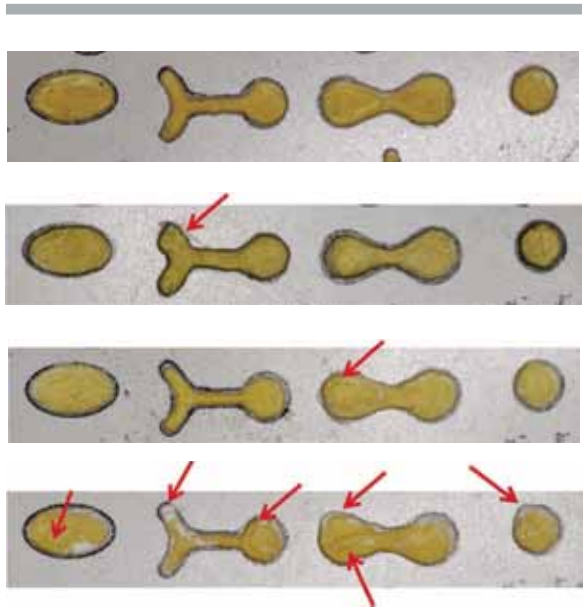

Figure 4. Examples of students' LAP II practical assignments, with arrows indicating course director's assessment of unsatisfactory performance (top to bottom: from most to least satisfactory)

LAP II preparations and the two practicals. Sixty percent (n=49) of the students were "within the lines" on the LAP II preparations, while only 32 percent (n=26) were able to demonstrate acceptable depth. Slightly more than a quarter of the class (n=23) was able to stay within the lines at an acceptable depth (Table 2). Substantially more students exhibited "undesirable" proficiency on the Class II practical (n=52, 64 percent) than on the Complex practical (n=34, 42 percent). With respect to simple bivariate relationships, neither pattern line nor depth results on the LAP II were statistically significantly associated with the grades received on either the Class II or Complex practical (Tables 3 and 4).

The student's ability to prepare patterns within the lines did not significantly improve the likelihood of receiving an A or B on the Class II practical

Table 2. Descriptive statistics for performance by students on the LAP II

	Acceptable Depth		
Within Pattern Lines	Yes	No	Total
Yes	23 (28%)	26 (32%)	49 (60%)
No	3 (4%)	29 (36%)	32 (40%)
Total	26 (32%)	55 (68%)	

(p=0.53) or on the Complex practical (p=0.37) when the depth on the LAP II preparation was controlled. However, when the student performance on pattern lines was controlled, then students who had an acceptable depth on the LAP II were nearly four times more likely to receive an A or B on the Class II practical (p=0.03) than those students who did not have acceptable depth. The ability to perform at an acceptable depth did not significantly improve the likelihood of receiving an A or B on the Complex practical (p=0.15) (Table 5).

Discussion

Students who were able to maintain acceptable depth on the LAP II on exercises early in the course were more than three times more likely to receive an A or B on the Class II practical than those who were not able to maintain acceptable depth. Sources of variation in LAP II performance among individual students may include natural ability to perceive depth, response to bur cutting efficiency, individual hand-

Table 3. Cross-tabulation of pattern line results and Class II and Complex practical grades

	Class II Practical Within Pattern Lines (p=1.0)		Complex Practical Within Pattern Lines (p=0.21)	
Practical Grade	Yes Number (percent)	No Number (percent)	Yes Number (percent)	No Number (percent)
Desirable				
A	2 (6%)	4 (8%)	2 (6%)	3 (6%)
B	10 (31%)	13 (27%)	20 (63%)	22 (45%)
Undesirable				
C	15 (47%)	24 (49%)	7 (22%)	16 (33%)
F	5 (16%)	8 (16%)	3 (9%)	8 (16%)

Table 4. Cross-tabulation of acceptable depth results and Class II and Complex practical grades

	Class II Practical Acceptable Depth (p=0.15)		Complex Practical Acceptable Depth (p=0.08)	
Practical Grade	Yes Number (percent)	No Number (percent)	Yes Number (percent)	No Number (percent)
Desirable				
A	4 (7%)	2 (8%)	4 (7%)	1 (4%)
B	20 (36%)	3 (12%)	32 (58%)	10 (38%)
Undesirable				
C	23 (42%)	16 (61%)	13 (24%)	10 (38%)
F	8 (15%)	5 (19%)	6 (11%)	5 (19%)

Table 5. Odds ratios and 95% confidence intervals for odds ratios for effect of pattern line and depth on preclinical proficiency (A or B) on Class II and Complex practicals

	Class II Practical		Complex Practical	
Effect	Odds Ratio	95% CI	Odds Ratio	95% CI
Within Line	0.72	(0.26, 1.99)	1.59	(0.58, 4.4)
Good Depth	3.73	(1.13, 12.29)	2.15	(0.77, 6.04)

piece turbine wear/eccentric bur rotation, and the operational speed of bur rotation. Sources of variation impacting Class II practical performance include potential variation in the amount of simulated caries and the stress of the practical environment in addition to those mentioned for the LAP II. The consistency of faculty feedback may also impact levels of student performance.

A previous study found a correlation between initial student ability to prepare patterns on an acrylic block with subsequent practical performance but did not report which aspect of the pattern preparation was most predictive.[10] In this study, half as many students were initially able to maintain an acceptable depth as compared with those who were able to stay within the lines. Analysis revealed that the depth aspect of performance on the LAP II was predictive of practical performance early in the course. Students begin dental school with varied natural levels of stereoscopic vision (stereopsis) that is required for depth perception. It may be that the untrained ability to control the handpiece is enhanced when the pattern lines can be clearly visualized on the surface of the block but that initial performance at an acceptable depth requires a minimum, innate level of stereopsis. Low levels of stereopsis can be augmented with training.[11] Research that evaluated first-year dental student stereopsis found that students with low levels of stereopsis still performed well with regard to manual dexterity in a preclinical operative dentistry course as assessed by average overall practical performance.[11] That study suggested that students compensated for low levels of stereopsis by learning to use monocular clues, such as bright and dark areas or physical landmarks, to inform their depth perception. The finding that unacceptable LAP II performance was not predictive of performance on the Complex practical at the end of the course may indicate that the length and rigors of the preclinical course were such that the necessary visual input required to inform handpiece control, with regard to depth, was gradually learned along with other decision making skills.

The LAP II preparations were accomplished using new 245 tungsten carbide burs. The cutting efficiency of the side of this bur is much greater than the end. It may be that some students initially tended toward using increased force and, as a result, lost control while establishing the preparation depth. Continuation of this tendency may have resulted in poor practical performance as well. Early recognition of this tendency may allow opportunity for instruction helpful in identification of steps that increase motor dexterity control.

All handpiece air turbines were fully functional, but no attempt to assess levels of bearing wear, which may result in eccentric bur rotation, was accomplished. Various amounts of turbine bearing wear were noted during the course progression, and this could have impacted student performance on the LAP II and on the subsequent practicals. Further study is required to assess the relative amount of impact that worn air turbine bearings may have on the ability to perform precise preparations and whether this could result in an incorrect evaluation of student manual dexterity.

Verbal instructions on the use of the handpiece speed control rheostat were given to all students, and preparation under maximum handpiece rpm was encouraged. Variation in the rotational speed greatly influences the amount of force needed to accomplish the LAP II preparations. Slower speeds may have encouraged increased force application and thereby increased friction. It is conceivable that pinpoint high temperature areas may have resulted in partial melting of the LAP II material followed by an immediate increase in depth. Inspection of all the LAP II blocks did not reveal any evidence of discoloration suggestive of excessive heat generation, but the potential, though unlikely, cannot be completely ruled out.

Consistency in the level of simulated caries (both in depth and spread at the DEJ) in the dentoform teeth depends on the quality control of the manufacturer. There are currently no published studies that evaluate the level of variation. For the purposes of this study, the variation was considered to be minimal; however, research is currently under way to address this potential concern.

Student feedback begins in the preclinical phase of the dental school environment and extends into the clinical phase, with much of the criteria for preclinical grading being transferred into the clinical arena. Consistent, accurate, and timely student feedback seems to be highly valued among teachers of restorative dentistry; however, steps to accomplish this goal may not be frequently practiced.[12] Obstacles that may result in compromised quality or timing of feedback may include high student to faculty ratios and inadequate faculty calibration. A large number of participating instructors may result in greater chance of variation in formative feedback during the course. In addition, timely individual student feedback may be delayed.

In this study there were eight students per instructor during the course (ten instructors participated in the laboratory component of the course). There were diverse levels of educational experience and advanced education among the laboratory instructors, and no formal calibration was accomplished. A review of course critiques revealed student frustration with regard to inconsistent and delayed instructor feedback. Methods of faculty calibration are being developed to address this course weakness.

The vast majority of the students in our study were able to eventually develop adequate basic handpiece skills through repeated projects accomplished in the course. This is in support of another study that found that the majority of dental students are able to develop motor skills necessary for dentistry.[13] The Complex preparation required more sophisticated problem-solving abilities than the Class II preparation while maintaining the same need for handpiece control. It may be that as the students become veterans of the practical experience, they become less susceptible to test pressures that have a negative influence on control of the handpiece as well as the ability to think rationally. Even so, by the time adequate basic skills are developed, some students may still receive an undesirable overall course practical grade average.

It is tempting to conclude that the LAP II is useful for the early identification of students who may benefit from additional individualized instruction in handpiece operation. Visual assessment of unacceptable depth performance on the LAP II and immediate communication with the student can be readily accomplished. Recognition of unacceptable performance could be followed by a prompt refocusing of course resources leading to rapid intervention. The goal would be for successful intervention to occur before poor performance on summative assessments has occurred. In addition to instructional ease of use, it might be argued that the LAP II has the potential to be a cost-effective initial alternative to plastic dentoform teeth (with simulated caries) if it were used as a means of early identification of students that would benefit from additional focused instruction. However, the data presented here show that only one relationship (acceptable depth) out of eight tested is associated with performance on one early laboratory practical. Whether this is a chance finding or is a real indicator is still unproven and requires verification. Practical grades represent evaluation by course faculty of overall global preparation performance on anatomically correct teeth in correct patient/operator positions. These preparations require much additional knowledge and skill beyond that used on the LAP II. Further studies will be required to compare the various components of preparation performance (wall orientation in the various tooth anatomic regions, wall smoothness, preparation transitions and depth) with early LAP II performance in order to identify/clarify any potential predictive value. These studies also should seek to identify if early identification and remediation of perceptual or technical errors, initiated by unacceptable depth performance on the LAP II, results in practical performance at a desirable level. The specifics of the remedial steps will need to be assessed to identify if there are educational strategies that, in addition to exercises involving repetition and discrimination, foster improved early handpiece operation and, ultimately, attainment of higher levels of preclinical competence.

Conclusions

Students tend to make errors in pattern preparation width, depth, or both, and a broad range of preparation performance can be readily detected on the LAP II. The LAP II may be useful for the early identification of students who would potentially benefit from additional individualized instruction in handpiece operation. Early intervention may result in more rapid development of handpiece handling skills, as assessed by performance on practicals given early in the course, and a higher average practical grade(s) in the course.

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