VIEWPOINT

Research-Driven Medical Education and Practice: A Case for T-Shaped Professionals

Nicholas Donofrio and Jim Spohrer and Hossein S. Zadeh

Deans at major universities know the problem all too well: There is too much for students to know, and too little time to teach it. Each year educators must decide what to drop to ensure time for the latest findings and forward looking research topics. Furthermore, employers expect new hires both to hit the ground running and to maintain relevant new skills through lifelong learning - self-directed and on their own time. Welcome to the new world of education and practice in an era of accelerating change, and research-driven knowledge creation across all sectors of industry and society.

Medical education and practice will continue to be ground-zero in this storm for the foreseeable future. Demographic shifts to more aged populations in the world's wealthiest nations, all but ensure more research investments and more innovations. Similar pattern od aging population is emerging in other countries as well. For example, the growth of ageing populations has been flagged by World Health Organization (WHO) as one of three global challenges likely to overwhelm struggling health systems [1]. This viewpoint makes a case for T-shaped professionals. T-shaped professionals combine the benefits of deep problem-solving skills in one area, with broad complex-communication skills across many areas. As knowledge growth continues unabated and technology augments both human problem solving and communications, this is one way forward that is coming into focus.

A case for T-shaped professionals in medicine is made in the following sections. First, relevant characteristics of research-driven medical education and practice must be considered, expanding on the points above. Second, the origins and arguments for T-shaped professionals in other areas, such at the fast changing world of Information Technology (IT) and knowledge-intensive business services, will be reviewed. Next, empirical data that go beyond the commonsense arguments used by advocates are summarized. Finally, a critical review is outlined, along with recommendations for future explorations that conclude with why this is a necessary, but difficult, change for medical and other professionals.

Research-Driven Medicine

The growing gap between clinical practice, medical teaching and research is a cause for concern [2]. Many stakeholders agree that research must be even more closely connected with teaching as the rate of knowledge creation continues to increase. The coupling between practice and teaching is also of importance. "Because the clinical medical workforce is much larger than the medical education workforce, the contribution of clinicians to medical education in terms of total time spent is substantial. In 2006, clinicians provided almost three-quarters of total medical teaching hours…" [2]. The three specialized roles, practitioner, educator, and

ABSTRACT

· Demand for medical education is increasing.
· T-shaped professionals have problem-solving (depth) and complex-communication (breadth) skills. The phrase originated in computer education and then spread to other areas in part to create a contrast with traditional, highly specialized I-shaped professionals.
· Cataldo, Carley, and Argote vary the ratio of specialists (depth) and generalists (breadth) in simulations of organizations to study performance effects including total knowledge transferred.
· Levy and Murnane analyze job descriptions in the US over a thirty year period and identify a trend toward increasing demand for expert thinking (depth) and complex communications (breadth).
· Collins and Evans study scientists and others to better understand models of expertise, and identified the importance of both contributory (depth) and interactional (breadth) expertise.
· The demand for T-shaped professionals in knowledge-intensive service-oriented economies is increasing.
· The potential benefits of T-shaped professionals to organizational performance are quite significant.
· Unfortunately, the challenges associated with creating more T-shaped professionals are also significant.
· National standards efforts for STEM (Science Technology Engineering Mathematics) education are beginning to move towards integrated curriculum to break down discipline silos.
· Service Science Management and Engineering (SSME) is an emerging discipline with over 250 programs in 50 nations seeking to create more T-shaped professionals.
· Future research directions aim to empirically demonstrate the benefits of T-shaped professionals in organizations as well as to develop improved approaches to the creation of T-shaped professionals.

researcher, must interact, or at least co-evolve in closer and closer synchronization. The number of people who engage in all three roles simultaneously is also growing. These people are also patients and often students, or at least lifelong learners.

The growth in number and diverse structure of new medical schools points to growing demand for medical specialists who dare to be different, and creatively span some of the well established boundaries of the past [3]. Some schools are increasingly providing curricula with emphasis on problem-based, and self directed learning. Approaches such as "horizontal integration between disciplines, vertical integration between basic and clinical sciences, early exposure to patients and increased emphasis on communication skills, ethics, and personal and professional development" have been taken by some universities [3]. Indeed some of the most sought after graduates are those who have combined

and developed research, professional and entrepreneurial skills by working alongside experienced researchers and industry representatives [4].

Of course industry has been known to be more dynamic and faster changing than academia. Furthermore, the context of accelerating change is not diminishing. "… [W]e are beset by change — social, technological, scientific, economic; the list continues. These changes have affected all areas of life, including medicine, and the medical schools have had to respond." [5]. Not only medicine, but all research-driven areas must respond. One response that seems to hold some promise is the creation of more T-shaped professionals.

Furthermore as the medical profession is becoming more dependent on technology and market forces than ever before, the decision making process of healthcare practitioners and clinicians is more and more informed and influences by non-medical factors. For example, many medical schools offer electives into legal, regulations, and policy of medical profession [6]. And this is by no means limited to the United States. In Australia, for example, a number of senior medical practitioners recently had to cease providing certain medical services out of concern for the prosecution of certain patients [7]. Even in places such as India, legal and ethical issues of medical practice is now being discussed in medical journals [8]. This tacitly means medical practitioners will need more than just medical knowledge to be able to work efficiently. This, in turn, implies creation of more T-shaped healthcare professionals is not merely a suggestion, but a necessity.

Origins and Advocates

While conversational usage is expected to be much earlier, the earliest known use of the phrase T-shaped people in print was in a 1991 London newspaper editorial. David Guest, responding to a report on jobs in computing, wrote: "This type of rounded personality is also sought in other branches of the same theory, which prizes individuals known as T-shaped People: These are a variation on Renaissance Man, equally comfortable with information systems, modern management techniques and the 12-tone scale" [9]. Others at the time preferred the term hybrids: "The hunt for a new breed of computer manager is on. The British Computer Society, in a controversial report published last year, described the quarry as a 'hybrid' manager who would combine business expertise with IT skills. The hybrid manager, it said, would be distinguished by his or her ability to relate to 'the broad picture' and to people, understanding their motivation and aspirations; he or she would also be energetic, intuitive, a good listener, and (cryptically) would have 'an unusual set of interests'" [10].

In the context of real-world R&D and complex systems, Harvard's Iansiti further popularized the term: "What follows is a typical profile for a successful integration team. In general, the members are the foundation of a system-focused approach to R&D. They possess a T-shaped combination of skills: they are not only experts in specific technical areas but also intimately acquainted with the potential systemic impact of their particular tasks. On the one hand, they have a deep knowledge of a discipline like ceramic materials engineering, represented by the vertical stroke of the T. On the other hand, these ceramic specialists also know how their discipline interacts with others, such as polymer processing — the T's horizontal top stroke." [11].

Universities, traditionally, create professionals who are specialized in one specific domain (I-shape). It has been proven many times that a change in technology or market conditions devalues knowledge of I-shape professionals. T-shape professionals, on the other hand, are those who have a deep understating of one field (their specific area of specialization) as well as good understanding of a broad range of other disciplines (see Figure 1).

Building on Iansiti observations, Leonard-Barton contributes the important connection to organizational incentives and the draw-backs of being T-shaped: "In most organizations, T-shaped skills are not created as a deliberate policy but emerge because individuals have been willing to risk a somewhat marginal career. Most formal organizational incentives encourage I-shaped skills — the deep functional experience represented by the T's stem. As a result, the individual is driven ever deeper into his or her expertise, which the organization continually draws on and rewards."

Do organizational cultures exist that might actually reward and encourage T-shaped people? According to Tim Brown, CEO of IDEO, top design firms do: "Recruiting T-Shaped People… We look for people who are so inquisitive about the world that they're willing to try to do what you do. We call them 'T-shaped people.' They have a principal skill that describes the vertical leg of the T -- they're mechanical engineers or industrial designers. But they are so empathetic that they can branch out into other skills, such as anthropology, and do them as well. They are able to explore insights from many different perspectives and recognize patterns of behavior that point to a universal human need." [13,14].

Advocates of T-shaped people often mention that the breadth of knowledge and experience enables faster adaptation and role changes, in addition to better
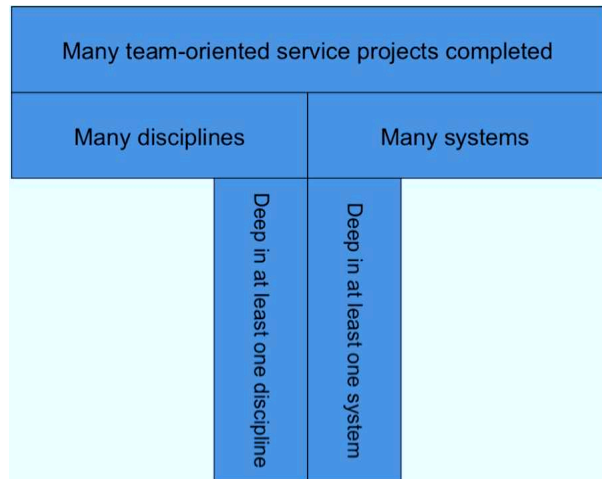
Figure 1 – T-shape professionals: combining problem solving (deep) and communication (broad) skills

communication skills for teamwork in multidisciplinary, multifunctional, or multicultural contexts. For example, Gartner uses the term 'versatilist' noting: "Versatilists are people whose numerous roles, assignments and experiences are enabling them to synthesize knowledge and context to fuel business value. Versatilists are applying their depth of skills and experiences to a rich scope of situations and challenges and implementing their cross-organisational insight to flesh out teams and fill competency gaps." [15].

For decades, IBM has advocated the need for more T-shaped professionals, especially in the areas of technology-driven business and organizational change. Most recently, since 2004, IBM has been working with universities, governments, and industry partners around the world to advocate a new discipline called Service Science Management and Engineering (SSME). SSME seeks to address the need for increased STEM (Science Technology Engineering and Math) education to meet industry's need for more research-driven service sector innovation [16]. SSME helps create T-shaped professionals who are better collaborative innovators [17] and adaptive innovators [18] because of their deep problem solving skills in one area and broad communication skills across many other areas. Considering the sheer range and depth of medical profession specializations, there is a strong need for T-shape professionals with their main field of expertise in the domain of medical profession.

The number of advocates is increasing, and even includes those who see the benefits of T-shaped managers for next generation knowledge management [19], T-shaped philanthropists [20], as well as the first T-shaped people consultancy service [21]. Nevertheless, most advocates of the benefits of T-shaped people in organizations do so by advancing what are largely commonsense arguments that are based on anecdotal experiences. The next section introduces some preliminary empirical evidence in support of their claims.

Empirical Support
To date there is limited consensus on the definition of what a T-shaped person actually is and even less empirical evidence that supports the specific benefits claimed by advocates. Nevertheless, three different sources of evidence begin to lay a foundation for a precise definition and measurement method of the benefits of a larger ratio of T-shaped professionals in and across interconnected organizations.

What is "the right" ratio of generalists to specialists in an organization? This age old question was put to the test using methods of computational organization theory develop by Kathleen Carley and her CMU colleagues [22]. The overall results were perhaps not too surprising, but using a simple model of demand and altering the ratio of simulated generalists and specialists in an organization, this research efforts findings were well aligned with the following: (1) in the case of constant demand, organizational performance can be optimized using all specialists, but (2) in the case of variable demand, organizational performance can be enhanced by increasing the ratio of generalists that increase knowledge flows across the organization. Up to a point,

the more demand varies, the more generalist are able to create performance benefits over alternative populations of strictly I-shaped specialist employees. Perhaps more important than the specific findings of these computational organization theory experiments is the development of a method for lending more precision to the definition of people with different "shaped skills" and measures of performance benefits when demand and skills vary.

Is there evidence that supports the need for more T-shaped people at the national level? Using thirty years of economic trends related to job descriptions, MIT and Harvard economists Levy and Murnane examine how computers create and enhance some jobs, while they eliminate and redistribute other jobs [23]. The result is a clear trend in U.S. occupational structure with most job growth in higher-end, high-skilled occupations, and most job elimination in the lower-end low-skilled occupations. Their recommendation is to recognize this division and to prepare the population for the high-wage and high-skilled jobs that are rapidly growing in number--jobs that use computers and require extensive problem solving (depth) and interpersonal communication (breadth). Again, perhaps more important than the specific findings of this economic trend analysis study is the development of a method that could lead to a more precise definition of T-shaped skills needed to improve the performance of nations as a function of increasing computer capabilities [24].

Is there evidence that depth and breadth are useful dimensions for the scientific analysis of human competence and performance in domains as diverse as management, technology, and medicine? Sociology of science researchers Collins and Evans at UK Cardiff University have studied the nature of expertise across many scientific and other professions [25]. They conclude that professionals exhibit both interactional expertise (complex communications about what are the interesting problems to solve and methods to use) and contributory expertise (expert thinking and problem solving that leads to solving problems and creating new knowledge), and mastery of either requires interactions with other professionals with more experience. No amount of book learning alone is adequate. Full competence in both interactional and contributory expertise requires social interactions with more experienced professionals.

While these three very different studies merely scratch the surface of what is needed to understand the costs and benefits of T-shaped professionals in organizations, nevertheless they provide converging evidence of the importance of this approach to conceptualizing expert performance in a domain. Each study makes clear that two primary dimensions of superior performance are complex communications (breadth) and problem solving (depth). These studies also make it clear that "the right" balance depends on environmental demands, the role and capabilities of technology, especially computer technology as augmentation for communications and problem solving [26], and the nature of social interactions between professionals with more or less experience.

Limitations and Critics

While advocates see more T-shaped professionals as urgently needed to improve performance in rapidly changing knowledge-intensive organizations and networks of organizations, the critics are not convinced. Perhaps the most damning criticism of the notion of "T-shaped" is simply that the notion adds nothing new. Critics are quick to point out that arguing for the importance of T-shaped people is like arguing for the importance of adults in society, or anyone with more experience. More experience is what is needed whether you call them T-shaped, I-shaped, or any shape. All experiences have the potential to contribute to the breadth (communication skills), depth (problem solving skills), or other dimensions of professional practice. Other critics point out that since a diversity of types of experience and skill profiles will always exist in organizations, the concept of T-shaped could easily be misused to isolate and demean workers who play important roles, but who are not T-shaped.

For example, Bill Buxton recently and eloquently argued that innovation calls for I-shaped people [27]. "T-shaped is highly desired, but not sufficient. In staffing up teams, interview and test for I-shapedness. I don't care how good someone is either at the pragmatic or abstract level, there is someone out there who is equally good and who has strength at both ends. Find that person. If you doubt such people exist, just look at the profile of a reasonable sample of Nobel Prize winners. What I suggest you will find —based on having done so myself—is that a very high number share these combined T and I attributes. ... the co-founder of IDEO, Bill Moggridge. He came up with the wonderful formulation of 'T-shaped people'. The vertical aspect of the T represents depth, and the horizontal bar is breadth. So a T-shaped person has basic literacy in a relatively broad domain of relevant knowledge along with real depth of competence in a much narrower domain." Buxton's point, and the point of many others, is that it takes many shapes, and hiring is a search for the best of that shape for your organization.

Stepping back, one quickly realizes these arguments are not so much against, T-shaped skills as they are arguments in favor of a diversity of shapes including T-shaped. What about alternatives to T-shaped people, that might improve organizational performance, adaptiveness, and be less costly to achieve?

For example, perhaps technology augmentation and a good knowledge base are better than human learning of knowledge that will be quickly out of date. It is hard for people to learn, but it is even harder for them to unlearn. Perhaps it is better not to internalize certain knowledge and rely instead on knowledge-based access to needed people and information. The trend toward a self-serve model of medicine is already well-established in certain areas, so as patients adopt self-service, they will become mini-models of the technology-enabled professionals.

Perhaps a more fundamental argument is that specialist and generalist are needed, but not T's because they are too costly. Dash-shaped people would serve the important communication role, and I-shaped people would serve the important problem solving role. This approach has the advantage that creating Dash-shaped and I-shaped people would be less costly than creating T-shaped people. However, what happens if the need for a particular type of I-shaped skill set goes away because of technological advances, or eradication of a disease or condition? Re-skilling T-shapes, because they already have some degree of interactional expertise in other areas, is likely to be both less costly and less demoralizing to individuals.

Applicability to Medicine
A time tested approach to the challenge of too much to know, and too little time to teach it, is specialization or more types of I-shaped people for each new knowledge silo. However, this solution evolved at a time when (1) change was slower, and specialization had value across a complete life span, and (2) information technology was relatively static across a complete human life span. Today, knowledge creation is not slowing down, but accelerating. The use of technology by professionals, and even by patients in a self-service mode, is increasing as well. The diversity of health care related organizations networked together is also expanding. Given these trends, can a case be made for benefits of T-shaped professionals as a focus for medical education and a standard with medical practice? We believe so.

First, it should not be surprising that the need for T-shaped people first arose in conjunction with computing professionals; the exponential rate of change in computing was given a name in the 1960's, and it is called Moore's Law. The trends associated with the growth of knowledge, technology, and organizations are not unique to computing or to medicine. IBM's Spohrer and Maglio [28] lay a foundation for service science and the study of service systems with their own version of a generalized Moore's Law of improvement. The traditional Moore's Law of computing is based on investing to create smaller and cheaper switches (e.g., transistors), but the generalized Moore's Law of service systems is based on investing to create more T-shaped people augmented or enabled by technology and organizations to create and harness the value of new knowledge better. Knowledge in the minds and hands of T-shaped people enables more value cocreation interactions with others.

Second, as the planet gets smarter - more instrumented (from sensors to smart phones for monitoring health), interconnected (local and global epidemiological patterns can be pooled), and intelligent (algorithms help recognize patterns and suggest appropriate individual and collective responses) - multiple strands of empirical evidence support the need for T-shaped people with deep problem solving skills in one area (not giving up the benefits of I-shaped people) and better complex communications skills across many areas. On a smarter planet, quality of life continuously improves because of improvements in service systems and quality of service. Stanford's James March wrote about systems that learn to survive in increasingly dynamic environments adjusting to favor more knowledge creation (exploration) over simply using existing knowledge (exploitation) [29]. In modern business, investment to continuously improve resource allocation choice is known as a Run-Transform-Innovate, where exploration can either be transformation (copy the innovation of others) or innovation (invent the innovation others may

copy). There is no reason why the same cannot be true in healthcare services.

Third, multidisciplinary teamwork is more and more prized, but to make teams work, better complex communication skills are needed across discipline silos; a strength of T-shaped people. Interdisciplinary programs, such as Professional Science Masters (PSM), Engineering Management, and others aim to create a greater integration of the study of science, engineering, and management; again the need for T-shaped people.

The trend towards T-shaped professionals is becoming increasingly clear, but the costs are also clear. T-shaped people are more costly to create, and traditional organizations (such as universities) have evolved to incent the creation of deeper and deeper I-shaped people, who are still very much needed. Recall the rise of T-shaped people does not mean the extinction of I-shaped people, only a change in the ratio for maximum performance in a changing world. Nevertheless, managing the cost is possible by harnessing advances in learning sciences, educational technologies, increasing gains to learning rates as people know more areas, lifelong learning, and even starting earlier with these ideas in primary education. These and other approaches suggest there is plenty of room for improving how much and how quickly people can learn, especially with better tools and organizational designs.

Educating more T-shaped people can improve the performance of multidisciplinary teams (which apply discipline knowledge) and interdisciplinary teams (which apply and create new knowledge), but it also sets the stage for true transdisciplinary thinking for the first time. Transdisciplinary thinking is perhaps as large a change (and investment) as when some countries decided that it was time for all citizens to have the right to a public education. Specialization has efficiency advantages (one person, one career), but for the society as a whole, a population with a general education is better prepared to adapt to change, and is given greater freedom of choice in careers. Freedom of career choice has real advantages for shaping a culture that aspires to limitless opportunities for all.

In sum, the folklore surrounding the early days of medical education can be summarized in the old adage: Watch one, do one, teach one. Today, the new model may be: research it, practice it, and teach it. From a service science perspective, this corresponds to innovate a system, run the system (to further validate), and then transform other systems. With more T-shaped professionals, medicine may very well better keep up with the challenges of more to know, and continue to expand the time available for lifelong learners to enjoy the benefits of greater knowledge.

Competing Interests

None identified.

Author Details

Nicholas Donofrio, IBM Fellow Emeritus

Jim Spohrer, IBM Global University Programs

Correspondence: spohrer@us.ibm.com

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