The MACH Model: From Competencies to Instruction and Performance of the Public Health Workforce

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In *A National Public Health Strategy for Terrorism Preparedness and Response 2003–2008,* the Centers for Disease Control and Prevention (CDC) outlined the 11 imperatives for preventing death, disability, disease, and injury associated with urgent health threats.[1] Imperative five, Competent and Sustainable Workforce, identifies four critical objectives: (*1*) increase the number and type of professionals who comprise a preparedness and response workforce; (*2*) deliver certification and competency-based training and education; (*3*) recruit and retain the highest quality workforce; and (*4*) evaluate the impact of training to ensure learning has occurred. The plan states: "Challenges that exist . . . include defining the role of certification, practicing quality assurance and performance measurement, developing customized standard competencies . . . ."[1]

The MACH (Miner, Alperin, Cioffi, and Hunt) Model, developed at the Rollins School of Public Health, serves as a logic map that describes the associations among the objectives and challenges within this imperative. The MACH Model places into context the organizational and instructional theories that underpin workforce preparation and practice. It also accounts for the two general types of needs within public health: those of the employee with skill deficits for specific tasks, which can be met through training or other expert systems; and those of the institution with deficiencies in the work environment, which can be met through management practices and organizational priorities.

PUBLIC HEALTH WORKFORCE DEVELOPMENT

The call for a systematic approach to workforce development in public health is not new. Public health draws professionals from a wide range of backgrounds with varying levels of skills and expertise. The science and practice of public health continues to change and evolve. The majority of the public health workforce—estimated at more than three quarters of the workforce—has little or no formal education or training in public health.[2] Given the central role that public health plays in protecting the health of our communities, it is incumbent upon leaders in practice and academe to ensure that the current and future workforce is prepared to face new and existing challenges.

The heterogeneous nature of the public health workforce presents both opportunities and challenges for education and training. The skills and knowledge of the workforce provide opportunities to build on existing talents if these are identified in individual

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workers and in the organization as a whole. Challenges arise from the gaps in worker capabilities, i.e., those expected for current performance or needed to address emerging issues. The ability to identify priorities and implement comprehensive approaches to public health workforce development is critical.

To establish effective and comprehensive learning systems within public health, it is helpful to first consider three pertinent topics: adult learning, instructional design, and competency-driven workforce development.

Adult learning

Public health workforce development is rooted in adult learning theory. Adult learners approach education from a mature perspective and an ability to draw on varied experiences from their personal, work, and educational backgrounds. Their continued learning is largely shaped by a spectrum of life experiences, which serve as a foundation for interpreting and understanding events in their lives. As such, adult education is a departure from the more traditional teacher-centered instruction often used with younger learners. To be successful, adult education programs must incorporate the perspectives of learners and involve them in the process of contributing to or transforming their current skills and knowledge.

Malcolm Knowles' theory of andragogy is perhaps the best known learner-centered model of instruction, and offers important insights into ways in which appropriate and effective education can be developed for adults.[3] The term "andragogy" was developed by Knowles to differentiate between traditional models of instruction to child learners (known as pedagogy) and adult instruction. Knowles' theory rests on four basic assumptions about adult learners, each of which provides guidelines for developing and implementing adult education programs:

- *Concept of the learner.* Adult personalities become more self-directed and less dependent. This assumption emphasizes the adult learner's involvement in identifying educational objectives (based on their own skill levels and needs); planning the learning process (including both course procedures and content); and assessing the program's success in meeting the learning objectives.
- *Role of learner's experience.* Adult learners accumulate a growing reservoir of experiences that assists them in their learning. This assumption suggests using experiential techniques that allow learners to apply previously acquired skills to the process of developing new ones and designing learning experiences that involve practical application (planned or rehearsed) of targeted skills.
- *Readiness to learn.* Adults' learning becomes prioritized according to their particular roles in life. Adult learning can be optimized by enabling learners to identify their own learning needs; setting and sequencing curriculum to ensure appropriateness to skill level and learning pace; and grouping participants to facilitate learning (e.g., group learners according to similar levels of mastery).
- *Orientation to learning.* Adults have an increased expectation of being able to directly and immediately apply what they have learned to fulfillment of their roles. Learning experiences should be tailored to the problems and concerns that adults have upon initiating a program, and curriculum should be centered on problem areas rather than predetermined content.[3,4]

Instructional design

The instructional design process incorporates the theoretical considerations presented above into a practice-based framework that bridges the gaps between learner needs, learning objectives, delivery of instruction, and evaluation. Instructional design can be defined as "the systematic process of translating principles of learning and instruction into plans for instructional materials and activities."[5] The process reflects the facets of adult learning, including its reliance on the perspective of the learner, rather than the content, to guide instruction.[6] This is a departure from the more traditional educational approach in which content is identified and presented, often without first evaluating learner needs and abilities.

Instructional design involves a high level of planning and precision that results in the transfer of specific and measurable skills. It can be used both for the development of general education under a wide range of circumstances, and training, which generally refers to the acquisition of specific and immediately applicable skills.[4,5]

Competency-driven workforce development

In recent years, the practice of competency-driven workforce development has become increasingly prevalent in the field of public health. A wide range of both general and topical competencies has been identified and applied to workforce development initiatives. The Institute of Medicine (IOM) report, *Who Will Keep the Public Healthy?*, calls for the development of additional competencies to set the standards for both graduate education in public health and continuing education for the public health workforce.[7] Competencies are used to develop, deliver, and evaluate instruction; identify job responsibilities; and assess individual and organizational capacity.

Generally speaking, competency in a certain skill can be defined as the ability to perform and sequence actions to attain a specific goal.[8] Lucia and Lepsinger provide a more detailed view of competency, defining the term as "a cluster of related knowledge, skills, and attitudes that affects a major part of one's job (a role or responsibility), that correlates with performance on the job, that can be measured against well-accepted standards, and that can be improved via training and development."[9] In the context of training and educational programs, competencies represent small, targeted components of skills and knowledge. Essentially, larger skill sets are broken down into competencies, which represent sequential levels of cognition or mastery. Competencies are functionally related; they progress from basic to advanced and reinforce one another as learning occurs.

Within the competency-driven workforce development trend, two main paths have emerged that are leading practice

in somewhat different directions. The first path has been followed by those for whom competencies are used primarily in the development of curricula and instructional materials. These types of competencies are referred to as "instructional competencies." Alternatively, those following the second path have tended to apply competencies to the identification and design of worker roles, responsibilities, and job descriptions. These are called "workforce competencies" and are traditionally used for managerial and administrative purposes.[10]

THE MACH MODEL

Applying the MACH Model to the currently bifurcated practice of competency-led workforce development provides practitioners the opportunity to integrate these two schools of thought into one comprehensive plan for training the workforce. Through the MACH Model's standardized approach, competencies can be used to fulfill both instructional and workforce needs.

The MACH Model (Figure) contains eight main components arranged in a multi-part structure. Within the model, many of the processes are cyclical and reinforce one another. The primary outcome is organizational performance, achieved through a system that targets the needs of individual workers.

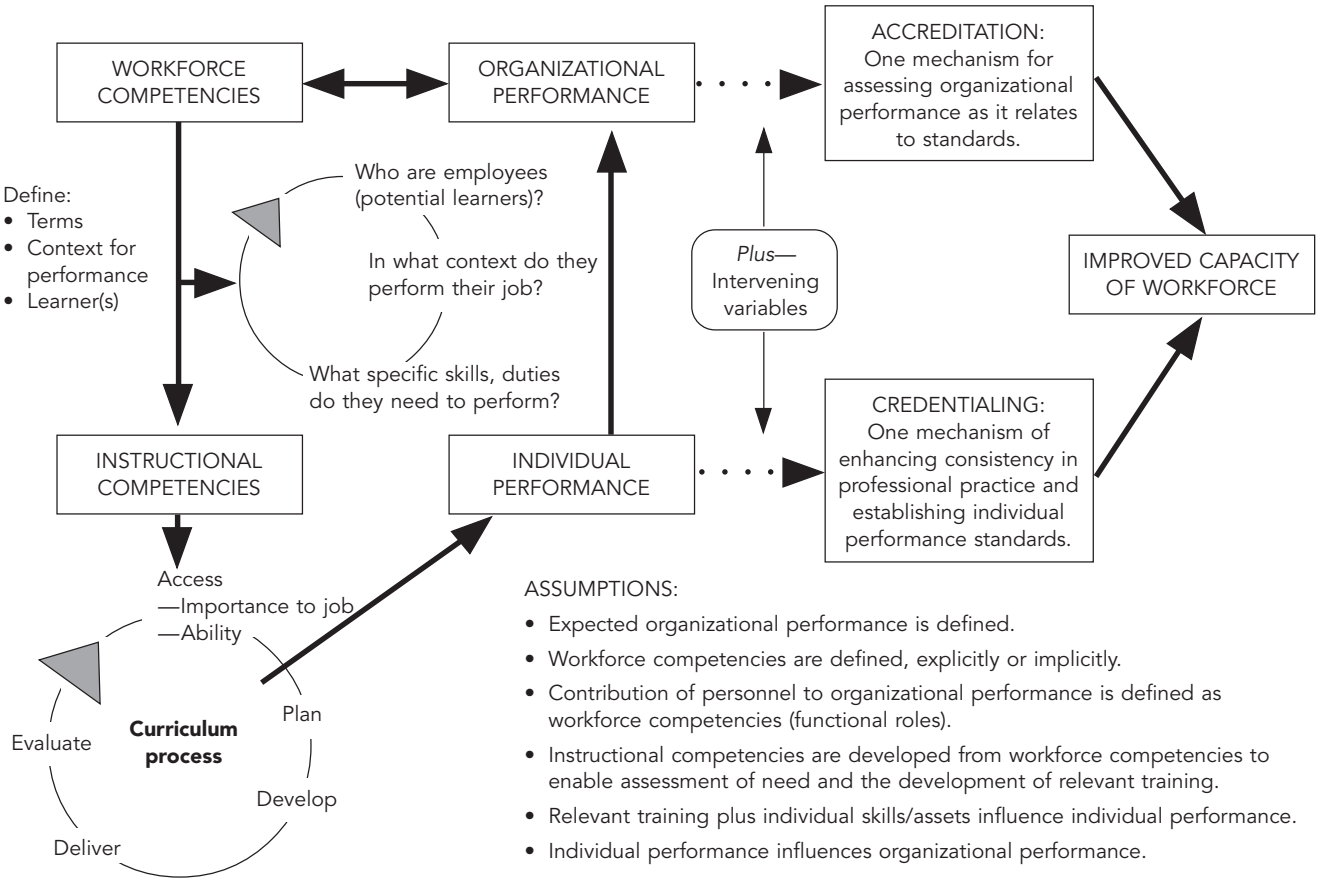
The MACH Model operates under a set of basic assumptions: (*1*) expected organizational performance is defined; (*2*) contribution of personnel to organizational performance is defined as workforce competencies (functional roles); (*3*) workforce competencies are defined, explicitly or implicitly; (*4*) instructional competencies are developed from workforce competencies to enable assessment of need and the development of relevant training; (*5*) relevant training plus individual skills/assets influence individual performance; and (*6*) individual performance influences organizational performance.

The model is comprised of eight components: workforce competencies; defining elements; instructional competencies; curriculum process; individual performance; organizational performance; accreditation; credentialing; and intervening variables.

Workforce competencies

Workforce competencies generally combine a series of different skills into one broad statement. These statements (explicit or implicit) are meant to define a wide scope of work, and generally include multiple actions, responsibilities, and content areas. In practice, workforce competencies are often used to create and define job descriptions. When explicit, they are generally presented in summary format to allow workers to appreciate the full extent of their positions,

Figure. MACH Model



while at the same time condensing the content to facilitate understanding. An example of a workforce competency is the statement: "The public health professional develops an emergency response plan, incorporating essential elements (e.g., incident command, communications, command/control, operations, logistics, planning, finance/administration, coordination)."[11] Accordingly, this statement is rather far-reaching and contains multiple components.

The broad nature of these descriptions can present implementation and evaluation issues, insofar as the criteria may vary widely and often lack defined levels of knowledge and skills. Workforce competencies generally do not outline the specific skills required to complete responsibilities; instead they tend to focus primarily on the final set of expected outcomes. To conduct training and/or evaluate worker skills, larger responsibilities must be broken down into more specific skills that can then be examined and/or targeted for training.

Defining elements

Before developing competencies for use in instruction (instructional competencies), it is important to understand the context in which employees are operating. Certain elements must be defined to inform both the identification of instructional competencies as well as the curriculum process. Simply stated, these elements cover the "who, what, where, and how" of the workforce. Information is collected on the nature of the workforce—how many there are, what backgrounds and experiences they draw from, and what their skills levels are. The context in which they perform their job is examined, considering such elements as nature and location of the worksite(s); schedules; resources; and management structure. Finally, it is necessary to determine the requirements of the workforce—specifically, which skills and responsibilities are necessary to perform their jobs.

Instructional competencies

Once an understanding about the specifics of a workforce is achieved, instructional competencies can be developed. Instructional competencies are modeled after the sequential stages of learning illustrated in Bloom's taxonomy. Created in the mid 1950s, Bloom's taxonomy[12] is based on six levels of abstraction within the learning process: knowledge, comprehension, application, analysis, synthesis, and evaluation. These six levels represent a hierarchy of education that is categorized from the simplest actions to the most complex.[13] Through the use of instructional competencies, larger skills are broken down into basic steps that build on and reinforce one another, leading to higher levels of learning. For example, an instructional competency might read: "The public health professional will describe the chain of command in emergency response."[14] This statement provides detailed information regarding what is expected of, and can be demonstrated by, the learner or specific members of the workforce.

This framework suggests training and evaluation processes that target specific, measurable components on an individual basis. On an organizational level, instructional competencies should be relevant to the scope of work undertaken by that agency. This process will essentially provide a menu from which individual worker competencies can be identified. Although the relevant competencies will differ by worker, having these competencies in place provides a structure by which individual needs can be assessed and subsequently met.

Curriculum process

Once instructional competencies have been identified, educators use them as a guide for developing and administering training programs. Instructional competencies influence the content, while the curriculum process provides a structure for designing and conducting the training programs. The curriculum process, therefore, encompasses the direct learning process—from needs assessment to evaluation. It is a central piece of the MACH Model, yet is not free-standing in its impact on workforce development. This stage involves cyclical interaction among five components: assessment, planning, development, delivery, and evaluation.

Assessment. The first step in the curriculum process is assessment of workers' roles and capabilities: identifying the instructional competencies relevant to individual job responsibilities, as well as individual levels of ability. Consideration of both responsibilities and abilities is essential, as it provides educators with an understanding of how important different skills are to individual workers, as well as their capacity to perform them. This helps prevent channeling resources to domains that are either irrelevant to the needs of workers, or in which competence is already well established. Furthermore, the assessment process provides adult learners a voice in the education process. Learners can use the process to directly communicate their needs to educators or uncover training needs that may have been unrecognized previously.

Assessments of workers' needs and capabilities can be conducted in several different ways. Individuals can participate in a needs assessment survey, in which they rate their job responsibilities and related abilities. They can complete an instrument that measures their knowledge on specific responsibilities. Managers and supervisors can also provide information related to their employees' job requirements and training needs. Combinations of these approaches or other assessment mechanisms might also be appropriate, depending on the environment and the nature of the workforce.

Planning. Information collected through the assessment process serves as the foundation for the planning stage of curriculum design. This process incorporates the needs assessment information into a plan for meeting the educational requirements of the workers. Essentially, a blueprint is created that outlines the learning objectives, topic areas, delivery mechanisms, and evaluation criteria for the training curriculum. Learners should be key participants in the process to ensure that the plan (including development, delivery and evaluation) meets their educational needs.

The planning stage also allows educators to identify the level at which instruction should occur. Within the context of Bloom's taxonomy, therefore, educators would be able to categorize students according to their particular need or level: knowledge, comprehension, application, analysis, synthesis, or evaluation. Understanding the learning levels of their students will allow instructors to tailor their curriculum to maximize the benefit of the training.

Development. The curriculum plan is then used as a guide for development of training content and materials. The general outline provided in the plan is broken down into parts, which are developed into lessons. Individual lessons are structured according to topic area, audience, available resources (e.g., time, space, technological access), and learning objectives. Course materials are also identified and/or developed.

In keeping with Knowles' theory of andragogy, lessons must be based around the experiences of the adults. Learners should be encouraged to use their own experiences and abilities as a framework on which they build additional skills. Furthermore, the lessons should provide an opportunity for learners to practically apply the content areas through such activities as case studies, role playing, problem solving, and simulation exercises.

Delivery. Delivering the curriculum involves actual implementation of the lessons. Workers participate in a series of learning experiences during which a transfer of knowledge and/or skills occurs. It is important that instructors carefully design the delivery of lessons to accommodate different learning styles and keep sessions interesting and engaging. As discussed earlier, the classroom experiences should be tailored to the concerns adults have upon entering the program. This is practiced in recognition that adult learning addresses a learner's particular problem or issue, rather than simply presenting predetermined content.[3] A common strategy to identify student needs early on is the initiation of a group discussion focused on expectations and what participants hope to get out of the course.

Evaluation. Finally, student performance and the efficacy of the curriculum are evaluated based on learning objectives and other criteria established in the planning stage. Evaluation outcomes are used to determine the effectiveness of the program and to identify any changes that need to be made. Criteria that inform the evaluation can include student feedback, instructor feedback, pre- and post-instruction assessments, observational assessments during simulations, and job performance.

Individual performance

The success of any training or educational efforts relies on individual performance. Even the best designed instruction cannot stand on its own without evidence that learners can demonstrate new or developed competencies. The overarching goal of workforce development is that individuals apply what they have learned during training or education to their work. Appropriate training can provide individuals with hands-on skills that can be applied immediately to their job responsibilities, while other experiences can contribute to general knowledge that may be applied under a variety of circumstances. Both are valuable for individual performance as well as overall workforce development.

Organizational performance

There is a reciprocal relationship between organizational performance and the performance of individuals in the organization. The underlying assumption that drives the demand for public health workforce development is that once enhanced individual performance is achieved, there is a logical extension to improved organizational performance. With a critical mass of prepared workers, the expectation is that the capacity to respond to public health emergencies will be improved. The organization can encourage life-long learning for its employees through support of continuing education, professional development programs, and a culture of quality improvement, safety-mindedness, and reflection. Conversely, the organization can impede life-long learning by discouraging or limiting access to training, literature, and technology.[15]

The steps described in the MACH Model can help organizations identify strengths and weaknesses (both overall and for individual workers), and take steps toward improved competency. Distinguishing those factors of organizational performance improvements that can be addressed by training groups of individuals or recruiting personnel with unique capabilities is critical in achieving the desired results.

There are many ways in which workforce development can benefit organizational performance. The application of learned skills by workers can further the goals of the organization, increase efficiency, and/or improve products and services. Increasing the skills and knowledge of workers can also create a ripple effect, increasing the potential for on-the-job learning and transfer of skills within the workplace. The overall result is a more highly skilled workforce, better prepared to meet the challenging demands of public health.

Accreditation and credentialing

The impact of improved organizational and individual performance in public health has potentially far-reaching consequences. The absence of consistent standards and processes of recognition, however, may create wide gaps within the system. Inconsistent or nonexistent standards could create situations in which public health organizations vary widely in their efficacy, fluctuate greatly over time, or direct resources to development efforts that are duplicative, ineffective, or irrelevant.

A logical next step for workforce development, therefore, would be the creation of mechanisms that can capture and assess organizational and individual performance according to relevant and consistent standards. The processes of accreditation and credentialing have been the subject of considerable debate within public health for many years, and continue to present both challenges and opportunities for implementation.

On an organizational level, accreditation is one important component of workforce development. Through accreditation, organizations can be evaluated against standardized and consistent criteria and held accountable for their performance. Although it may be assumed that enhancing the skills of workers will ultimately benefit organizations, determining the competence of a workforce as a whole requires the population-based approach that accreditation provides.[16]

Similar to the accreditation process, the credentialing of workers can provide standards and evaluation criteria for individual abilities. Credentialing offers consistent recognition of worker abilities that can be used to identify and meet training needs, coordinate job placement and advancement, and conduct organizational needs assessments. It can also provide a structure that supports ongoing workforce development, insofar as it is based on a system of periodic

assessment and training. To date, there has been much discussion about the need for credentialing in public health, yet no consensus on how the need can be met.[14]

Intervening variables

Despite the theoretical logic behind accreditation and credentialing within workforce development, such efforts remain challenged by several intervening variables. Potential barriers include financial and human resource burdens; disagreement over the content on which such systems would be based; inadequate support from workforce and policy makers; and insufficient knowledge about appropriate implementation strategies.[14]

Aside from logistical challenges, another critical intervening variable is the ability to determine if a worker and/or organization is competent. This issue requires consideration of both the criteria that will be used to identify standards, as well as the mechanisms for measurement and enforcement. Furthermore, once criteria and mechanisms are established, testing and validation are required.

APPLICATION OF THE MACH MODEL: THE G-TRAIN PROGRAM

Public health organizations have an important role in paving the way for competency-based workforce development efforts such as those illustrated in the MACH Model. Training and assessment activities conducted on a smaller scale provide opportunities to test relevant competencies and standards for the workforce as a whole. The Georgia Training Resource and Inventory Network (G-TRAIN) is an example of how the components represented in the MACH Model were used to develop a needs assessment and course management system for Georgia's public health workforce.

As part of the Centers for Public Health Preparedness (CPHP) network launched by the CDC and the Association of Schools of Public Health in 2000, the Rollins School of Public Health of Emory University developed a CPHP serving Georgia's public health workforce. In 2003, Emory's CPHP partnered with the Georgia Division of Public Health to develop G-TRAIN, a web-based needs assessment and course management system for use in training public health workers. The G-TRAIN system collects needs assessment data and maintains a course catalog of training resources.

Upon registration with the program, G-TRAIN users complete an in-depth needs assessment that yields a comparative analysis of their job responsibilities and abilities. The needs assessment is made up entirely of instructional competencies, organized into eight domains: analytic/assessment; policy development/program planning; communication; cultural competency; community aspects of public health practice; basic public health sciences; financial planning and management; and leadership and systems thinking. Competencies are defined as either "core," which are more general and pertain to the central functions of public health workers, or "bioterrorism," which relate to preparation for and response to emergency events, including terrorism. (The number of competencies varies by type of position: 101 for public health management and variously skilled professionals and 44 for administrative/clerical personnel.) For each competency, users are asked to rate importance to job responsibilities and current level of ability on a 1–5 Likert scale (not important at all to very important; no ability at all to very high ability). The system applies an algorithm to the two responses, calculating a training priority level for each competency (low, medium, high, or critical).

The G-TRAIN system is an example of the central role that instructional competencies can have in workforce development. The core and bioterrorism competencies were adapted from broader workforce competencies representing the eight domains (content areas) discussed above. Many are arranged hierarchically—resembling Bloom's taxonomy—according to related skill sets and topic areas. For example, a grouping of competencies in the analytic/assessment domain focuses on emergency assessment skills. Three related competencies are included in the needs assessment tool: "conducts assessments to determine the scope and severity of emergency events"; "evaluates assessment data to determine the scope and severity of emergency events"; and "incorporates community-specific risk assessments in the preparation of emergency response plans."[11] The first, the ability to *conduct* assessments, may be classified as the "application" level of knowledge (preceded by knowledge and comprehension, which are assumed for respondents who report the ability to apply the skill). The second refers to *evaluation* of assessment data, which in this case may be interpreted as "analysis," the fourth level in the taxonomy. Finally, the third competency is the ability to *incorporate* assessments into emergency response plans, synthesizing the information into a broader schema. These competencies are designed to capture different skill levels within a single concept—application, analysis, and synthesis.

A second example illustrates how instructional competencies can be used to differentiate among related yet unique topics. The analytic/assessment skills domain contains three instructional competencies that focus on knowledge of different agents that could potentially be used in a terrorist attack. Specifically, the competencies are: (*1*) "describes the signs and symptoms for exposure to category A bioterrorism agents"; (*2*) "describes the signs and symptoms for nuclear/radiologic exposure"; and (*3*) "describes the signs and symptoms for exposure to chemical agents."[11] This organization is driven by the assumption that the knowledge in these three areas (describing the signs and symptoms of bioterrorism agents, chemical agents, and nuclear/radiologic exposure), while related, is different enough to warrant targeted assessment and training.

These examples illustrate how the organization of instructional competencies in G-TRAIN benefits learners by breaking down larger responsibilities into individual units, around which targeted training can occur. The competency-based needs assessment process also allows for instruction to be tailored to an individual's specific job responsibilities, and for identifying workers who require skills in certain areas. This process thus enables educators to incorporate the central assumptions of Knowles' theory of andragogy in designing training for public health workers: (*1*) involving adult learners in the development of learning experiences; (*2*) building on previously acquired skills to help learners attain new and more developed ones; (*3*) tailoring programs to adults' individual roles; and (*4*) providing training that will be immediately applicable by participants.[3,4]

Furthermore, within the context of the MACH Model, the G-TRAIN system represents the functionality of the initial processes—the transformation of workforce competencies into instructional competencies, which are then assessed to inform the curriculum planning, development, delivery, and evaluation processes. The G-TRAIN system not only demonstrates the application of the MACH Model to workforce development within Georgia, but is also allowing administrators to test the validity of instructional competencies through continuous training and evaluation—a key step toward their possible use in future credentialing and/or accreditation mechanisms.

MACH MODEL OUTCOME

The MACH Model represents a systematic process for identifying and meeting training needs. Training alone does not make an individual or the workforce competent, yet approaching the task in a consistent, systematic fashion may be the best assurance for a prepared workforce. As illustrated in the model, the road from public health workforce competencies to individual and organizational performance can be lengthy, yet fitted with the right processes it can lead to successful workforce development. Furthermore, application of the model puts into place mechanisms for continued development, institutionalizing the processes that prepare the workforce for the challenges they continue to face.

The success of the MACH Model depends largely on the validity of the competencies being used. Competencies must be in line with how workers view their job responsibilities, and it must be demonstrated that the competencies are predictors of success in fulfilling those duties. The CPHP are in a unique position to validate competencies through their focus on workforce development and their relationships with state and local practice partners. Through their work that targets specific preparedness competencies, these centers have the opportunity to assess the extent to which competency-based training translates into improved job performance.

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