Optimizing Technology Development and Adoption in Medical Imaging Using the Principles of Innovation Diffusion, Part II: Practical Applications

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Abstract Successful adoption of new technology development can be accentuated by learning and applying the scientific principles of innovation diffusion. This is of particular importance to areas within the medical imaging practice which have lagged in innovation; perhaps, the most notable of which is reporting which has remained relatively stagnant for over a century. While the theoretical advantages of structured reporting have been well documented throughout the medical imaging community, adoption to date has been tepid and largely relegated to the academic and breast imaging communities. Widespread adoption will likely require an alternative approach to innovation, which addresses the heterogeneity and diversity of the practicing radiologist community along with the ever-changing expectations in service delivery. The challenges and strategies for reporting innovation and adoption are discussed, with the goal of adapting and customizing new technology to the preferences and needs of individual end-users.

Keywords Innovation adoption · Structured reporting · Medical imaging

Introduction

One of the frequently heard comments from medical imaging professionals is that industry does not innovate according to the needs of the rank-and-file end-users. Most technology producers seek out the clinical input of medical

advisory boards, which are customarily composed of academics whose clinical and technology experience is far different than that of their community counterparts. As a result, the advice offered does not necessarily reflect the everyday issues experienced by “front-line” medical imaging professionals who are not always using state of the art technology, do not always have the luxury of sub-specialist training, and must accommodate to diverse clinician and patient populations.

In order for an invention to be successful in clinical practice, the diversity of end-users must be carefully considered, with the goal of technology adaptability and customization. In the medical imaging community, this diversity can be defined on the basis of a number of variables including differences in occupation, personality, computer proclivity, education and training, institutional demographics and culture, patient populations served, and technology in use. Even within a single medical imaging department, the needs and preferences of practicing radiologists or technologists can be quite striking, which in turn creates great challenges for new technology development and successful adoption.

Defining End-user Diversity

The scientific principles of innovation adoption should always be considered during the invention and development process [1]. The heterogeneous community of end-users is traditionally divided into five adoption groups which can in turn be lumped into three groups for practical purposes. These three groups consist of the following:

1. Early adopters (a combination of innovators and early adopters)
2. Majority users (a combination of early and late majority end-users)

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3. Traditionalists (often referred to as laggards)

The early adopter group will typically embrace new technology and innovation more readily than their colleagues and are more risk tolerant and accepting of change. They tend to be adventuresome when it comes to new technology and often in search of the next new gadget or clinical breakthrough. Inventors who target this group will often get a receptive audience who are often willing to sacrifice short-term workflow challenges for what they perceive as longer term gains in quality and/or productivity. The problem however, is placing too much practical emphasis on this group, because they are in the numerical minority and may not be the principle institutional decision makers. While their perspective and influence is critical in successful innovation adoption, they must be considered as a part (and not whole) of a successful innovation strategy.

The majority group is far superior in number to the other groups and represents what is typically thought of as the proverbial mainstream of end-users. This group takes a “middle-of-the-road” approach to innovation, with a combination of practical skepticism and enthusiasm. The critical determinants in new technology adoption for this group are often predicated upon substantiated benefits, which can be directly observed and quantified, through everyday use. They are less enamored with theoretical benefits than their early adopter counterparts, and rely more on practical experience and the opinions of their mainstream colleagues. Their perspective tends to be balanced and they can be won over by demonstrating objective and reproducible improvements, in comparison to the preceding technology being replaced or improved upon.

The Traditionalist Group tends to be older in age, skeptical of change, and reliant upon maintenance of the status quo. They will often focus upon past mistakes associated with historical attempts at innovation, and view themselves as the “voice of reason”. They often require significant amounts of time and hand holding before attempting to adopt innovation, and do so with trepidation and even perhaps cynicism. A successful innovation strategy must carefully take their concerns into account and provide an alternative innovation adoption pathway; which can take the form of time delays, increased education and training, or an incremental (i.e., phased-in) adoption strategy. If this group can be convinced of the merits of innovation, they can serve as important advocates and ease the path for future innovation. If, however, they are ignored or pressured into adoption, they can serve as the proverbial “thorn in the side” and risk long-term dissatisfaction and disaffection, which can spread throughout the ranks of the department and institution.

Creating a Strategic Vision

With these often contradictory challenges to technology innovation, how can successful adoption take place? The answer lies in the strategic vision, identification of challenges, and a multi-track implementation strategy.

The strategic vision must identify a real-world deficiency in existing technology, workflow, and/or quality deliverables. The degree to which the proposed innovation can demonstrate objective and reproducible gains will play a critical role in adoption success; providing these gains can be realized throughout the heterogeneous population of end-users. Satisfying a particular sub-group will not translate into widespread appeal, and therefore the unique inter-group differences must be taken into account in order to demonstrate across the board gains for all end-users.

Challenges can take a number of forms including technical, psychological, clinical, and economic. In theory, the optimal innovation will address all of these challenges in some form or another. One must keep in mind that the population of end-users will perceive these challenges in different ways; depending upon their own unique practice environment. A successful innovation must be versatile enough to “sell itself” in accordance with the unique attributes and challenges of each individual end-user and institution.

A multi-track innovation strategy provides for temporal and clinical differentiation in innovation adoption. An early adopter who accepts and welcomes the innovation from the start may want to immediately implement the technology into everyday workflow without delay. A majority end-user may want to gradually or partially implement the innovation into workflow, until he/she reaches a pre-determined comfort level, at which time they will completely transition to the new technology. The traditionalist will in all likelihood want to maintain existing workflow for a period of time with the minimal amount of change, waiting to observe the results of their colleagues before beginning the transition, which should (in their opinion) be slow, methodical, and reversible. If the invention has the ability to provide multiple parallel adoption tracks, the likelihood of acceptance will be greater and provide for each individual end-user to transition at their own rate and comfort.

Application to Structured Reporting

In order to illustrate these innovation principles, we will look at a relevant example, in the form of radiology reporting. First, we will define the strategic vision, which consists of standardizing radiology report data for the purposes of reducing ambiguity and creating referenceable

databases [2, 3]. Next we will identify the challenges; which are numerous and often specific to individual end-users. From a psychological perspective, we are asking the radiologist community to make substantive change in something they have done their entire working careers; while creating a reporting product which will potentially provide a mechanism for performance assessment (which can in theory be used to criticize their work) [4]. From a clinical perspective, we will be asking the radiologist community to convert their existing verbiage into a standardized lexicon, which will constrain input options and force radiologists to re-learn acceptable terminologies [4]. From a workflow perspective, we are asking radiologists to make substantive changes in reporting workflow, which could adversely affect productivity and resulting economics [4]. In doing so, we run the risk that end-users may attempt to compensate for reduced workflow by “cutting corners”, which could potentially lead to errors and deficient quality. Lastly, we should create a multi-track implementation strategy which allows individual end-users to adopt the new technology in a manner of their choosing; with the goal of eventually leading all end-users to a common platform and output [5].

Here is one innovation strategy to illustrate how these principles can be converted into reality. In order to convert the existing free-text reporting model into structured or standardized reporting, we will define the lexicon (i.e., acceptable terminology) for all reporting output. Rather than force all radiologists to convert from their existing comfort zones to a rigid lexicon, we will provide an option for radiologists to input report data in their present form. The input report data will in turn undergo transition to a standardized nomenclature by utilizing a reporting ontology to map input report data to the defined standardized report data. When the ontology identifies the match between the non-standardized input and standardized output data, the radiologist is presented with the derived standardized data match and offered to accept or reject the match. If the match is rejected, an alternative “next-best” match is presented. As the new technology is being used, the radiologist learns the “accepted” terminology and begins to utilize this input data, thereby streamlining the conversion process and improving workflow.

An alternative input strategy could consist of a series of graphical annotations and symbols which can be directly applied to the imaging dataset, which is in turn mapped to the standardized lexicon using handwriting recognition software [6]. In this option, the reporting output consists of two options, a standardized report and the annotated image dataset (in which the corresponding standardized text would be presented to the reader when activating a given annotation).

In order to improve workflow (and productivity), a number of customizable reporting options can be utilized.

One option would be the ability to “auto-populate” prior report findings onto the current report, which in effect allows the current report to be edited, as opposed to created from scratch [7]. The end-user could select when this auto-population feature would be used (e.g., based upon imaging modality, exam type, and clinical indication) and in what manner the auto-population and editing would be performed (e.g., standardized text or graphical annotations). A practical example of when the auto-population of graphical annotations and/or text would be workflow enhancing would consist of repetitive imaging exams which often share common findings, such as a screening mammogram or ICU chest radiograph.

Realizing that such a dramatic change in clinical practice would induce a great deal of angst on the part of the radiologist community; the innovation strategy should provide multiple, parallel implementation pathways. At one end of the spectrum is the “traditionalist” path, which provides for the radiologist to continue reporting in their traditional manner. The dictated free-text report would then undergo conversion to standardized report data using natural language processing along with a reporting ontology. This conversion could take place “after the fact” and out of the direct view of the radiologist, so that it becomes transparent and inconsequential to workflow. The completed “mapped” report would later be presented to the radiologist at the time of final signature, with the final “mapping” available for their review. This would be akin to a Word document displaying the final version, with and without markup. As the radiologist becomes more comfortable with the new reporting technology, they can begin to transition (in part or whole) to an alternative pathway.

The intermediate adoption pathway (designed for majority users) would consist of a hybrid approach, where the end-user can migrate between “traditional” and “novel” reporting strategies. Using the hybrid approach, the radiologist could input data in their customary fashion, but request the computer to provide real-time feedback as to standardized text mapping, once reporting input has been completed. While this function might have a detrimental impact to workflow, it would provide critical education and feedback relevant to the conversion process. At any time, the radiologist could elect to shift to an alternative mode of operation; thereby providing workflow flexibility.

The “early adopter” pathway could consist of a more robust transitional approach, in which the end-user elects to exclusively use standardized input data during report creation. As the radiologist inputs the report concept of his/her choosing (e.g., pathologic finding and follow-up recommendations), the computer provides an immediate prompt which provides them with the available standardized reporting options (in both text and graphical formats). The radiologist would then select the corresponding standardized data which

would then become automatically incorporated into the standardized report. By utilizing this option, all report data input would be standardized and require no downstream modification or time delays in report finalization.

The end result of such a strategy is to provide a customizable and flexible strategy to innovation; accommodating to the unique needs, skills, and preferences of individual end-users. While the final reporting product would be the same, the implementation strategy would differ, with the hopes of improving the overall success of innovation adoption.

Conclusions

Innovation adoption in medicine is often determined by the “weakest link” in the adopting community, which has been referred to as traditionalists (or laggards) when applying the scientific principles of Ryan and Gross. The large diversity in the medical imaging community creates challenges for new technology producers and may in part explain why certain innovations, such as structured reporting have not gained widespread acceptance. One approach to address this end-user diversity challenge is a multi-track innovation strategy, which provides alternative adoption pathways based upon the needs and preferences of end-users, eventually leading to a single-workflow platform. In the

end, success or failure of innovation in medicine will be largely predicated upon technology producers’ ability to accommodate to the competing demands and diversity of end-users. This can arguably only be accomplished by creating adaptable and customizable technology, which ultimately leads to demonstrable gains in quality, workflow, and economics.

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