Taxonomy for Competency-Based Dental Curricula


Abstract: The objective of this article is to propose a classification of dental competencies. Interest in dental competencies has grown consistently during the last three decades. However, the dental education literature suggests that the term “competency” is understood and used differently by dental schools around the world. The taxonomic classification of dental competencies we propose follows a systematic approach starting at the highest level of complexity, i.e., the professional profile the teaching institution envisions for its graduates, and following in a decreasing degree of complexity to competency function, task, step, movement, and moment. This taxonomy has proved to be useful for more than thirty years in the Dental School of the Peruvian University Cayetano Heredia. Graduates of this school are successful practitioners, teachers, and researchers in Peru and other countries. The classification proposed here should clarify terms, facilitate curriculum design and learning assessment, stimulate further discussion on the matter, and facilitate communication among the dental education establishment.

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Why a taxonomy? A review of competency statements for the graduating dental practitioner, as they appear in lists provided by dental associations and schools around the world, suggests that a nomenclature and classification of dental competencies is needed to facilitate their handling in the development of curricula and to facilitate exchange among institutions and countries.1-7

Generally speaking, a competency can be defined as the capacity to identify a problem and act skillfully in its solution. In the health professions, this definition includes a wide variety of skills, ranging from those of highest complexity (for example, making a clinical diagnosis) to the less complex and more specific (for example, the body position and movements to make an appropriate visual inspection). Therefore, a classification system—taxonomy—is required to apply competencies into a rational, coherent, and efficient learning process. In the absence of such a taxonomy, an educational program becomes fragmented, nonintegrated, repetitive, and inefficient, and it may lead to the graduation of individuals lacking appropriate skills for their future professional deployment.8,9 As described by Krathwohl et al.,10 a taxonomy is a set of classifications which are ordered and arranged on the basis of a single principle or on the basis of a consistent set of principles. Such a true taxonomy may be tested in determining whether it is in agreement with empirical evidence and whether the way in which the classifications are ordered corresponds to a real order among relevant phenomena. The taxonomy must also be consistent with sound theoretical views available in the field. Where it is inconsistent, a way should be developed of demonstrating or determining which alternative is the most adequate one. Finally, a true taxonomy should be of value in pointing to phenomena yet to be discovered.

In the taxonomy we propose here, we will use terms with specific meaning, such as 1) profile, 2) competency, 3) function, 4) task, 5) step, 6) movement, and 7) moment, for each of the seven levels of complexity identified. The term “competency” is reserved for the second level of complexity, in order to avoid confusing terms such as “domain” and “sub-competency.” Our taxonomy is the result of function and task analysis11-15 performed by the faculty
team who developed and implemented the dental curriculum for the Peruvian University Cayetano Heredia (Universidad Peruana Cayetano Heredia—UPCH) School of Stomatology. The empirical observations obtained during more than thirty years of applying such taxonomy in the training of successful dental practitioners, teachers, and researchers support the validity of our proposition.

The Proposed Taxonomy

Our proposed taxonomy follows the scientific principles of systematic classification by grouping competencies according to their similarities within a set of relationships. To accomplish this objective, we used a classification parameter to rationalize the relationship between health problems and the competencies proposed to address them. At the core of the classification system resides the professional profile that the learning institution intends the graduate to have. The professional profile could be viewed as an explicit or implicit blueprint depicting the professional activities that the learning institution considers important in their graduates, including skills in the intellectual, affective, psychomotor, and volitive domains. In this profile are included a set of personal attributes such as creativity, ethics, aesthetics, and critical sense. Education in these personal attributes should be an integral part of the professional learning experience.

This professional profile constitutes our first and highest level of complexity. From this core, a branching system of progressively less complex procedures emerges.

In order to visualize the relationship between needs and dental health required, we used a double entry table (Figure 1), where the y axis represents the oral health needs and the x axis the levels of dental care required to address those needs.

The following is the classification of dental health needs:
1) diseases and conditions of the dental tissues,
2) diseases and conditions of the periodontal support,
3) variations in occlusion,
4) other conditions in the maxillofacial region,
5) systemic diseases with unidirectional and bidirectional effects on the tissues of the oral cavity, and
6) needs assessed at the community level.

The following is the classification proposed for the kind of dental care required:
1) diagnosis and treatment planning,
2) health promotion,
3) prevention of disease and associated risk factors,
4) recovering a healthy status,
5) form and function rehabilitation, and
6) administration.

In Figure 1, each column and each row represent a competency. To develop competencies to address dental caries, for example, a disease of the dental tissues, the students need to perform diagnostic, promotional, preventive, recuperative, rehabilitative, and administrative functions. On the other hand, diagnostic functions are required for each of the six dental needs. In consequence, the total number of competencies in our taxonomy is twelve. In this taxonomy, competencies are the second order of complexity.

The third order of complexity is the function, which results from the intersection of each dental need and type of care required. Each intersection, however, could have more than one function, depending on the nature of the dental need and the current state of scientific and technological development. For example, the intersection of “diseases of the dental tissues” and the function “rehabilitation” includes all functions dealing with the restoration of dental tissues caused by a variety of conditions and using a vast number of materials and procedures. Each one of these constitutes a function. A function, therefore, is a full set of procedures within the frame of a competency that, independently executed, leads to the resolution of a specific need, for example, the restoration of a decayed tooth or the extraction of an infected tooth.

Each function is composed of a set of sequential procedures called tasks. Tasks have specific outcomes not responsible for the full solution of a given dental problem. Furthermore, some tasks are shared by more than one function. For example, in both cases, tooth restoration or tooth extraction, one of their associated tasks is the application of local anesthetic, which has a specific outcome—the blocking of pain stimuli—but does not resolve the problem by itself. Tasks are the fourth order of complexity.

Each task could be broken down into steps. Steps are a sequential set of procedures needed to complete a task. For example, the task “application of local anesthetic” includes steps such as introduction of the anesthetic tube into the syringe. Steps constitute the fifth order of complexity.
Each step could be broken down into movements. For example, to fulfill the step “introduction of the anesthetic tube into the syringe,” a set of movements is needed to hold the syringe appropriately, open it, and introduce the anesthetic tube. Movements are the sixth order of complexity.

Finally, each movement is composed by an infinite number of moments, some of which the student needs to identify because it may affect the outcome of the movement. In our example, the moment observing “lack of red liquid—blood—in the syringe after aspiration” is a sign that the movement “introduction of the needle” of the step “delivering local anesthetic” of the task “application of local anesthetic” has been successfully completed. Moments are the seventh order of complexity.

The following is a hierarchical summary of our taxonomy as applied to our example:

1) Professional profile: Dental graduate.

2) Competency: Resolution and treatment of a tooth affected by decay.

3) Function: Class I restoration.

4) Task: Application of local anesthetic.

5) Step: Delivering of local anesthetic (injection).

6) Movement: Pull the handle before injecting the anesthetic.

7) Moment: Lack of red color in the tube after pulling the handle.

For number 7, “Moment,” if there is blood in the anesthetic tube, the needle is within a capillary vessel and the step “delivery of local anesthetic” cannot be completed. Therefore, this moment is critical in the fulfillment of the task proposed.

Figure 2 provides five additional examples from other curricular areas.

The current medical education literature is abundant in assessment and evaluation techniques.22–26
Because our taxonomy uses a systematic approach—from the minute qualitative detail of a moment to a complex competency—assessment and evaluation are direct extensions of the classification at each level of complexity. Figure 3 shows the evaluation tools and educational actions associated with our example of class I restorations.

Our taxonomy facilitates comprehensive faculty participation in the evaluation of the students. Instructors follow closely the student’s performance during his or her first attempts, assessing the attitude of the student, the quality of the work, and identifying deficiencies in a timely manner at each level of the process. Thus, our taxonomy focuses on the evaluation of process and outcome, the former being mostly qualitative and the latter mostly quantitative. Also, because most clinical activities in dentistry improve with repetition, close supervision could be eased once the student has shown appropriate skills.

### Discussion

We have described criteria and components of a proposed taxonomy of competencies in the learning of dental practice. Based on the professional profile, sets of competencies are defined, and functions, tasks, steps, movements, and moments are identified. We believe that the analytical process of identifying

<table>
<thead>
<tr>
<th>Area</th>
<th>Community Dentistry</th>
<th>Oral Diagnosis</th>
<th>Periodontology</th>
<th>Prosthodontics</th>
<th>Pediatric Dentistry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competency</td>
<td>Handle the problem of dental caries at the community level</td>
<td>Complete oral diagnosis</td>
<td>Complete periodontal therapy</td>
<td>Provide comprehensive treatment to a partially edentulous patient</td>
<td>Provide comprehensive prevention for dental caries</td>
</tr>
<tr>
<td>Function</td>
<td>Diagnosis of dental caries in a community</td>
<td>Radiological examination</td>
<td>Subgingival scaling</td>
<td>Prepare a three unit fixed bridge</td>
<td>Apply pit and fissure sealants</td>
</tr>
<tr>
<td>Task</td>
<td>Intraoral examination</td>
<td>Take a bitewing x-ray</td>
<td>Eliminate hard deposits</td>
<td>Prepare tooth for full crown abutments</td>
<td>Recognize teeth to be sealed</td>
</tr>
<tr>
<td>Step</td>
<td>Perform systematized and simplified oral examinations</td>
<td>Aligned X-ray tube and intraoral packet</td>
<td>Selecting hand instruments</td>
<td>Select appropriate burs for tooth reduction</td>
<td>Isolate teeth to be sealed</td>
</tr>
<tr>
<td>Movement</td>
<td>Accommodate the person to perform the examination</td>
<td>Provide the correct angulation for a bitewing x-ray</td>
<td>Moving the instrument appropriately</td>
<td>Insert bur in place</td>
<td>Insert isolation devices</td>
</tr>
<tr>
<td>Moment</td>
<td>Oral tissues exposed for proper examination</td>
<td>Tube and the x-ray film are parallel</td>
<td>Hard deposit-free surface</td>
<td>Bur in place</td>
<td>Sealant has covered all pit and fissures</td>
</tr>
</tbody>
</table>

In these examples, only one item of each competency, function, task, step, movement, and moment has been included.

**Figure 2. Five dental competencies and examples of some of their associated functions, tasks, steps, movements, and moments**
and describing all these elements benefits the efficacy, efficiency, and overall quality of the learning process in dental education. Furthermore, the underlying taxonomic principle can be applied to other disciplines requiring the involvement of cognitive, affective, psychomotor, and volitive domains. Bloom used the first three domains in the 1950s to classify educational objectives. We have identified volitive as a fourth domain. This domain relates to the will that a person needs to deploy in order to initiate a needed activity, continue it appropriately, finish it in due moment and time, and seek excellence in its performance. In Bloom’s classification, this characteristic was included within the affective domain. We believe that clinical problems require making educated decisions and to proceed accordingly for their prevention, diagnosis, and resolution, and therefore the need to single out the importance of the volitive aspect in the learning process. Also, we believe the volitive domain is teachable, not by trial and error, but by a supportive learning experience. Such a pursuit of excellence in science as well as in clinical skills is inherently opposed to authoritative models that were highly prevalent a few years ago. The volitive domain demands that students continue asking questions such as: Why? What is the scientific basis? Am I doing well? What other alternatives are there? Overall, what is best for the well-being of the patient and the community? These characteristics have a direct effect on the ethics and professionalism of the graduate. We recognize, however, that faculty need to be trained, especially if they were educated under traditional models.

Because competencies in dental education integrate all four domains by need, it can be said that they are holistic; because they have a specific purpose to fulfill, it can be said that they are also teleological. We believe that an integrated inclusion of these four domains with a definite stated purpose is crucial in the learning of dental competencies. Educational objectives could and should be envisioned taking into account these domains and purposes.

An additional comment on the difference between competencies and functions is warranted. A function can be quantitatively evaluated by measuring the number of tasks fulfilled. A competency can be evaluated not just by the number of functions the student has completed, but by the relationships the student can establish between those functions. Therefore, the evaluation of competencies is qualitative and involves a self-assessment manner with the input coming from an extensive period of observation and evaluation.
The four domains associated with functions and competencies are translated into practices that need to improve with repetition and time. However, learning in depth cannot occur if there is no critical assessment of the process involved. For example, it does not matter how many class II amalgams a student performs if there is no evaluation, by the student and faculty, of the similarities, differences, and alternatives that make each dental restoration unique. Clearly, developing competencies in a student is far more than just asking him or her to repeat a predetermined number of clinical activities. There are not fixed numbers of repetitions valid for all students to master a technique. Some students may require more learning experiences than others, according to their natural capacities.

In our proposed taxonomy, focus on competencies does not mean a departure from a integrative and holistic view of dental education as has been discussed by Marchese.32 Furthermore, our taxonomy does not see dental education purely as an economic tool as has been criticized by Jones and Moore.33 For example, in Figure 1, the needs assessed for “diseases at the community level” require development of all four domains, but with strong participation of volitive and affective domains associated with the practice of dentistry at the community level from diagnosis to administration.

In conclusion, a competency in dental education is a holistic and teleological highly complex mental scheme ready to be implemented—in tune with the professional profile of the learning institution— with the objective of solving problems in the realm of the interaction of dental needs and dental care required to attend those needs. From the standpoint of the student, a competency is the attribute to organize, appropriate, and practice a given mental scheme with the objective of providing a solution to a specific problem, all in a timely fashion and with minimum side effects, i.e., excellence. In consequence, dental learning institutions should identify, define, and classify the different levels of complexity in the activities that constitute the institutional dental profile for its graduates. Such taxonomy would benefit the teaching-learning-assessment process and improve the quality of their graduates, which, in turn, will benefit patients and communities. Furthermore, the establishing of a common language will facilitate communication among dental learning institutions.

REFERENCES