A FRAMEWORK FOR TRANSLATING KNOWLEDGE IN THREE STATES OF DISCOVERY, INVENTION & INNOVATION

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INTRODUCTION

Knowledge Translation is a process for moving research-based knowledge into stakeholder action [1]. The field of medicine needed an evidence-based process for reconciling and recommending research-based findings due to two conflicting trends: an accelerating volume of findings being published versus diminishing time available to health professionals to assimilate them. Health-related fields such as nursing and therapeutics soon recognized the same conflict.

At the same time, Federal programs sponsoring research projects were also facing two conflicting forces: academia's expectations that research findings contribute to the knowledge base independent of specific applications versus the public's expectations that science and technology are applied to solve societal problems [5]. Dr. Michael Gibbons [3] characterized this as a distinction between inquiry-driven basic science (Mode 1) and problem-oriented applied science (Mode 2).

The issues arising between Mode 1 and Mode 2 activities are familiar to technology-oriented fields such as rehabilitation engineering. Mode 1 knowledge provides an indispensible foundation for Mode 2 activities. The Mode 1 knowledge base is constructed through the traditional methods of scholarly inquiry reported in the public domain through peer-reviewed publications. Each contribution of new knowledge is available for the conceptual enlightenment of other scholars through the literature citation process. The inquiry-driven nature of Mode 1 science lends itself to the passive diffusion of knowledge from many sources in a variety of fields. Knowledge translation for such conceptual discoveries is now well described by the Knowledge to Action Model [4].

Mode 2, in contrast, is a deliberate and systematic effort to apply knowledge to a specific problem or need. For technology-based projects, this application of knowledge goes beyond research methods of science, to include the development methods of engineering. Mode 2 requires that the conceptual discoveries from research be reduced to some tangible form – a proof of concept called a prototype. Knowledge translation for tangible prototypes is not well described, as it typically falls between the boundaries of academic scholarship and industrial production.

If the resulting tangible prototype appears to offer value to improve an existing device or service, yet a third method called production is applied to create a market innovation. This may be considered a third mode of research activity (*Mode 3?*), since the production activity does not diminish the value of the original conceptual discovery The knowledge translation process for market innovations is well described in the industrial literature addressing new product introduction, marketing and sales. These are the means for moving production-based knowledge into stakeholder action -- the acquisition and use of the market innovation.

Three States of Knowledge arise from Three Different Methods

Knowledge translation literature that previously focused on knowledge from research methods, now recognizes that knowledge can be generated from other methods, that the knowledge outputs differ, and that the differences have implications for facilitating awareness, interest and use among stakeholders. Lane and Flagg [6] established that:

- Research methods generate knowledge in the state of conceptual discoveries;
- Development methods create knowledge in the state of tangible inventions;
- Production methods formulate knowledge in the state of market innovations;

Assistive technology devices and services depend on a solid foundation of biomedical science and engineering on the academic side, as well as active entrepreneurship and corporate health on the industry side. Government agencies funding projects intending to improve the state of practice, and investigators proposing projects intending to improve devices and services in the marketplace, both must commit to building a bridge between the academic and industrial sectors to ensure the original discovery is realized as a market innovation.

The bridge between academia and industry results from deliberate and sustained stewardship of a single kernel of knowledge as it progresses from discovery, through invention and out to innovation. The transition from discovery to innovation may involve multiple actors and organizations, as well as changes in ownership and priorities over time. Good stewardship of the knowledge – and any realistic hope of completing the transition, requires all participants to know the roles and responsibilities of themselves and all of the others. Otherwise, the value of the knowledge, and indeed the purpose for the investment of time and resources, be lost through improper action or neglect.

The Need to Knowledge (NtK) Model

Mode 1 research is appropriately conducted independent of application. Like a message in a bottle, the resulting discoveries are floated upon the sea of knowledge, to be found, read and cited as other scholars see fit. In contrast, Mode 2 research is conducted within the context of some intended application, and technology-oriented Mode 2 research necessarily includes development methods to create a proof of the concept in prototype form.

For that set of Federally-funded projects intending to generate technology-based innovations, and do so to contribute to the economy or to solve some societal problem, the methods of production are added at the back end to realize the innovation in the form of a device or service accessible to the marketplace. To make sound logical sense, all of the associated investment of time, money, expertise and labor, must be oriented to meeting a validated need. The authors created the Need to Knowledge Model to integrate the three different methods into one process visible to all the various actors and organizations [6].

The Need to Knowledge Model (NtK Model) reflects the advice of William Covey to “begin with the end in mind.” That is, Federally funded projects intending to result in technology-based innovations for the marketplace, need to begin with a need and then propose a viable solution to meet that need. Starting the process with a defined need does not obviate the need for Mode 1 research. Curing cancer is a need, and that

need may require additional basic knowledge in biology, chemistry or even quantum physics. However, a cure in the form of a conceptual discovery will still require additional outputs. These include development outputs such as treatment molecules or delivery systems within the knowledge state of inventions. These, in turn, will be designed for mass manufacture, distribution and support through production outputs deemed to be innovations.

The problems and solutions addressed by Federal agencies through technology-based innovations are diverse in detail. Yet a process can be readily described that links technology-based discoveries, inventions and innovations. The NtK Model presents a stage-gate model involving nine stages, each containing multiple steps. The overall model, the stages and their steps are each supported by nearly one thousand quotations excerpted from approximately three hundred peer-reviewed articles drawn from both academic and industry sources. Figure 1 shows the general outline of the NtK Model:

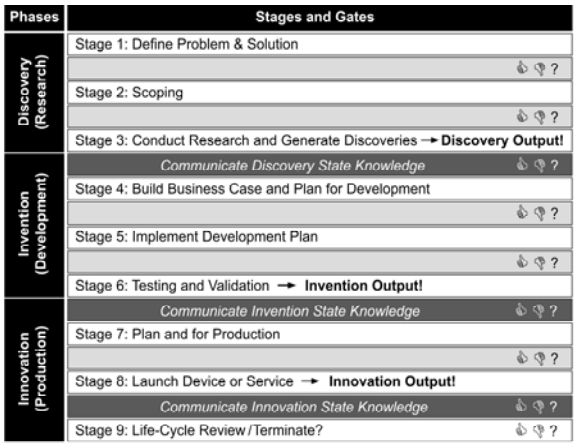

Figure 1. The NTK Model

The NtK Model is designed as a general roadmap and as an operational framework. As with any process model, participants have the option to modify, such as changing the sequence or running concurrent activities; even reiterating or skipping specific steps. The important point is to ensure that all participants understand the full process, and know their respective roles for accomplishing immediate outputs.

For example, scientists are trained to generate new knowledge which is valid and reliable, and to assess the quality of existing knowledge. Both skill sets may be required by a project as it attempts to formulate a technology-based solution to a societal problem. Their findings must then be transformed into tangible devices (hardware or software) by those skilled in engineering to assess their feasibility for operation under expected constraints. The culmination of the scientific research and engineering development should be something ready for hand-off to the production partner – likely an entrepreneur or established corporation. An awareness of the entire process helps each participant complete their portion within the capabilities of their planned partners. This increases the likelihood of continued progress toward their collective goal.

Equally important is learning what the downstream stakeholders need to accomplish their portions of the process, and presenting it in a form they recognize as having value to them. This is at the heart of applying knowledge translation to technology-based projects. Cohen & Levinthal [2] coined the term absorptive capacity to emphasize the core requirement for the recipient stakeholders to have the expertise and infrastructure in order to successfully adapt and adopt any new technology-based knowledge.

The entire NtK Model is predicated on a complementary requirement for ensuring the "absorption capability" of technology-based knowledge. That is, good stewardship requires the originating stakeholder to ensure that the new knowledge is presented in a form, content and status recognizable as valuable to recipients otherwise qualified to receive it.

CONCLUSION

The existing Mode 1 and Mode 2 models of research, are not appropriate for the highly integrated mix methods approach to achieving technology-based innovations. The Need to Knowledge Model is an evidence-based framework useful to sponsors and grantees alike who intend for their projects to result in innovations beneficial to society.

The NtK Model maps the process, but the actual exchange between knowledge creators and users depends on their collective commitment to achieve the intended results. The interplay of the sender's absorption capability and the recipient's absorptive capacity is the crux for any technology-based knowledge to cross disciplines, sectors and value systems.

For those interested in causing technology-based innovations to reach the marketplace to benefit society, the NtK Model, including all of the supporting citations and related materials, is freely available at the following website: ***http://kt4tt.buffalo.edu/knowledgebase/model.php***

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