Value-Mapping IT Platform Options in Global Health: A Multi-Year Case of Code Rot versus the Event-Driven Outbreak Economy

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Abstract
This multi-year action research case study examines a global public health organization’s efforts at innovation enabled by investments into an open source online IT platform. The case illustrates a core managerial challenge of balancing the tension between on-going maintenance and event-driven investments in an organization with few technology human resources internally. Using Fichman’s (2004) framework for assessing real options of IT platform assessments, we identify the specific sources of value from such an investment in this organization, drawing out research and practice implications.

1. Introduction

Recently, there has been a call for increased action research in the overlapping domains of information systems and global health due to the importance, complexity and difficulty of making advances there [1]. This paper reports on a multi-year action research case focused on advancing global epidemiological training and response capabilities facilitated in part by an implementation of an open source IT platform. The host organization at the center of this case is a program within a leading global non-governmental organization (NGO) supported by the US Centers for Disease Control and Prevention (CDC) as well as the World Health Organization (WHO) and more than 60 other governmental bodies around the world (mostly Ministries of Health) (budget ~$1.5B/yr.). The target community of participants in the NGO and its activities exceeds 8,000 medical professionals, mostly epidemiologists and epidemiologists in training, distributed around the world in more than 84 countries.

The project began in 2007. It began because organizations involved had experienced several notable setbacks in deploying technology prior to that, and innovation had stalled. The following sections present the case and activities over time, preceding from the IT platform shift and usage results to innovations attempted on that new platform. Next, we introduce the maintenance challenges and ‘code rot’ pressures that began to hinder further development, leading to partial abandonment of the platform in a major project. Then, we illustrate how the platform’s usage during the recent Ebola outbreak actually addressed an on-going challenge in public health management between balancing on-going investment with specialized event investments during outbreaks. Finally, we discuss the results of the case in terms of Real Options theory on IT platform adoption, concluding with some future research needs and specific recommendations for improving IT investment effectiveness in public health organizational contexts.

2. Background

Perhaps two of the most important and common phrases associated with the term “public health” are “outbreak” and “surveillance”. Unfortunately, they imply opposite requirements in terms of investment and structure, causing a dilemma. The tension is between on-going investment and vigilance versus episodic interest and funding. We explore it and trace it in relation to IT investments in this study.

To begin, consider a quote from the Executive Director of the Association of State and Territorial Health Officials (ASTHO) in the USA concerning the need for a sustained commitment to public health:

“States and territories have made significant progress in pandemic planning, as evidenced by our effective response to the ongoing novel H1N1 epidemic... During the last three weeks, the CDC, ASTHO, state, territorial, and local public health departments have stood up their emergency operations centers to coordinate planning and response issues and share practices among states for the benefit and use of every agency. But we cannot sustain this response without further resources.”[2]

In this statement, we can see a typical example of how public health must react to emerging circumstances by collaborating across organizational and geographic boundaries in unexpected ways on short notice. We also see that capacities for response may need to be developed and deployed specifically for a given outbreak as in the “emergency operations centers” referenced here. Later, he explains that on-
going vaccination and health maintenance activities of public health centers are already underfunded by 30-60% while outbreak-type activities often draw large portions of time and resources. Toward the end he goes on to state that a top priority for investment should be in disease surveillance - both in training more epidemiologists and in deploying effective systems for reporting and sharing information about outbreaks.

Sharing information by connecting people across organizations and geographical boundaries at low cost are central opportunities in the Internet age. So, there seems to be a large fit for information systems in creating the innovative agility needed in balancing between more efficient daily operations reaching more clients and epidemic outbreak responses redirecting toward targeted populations. Supporting this notion, in the information systems field, we identify agility as a key capability reachable through investments in IT [3]. Much like the episodes of outbreak response punctuating on-going public health operations, we see a similar pattern in the ways organizations tend to acquire and adapt information technologies [4].

In the case of public health, where services are already overburdened and few employees are trained in technology and systems innovation, we can especially expect that on-going IT investment and innovation will be low with occasional projects aimed at making major upgrades. Indeed, the preceding citation from ASTHO points to this problem. Money flooded into temporary capacity development for the H1N1 response but failed to build adequate long-term, durable capacities needed for more effective systematic disease surveillance and outbreak responses.

The H1N1 experience in the USA in 2009 is typical of the public health situation experienced in countries around the world. Outbreaks often require extraordinary capacities and resources not already allocated, and the on-going activities required for surveillance and health maintenance are often substantially underfunded.

Given this situation, a group of visionary epidemiologists from the US CDC, WHO, and several other governmental health organizations around the world founded an NGO named TEPHINET (Training Programs in Epidemiology and Health Interventions Network) in 1997 to help solve some of these problems. The central exploration in this case is how they have developed, deployed, and managed innovative information technologies to advance their agenda. Our core method is action research. Action research offers a powerful lens for improving complex organizational problem solving, particularly for understanding developing a client-system infrastructure [5]. Action research follows five steps: diagnosing, action-planning, action-taking, evaluating, and specifying learning. These roughly show in the timeline of the project. While the steps were followed strictly, the presentation of this paper follows more of a narrative structure.

Table 1 provides a timeline of major milestones in the case with indications of community activities and major effects observed in relation to the IT innovations implemented. Prior to the case, there had been three rounds major systems investments aimed at building a useful, online community space (2001, 2004, 2007). Unfortunately, none of these gained traction in the community. This project resulted. The core research question was how to create and sustain an effective online infrastructure to meet both the on-going training and other needs as well as the unexpected and episodic response needs.

<table>
<thead>
<tr>
<th>Year</th>
<th>IT Innovation</th>
<th>Community Activity and Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>Initial Web site</td>
<td>Informational site created</td>
</tr>
<tr>
<td>2001</td>
<td>Second Web site</td>
<td>Still informational only; few visitors; no data on visits</td>
</tr>
<tr>
<td>2004</td>
<td>First dynamic members site created using PHP language</td>
<td>Main site sees very few visits. Board members exchange reports and minutes in secure online space. Updated in 2007.</td>
</tr>
<tr>
<td>2008</td>
<td>First major online workflow</td>
<td>TEPHITRACT sub-site created, used to support conference paper submissions process</td>
</tr>
<tr>
<td>2010</td>
<td>Second dynamic members site created using Drupal platform</td>
<td>Updates to site became more frequent, members had access to outbreaks library and directory; increased usage</td>
</tr>
<tr>
<td>2011</td>
<td>Knowledge portal project; Learning portal project; Minigrants system project; Accreditation project webpage and external system</td>
<td>Some events hosted and attended virtually via the Website; mini-grants process begins to run through website; newsletter and additional content features draw in more usage; global home for FETP program accreditation created</td>
</tr>
<tr>
<td>2013</td>
<td>Epicore project</td>
<td>Services-oriented consortium project started to integrate new surveillance system into online system</td>
</tr>
<tr>
<td>2014</td>
<td>Ebola outbreak</td>
<td>Knowledge portal used in Ebola outbreak</td>
</tr>
</tbody>
</table>

Table 1 Timeline of Major Milestones

In diagnosing the initial problem, we could see that there was very little usage of prior systems. Content
was difficult to update, and had to be done through a vendor. The proprietary, homegrown codebase could not be edited or managed by a third party other than the hosting vendor, resulting in a clear vendor lock-in problem. Meanwhile, international accessibility and cross-browser compatibility were also problems. These all resulted in poor usage. Additionally, there was very little sustained funding for web development. Funding had arrived in the past in unpredictable allotments, leading to recognition of a need for a very low cost platform with a large community around it to help support and innovate it at low cost.

Table 2 provides estimated tracking of numbers of page views per month (gathered using Google Analytics; for the main www site only) along with numbers of registered users averaged across the year. The 2015 registered users count is an exact count as of May 19, 2015.

<table>
<thead>
<tr>
<th>Year</th>
<th>Views/Month</th>
<th>Registered Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-2010</td>
<td>110</td>
<td>24</td>
</tr>
<tr>
<td>2010</td>
<td>2,400</td>
<td>1,100</td>
</tr>
<tr>
<td>2011</td>
<td>3,800</td>
<td>3,000</td>
</tr>
<tr>
<td>2012</td>
<td>4,900</td>
<td>3,300</td>
</tr>
<tr>
<td>2013</td>
<td>5,500</td>
<td>3,800</td>
</tr>
<tr>
<td>2014</td>
<td>8,200</td>
<td>7,000</td>
</tr>
<tr>
<td>2015</td>
<td>8,000</td>
<td>9,136</td>
</tr>
</tbody>
</table>

Table 2: Timeline of Usage and User Growth

By 2015 the main Web site had visitors staying for 3.25 minutes per session with 2,066 unique viewers per month. Of these 53% were returning visitors. And the total page views per month capped out at about 8,000, down about 200 per month from the average in 2014. Of these views, 70% were in English with Spanish and Portuguese accounting for an additional 20% of the requests. Between 2008 and 2014, the number of users of the Internet increased globally by 53% [6]. From the point of time when the new dynamic Web systems became fully operational at TEPHINET in 2010 to 2014, the increase in usage (+533%) and registered users (+1,750%) far outpaced the growth of the Internet in general. We interpret this difference as one indication that the projects at TEPHINET had value-adding success beyond organic growth that would have happened on its own without the action research interventions applied in this project.

In the following sections, we will follow basic guidelines for presenting action research by examining what was done as this growth occurred, key issues that emerged in managing and maintaining the IS investments, and results from the various actions taken.

3. Diagnosis of Initial Situation

From the start, TEPHINET had the concept that they were building the international community of practice for field epidemiologists and epidemiologists in training. Due to the international nature of the network and the low budgets in public health, constant travel and face-to-face interaction was never an option. TEPHINET was born in the Internet age, and the expectation was that interaction online could provide a large support for the community, particularly between scientific conferences. Thus, the early efforts at site building in 1998 and 2001 were followed in 2004 by a round of investment to build interactive member space online, a walled garden, where reports and a member directory could be shared privately. These efforts in large degree followed basic advice at the time on how to cultivate an effective community of practice (CoP) [7].

By 2007, several technical problems had become apparent. The site would often go down, and the technical contractor would take a week or more to reset the server only after being prompted by TEPHINET staff. Advice on building CoPs failed to mention that vendor lock-in regarding technology platform updating and maintenance can be a major problem. TEPHINET was unable to post new content effectively. They had to go through the vendor for many basic types of posts, and responsiveness was poor.

Not surprisingly, few members had joined online, and there was no clear method for on-boarding new administrators for the online system. They discovered that high reliability onboarding processes were especially critical in a nonprofit (NGO) setting as turnover tends to be high [8], and three key online resource managers came and went over the 7 years of action research without effectively passing along key information.

Due to their receipt of some funding requiring ownership of their own code and data, TEPHINET ran into an additional problem in which the vendor running their site would not give them access to their code and data. They only discovered this problem after hiring one of the co-authors as a consultant. Also common to non-profit settings, TEPHINET did not actually have any technologists among their staff. So, such technical issues could easily remain invisible. Due to the multiple problems the management team agreed the online technology platform was an important central theme needing attention and investment.

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The process of next generation Website design and coding followed a fairly typical systems analysis and design approach, beginning with needs identification. Data were collected by one of the authors as an independent consultant via interviews of 35 community members proportionally representing key stakeholder groups: TEPHINET staff, field epidemiologists, trainers, and trainees. These interviews lasted 30 minutes to 1.5 hours each and followed a semi-structured format. The participants represented constituencies from 14 countries distributed around the globe, and the interviews took place face-to-face at international conferences in all but two cases, thereby providing neutral ground for authentic and honest input.

The needs data collected identified two major usage desires for the website, namely: 1) a private directory for finding other members and connecting/staying connected, and 2) a library of research and outcomes reports/abstracts focused on new knowledge and techniques for outbreak investigations as well as cases for training epidemiologists. As far as technical needs, a few managerial participants expressed concern about the site being maintainable, specifically that there be a community of people who could be contracted to work on the site’s code in the future. This administrative need made sense in light of the prior behavior of outsourcing all technical work at the NGO. There would be only very limited on-going funding of the actual technology and its direct support, since all such funding had to come from special projects and overhead allocations, both of which continued to shrink.

A number of other dreams emerged through the needs identification process, clarifying in general a requirement that the Web page technology be open to further expansion and extension into RSS publishing, data interchange, private group formation, jobs and newsletter dissemination, and other types of features like Skype integration. Given the limited project budget for developing the new Website as well as the fact there would be no dedicated technology lead in-house maintaining it, the project began to focus on web content management systems (CMS) as a solution for enabling these many capabilities. The rationale was that a CMS could provide a technology platform for launching desired capabilities over time at lower cost as well as a community as a source of contractors.

As a next step, the project team analyzed CMSes for potential to meet the identified needs. The private spaces implied a CMS with identity management and roles built in. The source of contractors suggested a CMS with a large existing community of developers. The need for low cost suggested a CMS with low to zero licensing costs. The need for ability to integrate a variety of emerging capabilities suggested a CMS with a lot of development activities happening and free access to testing and deploying extensions. Overall, the Drupal platform provided a free and open source (FOSS) fit for all of these needs. Other options evaluated included Joomla, Sharepoint, WordPress, and Ning.

Based on data collected through member technology surveys, browser, access hardware and bandwidth requirements imposed some additional constraints. Among community members, many were still using operating systems and browser software multiple generations behind current at the time. Additionally, members reported inconsistent access to the Internet. Access was most commonly available at work when they visited regional offices, but many members, as field epidemiologists, spent substantial amounts of time traveling. At the time, mobile devices among the user population did not have either SMS nor Internet access (<5% reported having either). Existing server logs and interview responses indicated that members could only be expected to have 56 kbps bandwidth, so files and page sizes had to be optimized to lower the transfer burdens while working on older browsers and hardware. The most consistent, economical online communication means available was email (over 80% reported having regular access at least once a month). Other means like Skype or online chat tools had low community penetration though some smaller subgroups were using them.

5. Initial Action: Basic Issues Resolved

By November of 2010, the new version of the website launched in conjunction with the biennial TEPHINET global scientific conference. Immediately, 400 users joined and used the site at the conference, more than quadrupling the prior number of registered users. During these sign-ups the implementation team observed and interviewed new users to understand their experiences and what went well or poorly. A variety of sign-up process kinks were discovered and corrected, such as a specific browser incompatibility, a required validity check CAPTCHA that did not load reliably, and creation and allocation of additional roles and permissions to enable managers around the world to see and manage their constituencies in the system. All of these were immediately discussed and implemented by the remote team at the conference through the administrative interface in the online system, a level of agility not possible in the prior system.
As expected, the two top uses of the new system were accessing content in the library (an archive of 2,000+ old documents had been digitized and uploaded) as well as accessing contact information in the directory. The most popular unexpected feature was the new jobs board, which logs showed was the most common feature drawing in members during the first six months post initial implementation. At this time there were no private interaction spaces in the main page. A beta-test of a project collaboration site had proven problematic and was scrapped.

Meanwhile, community managers began asking for more features in the library as well as space to post conference and program information as well as conduct mini-grants processes. Membership and viewership continued to rise, and the hosting server had to be upgraded to handle the additional memory required for having up to 50 concurrent logged in sessions (this spiked to 150 during a global conference, causing the server to shut down). Such hardware issues were solved fairly quickly by upgrading the hosting through the hosting vendor (Rackspace at that time).

6. Action: Platform-Enabled Innovation

Up to 2010, one dynamic online process actively worked among the three existing TEPHINET sites at that time. That process, still in use at www.tephitract.org, handles submission and review of presentation abstracts for the scientific conferences. With the new website running on the Drupal platform, new content more regularly appeared, since staff could post content directly through a browser (an additional dynamic online process). Additionally, RSS feeds and automatic cross-posting to Twitter enabled a greater reach, such that page views increased dramatically (see Table 2) through increased information, communication and calls to action [9].

Almost immediately, excitement about the new system led to further calls for features and improvements. Within a year, at least 9 different extension projects launched to enhance the online services. Among these (partially listed in the 2011 row of Table 1), several were complex integrations. For example, one project deployed open authentication and encrypted web services to add online class registration and live teaching via Elluminate (now Blackboard Collaborate). This same tool enabled live streaming of events like the keynote speeches at major hosted meetings while also optimizing for low-bandwidth connections. Another project added private group spaces in the library where authenticated end-users could setup interest groups and discuss and share data and documents. A third project added a geographic mapping engine that enabled graphical map for documents and members. Hovering over pins on the map displayed a link to that item’s details page. This tool also displayed managerial roles as differing pin colors (Figure 1).

7. Evaluation: Code Rot Problem

The complexity of the online Drupal sites grew quickly. One measure of this complexity is the count of modules deployed in the code base. By default, Drupal 6 (the underlying platform used) had 33 modules. The main TEPHINET site soon had over 100, with several custom modules built by different vendors. The software community defines the term “code rot” as a state of software stopping working due to being neglected while interacting code and processes continue to evolve [10], [11].

A quick look at a current sample of the site log gives a sense of the types of errors that began occurring (Figure 2). Here we can see a server programming language (“php”) processing error due to an upgrade of the version on the server without a corresponding change in a module implementing an old, deprecated method. We see an SSL certificate error due to an improperly applied SSL certificate renewal that failed to update the new information in all places where needed (“acquia agent”). We see that an outside information feed (“aggregator”) is no longer working as configured, perhaps because the host site changed how they publish it. The first two issues come from inadequate technical maintenance internally. The last one originates externally but can be solved by a vigilant internal manager handling it in a timely manner. As there was no individual assigned to this role and typical project grant funding would not pay...
for such roles, such errors were neglected and accumulated.

**Figure 2 Sample of site log**

<table>
<thead>
<tr>
<th>Time</th>
<th>Error Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>05/21/2015 15:11</td>
<td>Notice: Undefined property:</td>
</tr>
<tr>
<td>05/22/2015 13:45</td>
<td>SQL error creating socket i-999:</td>
</tr>
<tr>
<td>05/22/2015 13:45</td>
<td>The feed from PromED Mail Reports seems to ...</td>
</tr>
<tr>
<td>05/22/2015 13:45</td>
<td>Cron run completed.</td>
</tr>
</tbody>
</table>

Because the new platform provided easy access to the listing of errors with somewhat accessible explanations of what was wrong, TEPHINET was able to episodically contract services beginning in 2011 to find and fix some of these errors. One insight here was that non-profits entering into this sort of online service need to more explicitly hire and assign technical community and platform managers. These individuals would not only curate content but also oversee the technology platform maintenance as vendors and projects continue to add interacting new code that could cause code rot. Doing so would require specifying and funding such roles.

Another interesting note is that there was no browser-based, plain English access in the prior systems to this kind of information. So, when the site went down, TEPHINET would have to contact the original vendor for custom fixes, not knowing what caused the error or if its root cause was fixed. Plus, there was no proactive option for monitoring and discovering emergent errors (code surveillance) to maintain code health.

### 8. Evaluation: Use Increase Despite Errors

By 2012 the code rot problem was sufficiently visible at a level that TEPHINET was able to allocate resources to hire “white glove” managed site hosting. Such services promise to monitor and maintain not only the server platform but also the specific software health to fix problems as they emerge. The price for such services typically begins at $20,000/year and functions similarly to IT outsourcing done in the 1980s wherein a vendor provides all necessary capabilities depending on what capabilities fall under the arrangement.

A first effort at “white glove” service was attempted and failed in 2012. TEPHINET discovered that the service vendor covered server issues effectively and proactively but would only be active when prompted for software layer issues. This defeated the point of the service. A second vendor was then secured and the hosting moved in late 2012. This vendor, an acknowledged market leader according to a Gartner Research analysis, displayed some of the same issues, raising the question as to how “white glove” services vendors in the nonprofit, SME environment should most effectively arrange and manage their services. We believe this is a very active area of business innovation in great need of research. The key problem seemed to be that the “white glove” vendors assumed some technical lead would be present and active at the client site. However, this was not the case.

Though errors continued to appear from time to time, several major groups approached TEPHINET to host their communities inside the online community using the private group functionality added in the 2011 project. Among these groups were several governmental agencies with huge IT budgets and substantial online platforms of their own. One reason they reported for coming to host with TEPHINET was that the TEPHINET server was not constrained by various online policies and procedures that effectively blocked access for the target communities of internationally distributed epidemiologists. That said, some arrived expecting services and support similar to their homegrown experiences.

The initial efforts at hosting the external communities included group spaces with custom styling and public fronts as well as conference information websites. For this latter purpose, a conferences server was setup. An issue that had plagued the community over time due to the federated hosting of conferences web sites was that they would disappear soon after the conferences ended, taking the history of the conferences with them. It was hoped that having a central server through the global network would help solve this problem. While initial efforts began working, and five conferences were hosted, the service quickly broke down when the manager in charge of working with clients turned over and the service was no longer maintained.

Other group sites started (nearly 100), but few became active (about 5%). This may be a success in the world of social media but sounds like a failure in an organization used to traditional measures of utilization success [12][13]. By mid 2013, the individual overseeing the private group on-boarding process also turned over, leaving this service unmaintained. Fortunately, the existing groups by that time already had permissions and capability to update and maintain their own content. As a result, activity continued even without the manager present, though no new groups could be customized or given the specialized public/private configuration previously available. By mid May 2015 group page accesses accounted for 27% of all page views in the library server.

To some degree, the success of the Web platform and growth of the global user-base enabled TEPHINET to envision larger technology-centric projects. One such project started developing in 2010, leading to a three-year $3,000,000 grant funded by the Skoll Global Threats Fund (SGTF) in 2012 for a project to build more effective global surveillance and response systems. This project included a coalition of organizations including the active participation of SGTF, HealthMap, and ProMED with TEPHINET.

Among other initial features, this project focused on implementing a services architecture that accessed the TEPHINET epidemiologists securely and privately to ask them to confirm/disconfirm reports of outbreaks in their locales in a timely manner. Data would then be transferred back to HealthMap and ProMED enabling more accurate and timely verification of outbreak rumors/reports collected via social media and other informal sources. One of the key expected integrations for the TEPHINET site was the Drupal to Drupal connection between TEPHINET and HealthMap; however, the TEPHINET site ran on the version 6 core while HealthMap was using 7. Without a major upgrade, the TEPHINET site would not be able to use the needed code libraries. A deeper analysis of the difficulty of this upgrade determined that it would take too much time to be relevant in time for the grant’s timeline. This led to an architectural change in the team’s approach, minimizing integration and developing a separate site (www.epicore.org) for the message workflows and analytics processing.

A key learning through the upgrade analysis process was that TEPHINET needed to maintain a simplified but complete testing plan for each server. Each plan would have clear application guidelines and metrics for the priority features used. This plan would be applied each time a new feature was attempted. There had been many prior projects between 2010 and 2012, and some of them actually caused serious problems in the online sites.

For example, one dashboard project delivered by an outside vendor was never actually used. Its errors were immediately obvious. It caused data corruption and slowed the server responsiveness 50% when turned on, and the dashboard still failed to show the unified data promised. Other projects also caused interacting troubles, but these were typically not so obvious. Thus, having the structured testing plan in conjunction with a testing infrastructure allowing development, staging, and production versions of servers to be separated (implemented during the Epicore project) would enable more careful progress that would not ruin existing usage successes. Finding staffing that could be trained and remain involved in maintaining the technology platforms remained an unsolved problem. And, this staffing trouble only got worse with the updated infrastructure since simple secure FTP management of the servers was replaced by a code control system (GIT), which was harder for non-technical public health workers to understand and learn.

10. Evaluation: Ebola Outbreak

A core vision of the online sites and services at TEPHINET had always been to add value as a trusted, go-to resource in the global dialogues needed when major pandemics/outbreaks occur. To this end, a natural experiment occurred in 2014 with the Ebola outbreak in West Africa.

Figure 3 Library Server Unique Users 2012-2015

A recent Frontline episode on Public Broadcasting in the US highlighted the gravity of the outbreak response, pointing out that it was not until September 16, 2014 that President Obama held a press conference announcing “high level outbreak response” [14]. Prior to this press conference, fewer US resources were devoted to fighting Ebola. The outbreak had spread from Guinea to Sierra Leone, and African epidemiologists were trying to figure out how to identify the virus and best practices for treatment and containment. This type of knowledge (specific examples related to ebola investigations in Africa) is stored in the TEPHINET library abstracts and cases database. And, community members had been exposed to this resource over the preceding several years at conferences and through the newsletters. Would they use it in this time of need?

In an average month (2012 - 2015) the TEPHINET library server sees about 2,000 unique users. In August 2014 there were over 2,700 (Figure 3), seemingly indicating that an anomaly of usage had occurred. A simple t-test of these results indicated that there was a significant departure from the normal usage (P<.0001).

A geographic factoring of the library usage data during the time period showed that African usage had more than doubled from 139 sessions in June/July to 353 sessions in July/August, as the epidemic became a much more intense and international concern due to the spread to Sierra Leone and some surrounding countries [14]. Interestingly, other usage around the world also picked up at the same time. Unfortunately, data on specific article usage by geography by time

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period was not available. Otherwise, we would analyze the nature of the specific interests.

11. Specifying Learning: Discussion

As indicated at the outset of this case, public health faces a tension between outbreak response agility and investing in on-going capacity through surveillance, vaccinations, and similar programs. Information technologies have the potential to substantially transform how NGOs are able to partner and serve a role in these responses and programs globally [15].

During the Ebola outbreak, it appears that the TEPHINET system did in fact serve a role bridging this gap by being a known and already available resource. The library provided outbreak investigation reports, training cases, and connection information members could access and use to become more informed and effective. Such trusted resources are otherwise hard to find or create during an emergency response situation [16]. For example, as the Ebola outbreak became increasingly pandemic in September, TEPHINET was able to quickly launch and disseminate to the local communities affected an online training on “Outbreak of Ebola Virus in Nigeria” via the online platform with 142 views at that time.

This case highlights the challenges and needs for developing such on-going capacity in an NGO without strong, consistent technical managers able to focus on coding, code maintenance or server infrastructure. Apparently this is a common scenario still faced by a range of organizations attempting information systems innovations in the public health sector [17].

First, on-boarding new staff into technology management roles needs specific care. While user manuals and documentation for the servers existed, new staff would rarely receive training from the knowledgeable exiting staff and manuals became outdated quickly as vendors continued to develop new capabilities and methods for conducting workflows. We found that a testing plan applied during any code changes forced explicit delineation the high priority features. This became a resource new staff and old could use to quickly introduce the key operations delivered through the platforms. It also served as a natural bridge between the vendors and TEPHINET since vendors would never see the use manuals but would see the testing plan. And, if a new test were needed for new functionality, it would get added during the development projects and then would ensure that new managers would know about the functionality.

Second, deploying a platform enabled increased innovation and content updating in ways not seen when the organization was using only custom code. This effect gradually lessoned as the platform accrued errors. These errors were due to new features causing bad interactions in some cases, but frequently they were due to bugs in existing code. Free patches and updates often appeared in the open source community supporting the platform. However, there was no reliable means to get the code constantly updated and patched, even with “white glove” hosting services. This resulted in part in the Epicore project ultimately moving back to its own custom code. Gradually, open source IT platforms evolve when the community finds bugs or better ways to implement functionality and security. As such existing code experiences “code rot” and will require on-going maintenance. Should a public health NGO invest in and maintain such a platform?

Existing IS theory addresses this question from the viewpoint of real options economics for IT platforms [18]. We applied this theory retrospectively to assess the learning in the case. Options represent the potential that an IT innovation investment creates for an organization. Acquiring the open source Drupal platform theoretically enabled TEPHINET to access options for updating and maintaining code security at low cost and for implementing many sort of features not easily otherwise implemented. The value of these options relies on a twelve underlying factors from four different perspectives (Table 3). We assess the option value in the actual case circumstances for each in turn, pulling their definitions from Fichman 2004. In turn, we gather insight into the nature and need for research, managerial interventions and support to drive more effective IT platform-enabled innovation in such a global public health organization.

<table>
<thead>
<tr>
<th>Determinant of Option Value</th>
<th>Potential Value (Theoretical)</th>
<th>Assessed Actual Option Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radicalness</td>
<td>+</td>
<td>high</td>
</tr>
<tr>
<td>Strategic importance of affected products and processes</td>
<td>+</td>
<td>very high</td>
</tr>
<tr>
<td>Sustainability of competitive advantage</td>
<td>++</td>
<td>low</td>
</tr>
<tr>
<td>Innovative capabilities and endowments</td>
<td>++</td>
<td>negative</td>
</tr>
<tr>
<td>Knowledge barriers</td>
<td>?</td>
<td>low</td>
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<tr>
<td>Learning-related endowments</td>
<td>++</td>
<td>negative</td>
</tr>
<tr>
<td>Contributions to absorptive capacity</td>
<td>+</td>
<td>very high</td>
</tr>
<tr>
<td>Susceptibility to network externalities</td>
<td>++</td>
<td>very high</td>
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</table>
s a tradeoff effect, causing TEPHINET, the specific architecture globally [20].

... Rather, they would be proprietary platforms, or custom coded Web shows the extent to which a captures the extent to which an organization. In the case barriers would present capture the extent to which an IT indicates the degree to which an IT is, accessible error reports; a representative of the extent of knowledge barriers for using the IT platform in lingual domains [19]. From this data we gather that the large, including many in public health and multi-organizations around the world ranging from small to very large following (10,000+) among non-profit platform being adopted. The Drupal platform has a organizational learning needed consequent to the IT platform in and products. The IT platform in this case provided product and process capabilities somewhat beyond the prior system: consolidated, accessible error reports; a module plugin architecture; a global library of free modules, etc. So, radicalness options value was high. Strategic importance of affected products or processes refers to the extent to which potentially improved products/processes are central to the strategy of an organization. In this case, the NGO must enable global collaboration and knowledge access at low cost. Internet functionality provides a primary means for that mission. So, this determinant’s option value was very high. Sustainability of competitive advantage is the extent to which the platform would resist rapid duplication by competitors. Because the IT platform is open source and many extension functionalities are free and readily available, the option value from this determinant was low. The final technology strategy determinant, innovative capabilities/endowments connotes the extent to which an organization has resources that will enable the effective deployment of the innovation. In this case, and as cited above seems to be the case in other public health organizations, the human, technical, and organizational resources for dealing with new technology were very limited. Most personnel have training in medicine or public health topics with very limited, if any, Web technology building and management expertise. Thus, the actual option value for this factor was negative.

Organizational Learning Perspective

Knowledge barriers represent the extent of organizational learning needed consequent to the IT platform being adopted. The Drupal platform has a very large following (10,000+) among non-profit organizations around the world ranging from small to large, including many in public health and multi-lingual domains [19]. From this data we gather that the knowledge barriers for using the IT platform in general are low, and thus the option value is high. This determinant theoretically has a tradeoff effect, causing its impact on option value to depend on whether the expected value of payoffs or variability of payoffs dominate. In the case of TEPHINET, the specific knowledge barriers had no clear pathway for address, meaning that even small barriers would present substantial, persistent problems. Thus, expected value would be low but not because of the knowledge barriers (which would be low). Rather, they would be impacted by the following factor. Learning-related endowments capture the extent to which an organization has capacity to do the needed learning required to capitalize on the IT platform. The expected value from this determinant was negative. Contributions to exploitable absorptive capacity indicates the extent to which knowledge is needed of other strategic domains in an organization. In the case of this IT platform and the larger potential for innovation using online IT in global health, the potential for this determinant to impact TEPHINET was very high.

Bandwagon Perspective

Susceptibility to network externalities captures the extent that an IT platform increases in value as others also adopt and use it. Drupal is the largest enterprise, open source IT platform architecture globally [20]. Users freely share and rate code contributions. The potential value from this determinant was very high. Prospects for network dominance of the technology class indicates how much a technology class is likely to dominate versus alternate classes of technology. In this case, we can look at the alternative classes as open source platforms (selected), custom coded Web systems (prior strategy), proprietary platforms, or outsourced services without direct code access. In the non-profit and NGO space, open source platforms like Drupal and Wordpress are increasingly dominant. Thus the value from this determinant was high. Prospects for network dominance of the technology instance captures the likelihood that a specific IT platform will become dominant within its class. For non-profits, several open source platforms are competing for this title, especially Wordpress, Joomla, and Drupal [21]. Though Drupal has extended capabilities in terms of extensions and integration, it is third in market share, indicating its option value for this determinant was low.

Adaptation Perspective

Interpretive flexibility shows the extent to which a technology permits multiple interpretations of how to use it. The Drupal platform is especially high on this
determinant, as it can adapt to fit almost any online IT platform need from providing a blog and content management to serving as a data hub for mobile devices or headless middleware engine [19]. Thus, the value for this determinant was very high. Finally, divisibility indicates the extent to which an IT platform can be divided up into sequential implementations, smaller chunks of development with smaller risk. Again, the Drupal platform, and other open source IT platforms like it (Wordpress and Joomla) provide a high degree of this determinant’s value, as they include modular, extensible frameworks that prevent code from crashing a whole site and enable tracing of errors and effects of individual new features (reducing code rot impact). So, this determinant also had very high value.

12. Conclusion

IT platform investments like the one in this case promise high potential innovation value. Some of which was demonstrated. We see in this case that the actual value can be undermined by failure to maintain the platform (code rot issues) or failure to capitalize on the platform. Both of these issues relate to the negative value impact of organizational learning determinants (Table 3). As discussed, such factors relate to lack of technology expertise internally in a public health organization and to lack of knowledge updating/transfer/training mechanisms. These mechanisms can be developed and valued.

Future research in this domain should explore how providing the explicit options value assessment framework up front helps organizations, like ones in public health with few technologists, justify investments into building these capabilities. Similarly, we believe that applying and displaying in a shared dashboard some form of periodic reference assessment of realized options value from the IT platform investment would help maintain the strategic understanding and realization of actual value from the investment. A central on-going problem in public health, even without considering technology, is building durable capacity when many more resources often get channeled into event-driven outbreak responses. Technology investments suffer from this same problem. Public health organizations will have to figure out how to maintain IT platforms in a manner that keeps them relevant and capable so that occasions of usage, as during the Ebola outbreak, may rely on them. We believe this case helps identify ways in which these efforts may be more successful.

13. References