A new approach to the learning of dental morphology, function, and esthetics: the "2D-3D-4D" concept

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Abstract

A concept is proposed for an approach to the learning of dental morphology and occlusion. Dental morphology, function, and esthetics should reflect a fundamental driving force, that is, the faithful emulation of the natural dentition's structural (functional, mechanical) and esthetic properties. The innovative part of the proposed approach is the emphasis on visual arts and the 2D-3D-4D aspect that starts with drawing (2D/3D) and continues with partial wax-up exercises that are followed by labial wax-ups and, finally, full wax-ups using innovative technical aids (electric waxers, prefabricated wax patterns, etc). Finally, the concept of layers (4D) and the histoanatomy of enamel/dentin and optical depth are taught through the realization of layering exercises (advanced acrylic mock-ups and composite resin restorations). All these techniques and materials are not only used to teach morphology and occlusion, but also constitute essential tools that will be of significant use for the student dentists and dental technologists in their future daily practice. The *clinical significance* of the presented methodology should allow not only students but also practicing dentists and dental technologists to help their youngest collaborators to develop a deep sense of morphology, function, and esthetics.

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Introduction

Starting in 2004, a process of curricular review for the Restorative Sciences at the Herman Ostrow School of Dentistry of the University of Southern California (HOSDUSC) was undertaken, which generated significant changes at the clinical level. The Dental Morphology and Occlusion module has remained unchanged for many years across different schools in many countries and is a staple course in the dental curriculum. In early 2012, the author was offered the position of Module Director of Morphology and Occlusion by the Dean of HOSDUSC, and was requested to address the problem of students struggling with this early learning process and not understanding its value for their future careers. This problem, identified in the literature as "decontextualized technical learning", is not new, with attempts having been made in the past to shift towards more clinically applicable learning, the improvement of conceptual understanding, and the acquisition of psychomotor skills.[1] The Dean wanted the creation of a new approach to this module, one that would foster the use of updated and clinically relevant materials and techniques, and influence the students' entire future careers.

The author accepted the challenging task of renewing the module. First, the module was renamed Dental Morphology, Function, and Esthetics (DMFE) to take advantage of the appeal of the cosmetic/esthetic aspect of the profession in general. The curriculum was intentionally designed to start in Trimester I (15 weeks, 7 hours per week, including remediation and exam sessions) with a focus on mechanics, form, function, and detailed anterior tooth morphology, including esthetics and smile design. The last topic served as a stimulator before moving to posterior dentition in Trimester II (15 weeks, 9 hours per week, including remediation and exam sessions).

The new DMFE module provides a general foundation for all clinically based courses throughout the dental school and includes both theoretical and simulated experiences, including hand skills, drawing skills, and content in dental morphology, occlusion, and esthetics. It includes the integration of essential perceptual skills for drawing, various waxing techniques, and the handling of acrylic and composite resins. It also covers the essential objective and subjective criteria for dental esthetics.

A special effort has been made to produce detailed instruction manuals and films covering all laboratory exercises, as well as to introduce new materials and devices, such as new dental stone, special opaque wax, electric waxers, waxing aids (eg, prefabricated wax veneers, intact dentition reference models, etc), and new acrylic and composite resins. Specific materials have also been chosen to provide practical insights into dentin and enamel shape and distribution.

Core value and principles of the new module – the 2D-3D-4D concept

The core value of the new DMFE module is to best prepare learners for the novel biomimetic approach to restorative dentistry.[2] What is implied is that in order to

be emulated faithfully, the natural dentition's structural (functional, mechanical) and esthetic properties must be totally understood.

The innovative part of this approach is the emphasis on visual arts and the 2D-3D-4D concept (Fig 1) that starts with drawing (2D/3D) and continues with partial wax-up exercises that are followed by labial wax-ups, and finally full wax-ups, using some innovative technical aids (electric waxers, prefabricated wax patterns, etc). Finally, the concept of strata (4D) and the histoanatomy of enamel/dentin and optical depth[3] are taught through the realization of layering exercises (advanced acrylic mock-ups and composite resin restorations). All these techniques and materials are not only used to teach morphology and occlusion, but also constitute essential tools that will be of significant use for the students in their future clinical practice.

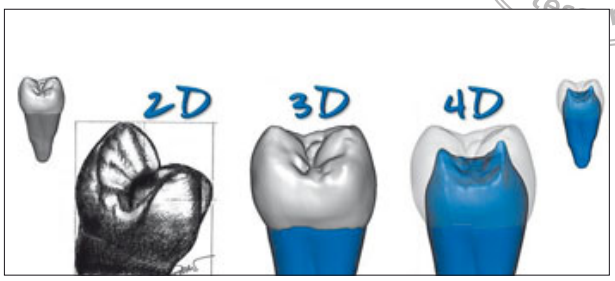

Fig 1 The 2D-3D-4D concept, starting with drawing (2D/3D) and moving to waxing (3D) and layering (4D).

A conceptual part of the DMFE module is learning how to draw in 3D using an approach inspired by Betty Edwards involving the five perceptual skills of drawing,[4] these being Edges, Spaces, Relationship, Light and Shadows, and Gestalt. These five perceptual skills were adapted to the situation of a tooth drawing (Frame, Contour, Elements, Shadows and Highlights, Composition), as depicted in Fig 2. This enhances the learners' creativity by stimulating the creative language mode of the right side of the brain. Each student is given 20 images (8 anteriors, 12 posteriors) as a model for drawing.

Another emphasis of the DMFE module concept is the progressive approach to the "3D" additive wax-ups, from partial coverage (class IV defect in anterior teeth, single missing cusp in posterior teeth) to full coverage, and from single to multiple teeth. In this way, the learners are also gradually introduced to the new materials and techniques. As current dental restorative techniques use an apposition approach (composite resins) rather than carving (as in the case of amalgam), students often question the value of carving exercises.[5] For this reason, wax-block carving exercises were abandoned and replaced by various additive techniques using wax.

One important motivation for the students is to present the typodont model as their "first patient", having to plan the case all the way from the study models to the diagnostic approach (progressive wax-up technique) and trial smile/mock-up/provisional using acrylic resins. The anterior smile design is followed by the same progressive approach for the posterior dentition, ending with the layering of composite resins (the final "4D" aspect).

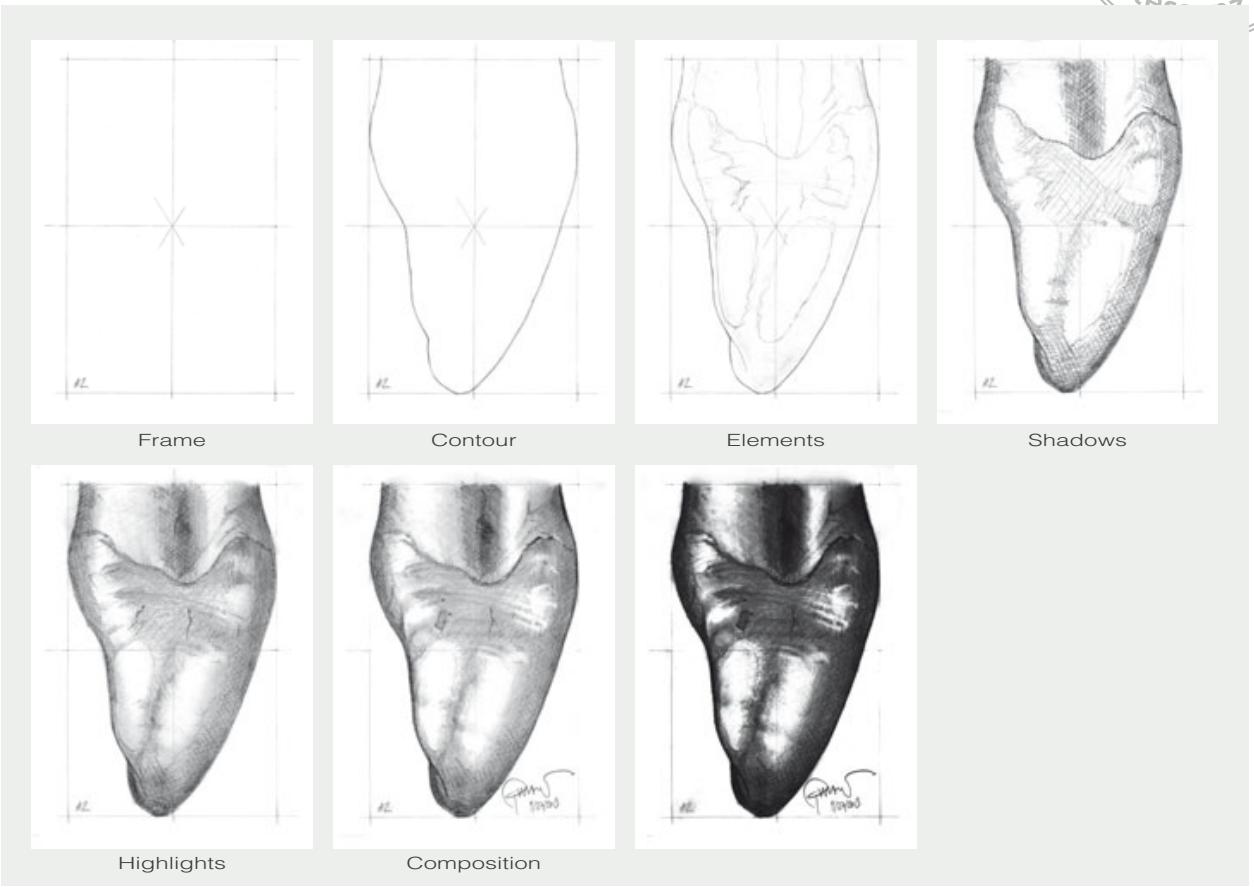

Fig 2 Drawing by the author, having adapted Betty Edwards' five perceptual skills of drawing.

Syllabus, instructional manuals and films

A comprehensive syllabus for the DMFE module is provided[6] (module description, objectives, assessment tools, detailed calendar, etc) in which the recently revised HOSDUSC competencies are embodied and which reflect the changes that have occurred in the field of dentistry, the new emphases of the Commission of Dental Accreditation (CODA) and the American Dental Education Association (ADEA), and the unique approach of the University of Southern California (USC) to dental education.

The new module aligns with:

- Competency 3: Apply principles of self-assessment, critical thinking, and problem solving, and seek information to enhance professional competency.
- Competency 15: Manage procedures that preserve and restore tooth structure to optimal form, function, and esthetics.

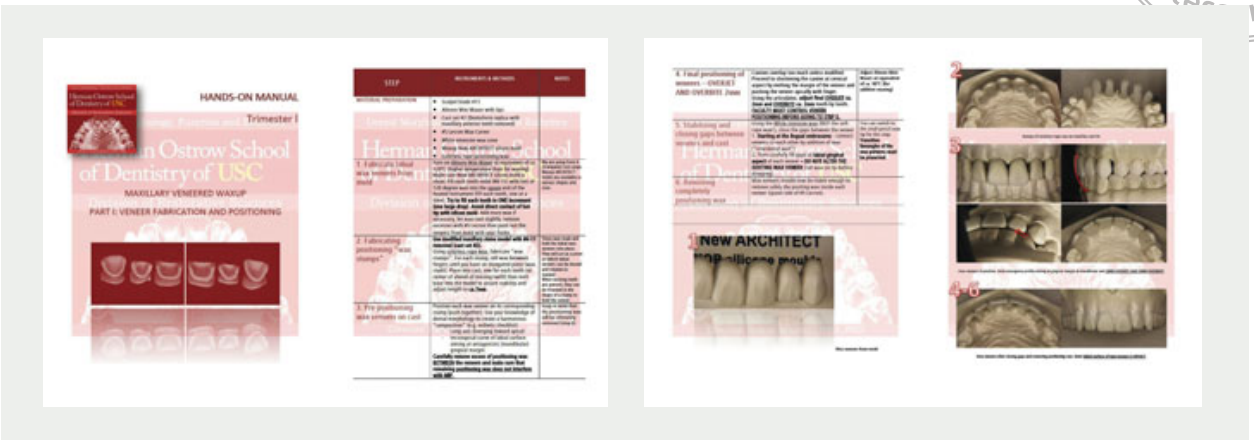

Fig 3 Example pages of instructional manual, including screenshots from instructional film.

A complete program of required resource sessions is offered in the morning, including guest speakers from outside of the university. Manuals and corresponding instructional films have been generated to accompany each laboratory session in the afternoon. The manuals include a detailed, step-by-step section, including the methods and materials for each step (Fig 3). The exact same steps are demonstrated in each corresponding film, which the students can access on the Blackboard online learning environment website. The beginning of each laboratory session includes debriefings, a live narration of the instructional film, and a discussion of assignments (student self-evaluations and faculty evaluations) from the previous session. The instructional film is then shown in a loop on the individual stations during the entire laboratory session. The advantage of a demonstration film over a traditional demonstration is that it can be viewed more than once, and frees the demonstrator to join the rest of the faculty to help the students. The film can also be streamed online by the students at their own pace on their personal laptops or tablets.

The DMFE-module teaching faculty consists of a student to faculty ratio of 8:1, with some of the teaching faculty being skilled dental laboratory technicians, staff from the HOSDUSC Dentistry Advanced Specialty programs in Operative Dentistry and Prosthodontics, and other university faculty staff. The resources used in the preparation of the module are listed in Table 1. Among these resources, two books (the Nelson and Ash, and the Wassel and Naru et al) are included in the student mandatory materials list as they also feature DVDs with 3D interactive media. This opportunity for additional independent learning appeals to and engages the new generation of students and complements the

Table 1 Recommended references for the new DMFE module

Bazos P, Magne P. Bio-emulation: biomimetically emulating nature utilizing a histo-anatomic approach; structural analysis. Eur J Esthet Dent 2011;6:8–19 and Bazos P, Magne P. Bio-Emulation: biomimetically emulating nature utilizing a histoanatomic approach; visual synthesis. Int J Esthet Dent 2014:9:330-352
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Magne P. Manual for Posterior Esthetic Restorations. USC Bookstore, 2005
Magne P, Belser U. Bonded Porcelain Restorations in the Anterior Dentition. A Biomimetic Approach. Quintessence Publishing, 2002
Nelson SJ, Ash MM. Wheeler's Dental Anatomy, Physiology and Occlusion, ed 9. Saunders/Elsevier, 2010 (part of the mandatory materials – book with DVD)
Dawson PE. Functional Occlusion: From TMJ to Smile Design. Mosby/Elsevier, 2007
Wassel R, Naru A, Steele J, Nohl F. Applied occlusion. Quintessence Publishing, 2008 (part of the mandatory materials – book with DVD)
Wiskott HWA. Fixed Prosthodontics. Principles and Clinics. Quintessence Publishing, 2011
3D Interactive Tooth Atlas v. 7.0 by eHuman (http://www.ehuman.com/products/3d-tooth-atlas-6)
Dental Decks, Part I, ed 2013–2014 (www.dentaldecks.com)

traditional course.[7,8] In addition, the Nelson and Ash is a reference book used in the National Board Examinations. A 3D interactive tooth atlas has been mentioned as a possible resource (Table 1), but has not yet been considered for the mandatory materials list.[9]

Materials update

Another important aspect of the DMFE module is the implementation of new materials. In many programs, students are expected to perform with excellence but are not necessarily using the most

appropriate materials, devices, and techniques. Therefore, a special effort was made to review the students' materials list. Optimizations were carried out to eliminate dated materials and upgrade others. A good example is when students were asked to perform wax-ups with "dark" green or violet on a yellow stone cast. The contrast between those colors makes it very difficult to assess the work, as "dark" has the connotation of "far" and "small", while "bright" can mean "large" and "close". These significant alterations in visual perception constitute a major limitation to teaching true morphology. Similarly, skilled dental technicians now use electric spatulas or induction devices to facilitate the application of the wax, whereas students are often asked to use a Bunsen burner. Therefore, various materials upgrades were made for the module, elaborated upon below.

Type IV white stone of high quality

Low-quality plaster in the hands of beginners often results in damaged and chipped models. A type IV stone (Fujirock EP, GC America) was therefore chosen to prevent damage and to compensate, so to speak, for the learners' lack of experience. This stone also offers a natural white color.

White opaque wax

It is fundamental not to interfere with the principle of visual perception during the development of a wax-up. Using light-gray or white wax is the most appropriate. For instance, light-gray clay is used in car design and modeling as it allows optimal perception of shadows. White is an easy match with the aforementioned stone. As some areas of the tooth will receive more wax than others, it is important that those different areas display the same visual thickness. Therefore, it is also important that the wax be totally opaque, like the stone cast itself (S-U 65 275 9 White Intensive Wax Cone, Schuler-Dental) (Fig 4).

Fig 4 Example of white-on-white stone cast and wax-up (canine to canine). Image courtesy of Michel Magne, MDT.

Electric waxers

In addition to the fact that Bunsen burners are dangerous because the butane gas can easily ignite, electric waxers allow for much better control of the temperature and facilitate the delivery of the wax to the desired location. Particularly small portable versions have been marketed (eg, Mini Waxer, Almore).

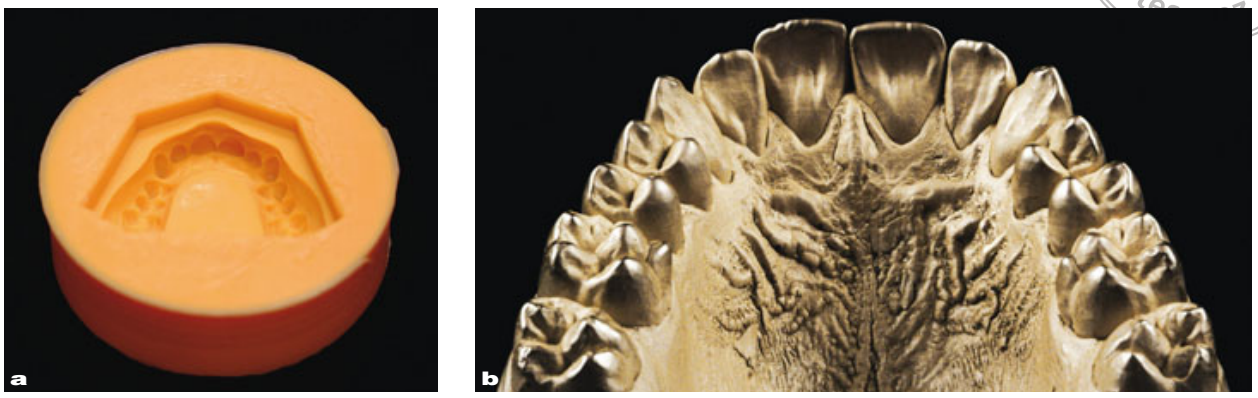

Fig 5 **(a)** Silicon mold and **(b)** corresponding cast of a reference natural dentition.

Example of intact natural dentition

During Trimester II of the module, silicon molds (Fig 5a) of an existing intact dentition (maxillary and mandibular arches) are provided, to be poured by the students using the same white stone (Fig 5b). In a further iteration of the module, we plan to provide an "alveolar" model[10] of the same dentition, allowing teeth to be removed one by one from the model in order to view the anatomy from the proximal surface as well.

Fig 6 New Architect silicon mold used to fabricate wax veneers.

Molds to fabricate wax patterns

An innovative, full wax-up technique, the so-called "veneered wax-up" (illustrated in the manual pages shown in Fig 3), consists in using silicon molds of intact teeth to prefabricate labial wax veneers (Fig 6). The veneers are then positioned over the edentulous area or over existing tooth stumps. Through the positioning of the wax patterns, learners can refine their knowledge of overbite/overjet and anterior guidance, and can then focus on the lingual morphology of those anterior teeth. Above all, this waxing technique provides a unique opportunity to teach about tooth arrangement, positioning, and smile composition, because the prefabricated pattern can be placed/moved/rotated very easily within the edentulous area. This technique will be of significant use when the students are planning implant-supported restorations, as well as for other clinical situations, eg, the replacement of an old set of crowns, fixed partial dentures (FPDs), etc.

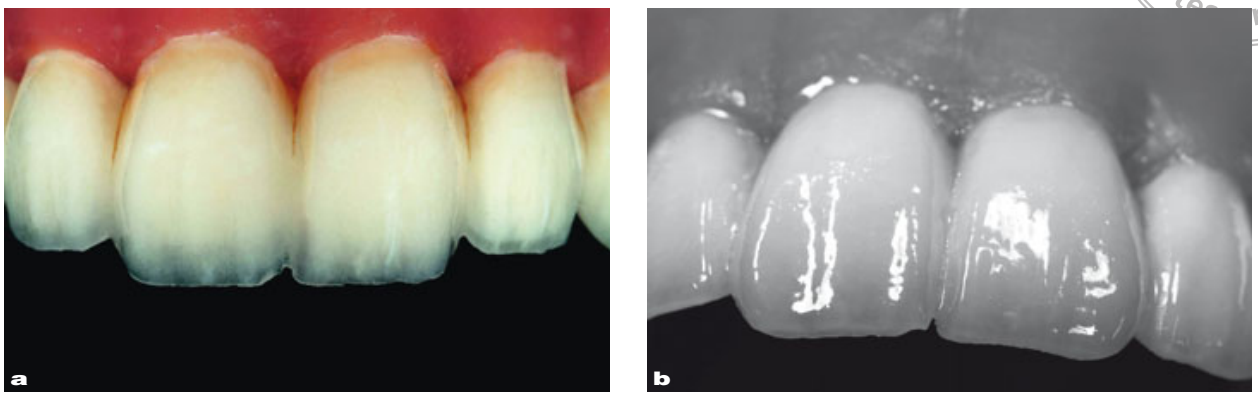

Fig 7 Enamel/dentin-like acrylic resin use in the try-in smile exercise on the typodont model (**left** dentin: cut-back and stain; **right**: after pressing and finishing the enamel layer).

Advanced acrylic resins and coloring resins

High esthetic demand from patients has had a major impact on the evolution of the dentistry profession. It is critical to be able to address potential changes in the esthetic zone using advanced visualizing techniques, such as mock-ups[11] and layered provisionals. To reflect that evolution, the DMFE module includes the fabrication of a layered try-in smile derived from the students' previous anterior wax-ups. For this reason, a new acrylic material (New Outline, Anaxdent) was introduced due to its optical properties,

Fig 8 **(a)** Original typodont model ("patient") and **(b)** corresponding study models by student Hoang-Ahn Tran.

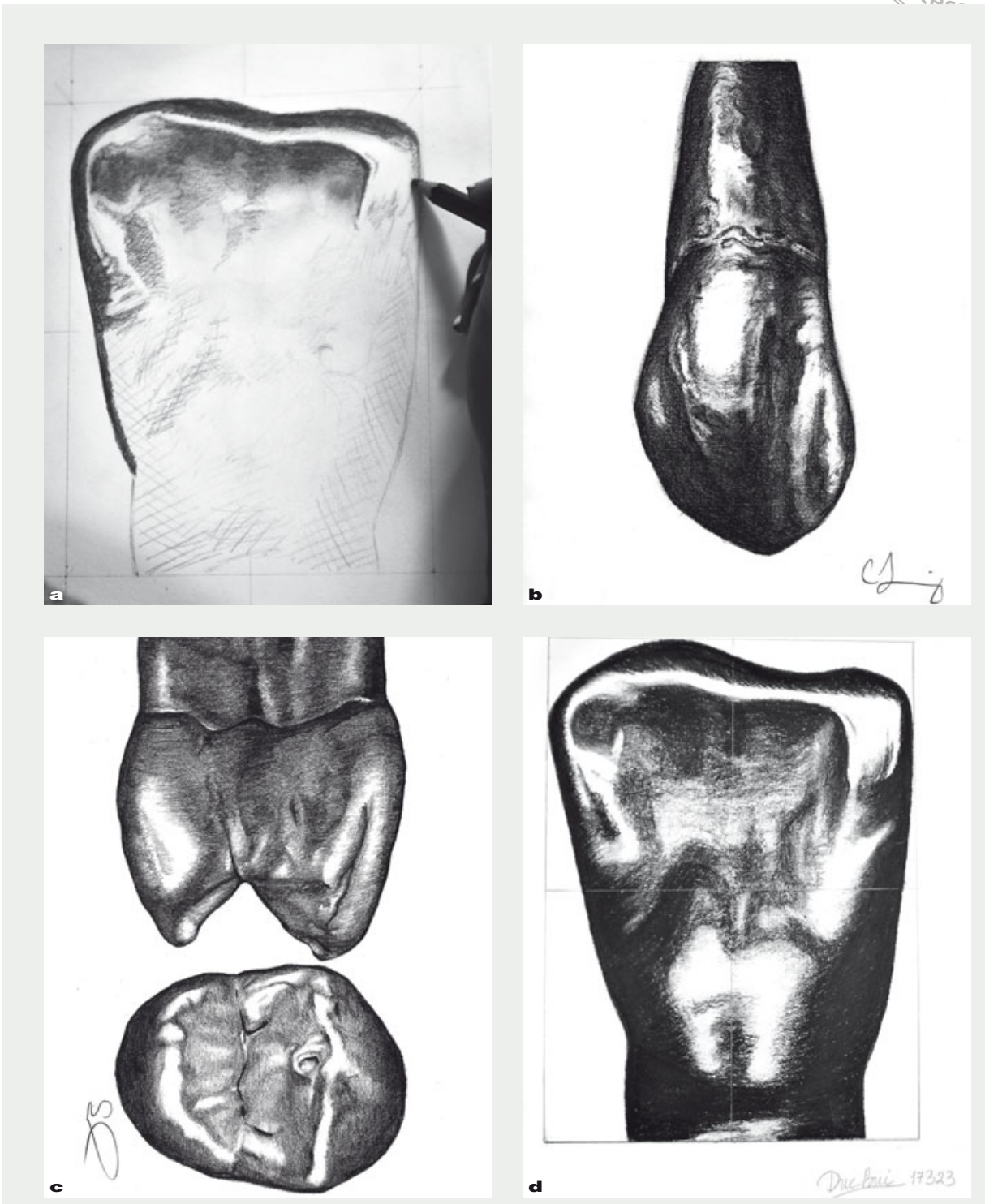

Fig 9 **(a)** Student during a drawing exam. **(b)** Anterior drawing by student Claire Leewing. **(c)** Posterior drawing by student Soo Lee. **(d)** Anterior exam drawing by student Duc Bui.

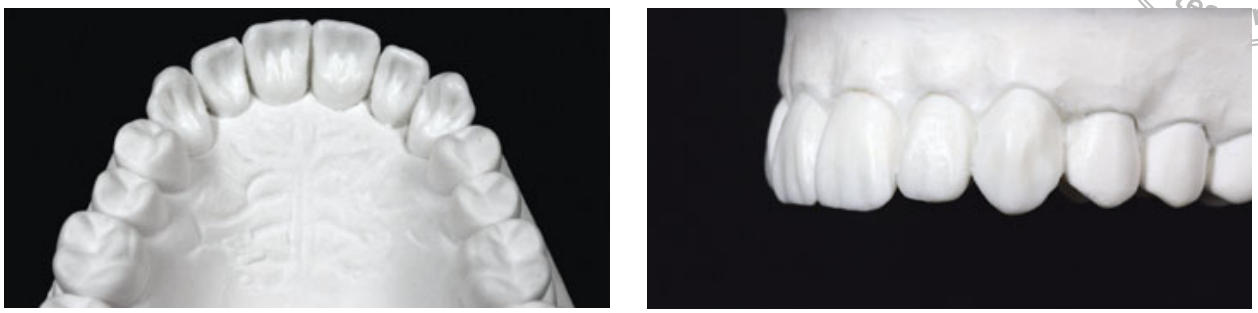

Fig 10a Stone cast and full anterior wax-up exercise by student Soo Lee.

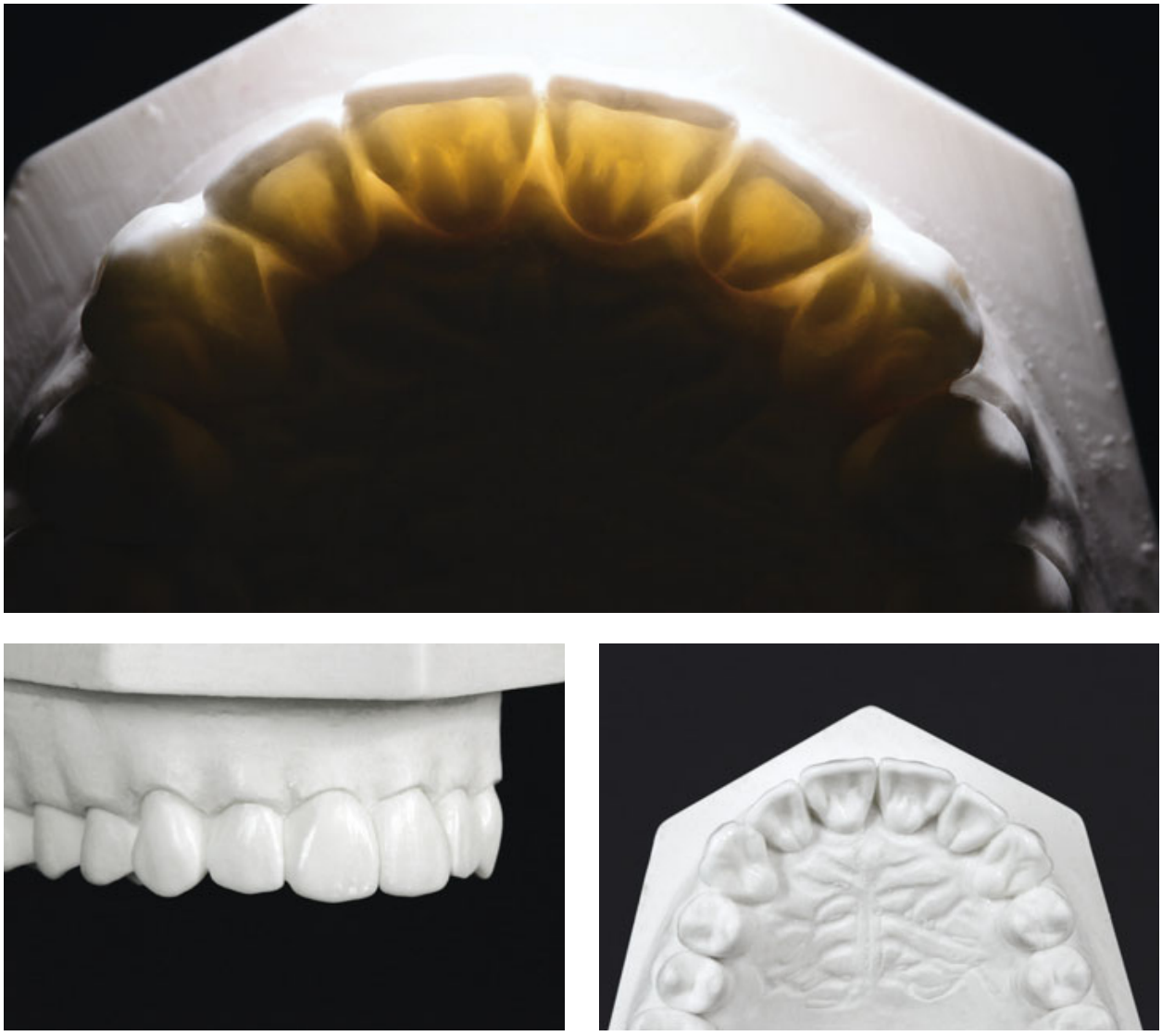

Fig 10b Stone cast and full anterior wax-up exercise by student Lily Xue Du.

Fig 10c Full anterior wax-up exercise by student Jiwon Kim.

chameleon effect, and enamel/dentin-like components. When used along with intense light-polymerizing colors (ochre, blue, white), this resin permits the application of the so-called sandwich technique, an essential method to introduce the fourth dimension of morphology, ie, the layers and subsurface effects within the tooth (Fig 7). Replication of enamel and dentin at the correct thicknesses leads the learners to a better understanding of the overall histoanatomy and tooth-structure distribution.

Students' laboratory works

Figures 8 to 13 show various students' work (DDS classes of 2016 and 2017) in order to illustrate the various aspects of the DMFE module.

Fig 11 Posterior wax-ups by student Jack Nguyen.

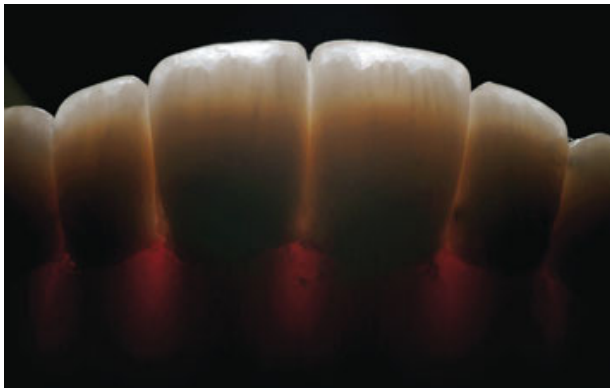

Fig 12a Bilaminar layered try-in smile on typodont model by student Ahn Tran.

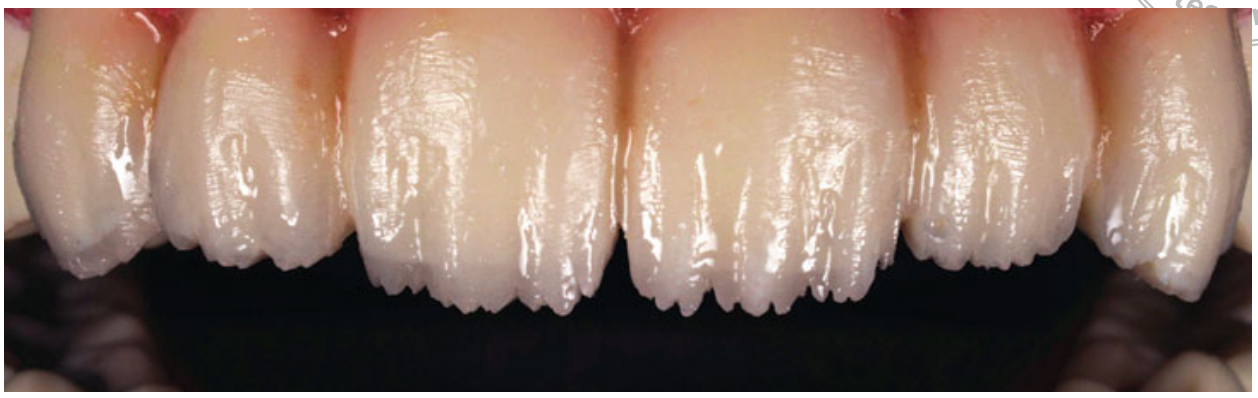

Fig 12b Dentin cut-back technique by student Lily Xue Du.

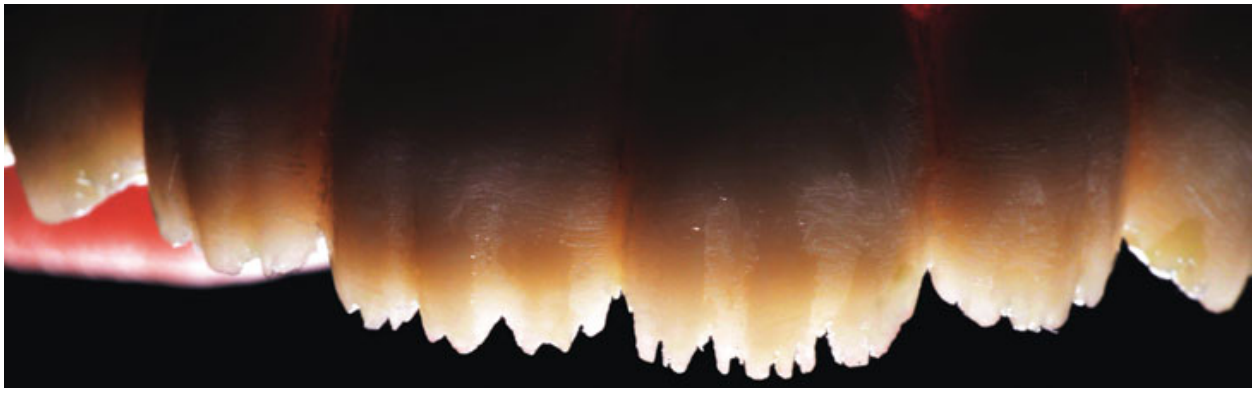

Fig 12c Dentin cut-back technique by student Katherine Schwartz.

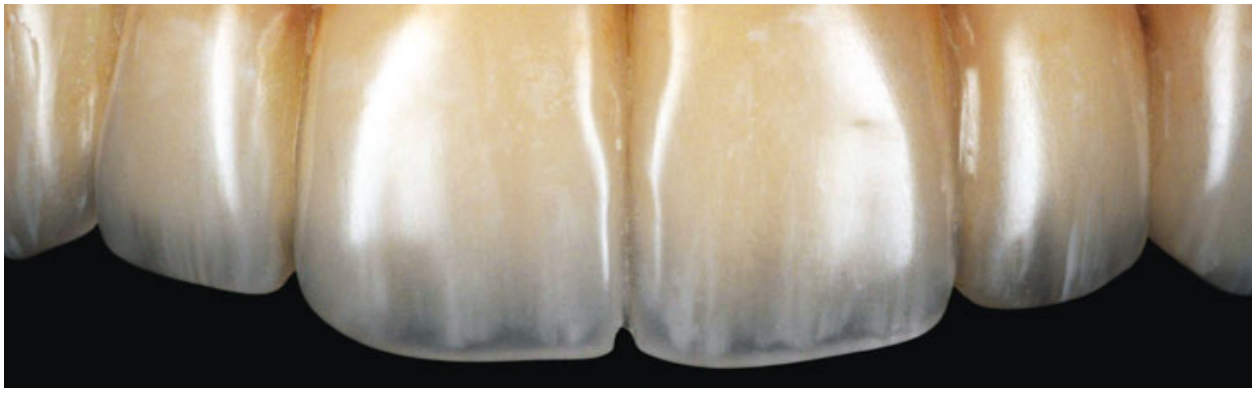

Fig 12d Bilaminar layered try-in smile by student Cody Caffall.

Fig 13 Bilaminar class I posterior composite resin restorations by student Thy Pham.

methodology is accompanied by state-of-the-art, clinically relevant materials, devices, and techniques, as well as detailed instructional manuals and films for all laboratory exercises. The redesign has already generated much satisfaction from the students, the faculty, and the teaching assistants at HOSDUSC. Furthermore, the approach is universally applicable to daily clinical practice in order to help dentists and dental technologists to stimulate their youngest collaborators to develop a deep sense of morphology, function, and esthetics.

Conclusions

A revision of the educational methodology for learning dental morphology and occlusion is proposed. A redesigned Dental Morphology, Function, and Esthetics (DMFE) approach, using the novel 2D-3D-4D concept, provides a practical and progressive learning methodology regarding dentin and enamel shape, function, and distribution. The

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