CE/HTM Professional Roles in Healthcare Delivery: Time for a Trajectory Reset?

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Since the early days of clinical engineering (CE) and healthcare technology management (HTM), the focus has been on ensuring the necessary support and availability of effective and safe healthcare technology.

Viewed another way, the nature of what is required to ensure the support and availability of effective and safe healthcare technology is at the core of what constitutes an effective CE/HTM role. Therefore, fundamental changes in healthcare technology and its associated support needs require corresponding changes in CE/HTM services and the requisite knowledge, skills, and abilities (KSAs) needed by these professionals.

A Critical Point
Healthcare technology continues to evolve, as exhibited by developments in areas such as robotics, three-dimensional [3D] imaging and printing, telemedicine and remote monitoring, micro- and nanotechnologies, individualized medicine (including use of genomics), connected systems of systems, cloud-based solutions (e.g., the Internet of Things, 5G), clinical decision support, artificial intelligence (AI), virtual reality (VR), and augmented reality (AR).

These new technologies tend to be increasingly complex and capable and, oftentimes, even disruptive. Consequently, they bear little resemblance to their technical ancestors. When viewed on a time scale, the evolution of technology appears exponential (Figure 1).

The implications of this exponential evolution of healthcare technology on CE/HTM professionals will be substantial. Successful and effective application of these technologies will occur only if CE/HTM professionals are substantively involved in both the selection and life cycle support of changing technologies. Successful support will occur only if CE/HTM professional competencies adapt to match the evolving needs of new technologies.

To take on the requisite support role, CE/HTM professionals must be prepared to:
• Recognize that their past and existing KSAs may be inadequate or sufficiently irrelevant to effectively support the new and coming generations of healthcare technology.
• Commit to the continuous acquisition of the KSAs needed to ensure their ability to support new and continuously evolving technologies.

For most CE/HTM professionals, this will necessitate a reset and acceleration of the acquisition of KSAs (Figure 2).

A reset is necessary because many of the KSAs currently possessed by CE/HTM professionals are based on the perceived support needs of past generations of healthcare technology. A broad examination of services provided today by the bulk of CE/HTM professionals would suggest that a

Figure 1. The exponential evolution of healthcare technology.
large portion of these are focused—as they have been for 40 years—on activities such as scheduled maintenance and electrical safety. Similarly, regulations (e.g., from the Centers for Medicare & Medicaid Services, Food and Drug Administration, accreditation standards, state health departments) that govern the CE/HTM industry, both today and for the past generation of technology, have focused on scheduled maintenance requirements.

The problem is that current-day healthcare technology and its needed support bear little resemblance to the technologies and support of previous generations. Today’s healthcare technologies are generally more capable, are less mechanical, require less energy, are more mobile, are more solid state, are more automated, are better at self-correcting, are more integrated, and have better self-diagnosticstics than medical equipment of a generation ago. However, little evidence suggests that the current KSAs of CE/HTM professionals reflect a corresponding evolution that meets the needs of today’s technologies. Further, even less evidence supports that the industry is prepared to address what will likely be even more rapid changes in the support needs of the next generation of healthcare technology.

For more than 10 years, the ECRI Institute has published an annual summary of what it considers the year’s “top 10 health technology hazards”—challenges that it believes demand the greatest attention in the coming year. Of the 100 health technology hazards cited over 10 years (some duplicates during that period), most fell into the categories of alarm issues (10), cleaning/sterilization issues (17), system configuration/integration issues (13), cybersecurity issues (3), adopting adequate safety precautions (21), and use, procedure, or process issues (26). Only one of 100 issues was related to equipment maintenance.

The ECRI Institute’s annual list is one illustration of the disconnect inherent in CE/HTM professionals’ continued focus on maintenance rather than the real healthcare technology challenges—which have moved well beyond maintenance. Further, many CE/HTM professionals claim that they have little time to take on new challenges because they are overburdened by activities (e.g., maintenance) related to the previous areas of focus.

**Categories of CE/HTM Professionals**

Today, CE/HTM professionals generally fall into one (or more) of three categories: technology managers, engineers, and engineering technicians. The three categories and a description outlining their relative relationships are illustrated in Figure 3.

The technology professional paradigm illustrated in Figure 3 shows the traditional roles associated with those involved in the technical aspects of technology conception, design, production, fabrication, installation, maintenance, and support. An individual’s qualifications for these roles would consist of possessing the appropriate KSAs, which

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**Defining Competency**

Knowledge, skill, and ability are the three attributes that typically determine an individual’s competency in a professional role.

- **Knowledge** is the understanding of theoretical concepts. Knowledge usually is obtained through education.
- **Skill** is the capability to apply theoretical concepts. Skill usually is obtained through training and experience.
- **Ability** is the demonstrated capacity to apply knowledge and skills simultaneously in order to complete a task.
are either innately owned or acquired through relevant education and training.

Technology managers typically would have a combination of a technology business management degree (e.g., bachelor’s, master’s) and management experience appropriate for their role. Engineers would have a combination of an engineering degree (e.g., bachelor’s, master’s, doctorate) and engineering experience appropriate for their role. Engineering technicians would have a combination of a certificate or engineering technology degree (e.g., training certificate, associate’s, bachelor’s) and technical experience appropriate for their role.

The current technology professional paradigm for CE/HTM, with roles and core competencies (as defined by their respective U.S. certification programs [i.e., Healthcare Technology Certification Commission, AAMI Credentials Institute]), is shown in Figure 4. The core competencies listed were largely derived from surveys of practitioners done in recent years. Consequently, these may not reflect competencies required for support of the latest generation of healthcare technology, and they do not include competencies for which practitioners haveyet to perceive the need or adopt practices. Consequently, some critical competencies may receive inadequate or no attention. Examples of some currently critical but often overlooked competencies include:

- Quality management systems.
- Systems engineering (e.g., design, integration, configuration, and management of systems).
- Cybersecurity (i.e., data integrity, availability, confidentiality) management, preparedness, and response.
- Compliance (e.g., regulations, accreditation, and authorities having jurisdiction).
- Incident/problem and knowledge base management.
- Data analytics.
- Data exchange/transmission integrity (e.g., wireless, networking).
- Life cycle management (e.g., maintenance, updates, recalls).
- Software management (e.g., remote management, diagnostics, troubleshooting, updates).
- Asset management systems (e.g., computerized maintenance management systems, configuration database management systems).
- Specializations (e.g., imaging, chemistry, robotics, micro- and nanotechnologies, 3D printing, AI, VR, and AR systems).

These competencies could appear in one or more professional categories. Division of responsibility for each competency typically occurs as follows:

- Healthcare technology managers are responsible for managing operations.
- Clinical engineers are responsible for designing, planning, monitoring, analyzing, and improving.
- Biomedical engineering technicians (BMETs) are responsible for testing, measuring, collecting data, and maintaining.

To remain relevant in healthcare and to ensure that patients safely receive the benefits of new and evolving technologies, CE/HTM professionals must proactively focus on achieving the new competencies needed to support those technologies. They also should be prepared to shed competencies and services for which a demonstrable benefit no longer exists.

Figure 3. The technology professional paradigm. Note that individuals will not always fit neatly within a single role but may exist in the overlapping areas of two or three roles.
**Career Path for CE/HTM Professionals**

Although CE/HTM professionals generally fall into one of three categories (i.e., technology manager, clinical engineer, BMET), the boundaries associated with these categories are not absolute and can be semipermeable. There are circumstances where individual roles and competencies may cross between professional categories. In practice, some technicians may come to perform engineering or management activities and some engineers may come to perform technical or management work. The occasional overlapping of technical, engineering, and management roles does not diminish the importance of distinguishing among the three separate professionals; instead, it demonstrates the reality that occasional overlap will occur.

Figure 5 illustrates the more common career paths for healthcare technology professionals and shows how information technology (IT) professionals factor into that path. In the early career stages for BMETs and IT professionals, many opportunities for jumping from one role to the other tend to be available. As BMETs advance, some have the opportunity to obtain an engineering degree and move into the CE career lane.

As they advance further, clinical engineers and BMETs usually have two reasonably distinct career path options. One option is to elect to become a supervisor and/or technology manager. Further progression for BMETs and clinical engineers in manage-

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**Terminology Note: ‘Biomedical Engineering Technicians’**

The terms “engineering technician” and “biomedical engineering technician” are used here rather than what the healthcare industry has traditionally referred to as “biomedical equipment technician.” The use of engineering technician helps reinforce the notion that these professionals no longer focus on discrete equipment but rather on providing technical support to the entire biomedical technology ecosystem. The use of engineering technician for these professionals also reflects the term’s traditional broad use for comparable roles in other industries.
ANALYSIS

The career paths illustrated in Figure 5 suggest that each healthcare technology professional role has several levels that can be achieved. These levels progress from basic (i.e., foundational education and minimal experience) to more advanced (i.e., additional education with specialization in either management or a technical area).

**Education and Credentialing**

Given the rapid evolution of healthcare technologies, the roles by which CE/HTM professionals—who are tasked with safely and effectively supporting these technologies—should be constantly reviewed to ensure an appropriate match exists between needs and capabilities. The traditional retrospective reviews of competencies required to support existing technologies will no longer suffice.

Professional review boards made up of representatives from healthcare delivery...
organizations (HDOs), manufacturers, academic institutions, regulators, professional associations, and current practitioners should be established to determine competencies (KSAs) and appropriate competency levels for each of the professional categories (i.e., manager, engineer, technician). Once established, KSAs defining each level in each professional category should be used to define:

- Education and training requirements for each professional at that level.
- Corresponding credentialing levels and required KSAs for those levels.

These professional levels and associated credentialing then would be used to identify the level of competency achieved, starting with entry-level professionals possessing only foundational education and training and progressing to more advanced professionals who have leveraged additional education, training, and skills to achieve further capabilities and/or specialization.

**Summary**

To support a healthcare technology environment that is rapidly changing, the industry must realize that the trajectory of CE/HTM professional development needs to be reset. CE/HTM professionals and the professional organizations that support them should follow Wayne Gretzky’s advice when he said, “I skate to where the puck is going to be, not where it has been.” Failure to plan for the future will compromise the ability of CE/HTM professionals to support the healthcare environment and undermine the promised benefit of the technological evolution.

Understanding the distinct and important roles of technology manager, clinical engineer, and BMET also is important. The existence and contribution of each role are vital to the successful support of healthcare technology. Individuals may occasionally occupy overlapping roles, but the underlying services associated with the roles must be provided by those who can demonstrate the necessary competency. Career paths with recognized levels for each role are necessary to ensure that professionals with appropriate competencies are in place and that CE/HTM professionals have challenging career paths open to them.

Finally, the industry must ensure the availability of appropriate education, training, and credentialing for CE/HTM professionals. Good education provides the necessary foundational knowledge, and effective training can provide the necessary skills. A CE/HTM industry board, either created anew or adapted from an existing professional board, should enlist expert representatives from HDOs, manufacturers, academic institutions, regulators, professional associations, and current practitioners to develop and revise, as appropriate, the knowledge (education), skill (training), and ability requirements for each level of a CE/HTM professional. This same CE/HTM industry board should advise those credentialing CE/HTM professionals with respect to which credential levels are meaningful and appropriate.

As CE/HTM professionals, we need to recognize that the healthcare technology industry ground is beginning to shift in major ways beneath our feet. We have a limited time to react before we otherwise find ourselves upended.

**Disclaimer**

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