Why integration is key for dental office technology

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"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."

—Mark Weiser (1952-1999), creator of the "ubiquitous computing" concept

The last several decades have seen significant development of new technologies in dentistry. Information technology, or IT, has been a particular hotbed of innovation. The number of computer-based devices and functions in the dental office has skyrocketed.

Integration is crucial to the efficient and effective functioning of the dental office.

As a result, the offices of many technology-minded dentists look like miniature technology parks. On the hardware side, computer workstations, network cables and the server infrastructure blanket the practice. Meanwhile, the clinical operatory may have one or two computers to access the practice management system, a stand-alone computer-assisted design/computer-assisted manufacturing, or CAD/CAM, device; an intraoral camera; digital radiology equipment; and any number of specialized devices (for example, caries detection sensors [such as DIAGNoent, KaVo America, Lake Zurich, Ill.] and computerized periodontal probes [such as the Florida Probe, Florida Probe Corp., Gainesville, Fla.]). On the software side, things are similar. Many dentists use several programs for practice management, digital imaging, capturing clinical data and supporting various aspects of diagnosis and treatment. The programs look and work as differently as the hardware menagerie that surrounds them.

While it clearly still is possible to practice dentistry without computers, information technology has become the lifeblood of many practices. In the administrative areas of practice—billing, insurance processing, treatment tracking and scheduling—computers...
are all but ubiquitous. In the clinical area, computers are making significant inroads. On the basis of data from an ongoing study, we now know that approximately 25 percent of general dentists in the United States use computers at chairside (T. Schleyer, D.M.D., unpublished data, 2004). However, in many practices, chairside computer use is limited to only a few areas of clinical documentation, such as charting, treatment planning and, occasionally, the recording of progress notes.

One of the major reasons for dentistry’s reluctance to adopt clinical computer technology to a larger extent is the lack of integration of information technology with the clinical work environment. This deficit in integration has significant costs. First, it is a more or less visible drain on productivity. The dentist who must execute four separate actions to display an intraoral image on the screen (removing the camera from the holder, switching the camera on, starting the image management program on the computer and selecting “image capture”) loses more time and exerts more effort, both cognitively and physically, than the dentist whose intraoral camera automatically displays the image on the computer monitor once the camera is removed from its holder. Lack of integration also increases the probability of “things not working together,” a phenomenon to which many dentists who have upgraded a software application on their computer can attest. Many times, upgrading the practice management system results in incompatibilities with other software components. As a result, the dentist must expend time and effort to get everything to work smoothly again. Insufficient integration also affects the ergonomics of the clinical environment. For instance, bad ergonomic design may require the dentist to move or turn every time he or she wants to use a computer. Lastly, poorly integrated devices result in significant clutter (cables, boxes, carts) in the operatory.

INTEGRATION: THE BASIS FOR EFFICIENT WORK

Today’s “dental unit” already is a highly integrated device, but mostly in a physical and mechanical sense. Over time, many formerly separate devices—such as the dental chair, the instrument tray and the handpiece—have evolved into the single, functional, ergonomically appropriate dental chair that is common today. Information technology devices—such as the computer monitor, keyboard, mouse, digital radiology sensor and computerized periodontal probe—have been added only recently. Thus, it is not entirely unexpected that those devices are among the least integrated in the dental operatory.

Typically, it takes some time until new devices are accepted enough in the marketplace for equipment vendors to consider integrating them into dental units and the operatory design as a whole. For instance, the first ultrasonic scalers appeared on the dental market in the 1950s. However, it took until 1983 for the first manufacturer, Siemens Dental (Erlangen, Germany), to integrate an ultrasonic scaler into the delivery tray of the dental chair. Introral cameras and curing lights are other examples of devices that only recently have been integrated.

Information technology presents a particular integration challenge to the field. Traditionally, the dental unit and the associated devices are primarily “hardware.” Dental equipment manufacturers worldwide have developed an enviable and significant research and development capacity in this area. Computers, however, are a different breed of equipment because they consist of both hardware and software. Typically, computer applications in dentistry have been developed by new companies, or companies new to the dental industry. Information technology, unfamiliar to most engineers in the dental industry, has so far achieved only a somewhat uneasy coexistence with the rest of the dental equipment. The failures of major dental equipment vendors in trying to integrate software into their business model is evidence of this struggle.

However, this situation is changing. Several companies, such as Henry Schein (Melville, N.Y.) and Patterson Dental (Effingham, Ill.), have taken steps to make integration a central business platform by acquiring manufacturers of component technologies, such as practice management systems and digital radiology equipment. The challenge that these companies now face is to integrate the multiplicity of product offerings into a smoothly functioning working environment.

In the following sections, I take a closer look at the different aspects of integration and how they are being implemented. Many vendors tout their level of integration, but careful scrutiny of such claims is warranted. For instance, the infamous “bridging” between two software packages is nothing more than a Band-Aid that does not mitigate the appearance of integration. Closer inspection
reveals that such "integration" extends to only the most superficial aspects of operation.

**INTEGRATION IN PRACTICE: PRESENT AND FUTURE**

Integration is a precondition for efficient and effective work in dental practice. Integration is closely related to ergonomics, an applied science that coordinates the design of devices, systems and physical working conditions with the capacities and requirements of the worker. Ergonomics is not applicable just at the physical level—say, by having an intraoral camera in a delivery tray within easy reach—but also at the cognitive level, for instance, by presenting clinical information in ways that optimally support clinical decision making.\(^5\)

To achieve true integration, one must think of hardware, information and software in the dental office as one system. One look at the average practice today confirms that this is not being done. In most vendors' offerings, computer hardware is poorly integrated, if at all. Several software vendors are making progress in integrating different software packages, as shown by the recent fusion of the Dentrix (Dentrix, American Fork, Utah) practice management system and the ViperSoft (ViperSoft, American Fork, Utah) intraoral imaging system in the form of the Dentrix Digital Office System. However, integration between hardware and software is almost nonexistent.

A second principle in integration is that it should be task-oriented. Task-oriented integration means that the work environment and its functions are configured optimally to support specific tasks. Take the comprehensive initial examination as an example. This task consists of many steps, such as obtaining the chief complaint, recording the medical and dental history, and conducting a thorough extraoral and intraoral examination. During this process, information is collected in a variety of ways: the patient interview; visual inspection; palpation; tactile examination; imaging, such as radiography and extraoral and intraoral photography; and direct measurement with devices such as Digital Imaging Fiber-Optic Trans-Illumination, or DIFOTI (Electro-Optical Sciences, Irvington, N.Y.), DIAGNODent and the Florida Probe. This multistep activity results in a voluminous and complex set of data, which is the basis for further clinical decision making.

True integration supports the work flow of the initial examination in a very natural way so that the dentist can concentrate on the actual task, rather than the mechanics of it. As the reader mentally reviews how this process happens in his or her own practice, it becomes clear how fragmented the systems supporting this process really are. In paper-based practices, the information at least is integrated on paper, even if it is somewhat cumbersome to review comprehensively. In practices that use both paper and computers, synchronizing the information about one patient for a comprehensive review is a hassle. In fully computerized practices, all information is stored on the computer, but the user must cope with the limitations and idiosyncrasies of reviewing it on a computer screen.

**Four levels of integration.** What types and levels of integration will the reader find right now in the dental marketplace, and toward what degree of integration should the dental industry work? I will discuss integration in practice at four levels: hardware-hardware integration, hardware-software integration, software integration and task-oriented information integration.

**Hardware-hardware integration.** Hardware-hardware integration is the combination of two previously separate hardware devices. Such integration is demonstrated in examples such as intraoral cameras integrated into the delivery tray (Figure 1), computer monitor mounts on dental chairs and multifunction foot pedals (to aid in tasks such as alternatively controlling handpiece speed and capturing intraoral images).

**Hardware-software integration.** Hardware-software integration is applicable in only a few areas—primarily in digital imaging. We speak of hardware-software integration when dental hardware (such as the chair, an intraoral camera or a digital radiology sensor) communicates with the software used at chairside. I cited one example of hardware-software integration in my introduction: the intraoral camera that communicates automatically with the digital imaging software when it is removed from its holder and displays the image immediately without further intervention by the dentist. Dentists using analog cameras are familiar with this functionality. Most of those using digital cameras, which require a software program on the computer to receive the image, are not.

**Software integration.** Software integration has received much attention in recent years, and for
Figure 1. KaVo ERGOCam 31 (KaVo America, Lake Zurich, Ill.) (on the right), an intraoral camera, integrated into the delivery tray of the dental chair. (Photo reprinted with permission of the manufacturer.)

good reason. As software applications for clinical dentistry have multiplied, dentists have demanded better integration among the various packages. Figure 2 shows the three historical stages of software’s integration.

Part A of Figure 2 shows the most traditional (and most outdated) approach to integrating several software applications—in this case, imaging. Each program is connected to the main practice management system, or PMS, with a software bridge. In practice, the bridge has only two functions: to allow the user to start or switch to the imaging application from the PMS (usually by pressing a button or choosing a menu item), and to permit the imaging application to display the same patient record as the PMS. This system involves a multitude of databases and user interfaces, and thus increases the chance of failures and/or incompatibilities, as well as the cognitive overhead for the user. Part B of Figure 2 illustrates the most common approach to software integration between PMSs and imaging applications today. The PMS connects to a single imaging application, which manages images from all types of imaging devices. Many imaging applications, such as CDR (Schick Technologies, Long Island City, N.Y.), DentalEye (DentalEye AB, Spanga, Sweden) and ViperSoft, employ this approach. While the potential problems and inefficiencies are fewer than those associated with the first approach, they are not eliminated. Part C shows the optimal approach, which maintains all information in a single clinical information system using one database. Few dental software applications on the market have implemented this model. Both the Dentrix Digital Office (Figure 3) and EagleSoft (Patterson Dental) are exceptions. Both programs use a single database for all patient data, including free text, numbers, dates and images.

Task-oriented information integration. The last type of integration to be discussed here, task-oriented information integration, still is quite rare and is a near-term challenge for the dental IT industry. Task-oriented information integration begins with three seemingly simple questions:

- What information is needed to complete a particular task?
- How should the information display be designed?
- How should computer-based functions support completing the particular task?

Most software is designed by programmers or engineers, who typically do not apply a philosophy
of user-centered design. As a result, many software applications satisfy the needs of their users only to some degree and are, if at all, improved based on sporadic and nonsystematic user feedback. As computer users, we often share the common experience of thinking: "This function would be much easier to use if the developers had only ... !" Typically, these reactions do not indicate a need for a new and esoteric software function, but simply for rearranging the information displayed on the screen, or eliminating a few mouseclicks or keystrokes.

In a literature review, I found that only one development project made extensive use of cognitive science and user-centered design principles in the design of a new type of computer workstation for clinical dentistry. In this project (now available as DRI software [Planmeca Oy, Helsinki, Finland]), researchers studied the work patterns of dentists extensively before designing a task-based computer-based work environment. This environment includes a full computer-based oral health record, decision-support functions and modules for collaboration with other dentists and dental technicians.

Figure 4 shows a screenshot of an upcoming version of the DRI software during progress note entry. Most of the screen real estate is dedicated to the display of information, not to buttons, menus, scrollbars and other navigation elements. The intraoral status occupies the top left portion of the screen. The recorded progress notes for the appointment are visible in the lower left portion, while radiographs are accessible in the lower right portion of the screen. Above that area, the user has invoked functions to enter the details of the clinical procedure that was performed.

Designing task-based software is not a trivial undertaking. The obstacle most frequently encountered is the limited size and resolution of computer screens. As a result, the amount of information that can be displayed on a screen at one time is limited. When Powsner and Tufte developed a prototypical information display for patient information in medicine, they recommended that their design be used on paper only owing to the insufficient resolution of computer screens. Other constraints for designing task-based software applications include cognitive limitations of the user, ergonomic considerations and obstacles to effective interaction design (such as infection control).

THE OUTLOOK FOR INTEGRATION

As this article has shown, integration in dental practice is extremely important, but also very difficult to accomplish. The number and variety of devices, components and software applications makes the dental operatory a complex environment. Useful integration will occur only with significant investments in research and development by the dental industry as a whole. However, the payoff is significant. Integration not only increases efficiency, but also has the potential to improve patient outcomes. When dentists spend less time on making their “technology park” work, they will have more time to focus on what is really important: improving the oral and general health of their patients. The good news is that several large dental companies have begun to focus on integration as a key objective of their research and development efforts. But collectively we are at only the beginning of the road to full integration.

How can industry, academia and others propel the concept of integration in the dental office to higher levels? A useful first step would be to integrate and adopt user-centered design principles into research and development processes. While no design approach guarantees an optimally designed product, user-centered design makes success in this area more likely. When users become the focal point around which the hard work of developers, engineers and programmers is centered, the dental technology environment is sure to benefit.
A second strategy is to promote the development of standards for interoperability and adoption of dental technology products. The ADA's Standards Committee for Dental Informatics has worked on such standards for many years. For instance, the American National Standards Institute/American Dental Association, or ANSI/ADA, Specification 1000: Standard Clinical Architecture for the Structure and Content of an Electronic Health Record has been published for several years, though so far it has not been incorporated into any practice management system. Unfortunately, the participation and interest level of the dental industry, and the practitioner and research communities, still is far below what would be needed to accelerate this process and improve its outcomes.

In the absence of “official” ANSI/ADA standards, however, the industry can and should work toward de facto standards that simply are developed and adopted by the marketplace. Much innovation comes from the smaller companies in the dental marketplace that do not have significant market power of their own. Larger companies could provide interfaces to their products that facilitate integration of such innovations. This would be a change from the traditional behavior of an industry that has considered proprietary technologies as the source of competitive advantage.

As the evolution of the Digital Imaging and Communications in Medicine Standard in the medical imaging market shows, however, open standards can stimulate significant competition and innovation based on product features, not on trying to lock customers into proprietary technology.

**CONCLUSION**

Technology integration in the dental office is essential for increasing the efficiency and efficacy of the dental care system. Successful integration requires the cooperation of many stakeholders, including the dental industry, academia, and the practicing community. Let's get to work! •

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