Snooping around a Fence: A Lesson from the Education Sector in a Software Service Ecosystem

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Abstract. Although the education sector has recognized the value of information technologies since the early 1990s, the advancement of education services is not clearly shown in the information technology era. This paper visualizes the trace of education services development in a software service ecosystem with real data about software services and their combinations resulting in composite services. Our graphical analysis results show that education services continuously emerge through reusing and recombining popular software services such as Google Maps and Facebook, although only a few education software services open their functions and data to the ecosystem. Moreover, our analysis results show that there no service groups that are built around education services. Our findings suggest that the education sector is immature within the software service ecosystem and that a software service sector has not been formed yet.

Keywords: Education, IT Adoption, Software Service, Network Analysis.

1 Introduction

Education has been adopting information technologies (IT) since the early 1990s [1, 2]. IT technologies support the access to information, simplifies the knowledge transfer at classrooms [3], and enables equal opportunities for students in remote areas and for disabled students [4]. This service is not just expected to be provided to secondary and tertiary students but also students at early childhood [5].

Although the prior work suggests various opportunities of IT adoption in education, a few recent studies raise issues on the market response to IT in the education sectors. The continuation of the IT transformation of classrooms is doubtful, if the government adopts IT due to technological possibilities instead of market demand [6]. The emergence of breakthrough innovation is also in question, if the market demand does not pull the technologies [7, 8].

Our motivation of research is to address the issue of market response to IT adoption in education. The market demand drives the evolution of technologies by recom-

bining previous technologies and new technologies [8]. Thereby, we conjecture that the evolutionary path reflects the market demand on the synthesis between information technologies and education services, and the extension of the synthesis to another technology fields (e.g., finance, manufacturing, and transportation).

In this research, we address this by investigating the evolution of education software services in a software service ecosystem. Several recent studies suggest that software services advance through interacting with each other in an entire ecosystem. They diagnose services' creativity and sustainability and forecast the future facets of technologies and societies [9, 10]. In a similar line, we address how much an education sector embedded in the software service ecosystem, and what technologies the education services mainly interact with.

To investigate this, we aggregate empirical data from www.programmableweb.com, which lists the information of software services (represented as APIs) and their use in composite services (represented as mashups). Our data set consists of 127 composite services in education sector and 421 software services that are used to develop those composite services between 2006 and 2017. In a graphical view, we define a software service ecosystem as a set of vertices, representing software services, and their edges, indicating co-reuse of software services in a composite service. We measure the network position of an education service with centralities, indicators of social network analysis, and their memberships in clustered subgroups.

Our analysis results show the followings. First, new education services emerge through the convergence of software services belonging to other sectors than the education sector. Second, only a few software services belonging to the education sector enter the software service ecosystem. Rather, education services are created around a few popular software services such as Google Maps, Facebook, Flickr, and Twitter. Third, the education sector looks declining in recent years. On the ground of those findings, we carefully conclude education is snooping around a fence to IT adoption but did not yet hurdle over the fence.

Our findings contribute to both academia and business. From an academic perspective, our findings suggest a graphical analysis of well-known social network analysis tools reveals the actual shape of the IT adoption of education. Our findings show the real innovation could be different from expectations that are based on theory. Education does not actually reap to the core of the software ecosystem, while the IT adoption is believed to be universal in a long history and provide opportunities [1–5]. This academic contribution leads to a managerial implication. The innovation through the convergence between education and another technology should be carefully designed on the ground of the market demand, while the academic research underlines the opportunities of new technologies.

2 Theoretical Background

2.1 IT Adoption in Education

Education is the communication on a specific subject between a teacher and students and among students [11, 12]. A talk in a certain physical place is a typical way of

communication in the Ancient Greek schools, the medieval universities, and in a modern classroom [13]. As books remove the temporal and special constraints of communication, information of a teacher could spread quickly and widely to any students, who can buy a book and read it [12]. Now, education practitioners and experts in recent two decades paid attention to information technologies (IT) that support the communication among people, which is just the key to education, and fast adopt the IT in education for distant communication, easy modification of teaching materials, and visualization of its object [1, 14–18, 54].

The IT adoption in education transforms the way of teaching and learning within classrooms as well as out of classrooms. First, the IT mediates the communication between a teacher and students, and among students in a classroom [1, 2, 15, 16, 19–21]. If the traditional education focuses on unidirectional knowledge flow from a teacher to students, the IT in a classroom extend the education into constructivist, socio-cultural, cognitive and collaborative ways [2]. In detail, personal computers connected to each other through Internet support the students share their knowledge to build new knowledge by their practice [19, 20]. Multimedia-systems and simulation environment, as well as, help students' cognitive experience in concrete objects that they learn [2, 17, 22]. Those promote provides students with creative thinking, while the conventional one stops at just bringing knowledge to students [5].

Second, the IT reduces the spatial and temporal restrictions in communication between a teacher and students [2, 17, 19, 20, 22–30]. Through the Internet, the education service can also be provisioned to students uncomfortable to move [4], and living in a distant rural area such as Outback of Australia [17]. The video conference system and online transmission of class materials makes it indistinguishable between a physical classroom and a screen [22]. On the ground of Web services, furthermore, a teacher provides their service to a bigger market, which has no size limitation, than a classroom of 50 students at most [15]. As the lecture is stored in a Web server, a student, who hard to match their schedule to class, can attend the class on screen at their convenient time [31].

In summary, the IT adoption in education removes the physical, spatial and temporal barriers to the interactive and distant communication. This technological advance attracts the IT entrepreneurs to provide facilities that support teaching and learning [17], and extends the beneficiary group of education [32–34], although it does not provide all functions of traditional education such as the emotional interaction through physical touch [23]. The economy of scale in education then reduces the price of education [22], and potentially increases the quality of the education service [18]. If the IT opens a new market in education, the remaining issues are now whether and how actively the market pull the innovation[8].

2.2 Software Service Ecosystem

A software service is software that is provisioned as a service to support the interaction between a person and a machine, and/or among people on the Web [9, 10]. For example, end users access the server of Google Maps that contains map data and related functions through a Web browser to read a map of Waco in Texas. These end

users do not need to install a standalone package with a map on their personal devices [35]. Amazon provides even computation as a service, which was previously provided as a product (i.e. a personal computer and a shared server); a user does not need to know the location of computers and pays for the service on demand [36].

An advanced way of using software services is accessing to the data repositories and computation resurces through a standardized interface, or generally called an open application programming interface (open API) [37]. A user can then automate using the functions that a software service provides, so that they embed the functions in its own service as its components. The access to the software services through the open API leads promoting innovation in an open manner. That is, a third party user creates a new service, which is called a composite service, by adding their own data and functions on top of one or more software services shared through the Internet [10, 37]. In this way, various servcies in a "long tail" can be released, with reducing the burden on a huge amount of investment in basic functions such as map data, search engine, data storage and servers for computation [38].

The new style of innovation builds an ecosystem of software services. Software services support creating composite services; composite services satisfies end users' demand, and composite services feed the economic return to the software services they are based on [10, 39]. Furthermore, some software services supplement another software services, as well as compete with them. Although Yahoo is a competitor of Google in the search engine market, for example, search engines of the two rivals are both used in creating Maps Compare, in which one covers what the counterpart does not take [40]. Kim et al. [10] named it a "software service ecosystem", the intertwined relationship among software services and composite services, on the analogy to the ecosystem of animals, plants and fungi that form a complicate set of competitive and symbiotic relationships.

Education is one of the sectors of software services that consist of the software service ecosystem. By December 2017, 421 software services were released to cover education among around 18,000 software services in all sectors, and 127 composite services were developed with software services during the same period [40]. Those services extend the area of IT in education from communication within and over a classroom to anything related with education, including knowledge management and education administration. For example, Mendeley opens its functions third parties for supporting scholars to manage their literatures and collaborate in writing an article [41]. UC Berkeley opens its data for education services (e.g. applicants' status, class information, and so on) through open APIs [42]. A remaining issue is then how vigorous the innovation is through the participation of software service providers and third party developers.

2.3 Diffusion of Software Services

The market needs time in adopting a technology, but a technology has a limited longevity in the market. A technology shows a bell shape curve from its birth to death through prosperity as inventors and imitators in a limited population adopts the technology [43, 44]. Although an old technology fades out in the market at the end of its

longevity, a successive technology replaces the old one to continue the growth of industry as long as the market demands it [45]. However, all technologies do not surf on this life cycle successfully. Even an advanced technology can fail to attract the majority of consumers, if it does not satisfy the market demand in front of the "chasm" between early adopters, who responds to technological opportunities, and the early majority, who fulfill their own demand [46].

Some software services show the bell shape curve of lifecycle of connectivity in the software service ecosystem [10]. The market responds to a software service in two ways. End users directly use a software service through the Web pages on their demand. As well as, third party developers reuse the software service to create composite services that satisfy end users. In this line, we can make an analogy of the relationship between software services and composite services to the relationship between invention and imitation of technologies. Remaining issues are then how actively the market responds to the education software services, whether they surf on the lifecycle like successful software services or snoop around the chasm to decline at last.

3 Methodology

Our data of software services and composite services are aggregated from http://www.programmableweb.com [9, 10]. This website provides the information of software services that open their APIs and mashups that use those software services with open APIs. Around 18,600 software services and 7,900 composite services are listed in the website and sorted into 482 service sectors. Among the software services released between September 2005 and December 2017, we select 421 software services and 127 composite services that belong to the education service sector.

We apply a social network approach to those empirical data of software services and composite services. Each software service is represented with a vertex in a network graph. We consider an edge is formed between a pair of vertices if software services corresponding to those vertices are used together for developing a composite service. Each vertex contains its attribute information of the provider (e.g. Google, Yahoo, and Amazon), the service sector (e.g. mapping, social networking, education) and the release date of the corresponding software service. Each edge has no information of direction, and contains the weight meaning the number of concurrent use of the corresponding pair of software services for developing composite services.

We measure three indicators in the software service network to determine whether the software services in education are just snooping around a fence of chasm or hurdling over the fence. The first indicator is the number of software services that newly enters the market for each month. Releasing a software service requires the data and function to be shared, and the motivation of the service provider to share its service functions [47]. For example, UC Berkeley opens its API to the public because it has systematically accumulated the data of its education experience, and its sharing strategies potentially attract more and better scholars thanks to its enhanced utility of the university members through the convenient education services [42]. Therefore, the number of software service in education indicates the technological maturity that

promotes the innovation in education through responding the fine demand of the market.

The second indicator is the position of a software service that is measured on the ground of the edges in the software service network [10]. We apply two indicators of social network analysis, or degree centrality and betweenness centrality to the software service network of education [9]. Degree centrality of a vertex is the number of edges that are attached to the vertex. This means how frequently a software service is used together with another software services for developing composite services. Betweenness centrality of a vertex is the number of shortest paths of a pair of vertex that passes by the vertex divided by the number of all shortest paths connecting the pairs of vertices. This implies how much the software service connects the entire parts of the software service network of education.

The last indicator is the existence of clusters of software services that rally around education service sectors. A cluster in a network is a group of vertices that are connected with each other more densely than with the vertices out of the group [48]. A cluster means that vertices belonging to it share some properties such as same opinions in case of a social network [49]. Likewise, a cluster in a software service network represents a latent sector that software services contribute to complementarily together. We implement the leading eigenvector algorithm to detect clusters in the software service network of education [50].

4 Analysis Results

Figure 1 describes the annual trend of the number of software services and composite services between 2006 and 2017. The number of software services released in education sector soared up from 11 in 2010 to 93 in 2012 and decreased afterwards. On the other hand, around 20 composite services were developed in the education sector between 2006 and 2010, and the annual number of composite services dropped from 29 in 2010 to 6 in 2011 with remaining stable afterwards. The results suggest that there was a boom of releasing software services around 2012, but the innovation on the ground of software services does not follow their release. This boom in education is not so small comparing to the number of software services in the entire sectors. During the study period, 421 software services were released in the education sector, while each service sector contains 38.6 software services (i.e. 18,600 software services are released in 482 service sectors during the same period).

Table 1 depicts six representative software services. The first five software services are most frequently used for developing composite services in education (Google Maps, Facebook, Twitter, Flickr, and YouTube). Google Maps is the software service at the top of reused software services among all sectors as well as in the education sector. This result is consistent to the description of Kim et al. [10], which shows the software service ecosystem evolves mainly on the ground of Google Maps as a platform combined with photo and video services in the early periods, and social networking services in the later periods. DonorsChoose, an online charity that promotes students who needs support [40], is the most frequently used software service among

education software services. Those results suggest that innovation in education services do not frequently reuse software services in education sector. Instead, the innovation is mainly led by the software services that are most frequently used in the entire software service ecosystem.

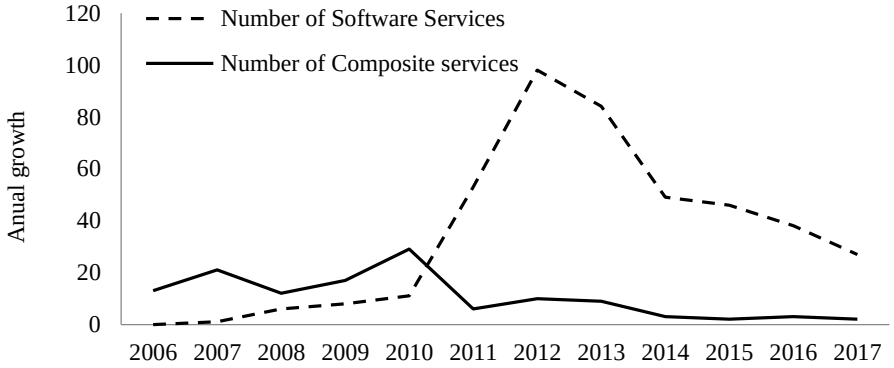

Fig. 1. Trend of the Number of Software Services and Composite Services

Table 1. Top 7 reused software services over time

Service Name	Release Date	Provider	Service Sector	Number of Reuses in All Sectors	Number of Reuses in the Education Sector
Google Maps	December 2005	Google	Mapping	2578	66
Flickr	September 2005	Yahoo	Photos	635	11
YouTube	February 2006	Google	Video	707	9
Facebook	August 2006	Facebook	Social	451	9
Twitter	December 2006	Twitter	Social	826	7
DonorsChoose	March 2009	DonorsChoose	Education	16	14

Figure 2 depicts the position of software services in the map spanned with degree centrality and betweenness centrality. Google Maps is connected with most of software services in the entire system as well as mediates the connection of a majority of software services. Facebook follows the position of Google Maps according to degree centrality and betweenness centrality. We call the vertex at the position that mediates the entire network with rich connectivity a "hub" [9, 51]. The entire network is rigid as long as the hub works without errors [52]. Although the hubs in the entire ecosystem play the role of hubs in the education sector, we do not see any education software services at a central position near to the hubs. DonorsChoose is the most frequently used software service in the education sector, but it is located far from the hub position on the map of education software ecosystem. In other words, the software

service ecosystem of education maintains mainly through the reuse of and recombination with software services out of the education sector.

Figure 3 shows the network of software services connected through concurrent reuse for developing composite services. The color of vertices represents the membership in clusters, and their sizes are proportional to their frequency of reuse. Five clusters are detected in the main components, and three clusters in the small independent components. The six representative software services belong to each of the clusters in the main component which are distinguished by different grey-scale. However, no education software services contribute to the connectivity of each cluster in the main component. Only a small independent component consists of education software services: Finalsite, Schoology and Whiplehill, and the cluster is formed by developing one composite service (CustomSync for The Education Edge).

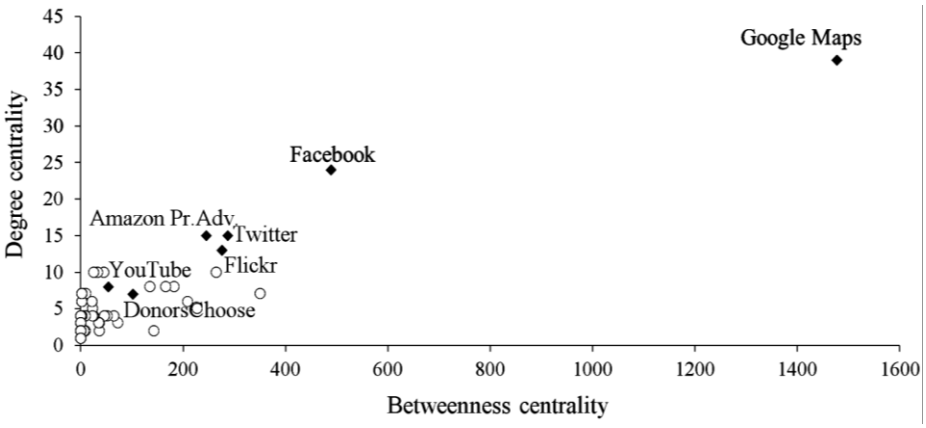

Fig. 2. Betweenness and Degree centrality map

5 Concluding Remarks

Our analysis results show that the innovation of education services is not so impressive as could be expected according to the opportunities that IT shows in education [1, 2]. We expected that an education sector is much likely to be built in the software service ecosystem, because the education sector has adopted a variety of information technologies since 1990s [1, 2, 15], and any society must underpin the education to maintain its sustainable growth and support the competence of individuals. That is, technologies are introduced to the market; i.e., an amount of software services opened their APIs. And the market expectedly demands them. However, our analysis results show that creating composite services do not rely on education software services but on software services in other sectors.

Our findings suggest education software services do not hurdle over but still snoop around the fence to the diffusion of innovation [46]. Our findings require explanation because they are bizarre in the sense of prior theory both to IT adoption in education and the diffusion of innovation [46, 53]. In our further studies, we will discuss the

reasons of snooping-around-a-fence from three perspectives. First, the education sector is waiting for killer services like Facebook and Twitter did in the social networking service sector [10]. Second, software services might originally be interdisciplinary. Therefore, an education service is much likely to be invented by combining one or more software services in other sectors. Finally, the IT adoption in education might be driven by a political need instead of market demand, so that the education sector does not emerge in the software service ecosystem, where the market demand dominates.

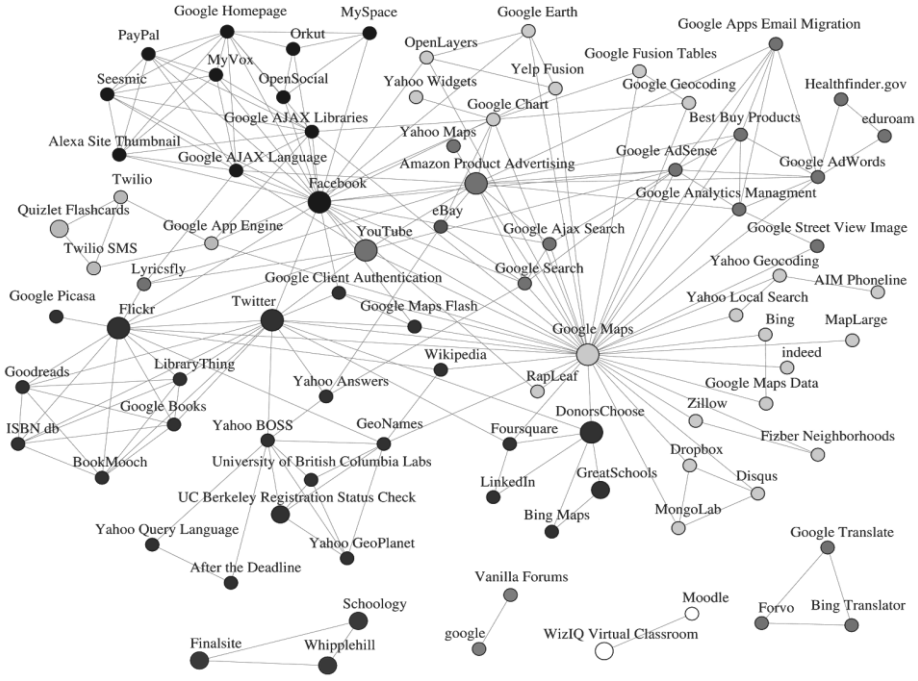

Fig. 3. Co-Reuse network map of software services (All periods 2006-2017)

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