

Curriculum-Based Evidence of Competence in Dental Materials Science: Integrating C4 Lectures, P5 Practicals, and Assessment

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ABSTRACT

Competence in Dental Materials Science requires students to connect material composition, properties, manipulation, indication, and professional judgment. This study examined whether Materials-Decision Studio Sequencing (MDSS) can make such competence visible in curriculum records from a competency-based Dental Materials Science course. The record set included 25 lecture topics, eight practical sessions, and six delivery–assessment weighting entries. MDSS was applied through Competency-Trace Audit (CTA), Evidence-Contact Reallocation (ECR), and Handling-Readiness Laddering (HRL) to identify evidence of explanation, selection justification, manipulation, feedback, assessment position, and readiness. The course contained 39 records, including 33 topic records and six weighting records. All 25 lectures were traceable to CLO1 and CLO2 at C4 level, while all eight practical sessions were traceable to CLO3 at P5 level. Delivery contact shifted from 82% cognitive and 18% psychomotor to 79% cognitive and 21% psychomotor contact. Assessment changed from 40% formative and 60% summative weighting to an equal 50% formative and 50% summative structure. Psychomotor assessment was redistributed from one 25% OSPE weighting to 10% laboratory practical and 10% OSPE weighting. CTA showed strong explanation coverage, dense cognition in adhesive-restorative topics, clear lecture–practical contact for record-supported materials, limited practical contact for ceramic-metal-device topics, and single-exposure treatment of emerging biomaterials. HRL interpreted the eight practical sessions as a readiness pathway from recognition to independent justification. The findings answer the research question affirmatively but conditionally: MDSS reveals competence when the course is read through explicit evidence positions, with strongest evidence in C4 explanation, P5 handling, formative reallocation, and decision-ledger positions.

KEYWORDS

Dental Materials Science; competency-based dental education; curriculum alignment; formative assessment; psychomotor readiness; material selection



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1. INTRODUCTION

There is a clear uniqueness of the Dental Materials Science course in the context of the undergraduate dental curriculum because it combines materials science education and prepares for clinical practice. The learner

should understand such concepts as setting reactions, dimensional stability, corrosion, polymerization, bonding, cementation, wear, finishing, surface behavior, and biocompatibility; however, the importance of this knowledge is demonstrated only if it influences material selection, manipulation, error identification, and justifications of material usage. Hence, the ability to describe glass ionomer cements, mention the applications of gypsum, or define polymerization does not guarantee the successful completion of the course if the student is unable to apply this knowledge in a clinical situation, handling material risks, and making justified decisions about using the material.

Competency-based approach increases this requirement. Competence of a dentist is not the result of recall, but the process of interpretation of the situation, decision making, safe performance, and learning from feedback. The need for moving beyond named outcomes to observable tasks in dental education curricula has been highlighted in literature [1]. Competency frameworks used for organization of dental education focus on reviewable professional performance [2]. Competence-based education in health professions has been defined through observable abilities. Entrustable professional activities connect abilities and professional tasks [3]. Competence as a developmental process is characteristic of milestone approaches [4]. Reform of health professions' education warns against terminal test [5]. In other words, for Dental Materials Science, it means that one written answer cannot prove that students are able to proportion, mix, time, adapt, inspect, and correct materials in laboratory conditions.

Another challenge of the course is its location among others in the curriculum, meaning that many students will not be able to fully comprehend the impact of material behavior on further operative, prosthodontic, orthodontic, implant, endodontic, pediatric, and laboratory decisions. If topics of materials are organized separately, as scientific units, the students will feel that material science is something apart rather than a series of decisions in clinical and laboratory situations. Perception of the stand-alone dental materials education has proven relevance, integration, and feedback in this field [6]. However, the curricula of health professions should also protect scientific width; the reduction of content is not the aim.

Alignment is crucial for this problem. Constructive alignment connects outcomes, teaching activities, and assessment opportunities, but the syllabus can be aligned without revealing the exact moment when the competence expectation becomes observable [7]. Programmatic assessment will interpret multiple pieces of evidence over time [8]. This approach also incorporates formative feedback with summative assessment [9]. Direct observation and feedback provide an important performance dimension [10]. All this is especially relevant to Dental Materials Science because the timely feedback is very important. The student's miscalculation of the time, proportion, conditions of bonding, contamination risk, thickness, or dimensional stability requires correction before OSPE, not only the mark after it.

MDSS responds to this educational problem through the reading of Dental Materials Science in terms of material decisions. A material decision episode combines scientific concept with handling/observation task, feedback opportunity, and justification of material usage or rejection. 25 lecture topics and 8 practical sessions can be read for the purpose of generation of evidence. CTA, ECR, and HRL help to answer the following research question: Can a Dental Materials Science course record containing 25 C4 lecture topics, 8 P5 practical sessions, and 6 delivery-assessment entries reveal the places where the students generate visible evidence of explanation, material selection, manipulation, feedback, assessment readiness, and interdisciplinary translation?

The overview of the course record in Figure 1 establishes the scope of the paper. Three panels combine lecture records, practical records, and delivery-assessment records in relation to the same competence target.

This record overview focuses on the record set at the level of curriculum evidence and not learner achievement. The 25 lecture cards cover the cognitive breadth of the course, the practical objects are examples of manipulation and observation, and the six record forms indicate the delivery-assessment structure. Interpretation of the record set thus pertains to record-visible competence: the crucial issue is how competence is visible in the design of the course, not how learners scored.



Figure 1: Course record overview.

2. MATERIALS AND METHODS

2.1. Study design

The curriculum record analysis in this study considered the course record as the unit of analysis. Individuals such as students, faculty members, patients, and clinical cases were thus excluded from the record set. It sought to identify whether the records in the Dental Materials Science course reveal an evidence pathway from content exposure to explanation, selection, handling, feedback, and readiness. There were no student scores, survey data, patient records, or faculty evaluations included in the analysis.

2.2. Curriculum record set

The input records in this curriculum record analysis were from the competency-based Dental Materials Science curriculum by Lin, Foong, and Kumaresan, which provided a list of 25 lectures, eight practical sessions, three course learning outcomes, target cognitive and psychomotor levels, teaching arrangements, assessment pathways, and delivery-assessment weighting ratios [11]. The topic-record section consisted of 33 records: 25 lecture records and 8 practical session records. Each lecture preserved its name, alignment with CLO, and C4 target level. Each practical session kept its name, alignment with CLO, and P5 target level. The weighting-record section had six entries: cognitive teaching delivery, psychomotor teaching delivery, cognitive formative assessment, cognitive summative assessment, psychomotor formative assessment, and psychomotor summative assessment.

Table 1 describes the exact sequence record: 33 topic records and 6 weighting records. The all-C4 lecture alignment determines the cognitive record level as explanation and justification. The all-P5 practical alignment determines the psychomotor evidence record beyond imitation and towards coordinated, independent handling. The main analytic problem, therefore, is the contact between the two record types.

2.3. Materials-decision studio sequencing

MDSS divided lecture topics into material-decision families and established the connection of practical sessions to studio-laboratory episodes. Every studio episode consisted of four associated elements: material problem, handling or observation task, feedback and clinical justification. This way, outcome, activity, and assessment opportunities are aligned within the recorded course inventory [7].

The C4–P5 alignment perspective in Figure 2 illustrates the sequencing in a contact map. Intersected woven intersections identify material groups with the direct contact of lecture explanation and laboratory handling such as gypsum products, impression materials, waxes, composite resin, liners, bases, glass ionomer cement, dental cements, polymers and denture lining materials.

Interpretation of the loom demonstrates that the alignment is uneven, not missing. Record-support materials and restorative-protective materials have high intersections because the laboratory contact is close to the lecture content. Ceramic, metallic, orthodontic and implant-related materials have low practical weave because the lecture area is

broad but the practical contact is narrow. The distinction allows us to interpret dense and weak evidence contact rather than the topic count in the Results section.

Table 1: Course topic inventory.

Type and no.	Course topic	Learning outcome	Target level
Lecture 1	Introduction to clinical and laboratory dental materials	CLO1 and CLO2	C4
Lecture 2	Properties of dental materials	CLO1 and CLO2	C4
Lecture 3	Gypsum products	CLO1 and CLO2	C4
Lecture 4	Tarnish and corrosion	CLO1 and CLO2	C4
Lecture 5	Synthetic polymers	CLO1 and CLO2	C4
Lecture 6	Denture base polymers	CLO1 and CLO2	C4
Lecture 7	Bonding of resin-based materials	CLO1 and CLO2	C4
Lecture 8	Impression materials	CLO1 and CLO2	C4
Lecture 9	Principle of adhesion: acid etch and bonding agent	CLO1 and CLO2	C4
Lecture 10	Dental composite resin	CLO1 and CLO2	C4
Lecture 11	Glass ionomer cement	CLO1 and CLO2	C4
Lecture 12	Resin-modified glass ionomer cement and compomer	CLO1 and CLO2	C4
Lecture 13	Dental cements	CLO1 and CLO2	C4
Lecture 14	Linners and bases	CLO1 and CLO2	C4
Lecture 15	Dental abrasive and polishing materials	CLO1 and CLO2	C4
Lecture 16	Dental wax	CLO1 and CLO2	C4
Lecture 17	Denture lining materials	CLO1 and CLO2	C4
Lecture 18	Introduction to metals and alloys: concept, structures, and properties	CLO1 and CLO2	C4
Lecture 19	Cast dental alloys	CLO1 and CLO2	C4
Lecture 20	Steel and wrought alloys	CLO1 and CLO2	C4
Lecture 21	Dental ceramic	CLO1 and CLO2	C4
Lecture 22	Porcelain fused to metal	CLO1 and CLO2	C4
Lecture 23	Materials in orthodontics	CLO1 and CLO2	C4
Lecture 24	Metal and alloys in dental implants	CLO1 and CLO2	C4
Lecture 25	Emerging dental biomaterials and advanced technologies	CLO1 and CLO2	C4
Practical 1	Introduction to clinical and laboratory dental materials	CLO3	P5
Practical 2	Physical and mechanical properties of dental materials	CLO3	P5
Practical 3	Mixing and manipulating gypsum products in dentistry	CLO3	P5
Practical 4	Mixing and manipulating dental composite resin, liners, and bases	CLO3	P5
Practical 5	Mixing and manipulating glass ionomer and other dental cements	CLO3	P5
Practical 6	Mixing and manipulating impression materials and dental waxes	CLO3	P5
Practical 7	Mixing and manipulating dental polymer and denture lining materials	CLO3	P5
Practical 8	Introduction to dental ceramic and metal alloys	CLO3	P5

2.4. Competency-trace audit

CTA was used to every topic and weighting record. Every record was read for five evidence signals. Explanatory evidence meant whether the record requires the students to explain composition, properties, setting behaviour, physical reaction, mechanical performance, degradation and surface behaviour. Justificatory evidence meant whether the record allows the students to defend selection or rejection of the material for particular clinical or laboratory usage. Manipulation evidence meant whether the handling, proportioning, mixing, timing, adaptation, inspection or recognition of performance-altering mistake can be observed. Feedback evidence meant whether the record creates the possibility of correction before summative judgement. Assessment evidence meant the position of the signal: formative, summative or both. CTA was limited to course-design evidence.

2.5. Evidence-contact reallocation

ECR compared conventional and competency-based delivery-assessment structures. The percentage-point difference was calculated for cognitive teaching delivery, psychomotor teaching delivery, total formative assessment, total summative assessment, psychomotor formative assessment, psychomotor summative assessment and total

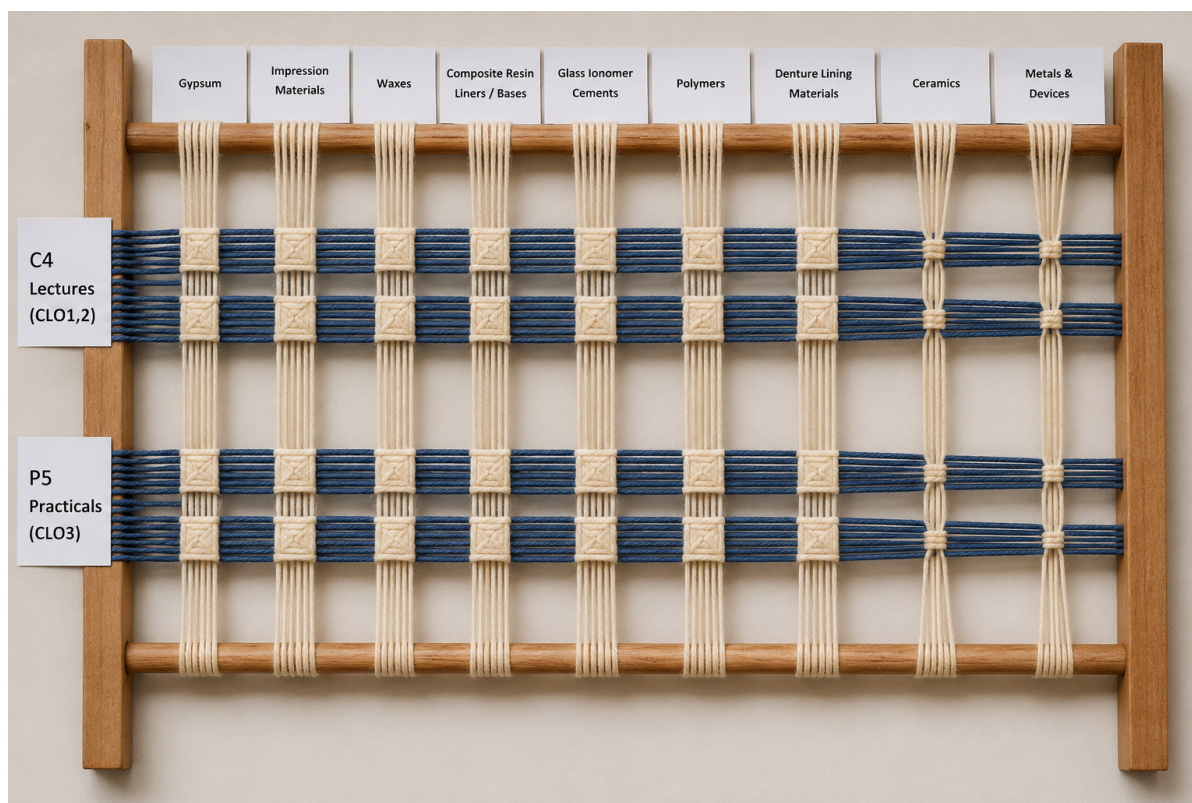


Figure 2: C4–P5 alignment.

psychomotor assessment. Interpretation was based on whether the psychomotor evidence remained concentrated in the terminal OSPE performance or became distributed through laboratory practical assessment and summative OSPE. Repeated assessment information provides credible judgement [8]. It becomes more useful for learning if the evidence is interpreted in multiple assessment moments [9]. Dental assessment scholarship supports the same approach of learning-oriented evidence [12].

2.6. Handling-readiness laddering

HRL converted the eight practical sessions into the readiness path. The five stages were material recognition, behaviour interpretation, controlled manipulation, selection justification and independent readiness. Recognition described identification of material groups and general use. Behaviour interpretation described connection of the observed property to its consequence. Controlled manipulation described the accurate handling under laboratory conditions. Selection justification required students to defend their choice using function, limitation and risk. Independent readiness described performance and justification under OSPE-like conditions. The feedback orientation of HRL is based on the understanding that students need to receive interpretable information on how current performance differs from the expected performance [13]. Feedback also needs to be clear enough to guide improvement [14]. Students also need to be supported in using feedback effectively [15].

2.7. Analysis and ethics

Counts characterized 33 topic records and 6 weighting records. Percentage-point differences described the changes in delivery and assessment. Topic families were interpreted according to the decision demand and evidence strength. Practical sessions were mapped to HRL stages and associated with observable evidence demands. No interaction with human participants, identifiable records or patient information was included.

3. RESULTS

3.1. Curriculum trace alignment and topic-family distribution

The curriculum trace record set comprised 39 items. The 33 item topic entries included 25 lectures and eight practical sessions, resulting in a lecture-to-practical ratio of 25:8. The lecture list included introductory dental materials, materials properties, gypsum, tarnishing and corrosion, artificial polymers, denture base polymers, resin bonding, impression materials, adhesion, composite resin, glass ionomer cement, resin-modified glass ionomer cement and compomer, dental cements, liners and bases, abrasives and polishing materials, dental wax, denture lining materials, metals and alloys, cast alloys, steel and wrought alloys, dental ceramic, porcelain fused to metal, orthodontic materials, implant-related metals, and emerging dental biomaterials. The practical list included material orientation, physical and mechanical properties, gypsum manipulation, composite resin with liners and bases, glass ionomer and other cements, impression materials and dental waxes, dental polymers and denture lining materials, and introductory ceramic-metal alloy manipulation.

The lecture-topic distribution shown in Figure 3 includes five material-decision families: foundations and material behaviour, adhesive-polymeric-restorative-protective materials, record-support-prosthodontic-processing materials, ceramic-metallic-orthodontic-implant-related materials, and emerging biomaterials.



Figure 3: Lecture-topic families.

The arrangement into groups makes clear the major distribution result. Adhesive, polymeric, restorative, and protective materials are the largest family including nine topics, thus making this domain the most cognitively dense, and requiring the most explicit decision-justification records. Ceramic, metallic, orthodontic, and implant-related materials are the second largest family, including seven topics, yet their practical manipulation is limited to one introductory ceramic-metal session. Foundations and record support topics both include four topics and perform different functions – the former supplies explanatory vocabulary, while the latter provides strong manipulation links. The emerging biomaterials are limited to a single topic, thus requiring an evidence appraisal task to make the topic produce more than awareness.

All lecture records were aligned with CLO1 and CLO2 at C4, thus providing for explanation and justification. All practical records were aligned with CLO3 at P5, thus providing for independent and coordinated manipulation. The curriculum question was about meeting of these two traces in observable locations. CTA produced the strongest links between the trace and topic where there was a nearby practical analogue to a lecture topic, such as gypsum products, impression materials, dental waxes, composite resin, liners, bases, glass ionomer cement, other cements,

dental polymers, and denture lining materials. Weaker links appeared where several lecture topics were dependent on a single practical encounter, such as ceramics, metal alloys, porcelain fused to metal, orthodontic materials, and implant-related metals.

3.2. Delivery and assessment evidence

The weighting records show a small delivery adjustment and a larger timing adjustment of evidence. The cognitive delivery of teaching fell from 82% to 79%, losing three percentage points. Psychomotor delivery rose from 18% to 21%, gaining three percentage points. This did not undo the dominance of cognitive delivery, but it clarified the role of laboratory contact in delivery.

There was a larger change in assessment. Formative assessment went up from 40% to 50%. Summative assessment decreased from 60% to 50%. Psychomotor assessment went from 25% summative OSPE to a new two-part pattern of 10% laboratory practical assessment and 10% OSPE. Psychomotor assessment decreased from 25% to 20%, but it achieved a stronger position in the learning process since half of psychomotor evidence was moved to before the terminal examination. This is important since errors in proportioning, mixing, timing, contamination control, adaptation, and dimensional stability need to be corrected while there is an opportunity to correct technique.

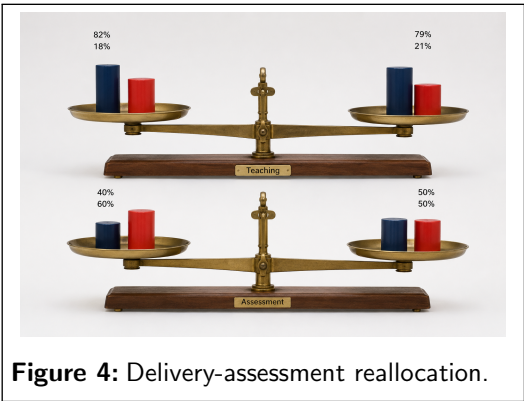


Figure 4: Delivery-assessment reallocation.

Paired balances in Figure 4 show the separation of delivery adjustment from assessment adjustment. Teaching balance is barely adjusted, but assessment balance adjusts the educational role of psychomotor evidence.

The balance display supports the central quantitative analysis: the major gain was not three percent increase in psychomotor delivery, but the repositioning of psychomotor evidence into formative space. A 10% laboratory practical component gives faculty a legitimate position to observe and correct technique prior to OSPE, while a 10% OSPE component retains a judgment of final performance. This provides an answer to the first part of the research question.

Table 2: Delivery and assessment changes.

Curriculum element	Conventional	Competency-based	Change	Interpretation
Cognitive teaching delivery	82%	79%	−3 points	Cognitive teaching remains dominant while practical contact becomes slightly more visible
Psychomotor teaching delivery	18%	21%	+3 points	Laboratory contact receives a clearer place in delivery
Total formative assessment	40%	50%	+10 points	Evidence is collected during learning rather than mainly at the end
Total summative assessment	60%	50%	−10 points	Terminal judgement becomes balanced with formative information
Psychomotor formative assessment	0%	10%	+10 points	Practical performance becomes visible before OSPE
Psychomotor summative assessment	25%	10%	−15 points	OSPE remains present but no longer holds all psychomotor evidence
Total psychomotor assessment	25%	20%	−5 points	Total weight is lower, but timing is stronger for feedback

The rows of ECRs in Table 2 illustrate that reduced total weight of psychomotor assessment does not automatically result in less strong psychomotor evidence. Conventional 25% OSPE places evidence burden at the end. Competency-based 20% split produces two evidence events: practical checkpoint during learning and OSPE end event. Educational benefit comes from this altered evidence sequence, not from the increased percentage.

3.3. Competency-trace audit across material-decision families

CTA grouped 25 lecture topics into five material-decision families. Foundations and material behavior included four topics: introduction to clinical and laboratory dental materials, properties of dental materials, tarnish and corrosion, and dental abrasive and polishing materials. It generated strong explanatory evidence since students need to learn about the categories of materials, physical and mechanical properties, surface changes, degradation,

and finishing. Trace vulnerability of this family was abstraction: if there is no related observation or decision event, students might have a knowledge of the concept but lack its application to handling errors or clinical situations.

Adhesive, polymeric, restorative and protective materials included nine topics: synthetic polymers, denture base polymers, bonding of resin-based materials, principle of adhesion, dental composite resin, glass ionomer cement, resin-modified glass ionomer cement and compomer, dental cements, and liners and bases. It was the largest and cognitively complex family. High justification potential of this family was in the necessity to compare indications, contraindications, moisture sensitivity, bonding condition, polymer behavior, protective properties, and restorative properties. Its risk was of overload if the topics were taught separately as separate material categories.

Record, support and prosthodontic processing materials included gypsum products, impression materials, dental wax, and denture lining materials. This family had the highest connection potential between the lecture and practical work since all four topics had obvious manipulation or serviceability relevance. Trace importance of this family was not whether the students can manipulate the materials, but whether they can explain the effects of manipulation on the accuracy of the dimensions, set response, patient comfort, further prosthodontic quality, repair and maintenance.

Ceramic, metallic, orthodontic and implant-related materials included seven topics: introduction to metals and alloys, cast dental alloys, steel and wrought alloys, dental ceramic, porcelain fused to metal, materials in orthodontics, and metal and alloys in dental implants. High clinical importance of this family was in engagement of such characteristics as strength, esthetics, corrosion, surface behavior, biocompatibility, and device function. The trace vulnerability point of this family was lack of practical evidence relatively to the topic diversity. Emerging dental biomaterials and advanced technologies included one topic. The importance of this family was in the awareness of innovations, but the evidence signal was narrow until students assessed the clinical potential, handling issues and readiness to use the new technologies.

The ceramic-metal-device contact issue is highlighted in Figure 5. Seven C4 lecture topics are contrasted with the narrow P5 practical contact provided by the introductory lecture on ceramic and metal alloys.

The cutaway message is not in removing ceramic, alloy, orthodontic or implant-related lectures. The point is that the selection reasoning is wider than practical observations in this family. Specimen identification task, material selection note, or decision-ledger entry may improve evidence visibility among the recorded topics. This is the most detailed trace vulnerability point in the lecture-practical record (Table 3).



Figure 5: Ceramic-metal contact pressure.

Table 3: Material-decision family traces.

Material-decision family	Topics	Primary evidence strength	Trace action
Foundations and material behaviour	4	Explanation of material categories, properties, corrosion, and surface finishing	Attach short fault-recognition prompts to prevent abstraction
Adhesive, polymeric, restorative, and protective materials	9	Justification of bonding, restoration, cementation, protection, and polymer use	Use decision ledgers for indication, limitation, and handling-risk comparison
Record, support, and prosthodontic processing materials	4	Manipulation linked to accuracy, stability, processing, comfort, and serviceability	Connect every manipulation task to a clinical or laboratory consequence
Ceramic, metallic, orthodontic, and implant-related materials	7	Selection reasoning for strength, esthetics, corrosion, compatibility, and device function	Add specimen identification and selection-justification tasks
Emerging biomaterials and advanced technologies	1	Awareness of innovation and advanced material use	Require evidence appraisal rather than descriptive exposure alone

Family-level conflicts contain the qualitative results of CTA. It is important to notice that the evidence is of different quality depending on material families: some material families produce manipulation evidence more naturally, some

produce explanation evidence, and some require specific prompting to make justification evidence observable. At the same time, the table does not allow making an overgeneralized interpretation of curriculum alignment: one course might be aligned at the CLO level but at the same time require different evidentiary actions in different material families.

3.4. Handling-readiness ladder

HRL has helped transform eight practical sessions to a step-by-step readiness ladder. Introduction to clinical and laboratory dental materials practical has been allocated to material recognition position. Physical and mechanical properties of dental materials practical has been assigned to behaviour interpretation position. Gypsum manipulation and composite resin with liners and bases practical have been allocated to controlled manipulation position. Practical five and six of glass ionomer and other cements, impression materials, and dental waxes have been assigned to selection justification position. Dental polymers and denture lining materials practical has been allocated to serviceability justification position. Finally, introduction to ceramic and metal alloys practical has been allocated to independent readiness position.



Figure 6: Practical readiness benchline.

The eight practical sessions of P5 course are illustrated in Figure 6 as a benchline of laboratory activities.

Interpretation of the benchline explains why practical inventory is important for research question. Material vocabulary is created through recognition and behaviour interpretation. Material behaviour is transformed to a handling event with controlled manipulation. Finally, selection and serviceability justification link handling to clinical or laboratory consequences.

The readiness rows in Table 4 explain why HRL is not just a list of practical sessions. The column of observable evidence gives a performance significance to each laboratory topic. Early practicals develop language and interpretation; mid-practicals develop handling control; late practicals need to justify material selection and suitability. The final practical is the readiness check because it integrates material selection, use in the clinic, and justification in constrained circumstances.

	Clinical cue	Date: _____
	Material decision	_____
	Handling risk	_____
	Evidence statement	_____
	Feedback action	_____
Student: _____		Assessor: _____

Figure 7: Decision-ledger card.

Table 4: Handling-readiness ladder.

Practical	Laboratory topic	Readiness stage	Observable evidence required
1	Introduction to clinical and laboratory dental materials	Material recognition	Student identifies representative material groups and states their role in care
2	Physical and mechanical properties of dental materials	Behaviour interpretation	Student links an observed material property to a likely clinical consequence
3	Mixing and manipulating gypsum products in dentistry	Controlled manipulation	Student proportions, mixes, and explains setting or accuracy consequences
4	Mixing and manipulating dental composite resin, liners, and bases	Controlled manipulation	Student handles restorative or protective materials and recognises handling-sensitive error
5	Mixing and manipulating glass ionomer and other dental cements	Selection justification	Student selects a cement for a defined use and defends the choice by function and limitation
6	Mixing and manipulating impression materials and dental waxes	Selection justification	Student connects manipulation to record accuracy, stability, and prosthodontic quality
7	Mixing and manipulating dental polymer and denture lining materials	Serviceability justification	Student explains how handling affects comfort, repair, maintenance, and durability
8	Introduction to dental ceramic and metal alloys	Independent readiness	Student identifies material class, states clinical use, and justifies selection under OSPE-style conditions

3.5. Decision-ledger output

CTA, ECR, and HRL come together in a decision-ledger for the studio and the laboratory sessions. It is a compact formative document instead of a replacement of written assessment or OSPE. It invites students to document the clinical cue, the material selection or rejection, the handling risk that could threaten the success of the task, the evidence that supports the selection and the feedback actions necessary to be ready for independent performance.

The five-field document in Figure 7 contains the clinical cue, material decision, handling risk, evidence statement and feedback action in one sheet.

The visual format emphasizes the practical value of the decision-ledger. Each field screens a typical weakness in materials education: disconnected facts, unconnected material selection, unknown handling risk, removed from the context scientific evidence, or unlinked feedback and action. Because of its brevity, the document can be used during laboratory sessions but will still present readiness evidence before summative assessment.

Table 5: Decision-ledger fields.

Ledger field	Student-facing prompt	Competence evidence produced
Clinical cue	What clinical or laboratory need is being addressed?	Recognition of indication and treatment context
Material decision	Which material is selected or rejected?	Justification of material choice
Handling risk	Which manipulation error would most likely compromise the outcome?	Awareness of proportioning, timing, mixing, contamination, or dimensional stability risk
Evidence statement	What property, behaviour, or observation supports the decision?	Connection between material science and clinical reasoning
Feedback action	What must be corrected before independent performance?	Formative action tied to readiness stage

The five fields in Table 5 turn material science into a concise competency record. The clinical cue prevents material selection from being a memorized preference. The decision field requires a responsible material decision. The handling-risk field transforms technical error into an explicit target for correction. The evidence statement connects material properties or clinical consequences to reasoning. The feedback-action field completes the process by demanding a step toward further action before independent performance.

4. DISCUSSION

The record analysis answers a precise curriculum question: whether MDSS can reveal learners' competencies across C4 lectures, P5 practicals, and assessment weights. The answer is affirmative when the course is interpreted as an evidence system rather than a topic catalogue. The curriculum includes clear elements of competency-based design: all lectures are at the C4 level, all practicals are at P5, formative assessment weight reaches 50%, and psychomotor evidence is not limited to OSPE anymore. The findings are educationally significant because competence in Dental Materials Science requires evidence of material explanation, justification, manipulation, feedback, and readiness.

The literature review helps interpret this finding. Competency-based education puts an emphasis on observable performance [5]. Entrustable professional activities link performance to professional tasks [3]. Developmental framework facilitates judgement of learners' competencies at different stages of development [4]. Programmatic assessment is based on multiple evidence points [8]. It also stresses feedback-oriented assessment activity [9]. The literature about dental education similarly acknowledges the importance of learning-focused rather than summative feedback and assessment [12]. The present record set gives these principles a material-specific interpretation. In this course, the main issue is not whether the language of competencies is used; it is whether the curriculum records reveal locations of material explanation, justification, manipulation, feedback, and readiness.

The evidence signals throughout the course are visualized in Figure 8. The five panels symbolize explanation, selection justification, manipulation, feedback, and assessment as recordable course events.

The panels provide further explanation by distinguishing types of evidence from formats of teaching. Explanation may take place in a lecture, but it becomes stronger when it is connected to a material property or clinical consequence. Manipulation may take place in a practical, but it becomes educationally more powerful when handling error is named and corrected. Assessment may take place in OSPE, but it becomes more credible when prior records reveal the development of readiness. This interpretation makes clear why the course should be evaluated on the basis of evidence visibility, not just contact hours or topic number.

The topic-family results clarify the difference between coverage and competence. The adhesive-restorative family includes the largest topic count and, therefore, requires repeated selection-justification records allowing to compare indications, limitations, moisture sensitivity, bonding conditions, and handling errors. The record-support family has fewer topics but better practical contact due to natural connection between manipulation and dimensional accuracy and prosthodontic quality of gypsum, impression materials, waxes, and denture lining materials. The ceramic-metal-device family has good clinical relevance, but one introductory practical cannot reveal readiness for seven lectures. Emerging biomaterials require evidence evaluation because one lecture can raise awareness without revealing whether students can judge clinical maturity and handling implications.



Figure 8: Evidence signal panels.

The ECR result should not be understood as a mere increase in practical teaching. Teaching delivery is changed marginally. The more important result is that psychomotor evidence becomes available during learning via the 10% laboratory practical component. Students require information which can help to improve their future performance, not just remarks given after the opportunity to improve is lost [16]. Feedback also has to be specific and actionable [14]. Learners have to get chances to interpret and use the information [15]. It is aligned with evaluative judgement as well, because students learn to assess the quality of material handling and justification through repeated visibility of the criteria [17].

The HRL result provides the developmental reading of the psychomotor part of the course. Practical work may turn into a procedure checklist if students follow instructors' instructions blindly. HRL changes the reading of the same practicals by posing questions about readiness evidence each of them may generate. Recognition and behavior interpretation provide the language of materials. Controlled manipulation allows students to feel how manipulation influences material behavior. Selection and serviceability justification link manipulation to patient treatment and laboratory quality. Independent readiness prepares students for OSPE-type judgements by asking them to identify, explain, manipulate, and justify under constraint. The literature about OSCE stresses the value of performance assessment which involves tasks aligned with assessed competence [18].

The decision ledger is the most practically oriented translation of the findings. It allows students to concisely connect a cue, a material decision, a handling risk, an evidence statement, and a feedback action. The ledger also facilitates faculty calibration, because instructors are able to compare specificity of evidence statements and feedback actions. Entrustment judgements are strengthened by linking to observable behavior [19]. Readiness decisions also benefit from shared descriptions and explicit performance standards [20]. In Dental Materials Science, those descriptions can be material-specific: correct proportioning, accurate mixing, controlled timing, appropriate selection, risk recognition, and justified use.

The interdisciplinary translation of the record set is represented in Figure 9. The dental arch displays the locations of material groups relative to operative dentistry, prosthodontics, dental technology, orthodontics, implant dentistry, pediatric dentistry, and endodontics.

The dental arch illustrates why Dental Materials Science cannot be considered an isolated preclinical discipline. Composite resin, glass ionomer cement, liners, bases, and adhesion materials facilitate operative dentistry. Impression materials, dental waxes, gypsum products, denture base polymers, and denture lining materials facilitate prosthodontics and dental technology. Metals, ceramics, orthodontic materials, and implant-related materials facilitate prosthodontic, orthodontic, and implant-related decisions. Curriculum coherence depends on shared educational goals across teaching domains [21]. It also relies on deliberate connections between subjects and learning environments [22].

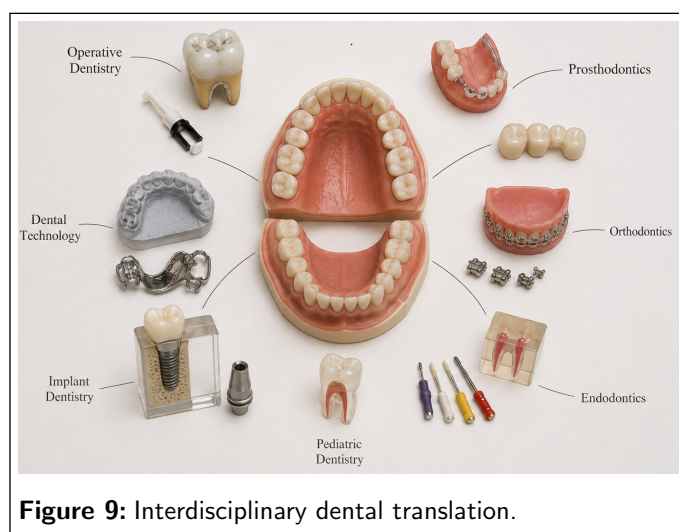


Figure 9: Interdisciplinary dental translation.

The findings are included in the curriculum record set. The curriculum-level records do not measure student achievement, faculty workload, patient outcomes, or test-score reliability. Therefore, the results illustrate the visibility of evidence positions, not the proof of improved student performance. Faculty calibration remains important, especially for judging the specificity of decision-ledger evidence statements and consistent application of HRL readiness stages. The ledger should also stay concise; otherwise, it may become a burden rather than a means of formative feedback.

The overall contribution is a material-specific answer to a curriculum quality question. A material-rich Dental Materials Science course may be educationally poor if it does not demonstrate where students are observed, corrected, and asked to justify decisions. At the same time, a course involving minor changes in contact percentages can become more accountable if evidence for assessment approaches learning and practicals are read as readiness stages. In this record set, the most important result is the combination of C4 cognitive alignment, P5 practical alignment, split psychomotor assessment, and decision-ledger fields. Together, they indicate where students can explain material behavior, justify material decisions, manipulate materials precisely, receive correction, and prove readiness for further learning.

5. CONCLUSION

The research question was whether MDSS would reveal competence evidence visibility in a Dental Materials Science course with records of 25 C4 lectures, 8 P5 practical classes, and 6 entries of delivery-assessment weighting. Yes, but the qualification is that competence visibility requires reading of the curriculum via evidence positions rather than only topics presented. C4 lectures provide a good level of C4 explanation and justification. P5 practical classes present a good potential for P5 handling. In ECR, an educationally meaningful role of the assessment is achieved through moving psychomotor evidence from the single 25% OSPE entry to the combined 10% laboratory practical + 10% OSPE endpoints. In CTA, areas of evidence strength are shown to be the adhesive-restorative and record-support material ones, while areas of vulnerability include ceramic-metal-device and new biomaterials content. In HRL, the 8 practical classes build up a readiness progression from recognition to independent justification. Thus, the answer is not only the alignment, but also the demonstration of where learners have to explain, select, manipulate, correct, and justify their knowledge of dental materials.

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