

Scientific Communication in Medical Education: Modeling the Adoption Rate in Multiple Peer Networks

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Abstract. The continuous advances in medical education and biomedical research requires that researchers, educators, and practitioners monitoring the development of new procedures, protocols, and products in a wide variety of specialties. New information gathering behaviors have come to supplement traditional forms of learning within these communities. In the present study, we examine the innovation diffusion process for a surgical instrument book. We examined the diffusion process in three kinds of innovation networks: a social networking and news website (Reddit), academic conferences, and formal training activities within an academic institution. Despite being freely accessible online, we observed geographic differences in adoption rate suggesting different approaches to information gathering in medical education communities. Moreover, we also observed that the highest download frequency were associated with the presentation of materials on social networking sites in comparison to traditional sources (i.e., presentations during academic conferences and institutional educational activities).

Keywords: Medical Education, Information Diffusion, Social Network Analysis

1 Introduction

1.1 Diffusion Models

Health care professionals must continue to enhance their skills, adopt new procedures, and technology. Researchers, educators, and practitioners must also evaluate the extent to which potential innovation can impact practice as well as their integration into the medical education curriculum. Consequently, the innovation process remains a central concern. Innovation has been variously defined as the creation, modification, and diffusion of an idea, procedure, or instrument throughout social networks (e.g., Hughes, 1985). The dissemination of information within and between social networks in the health care professions is of critical importance in making available new approaches to implement and change practice (Consoli & Mina, 2008).

In the present study, we examine the innovation diffusion process within potentially distinct medical education communities (e.g., Wallace, 1997). We present a quantitative analysis of the innovation diffusion process resulting from public presentations of a surgical instrument eBook in formal (i.e., conferences, educational activities) and informal academic networks (i.e., a

social networking and news website, Reddit). We additionally examined adoption behaviour within geographic regions in order to identify potential similarities and differences in medical education communities.

1.2 Social Networks and the Diffusion Process in Medicine

Social networks are groups of individuals that exchange information, share resources, collaborate, as well as monitor and regulate each other's behavior. Rather than acting in a single social network, individuals are embedded within multiple social networks. The multiple roles and competencies require of health care professionals (e.g., practitioner, researchers, and educators) reflect the need to balance the demands of potentially non-overlapping social networks. Social networks can be formal highly organized institutions (e.g., companies, universities, or professional societies) or informal aggregates of individuals who are not organized into a formal organization (e.g., subscribers of a newsletter, patients, students). The extent to which an idea becomes widely adopted (i.e., an innovation) requires an understanding of the properties and dynamics of social networks.

Dynamics of Social Networks. Social networks are affected by a number of social and cognitive factors related to general features of social life and individual differences in how information is gathered and processed. Social contagion is observed when individuals within a social network adopt a behavior, convention, or concept due to their observations of, or referrals by, other individuals. Social contagion can be the result of normative pressure to conform to the behavior of others or information transfer concerning costs and benefits (e.g., Van Bulte & Lilien, 2001). Actors within a social network also differ in terms of their sociality, the number of connections within a social network (i.e., their centrality), their formal status within a social network, and the extent to which they are connected to other social networks (e.g., weak ties). These factors will determine how widely the innovation is distributed and the extent to which it is adopted.

One process that influences social contagion is word-of-mouth (WOM) wherein individuals refer others to potential innovations (Coleman et al., 1966; Van den Bulte & Lilien, 2001; Stephen & Lehmann, 2009). WOM is an important feature of online communities. Supporting this, there is some evidence that WOM (the number of book reviews) is an important determinant of book sales (Chevalier & Mayzlin, 2006). Studies of innovation must distinguish these efforts from other factors that influence the diffusion process such as marketing (e.g., Van Bulte & Lilien, 2001), including marketing. Indeed, there is some evidence that more informal approaches such as WOM can be more effective at increasing adoption rate than other sources (Trusov, Bucklin, & Pauwels, 2009). For instance, Trusov et al. revealed the WOM referrals were the greatest determinant of signing up on a social network site, relative to media appearances or marketing events. Thus, we sought to consider the impact of social contagion on the innovation process in medical education.

2.0 Diffusion of Innovations within the Health Care Professions.

There are a number of precedences for the study of the innovation process in medical education within medical innovation studies (e.g., Van den Bulte, & Lilien, 2001; Valente, 1996; Wallace, 1997). For instance, Coleman, Katz, and Menzel (1966) examined diffusion of the drug tetracycline within social networks of 125 physicians in four Mid-Western American communities (for a re-analysis of these data, see Van den Bulte, & Lilien, 2001). However, it is an open question whether similar factors affect adoption rate in contemporary medical education communities.

While accrediting councils such as Accreditation Council for Graduate Medical Education in the United States and the Royal College of Physicians and Surgeons in Canada designate universities as the primary source for medical knowledge, both formal and informal networks influence physicians' decisions. Formal channels such as academic conferences and journals provide venues wherein researchers present new medicines, treatment protocols, and educational interventions. Indeed, practitioners are required to engage in such continuing professional development activities (also referred to as continuing medical education). Medical students and physicians have also come to rely on alternative sources of information such as the Internet (e.g., Baker et al., 2002; Bennett et al., 2004). In an analogous way to early studies of innovation diffusion (e.g., Caplow & Raymond, 1954), these new sources of information will also likely exert a considerable influence on physicians' information gathering behavior. For instance, social networking sites wherein medical students come to share information might be seen as a credible source of information (e.g., peers are providing social proof). Thus, an examination of traditional and new methods for the dissemination of information is necessary.

3.0 Present Study

The present study examined adoption behavior within the medical education social network. Rather than a well-publicized innovation promoted by experts, we consider an eBook describing properties and uses of surgical instruments as we feel that it reflects a [typical] product of the medical education community. While we assume that the effects of marketing and social contagion cannot be entirely separated, we can examine adoption behavior during and following the release of the eBook (via iTunes) within an online community (Reddit) as well as its presentation at academic conferences and educational activities within the university setting. We additionally considered adoption rates within specific regions in order to examine whether there were differences in adoption behavior between medical education communities.

3.1 Methods

Download frequencies were obtained for each day following the release of the eBook online through iTunes.com (April 1, 2014) for a period of 8 months (ending November 28, 2014). This allowed for the identification of geographic social networks.

3.2 Results and Discussion

User downloads were first divided into geographic regions in North America (Canada, United States), Latin America (incl. Mexico and the Caribbean), Europe, and Asia/Pacific. We obtained the proportion of downloads accounted for by each data, and created a cumulative distribution function for each geographic region. We conducted linear and sigmoid ($f = a/(1 + \exp(-(x-x_0)/b))$) curved-fitting analyses to examine the nature of this adoption behaviour using SigmaPlot and a maximum of 200 iterations to produce the model fit. The resulting functions (see Figure 1) suggest that adoption rates differed within each of the geographic regions, with Canada and the United States have the highest adoption rate. As Table 1 indicates, a logistic function (3-parameter sigmoid) generally provided a marginally better fit for all adoption functions. A number of patterns are evidenced evidencing regional differences. Adoption behaviour in Canada and the United States appear highly similar, as did the adoption behaviour of Australia and Asia/Pacific, and the United Kingdom and Europe.

Table 1. Correlation coefficients for linear (Lin.) and sigmoid (Sig.) functions. Global pattern reflects the average of all functions.

Model	Region							Global
	Canada	United States	United Kingdom	Australia	Latin/Carib.	Europe	Asia/Pacific	
Lin.	0.98	0.98	0.96	0.98	0.88	0.98	0.99	0.99
Sig.	0.99	0.98	0.97	0.97	0.94	0.99	0.98	0.98

In order to determine whether the differences in region were significant, we conducted a one-way analysis of variance (ANOVA) with the average proportion of adoption for each 10-day interval. This revealed significant differences for each region, $F(6,168) = 3.30$ $MSE = .068$, $p = .004$. Thus, despite the availability of the material online within each of these regions, adopters' location was still an important determinant of adoptions. Bonferroni *post-hoc* comparisons were conducted to examine the significance of regional differences. Most comparisons did not reach significance, suggesting that adoption patterns were quite similar. However, adoption rates in Latin America/Caribbean were significantly different from those in Canada ($p = .005$) and the United States ($p = .023$) and were marginally different from those in Australia ($p = .182$).

To analyze the effect of an event (e.g., presentation, social media posting) on download behavior, we included the date of the event (i.e., t_1) as well as the following day (i.e., t_2) and obtained an average. In the case of multi-day events (e.g., training programs), we obtained an average for the first two days of the event wherein the eBook was introduced.

Table 2. Number of downloads following communication activities.

	Social Network Activity			
	News Forum	Professional Conference	Educational	Null
Mean (Download)	35.00	14.5	5.15	2.67

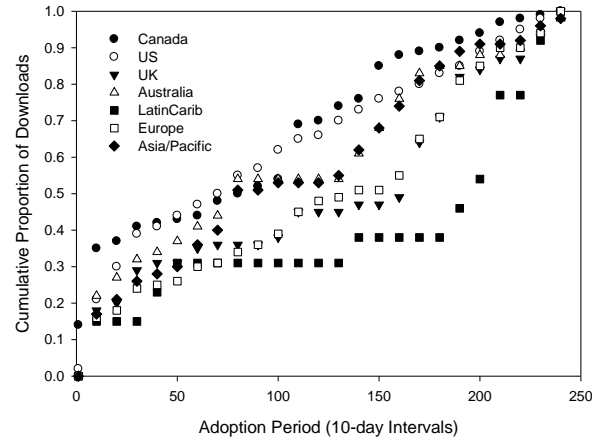


Figure 1. Cumulative proportion of downloads within geographically distributed social networks.

We selected dates whereupon collaborators on the eBook 1) posted the eBook on iTunes and Reddit ($n = 2$), 2) presented the eBook at conferences ($n = 2$), and 3) during instructional activity ($n = 10$). We additionally compared these activities to intermediate periods where no [promotion] occurred, i.e., 4) Null. The only criterion for the selection of the dates for null activity was that they did not occur during one of the three activity types. Six random dates were selected for comparison. Thus, the null category provides a measure of social contagion without explicit promotion. The results are presented in Table 2. An ANOVA revealed a significant differences between these activities, $F(3,16) = 5.60$, $MSE = 106.59$, $p = .008$. Bonferroni *post-hoc* comparison revealed that news forum posts were significantly different from null events ($p = .009$) and educational activities ($p = .011$) suggesting that promotion on the forum was more effective at increasing downloads than a comparatively passive social contagion process.

3.0 Conclusions

Our examination of download behaviour has some important implications for dissemination of information in medical education. First, we observed significant differences in the nature of downloading between geographic regions. This is especially interesting given that the eBook was potentially accessible to anyone regardless of geographic location. With the notable exception of Latin America/Caribbean, download patterns were similar between many regions, especially those that were adjacent (e.g., Canada-United States; UK-Europe; Australia-Asia/Pacific). Thus, these differences might reflect communications patterns between medical education communities within these regions facilitated by regional activities (e.g., conferences).

A second observation of the present study has important implications for the dynamics of medical education social networks. Specifically, we found that the greatest number of downloads co-occurred with posting of the information on an online news forum (Reddit).

While the first instance coincided with the release of the eBook on iTunes, a posting to a different forum on the same website yielded a similar increase in download behaviour. While mean download rate during formal conference presentation appeared greater than educational activities and periods wherein there was no promotional activity, this difference was not statistically significant. Thus, traditional methods for dissemination were associated with fewer downloads. We should also note that in the case of educational activities, these social networks were defined by fewer individuals (e.g., attendance of conference sessions and education activities might be defined by 10-40 potential adopters). Thus, it is less clear whether the proportion of adopters differs.

4.0 References

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