Ph. D. Dissertation in Engineering

Strategies for Improving Education Services through Collective Value Creation

August 2019

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Abstract

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Education is an important sector for building sustainable societies and achieving economic prosperity for which teaching and learning are considered a valuable activity. The way educational content is delivered in a certain physical place progressed from ancient Greek schools to medieval universities and later to existing classrooms. Each era had its own practices and approaches for educating learners, and from the late 20th century this also included a vision for strengthening education with innovations around information and communication technologies.

Enabling information technology (IT) opportunities facilitated the emergence of new ways of knowledge delivery to learners. For instance,

multimedia technologies have improved ways of knowledge representation and the Internet cuts the spatial and temporal divide between learners and educational institutions. But all these opportunities have not yet helped in addressing the challenges faced by the education sector all over the world. Accordingly, preparing competitive graduates for high demanding job markets has remained a tough mission. A negative feedback effect coupled with poor education outcomes and human resources slows down a country's sustainable development.

For understanding these concerns in the education sector, this dissertation addresses two main research problems:

1. Implementation of knowledge exchange services for improving the quality of educational content, and applying incentive schemes for teachers' adoption of such services in different contexts;
2. Addressing the deviations in supply and demand for improving the quality of educational services using innovations of the software service ecosystem.

The dissertation uses the collective value creation approach among stakeholders of education and the parties outside education. Hence, the general research objective of this dissertation is: Studying the ecosystem strategies and policies for improving the quality of educational services by

stakeholders' value co-creation in knowledge building and innovating for education

Providing the most relevant and up-to-date educational content to learners remains as a big challenge for educational institutions. Hence, the specific research objective 1 of this dissertation (SRO1) suggesting an educational content creation model for teachers' collaboration in knowledge exchange enhanced by a stimulation policy by system holders. The model includes ranking and incentive mechanisms to motivate teachers on the exchange of educational content.

Its specific research objective 2 (SRO2) is analyzing the stimulation policies in the education ecosystem for teachers' acceptance of collaborative knowledge creation and exchange. The research does a simulation analysis using agent-based modelling by applying iterated games such as a prisoner's dilemma, the snow-drift game, and the stag-hunt game. It includes configurations of the simulation scenario in three types of environments (payoff matrices), four sets of teachers' behaviour, and three types of incentive mechanisms. In all, it uses 36 simulation scenarios with the aim of analyzing teachers' behaviour within possible environments as also the different incentive mechanisms.

The results highlight that knowledge sharing is almost impossible without

an incentive where the educational content has some relative advantage for the owner. The findings of the simulation analysis show that it is essential to have a proper incentive system for increasing cooperation on knowledge sharing within an educational institution. However, optimum solutions for delivering incentive mechanisms related to teachers' behaviour need to be found. Teachers' interest in self-well-being should not drive the collective irrationality that leads to the system being misused. In general, the suggested model can be employed as an alternative to educational content exchange with the aim of improving the curricula offered by educational institutions.

This dissertation's specific research objective 3 (SRO3) is studying stimulation strategies for the adoption of software service innovations in the education sector through supply and demand adjustments. Existing strategies for developing the ecosystem miss market demand and guide end-users to rally to a software service. This research discusses market demand for software services and their lifecycles based on the patterns of innovation around individual software services, their relations, and their clusters.

The study uses empirical data collected from the well-known platform for software and composite services – www.programmableweb.com. It uses a social network analysis methodology that focuses on the nodes and emerging links between a pair of nodes to analyze the empirical data. It uses

betweenness centrality and degree centrality to define the position of the nodes in a software service ecosystem and applies the leading eigenvector algorithm to conduct a cluster analysis of the network.

Our results using empirical data of software and composite services in education show that the areas covered by current software services in education deviate from market demand, and that software services around plentiful educational content and experience can fulfil knowledge dissemination and also provide administrative support. Our findings suggest that theories about the ecosystem of software services should adopt market demand for software services for a pragmatic discussion.

Overall, the dissertation contributes to academia and management both theoretically and practically. The major academic contributions of the dissertation are applying the social network analysis and iterated games to answer the research questions.

Its managerial contributions provide guidelines for implementing teachers' collective knowledge exchange systems for improving educational services and the important behavioural aspects that it highlights. As the logical continuation of bringing about improvements in educational services, the dissertation provides managerial guidance on how to address the demand for innovations in educational institutions.

Keywords: IT adoption in education, Software Services, Ecosystem of Education, Sharing Educational Content, Agent-Based Modelling, Network Analysis

Student Number: 2016-32108

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Chapter 1. Overall Introduction

1.1 Research background on IT innovations in education

The last decades of the 20th century were characterized by developments in technology and human lifestyles. Societies' vision about the implementation of modern technological solutions and paradigms to solve the core challenges in different sectors changed. Finance, banking, healthcare, demography, education, and science are some of the sectors that are benefiting from the advancement of technologies, especially information technologies. Like the other sectors, the education sector is also seeking to optimize its functionalities and operations through the use of modern technologies and technological services. This is necessitated by the demand for contemporary approaches for making the education sector effective and productive in supplying outcomes for competitive job markets.

It has been proven that with advancements in the education sector, countries can enhance their human capital, which contributes to productivity growth and efficiency in a wide range of human activities (Benos & Zotou, 2014). Countries that have realized the promises of advanced education for the society's well-being have been consciously investing in education and

coming up with appropriate and timely reforms in the sector. Undoubtedly, to achieve its goal the sector needs reforms that embrace all stages of education.

Economic growth can be achieved by ensuring a sustainable foundation for endogenous growth, ensuring innovative capabilities, and using relevant science and technology for modern industries (Benos & Zotou, 2014; Hanushek & Woessmann, 2008). However, the education sector cannot advance overnight (Ghaffarzadegan, Larson, & Hawley, 2017) as it requires time, effort, and finding complex solutions in terms of finance, management, and the society's philosophy that is directed at achieving the proposed objectives. Even though societies want to improve their economic performance, not all of them take into consideration the intensive transformations that are needed in the education sector for achieving this (Adetula, Adesina, Owolabi, & Ojeka, 2017).

The education sector has been adopting information technology (IT) since the early 1990s (Leidner & Jarvenpaa, 1993, 1995), thanks to the availability of enabling IT opportunities and demand for progressive education in some countries. Consequently, these countries are benefitting from the positive values and contributions of the education sector in transforming their societies into knowledge-based economies. For instance, existing research stresses the efforts made by the Government of Korea Republic for the widespread

adoption of IT in education because of which the country has become one of the leaders in implementing e-learning and integrating education with IT (J. Sánchez, Salinas, & Harris, 2011).

Strengthening the education sector by employing IT can be seen as the impact that IT has at the macro-level. It formulates patterns of knowledge building and human capabilities and shapes the economy based on knowledge. At a micro-level, education supported by IT leads to a reduction in the divide in educational services for a wide range of population (Anohina, 2005; Ozdemir & Abrevaya, 2007; Piccoli, Ahmad, & Ives, 2001) and enables new methods of knowledge sharing through learners' communities (Jonassen, 1996; Xu, Huang, Wang, & Heales, 2014). As recent literature points out, adopting IT supports access to broad knowledge and information, and simplifies knowledge transfers among teachers and learners in the classroom (Wastiau et al., 2013). Besides, it enables equal opportunities for learners who are located in remote areas and also for those who have difficulties in attending everyday classes (J. J. C. Sánchez & Alemán, 2011). These patterns of educational services usually cover a large geography and all educational stages from early childhood to tertiary education (Tezci, 2011).

Let us assume that education's core service is teaching learners. As service providers, educational institutions implement different services like formal

and informal education (Jagušt, Botički, & So, 2018), application and concepts of knowledge building and delivery (Mu, Liang, Lu, & Huang, 2018), and administration and management to maintain the quality of the core service. However, supportive services might be seen as being peripheral even though they contribute with the advancements in IT. Today the quality of educational outcomes is not only dependent on the core service but it is also characterized by a productive arrangement of peripheral services.

Unpredictable challenges can come up in implementing educational reforms while developing and adopting these supporting services. If this happens then the results of educational reforms move away from the purpose for which they were implemented. Challenges and their origins can have different shapes and features depending on the local context of each society (Odhiambo, 2011). Understanding the probable broad scale and scope of such challenges, this research follows two cases: a) improving the quality of educational content by implementing IT solutions for knowledge exchange among teachers, b) improving the quality of educational services by applying innovations of the education software service ecosystem.

In the first case, the target is using specific solutions for improving the quality of educational content that is delivered to learners. The main purpose is bundling quality educational content as a service before presenting it to

learners. Existing literature discusses the advantages of adopting innovative IT solutions in education for knowledge transfer from teachers to learners. For example, active communication in a classroom can be enhanced by implementing a multimedia system (Jonassen, 1996; Leidner & Jarvenpaa, 1995; Xu et al., 2014). The Internet removes the digital divide and spatial and temporal restrictions in communication (Anohina, 2005; Aparicio, Bacao, & Oliveira, 2016). In general, technology is helping in improving knowledge delivery from the teacher to the students (Ozdemir & Abrevaya, 2007; Piccoli et al., 2001). What needs to be found out is whether these IT opportunities in education can also help in educational content sharing among teachers.

The second case considers the application of a wide range of innovations on a broad scale of educational services that match existing demand for innovations in academia. Demand for innovations can be observed in an educational institution's knowledge dissemination; administration and management (Sultanov, Kim, & Altmann, 2018); active communication; and information provisioning services. IT innovations have an extensive landscape located in different fields of study which have to be practically implemented cross-sectorally. An example is innovations in the software service ecosystem. The new trend of innovation creation and adoption in software is the provision of software services as a platform to enable third-party developers to create

new composite services by utilizing open interfaces of software and services (Campbell-Kelly, 2009; M. Cusumano, 2010a; K. Kim, Lee, & Altmann, 2015). The business model of this innovation is built on the basis of aggregating third-party developers to release a number of different new services attracting users to these services and gaining economic benefits from the end-users (Gambardella, Raasch, & von Hippel, 2016). Attracting and increasing the number of end-users within the platform depends on sectors (finance, mapping, social networking, and education) where users demand innovations which have to be supplied by providers and third-party developers. Despite having great innovative capabilities, enabling opportunities in the software service ecosystem for improving the quality of educational services is still untapped.

1.2 Problem statement

A major concern in the education sector is building and delivering the most relevant and up-to-date knowledge and educational content to learners (Eames, McKenna, Worrall, & Read, 2003; Van Driel & Berry, 2012). In almost all educational institutions teachers are responsible for the creation of educational content (DiPaola, Tschannen-Moran, & Walther-Thomas, 2004; McHatton, Boyer, Shaunessy, Terry, & Farmer, 2010), and they are the main actors in

transmitting this content to learners. However, this teacher-centred approach in knowledge building comes with the risk of a monotonic conceptualization of knowledge and teaching. In other words, teachers ignore new knowledge in the classroom as it requires extra time, effort, and other resources.

To improve teachers' effectiveness and productivity in the education sector, what is needed is creating an environment for thinking of a new system in which innovations can be applied. This environment should motivate teachers to collaborate on collective knowledge building and changing their attitudes towards using innovations for improving educational services. Two major issues are identified here by reviewing existing studies on innovations and education: a) modelling a service for knowledge exchange and studying teachers' behaviour towards adopting this service; b) applying the innovations of software services in the education sector.

In the first issue, we accept that educational content sharing among teachers is a pattern of knowledge sharing among them. It is targeted at collaborating for creating a collective value for improving the curricula. Knowledge sharing remains significant for the creation of new knowledge (Al-Hawamdeh, 2003). Recent literature underlines the existence of a gap in the patterns of knowledge sharing in educational institutions (Al-Kurdi, El-Haddadeh, & Eldabi, 2018). Besides, structures and the processes of

knowledge sharing within the academia are not known yet and most of the existing literature focuses on knowledge sharing across the boundaries of educational institutions (Dee & Leisyte, 2017).

In general, researchers mention that the lifecycle of the syllabi in technology-related programs is 3.5 years but in computer science, it is 1.5 years (Kalanidhi, 2016). Educational content and syllabi are experiencing decreasing quality and relevance in their lifetimes which the teacher is not concerned with them. This, in turn, leads to the risk of the declining quality of learning outcomes (Giannikas, 2013). This motivates us to raise the issue of new patterns of educational content sharing among teachers to maintain the quality and relevance of the curricula.

We also need to study the behavioural patterns of teachers on the acceptance of the services in which they have to collaborate for collective educational content creation. As a space for interaction of heterogeneous stakeholders (for example, teachers, students, and system holders), the education system can face various challenges while providing services to learners. Solutions are mostly attained through strong relations among the stakeholders (Aimin & Rizen, 2014; Smith & Palmberg, 2009) which can lead to the emergence of new system behaviour (Newell, 2008). The creation and delivery of up-to-date educational content and relevant knowledge to learners

remains a big task for the stakeholders.

In the second issue, we have to understand the market demand for software services and their lifecycle on the basis of patterns of innovation around individual software services, their relations, and their clusters within the education sector. Existing research emphasizes ways of enabling the positive-feedback system by holding core services inside and opening peripheral services to be committed by third-parties (Ceccagnoli, Forman, Huang, & Wu, 2012), adjusting openness of software services (Gawer, 2014), and distinguishing the money side from the subsidy side (Eisenmann, Parker, & Alstyne, 2006). The motivation for the research is investigating if these strategies are enough to enable a positive-feedback system within the software service ecosystem. As per our knowledge, if they are sufficient, then each category of software services can adopt the current approach of innovations at a level similar to social networking or the mapping software service ecosystem (K. Kim et al., 2015).

The education software service category is a good example to consider here. We accent the consistency between the market demand of end-user and the demand coverage by the software service. End-users try to satisfy their broad demands for software services and third-party developers react to this demand by supplying different composite services within the ecosystem

(Eisenmann et al., 2006). Accordingly, the demand and supply mechanisms of the market emerge in the software service ecosystem. Focusing on these concepts of the ecosystem, the current study is interested in the application of software services innovations for improving educational services.

1.3 Research objective

Rapid developments in the IT sector promoted the discovery of new markets located around consumer demand for innovations. Smartphones and their applications market is an example of a recently emerged and rapidly growing market that has expanded its consumer base to almost 30 per cent of the world's population in the last two decades; by 2017 it had reached 2.32 billion users (Simms, 2017). While the global mobile applications market had around 12 million application developers in 2016 (Evans Data Corporation, 2016) the number of mobile application downloads reached 197 million in 2017 (Dogtiev, 2018a), even as market revenue from mobile applications reached US$ 88 billion in 2016 (Dogtiev, 2018b). Statistics show the dynamics and the potential of the mobile applications market around 2.32 billion users.

If one looks at educational participants, there is a potential market with more than 2 billion teachers and learners worldwide (Max Roser, 2017). Let us assume the potential global market for educational innovations in terms of

software services with 2 billion consumers. The question which arises here is about implementing software services for improving educational services.

The demand side of educational innovations comes with existing challenges in adoption and acceptance related to user behaviour. In particular, if the innovations are related to information or knowledge sharing, then the entire business process of the service should be carefully designed by considering user behaviour.

As open knowledge sharing platforms, we can highlight Wikipedia (www.wikipedia.org) which is a free, online, and a multilingual encyclopedia that has been built on a base of users' collaboration in creating knowledge sources. More than 36 million users, almost 140,000 active users (registered users who performed in the last 30 days), and 1,177 administrators of the English version of Wikipedia have created a big repository of knowledge (Figure 1.1).[1]

[1] Wikipedia: Statistics, https://en.wikipedia.org/wiki/Wikipedia:Statistics

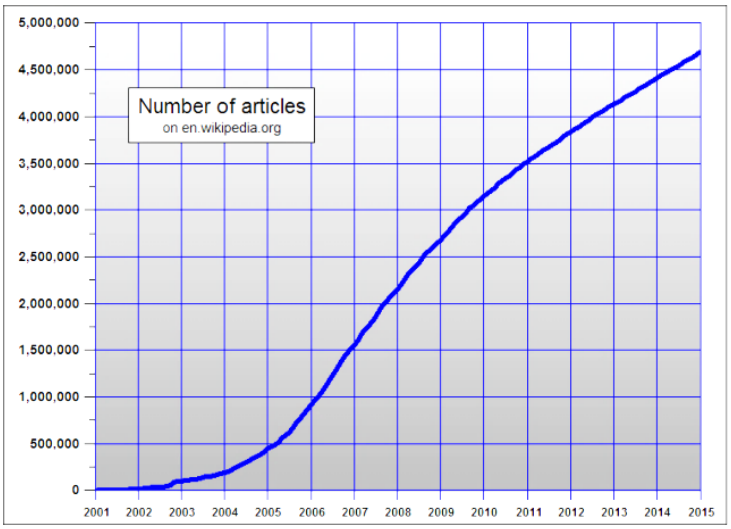


Figure 1.1 English-language Wikipedia article count

Source: Wikipedia: Statistics page, https://en.wikipedia.org/wiki/Wikipedia:Statistics

Figure 1.1 gives the dynamics of the knowledge articles created on the English version of Wikipedia. If we consider that Wikipedia is an online, non-profit platform that has come up with almost 5 million articles in 15 years, then it can be a great motivation for thinking about teachers sharing their knowledge with each other. As the creation of educational content is costly in terms of time, effort, and money, we consider the system within an educational institution or a country level. Furthermore, considering smaller teachers' communities for analysis can be effective in terms of studying possible variations in behaviour, environments, and incentive mechanisms.

Given this background, this dissertation deals with two research problems:

1. Implementation of knowledge exchange services for improving the quality of educational content, and applying incentive schemes for teachers' adoption of such services in different contexts;
2. Addressing the deviations in supply and demand for improving the quality of educational services using innovations of the software service ecosystem.

Addressing these research problems will help maintain the quality of services in the education ecosystem. Tight interactions among the stakeholders gathered around the research problems shape the education ecosystem. These research problems can overlap around the management for the dynamics of the education ecosystem. Figure 1.2 gives the intersection of the research problems in the education ecosystem. It follows an approach of overlapping two problems related to stimulating content exchange and releasing educational innovations through the software service ecosystem in the education ecosystem. Adjusting strategies and policies around the education ecosystem helps in creating healthy interactions among the stakeholders.

Stimulating policies include incentive schemes for motivating teachers to actively exchange educational content. We believe that a properly thought out stimulating policy increases teachers' efficiency in educational content sharing.

The self-organization of the ecosystem helps take progressive steps forward when there is a close interaction among the stakeholders for creating collective value.

Alignment of software services innovations with demand for education is another stimulating strategy for the software service ecosystem's participants to bring more innovations to the education process. Earlier we discussed how education can be a giant consumer as it has more than 2 billion participants. If this is the case then suppliers need to be attracted to this market so that they can adjust their innovations to suit this potential demand. If consumers and providers create value on the grounds of strong cooperation, then an alignment between demand and supply can be successful in introducing innovations in the education ecosystem.

Both the stimulation strategy and the policy maintain that there should be service quality in the education ecosystem. If teachers are stimulated to exchange educational content they can create new methods of teaching based on new knowledge sets. At the same time, new methods of knowledge delivery can lead to the emergence of demand for the innovations which suppliers have to react to. Then the education ecosystem can embrace the stimulation policy and strategies for improving self-organization and outcomes.

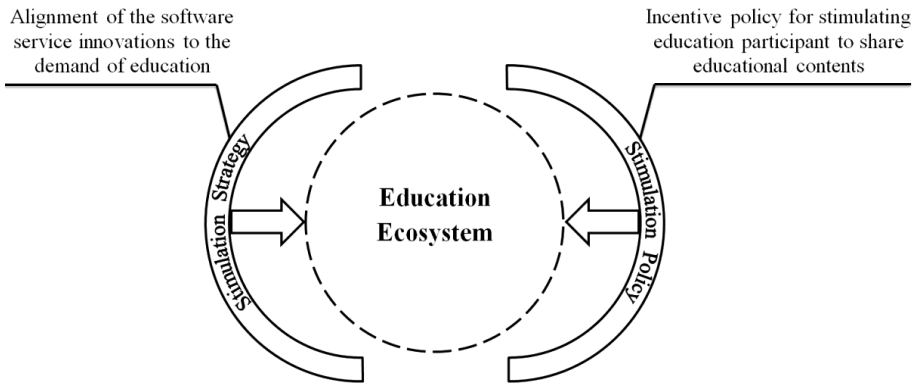


Figure 1.2 The two overlapping research problems in the education ecosystem

Wikipedia is also a good case for understanding how a community of people can co-create value around open resources and within their interactions. This dissertation studies the possibilities of addressing problems in improving educational services following the value co-creation approach by stakeholders. Our goal is collecting the 'power' of all stakeholders around a specific educational problem, namely, improving the quality of educational content and the adoption of innovations for improving educational services. In both these cases, there is an opportunity for the stakeholders to be involved in mutual interactions thus increasing the value of the services. The two research problems shown in Figure 1.2 are good examples of contributing to the quality improvements in educational services thanks to tight interactions among stakeholders. With the aim of finding possible solutions for the two research problems mentioned earlier, this dissertation follows the approach of value co-

creation. The general research objective of this dissertation is:

General Research Objective (GRO): Studying the ecosystem strategies and policies for improving the quality of educational services by stakeholders' value co-creation for knowledge building and innovating for education.

We split this general research objective into three specific research objectives with questions specific to all of them which this dissertation addresses.

1.4 Specific research objectives and research questions

Based on the research problems and the general research objective this dissertation discusses three sets of research questions for its specific research objectives.

The first specific research objective suggests a model of educational content sharing. The model focuses on providing an environment for teachers to collaborate on combining individual values for creating new knowledge sets. Additionally, it includes techniques for encouraging all teachers to improve their performance in knowledge exchange. Knowledge sets and educational content are values and these have to be circulated among the teachers' community. Coming from these aspects the specific research

objective is:

Specific research objective 1 (SRO1): Suggesting an educational content creation model for teachers' collaboration in knowledge exchange enhanced by a stimulation policy by system holders.

The question that is addressed for organizing studies around the suggested model of collaborative educational content creation is:

- Research question 1 (RQ1): How to design an educational environment that supports collective knowledge creation and sharing?

Specific research objective 1 and research question 1 are discussed in Chapter 3.

As a logical and conceptual continuation of SRO1, the second specific research objective focuses on the acceptance of such a collective knowledge sharing environment by the teachers. Accordingly, SRO2 is:

Specific research objective 2 (SRO2): Analyzing the stimulation policies in the education ecosystem for teachers' acceptance of collaborative knowledge creation and exchange.

On the basis of SRO2 the following research questions are formulated and devoted to answering these questions:

- Research question 2 (RQ2): How do teachers behave towards educational content sharing in case there are different payoffs in the

environments?

- Research question 3 (RQ3): How do incentive mechanisms affect teachers' behaviour on educational content sharing?

SPO2 and its research questions are addressed in Chapter 4

The next specific research objective discusses the factors that affect the diffusion of innovations of software services in education. The software service ecosystem is considered as an example of a value co-creation environment. It relies on interactions among different stakeholders and their resources. Based on this the third specific research objective is:

Specific research objective 3 (SRO3): Studying stimulation strategies for the adoption of software service innovations in the education sector through supply and demand adjustments.

To address this research objective the research questions are:

- Research question 4 (RQ4): How frequently is a software service in education re-used to create composite services?
- Research question 5 (RQ5): Does a software service in education lead to any relations among the software services?
- Research question 6 (RQ6): How many software services in education are embedded in clusters of software services?

SPO3 and its research questions are addressed in Chapter 5.

1.5 Visualization of the research process

Figure 1.3 gives a graphic representation of the research process. It has three main blocks ‘stakeholders’, ‘value co-creation around education services’, and ‘outcomes for stakeholders’. The stakeholders block includes actors who are actively joining hands for the provisioning and consumption of education services. These are managers, teachers, students, the learning environment, and educational content.

The value co-creation block represents the main construct of the research which is divided into two parts: a) creation and consumption of software services in an education ecosystem, b) collaborations on educational content creation and exchange. Actors’ interactions and the value exchanging process are given for each part of the research construct. Finally, in the last block, outcomes are shown for all the education stakeholders.

Figure 1.3 also shows how stakeholders in the education sector can obtain value by getting involved in the suggested ecosystems which focus on collective value co-creation. The ecosystem of ‘educational content sharing’ is addressed by SRO1 in Chapter 3, which also discusses the suggested model in detail. To test the dynamics of an ecosystem of educational content sharing, SRO2 gives an analysis of teachers’ behaviour towards the adoption of such a

system. Chapter 5 includes an innovation creation and diffusion analysis of the software service ecosystem in which interactions among stakeholders is described on top of the value co-creation block in Figure 1.3. SRO3 investigates the current status of adopting software service innovations in education and provides guidelines for increasing the diffusion of composite services in the education sector.

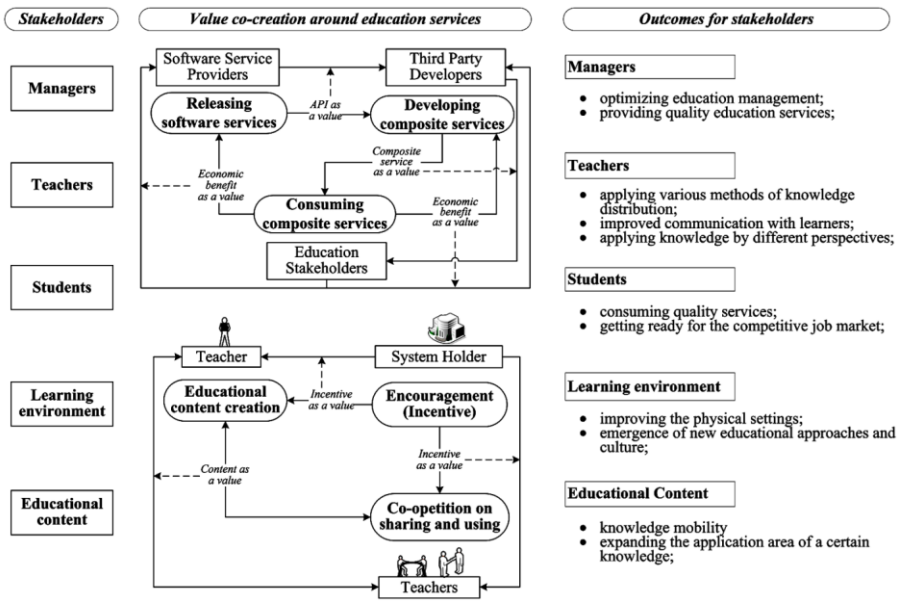


Figure 1.3 Visualization of the research

A graphic display of the research process shows the main philosophy of the research from the beginning to the conclusion and the particular research methods that are used in this process.

1.6 Research outline

This dissertation has six chapters (Figure 1.4). Chapter 2 discusses the theoretical and practical aspects of IT and innovation adoption in education. It discusses the key players and drivers of reforms and innovations in the education sector, case examples, facets of knowledge sharing, and educational content creation to highlight the theoretical concept of the dissertation.

Chapter 3 gives the model of interactions among stakeholders for creating collective value. It suggests a model of educational content sharing among teachers and discusses this model. This chapter also describes shared values among stakeholders in terms of knowledge and incentives.

Chapter 4 investigates the impact of environmental characteristics and incentive mechanisms on teachers' behavioural changes in educational content sharing. It does the agent-based modelling simulation analysis applying well-known iterated games - prisoner's dilemma, the snow-drift game, and the stag-hunt game. It discusses the practical and theoretical implications of the results of the simulation analysis.

Chapter 5 is devoted to finding answers to research questions on innovations in an education software service ecosystem by discussing one of the biggest software and composite service ecosystems,

www.programmableweb.com. The collected data and the research concept is also described in this chapter which also gives the metrics of the social network analysis that are applied. It discusses the results of the analysis and gives their theoretical and practical implications for academia, providers and developers of software services, and end-users.

Chapter 6 gives a summary of the dissertation by discussing its contributions and findings. Besides, it also highlights the limitations of the research and gives suggestions for future research. Figure 1.4 gives an outline of the dissertation showing how the chapters are related.

Phase	Structure	Components	Details
Research Context	**Chapter 1. Overall Introduction**	Research Motivation:	New generation of education services should be enhanced with the innovations of IT. Education services have to support collective value creation among teachers for building and delivering the knowledge
		Research Problem	• The tasks related to the development of knowledge exchange environment in education • The tasks related to the innovations of software service ecosystem to enhance the education services; • The issue related to the behaviour of teachers on accepting knowledge exchange environment
		General Research Objective	Studying the ecosystem strategies and policies for improving the quality of educational services by stakeholders' value co-creation for knowledge building and innovating for education.
Literature Review	**Chapter 2. Literature Review on Innovations and Education**	Innovations around education	• IT Adoption in Education • Value co-creation • Relations of software service ecosystem to the innovations in education • The Importance of Knowledge Sharing in an Education
		Aspects of private and public sector in innovation	• Difference of Government Demand and Consumer Demand • Innovation in the Public and Private Sector
Research Methods and Experiments	**Chapter 3. Value Co-Creation Models for Improving Education Service**	Research Questions	**RQ1**. How to design an education environment supporting collective knowledge creation and sharing?
		Method	Stakeholders' Activity modelling
		Findings	• Defined a stakeholders' interaction model for value co-creation; • Suggested a model for the knowledge sharing among teachers
	Chapter 4. ABM Analysis of Exchanging Educational Contents among Teachers	Research Questions	• **RQ2**. How do teachers behave towards the educational content sharing in case of different payoffs within environments? • **RQ3**. How do incentive mechanisms affect the behaviour of teachers on educational content sharing?
		Methodology	• Agent-Based Modelling by applying Iterated Games (Prisoner's Dilemma, Snow-Drift and Stag-hunt games)
		Findings	• Incentive schemes can affect the sharing of educational contents; • Altruistic teachers will take advantages when the incentive is enough; • Ego-centered and responsive teachers will take advantageous in case of no incentive by the system holder
	Chapter 5 Innovation of Education Services in a Software Service Ecosystem	Research Questions	• **RQ4**. How frequently is a software service in education reused to create composite services? • **RQ5**. Does a software service in education lead the relations among software services? • **RQ6**. How many software services in education is embedded in clusters of software services?
		Methodology	• **Analysis methodology**: Social Network Analysis • **Data:** Software and composite service data from www.programmableweb.com
		Findings	• Education services are not matured yet, and it is not because of the insufficient supply; • Because of the deviation of software services from the market demand.
Conclusion	**Chapter 6. Concluding Remarks**	Summary of the results	Summary of the results of experiments have been discussed
		Major contributions of the dissertation	Major contributions of the study have been discussed
		Implications for the education stakeholders	Implications of the results of the dissertation to the education stakeholders have been discussed
		Limitations and future outlook	The limitations have been highlighted, and links have been shown to the future work

Figure 1.4. Research outline

Chapter 2. Literature Review on Innovations and Education

2.1 Organization of the literature review in the entire dissertation

This dissertation does a review of the literature in the chapters that follow. Figure 2.1 gives the organization of the literature review for the thesis.

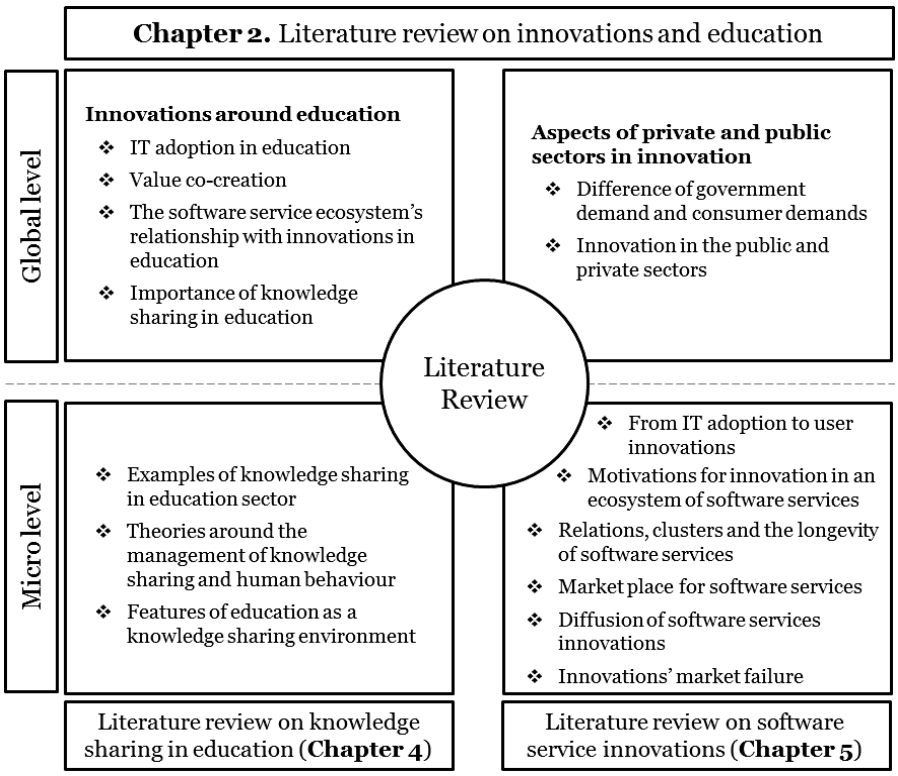


Figure 2.1 Organization of the literature review

This chapter includes a review of existing studies at the global level (broad range), covering the basic and main concepts related to the thesis. This is organized around two broad topics -- 'Innovations around education' and 'Aspects of the private and public sectors in innovations'. They are given as sections and discuss various aspects. Chapter 4 and Chapter 5 cover literature related to the topic discussed in each research work respectively. All text in bullet points in Figure 2.1 shows the title of the part covering the specific topic.

2.2 Innovations around education

2.2.1 IT adoption in education

Education is communication on a specific subject between a teacher and his/her students and among students (Frymier & Houser, 2000; McCroskey & Andersen, 1976). Talking in a certain physical place was a typical way of communicating in ancient Greek schools, medieval universities, and in modern classrooms (Goldin, Pezzatti, Battro, & Sigman, 2011). As books remove temporal and special constraints of communication, a teacher can spread the knowledge quickly and widely among students who can buy a book and read it (Frymier & Houser, 2000). In the last two decades educational

practitioners and experts have started paying attention to information technology (IT) that supports communication among people acting as a key to education and the fast adoption of IT in education for distant communication, easy modification of teaching material, and visualization of its object (Alavi, 1994; Alavi, Wheeler, & Valacich, 1995; Gupta & Bostrom, 2013; Leidner & Jarvenpaa, 1993; Ozdemir & Abrevaya, 2007; Söllner, Bitzer, Janson, & Leimeister, 2017). IT in education promises to increase learners' motivation towards learning by enhancing their communication skills, cultural awareness, aiding their preparation for global job markets (Fabos & Young, 1999), and ensuring access to diverse knowledge content from multiple perspectives (Smeets, 2005).

IT adoption in education has transformed teaching and learning both in classrooms as well as out of classrooms. First, IT mediates the communication between a teacher and his/her students, and among students in a classroom (Alavi, 1994; Alavi et al., 1995; Jonassen, 1996; Leidner & Jarvenpaa, 1993, 1995; Santhanam, Sasidharan, & Webster, 2008; Xu et al., 2014). If traditional education focused on a unidirectional knowledge flow from a teacher to students, IT in a classroom extends education in constructivist, sociocultural, cognitive, and collaborative ways (Leidner & Jarvenpaa, 1995). In other words, personal computers connected to each other through the Internet help

students share their knowledge to build new knowledge using their practices (Jonassen, 1996; Santhanam et al., 2008). Multimedia systems and an interactive and simulation environment also help students' cognitive experiences through concrete examples (Leidner & Jarvenpaa, 1995; Ozdemir & Abrevaya, 2007; Webster & Hackley, 1997) and increase performance parity by reducing the inequalities in the learners` progress (López, 2010). This help promotes creative thinking among students, while the conventional method is limited around bringing knowledge to learners (Tezci, 2011).

Second, IT reduces spatial and temporal restrictions in communication between a teacher and his/her students (Anohina, 2005; Aparicio et al., 2016; Chang, 2016; Jonassen, 1996; Keleş & Özel, 2016; Leidner & Jarvenpaa, 1995; Ozdemir & Abrevaya, 2007; Piccoli et al., 2001; Santhanam et al., 2008; Tomei, 2008; Wan, Wang, & Haggerty, 2008; Webster & Hackley, 1997; D. Zhang, Zhao, Zhou, & Nunamaker Jr, 2004). Recent literature on knowledge management and sharing emphasizes that IT can enhance the flow of knowledge over wide geography if the shared knowledge is in the common interest of peers (Forman & van Zeebroeck, 2018). Using the Internet, education can also be provisioned to students who cannot come to classrooms (J. J. C. Sánchez & Alemán, 2011) as they live in distant areas such as the Australian Outback (Ozdemir & Abrevaya, 2007).

Video conferencing and online transmission of class material reduce the differences between a physical classroom and a screen (Webster & Hackley, 1997). Using web services, teachers can provide their services to a bigger market which has no size limitations instead of a classroom of 50 students at the most (Alavi et al., 1995). As a lecture is stored on a web server, a student who finds it difficult to match the classroom schedule can attend the class on screen at a convenient time (D. Zhang, Zhou, Briggs, & Nunamaker Jr, 2006). This paradigm of learning was enhanced recently with the possibilities of podcasting of media content (Evans, 2008), first-person viewing of real-time video streaming using distant environments through augmented and virtual reality (Bower & Sturman, 2015), and using supporting social networking systems that increase interactivity among education actors by motivating collaborative learning (Hamid, Waycott, Kurnia, & Chang, 2015).

In summary, IT adoption in education removes physical, spatial, and temporal barriers leading to interactive and distant communication. This technological advancement has led IT entrepreneurs to provide facilities that support teaching and learning (Ozdemir & Abrevaya, 2007) and extend beneficiary groups of education (Mumtaz, 2000; Straub, 2009; Tabata & Johnsrud, 2008), although it does not provide all functions of traditional education such as emotional interaction through physical touch (Wan et al.,

2008). Emerging and popular technologies among the youth are fast and can be extensively used for educational purposes, for example, m-learning solutions can be effective as most of the learners adopted mobile technologies (Cheon, Lee, Crooks, & Song, 2012). The economies of scale in education reduce the price of education (Webster & Hackley, 1997) and potentially increase the quality of education services (Söllner et al., 2017). If IT opens a new market in education, the issues that remain are whether and how actively the market will pull the innovations (Dosi, 1982).

At a macro-level, the success of IT adoption in education is dependent on the education provider's ICT plan and the regional and countrywide ICT policy (Tondeur, Van Keer, van Braak, & Valcke, 2008) which can reduce the digital divide and strengthen the quality of education (Skryabin, Zhang, Liu, & Zhang, 2015). Decision makers need to carefully design ways of transforming efforts and investments in IT into productivity and efficiency of organizational performance (Sabherwal & Jeyaraj, 2015) in the education sector. At the micro-level, this will be more sensitive to the behaviour of learners and teachers towards IT usage in everyday activities. Besides, technology providers can also contribute to IT's effective and intensive adoption by enhancing technology support and technology knowledge transfer to consumers (Retana, Forman, Narasimhan, Niculescu, & Wu, 2018).

Availability of technology or its mandatory use in the classroom does not bring IT's effectiveness to education as it needs teachers` understanding and true belief that technology can enhance the education process (Y. Baek, Jung, & Kim, 2008).

Teachers' belief in IT in education is related to teaching methods, for example, constructivist teachers trust the possibilities of IT in the classroom more than traditional teachers do (Hermans, Tondeur, van Braak, & Valcke, 2008). The correlation between technology and learning models can be seen in actual achievements of learners such as in MOOCs which have a very low completion rate where learners are taught following the objectivist-individual approach (Toven-Lindsey, Rhoads, & Lozano, 2015). Hence, using multiple methods makes education more interactive and helps in achieving more learner outcomes (Kong, 2014; Z. Yang & Liu, 2007). Despite its positive value, IT in education is not always immediately productive as it seeks complex solutions around education (Muir-Herzig, 2004) but the education process is time dependent and cannot be reformed overnight (Ghaffarzadegan et al., 2017).

2.2.2 Value co-creation

Economic progress on the global scene has led to the modern phenomenon of market mechanisms becoming important. These mechanisms tend to refine not only the supply and demand concepts around products and services but have also shaped a tight interaction between the parties in economic exchange. A comparatively new economic phenomenon called 'value co-creation' has been introduced as a way of collaboratively creating value through interactions among parties in a mutual exchange (Galvagno & Dalli, 2014; Vargo, Maglio, & Akaka, 2008). From a market perspective of products and services, value co-creation refers to the joint creation of value by the provider and the consumer (Prahalad & Ramaswamy, 2004; Ranjan & Read, 2016) through the merger of their resources and use of expertise (Vargo & Lusch, 2008; Vargo et al., 2008). This approach to a product or service helps avoid the provider-centred way of creation to an interactive co-creation by the beneficiary parties (Fagerstrøm & Ghinea, 2013; Grönroos, 2008).

Value co-creation only happens when there is more than one party involved in developing a product or service and there is tight integration between the parties especially in openness about resources (Vargo et al., 2008). Existing literature argues that involving the expertise and experience of the

consumer in the creation process enhances competitive advantages (Prahalad & Ramaswamy, 2004). Highlighting the importance of interactions among parties, one study states that co-creation emerges only if there is direct interaction among the provider and the consumer (Grönroos, 2011). From this perspective, the locations of the provider and consumer are on the same side of the supply and demand space and they jointly work for further opportunities (Galvagno & Dalli, 2014).

An important point for the provider is detecting consumers' desire and demand for supplying a new product or service to the market or improving an existing one (Payne, Storbacka, & Frow, 2008). For example, the software service ecosystem of the education sector is inactive when it comes to innovations in the education process because of an improper relationship between supply and demand (Sultanov et al., 2018). This software service ecosystem supports the statement that parties suggest the potential value to each other, instead of one party creating value for another party (Grönroos, 2011; Vargo & Lusch, 2011).

Interactions among parties depend on resources which all parties add to the value and cooperate through them (Díaz-Méndez & Gummesson, 2012). Accordingly, integrating the parties' available resources has a more significant role as compared to co-producing, since the value is added by extraction of

certain resources that are merged for co-creating a new value (Hilton, Hughes, & Chalcraft, 2012). Here all parties have to be responsible for the co-creation of a new value (Dorri, Yarmohammadian, & Nadi, 2012). For instance, providing open software services enables third-party developers to add their value and create new composite services. Attracting end-users to help expand the demand for software services through their composites can be managed by creating a feedback system.

Despite the comparatively recent emergence of the concept of value co-creation, researchers and practitioners have already applied it in different areas (Galvagno & Dalli, 2014). Education is also a good example of mobilizing the stakeholders and their resources to co-create the necessary value for the well-being of the sector. Let us assume that teachers co-create value around educational content. Teachers can improve content as individual parties creating value and they can also contribute to value co-creation and improve other participants' resources (Osborne, Radnor, & Strokosch, 2016). Considering education as a service we can underline that mutual interactions characterize resource integration, referring to contributions by all teachers (Hilton et al., 2012). Currently, social networking services facilitate education participants to exchange their educational content, interact with each other, and co-create educational value (Fagerstrøm & Ghinea, 2013). System holders

have to think about appropriate compensation mechanisms so that teachers are not treated unfairly in the process of value co-creation (Galvagno & Dalli, 2014).

2.2.3 The software service ecosystem's relationship with innovations in education

The new paradigm of innovations builds an ecosystem of software services. Software services support creating composite services; composite services satisfy end-users' demand while composite services provide economic returns to the software services that they are based on (Haile & Altmann, 2016b; K. Kim et al., 2015). Furthermore, some software services supplement other software services; they also compete with them. For example, Yahoo is Google's competitor in the search engine market yet the software services of the two rivals are used in creating Maps Compare, in which one covers what its counterpart does not deal with ("ProgrammableWeb," 2019).

Kim et al. (K. Kim et al., 2015) call a 'software service ecosystem' the intertwined relationship among software services and composite services by using the analogy of an ecosystem of animals, plants, and fungi that form complicated competitive and symbiotic relationships. The market for such an ecosystem is captured by the factors and policies surrounded by the network

effects within a platform and pricing rules related to awareness and trial versions even after a price-free competitor enters the market (Gallaugher & Wang, 2002).

The competitive advantage that a software service provider has in the market as compared to a traditional software supplier can be measured in relation to the network effect and the time period used in making quality improvements to a new product (Guo & Ma, 2018). In order to compete with other rivals, platform provider extends the openness of the platform that is not costly but increases the spillover of software service developers who can create value within a platform (Parker, Van Alstyne, & Jiang, 2017).

The software service ecosystem shows the characteristics of an open innovation paradigm by combining internal (API) and external (Mashup) ideas in the platform business model (Chesbrough, 2006; K. Kim & Altmann, 2012). These innovations in the ecosystem are categorized according to the functions of software services such as mapping, social (networking), finance, videos, and photos. Similarly, the education category of software services is an example that highlights the progress made in the education sector using technology innovations (Bicen & Uzunboylu, 2013).

The education category of the software service platform, www.programmableweb.com had 425 software and 127 composite services in

August 2018 (“ProgrammableWeb,” 2018b, 2018c). “Those services extend the area of IT in education from communication within and over a classroom to anything related to education, including knowledge dissemination and education administration” (Sultanov et al., 2018).

For instance, by opening API for third-party developers, Mendeley enabled the emergence of innovations for researchers to manage bibliographies and formalize them in an easier way (Mendeley Ltd., 2018). To create better services for learners, applicants, and their parents, UC Berkeley has opened its software service for providing data on ‘applicants’ status’ and ‘class information’ (Berkeley University of California, 2019).

Innovations in social networking services contribute to education in multiple ways such as supporting communication and providing knowledge flows among education participants. Existing research mentions the increasing patterns of communication in the learners’ community by using social networking services like Facebook and Myspace (Selwyn, 2009). Another study underlines the extension of the usage purpose of social networking services (Facebook) from a social communication medium to a tool for informal and formal education (Towner & Lego Muñoz, 2011). By providing open software services, Facebook has expanded its contribution to the education sector. In August 2018, nine composite services in the education

category were released by re-use and concurrent re-use (with other software services) by Facebook (Sultanov et al., 2018). To fulfil the demand by learners, social networking services have been ensuring opportunities for knowledge sharing among communities of learners. In this way, the software service ecosystem has contributed to the education sector especially to knowledge exchange among education participants.

In general, composite services in the education sector have helped enhance knowledge sharing and educational administration processes based on open API. For example, DonorsChoose.org provides the public with its software functions for supporting classrooms in need by funding through an online charity (DonorsChoose.org, 2019). To use mapping services, Google Inc. is providing developers access through API to one of its most popular projects Google Maps (Google Inc., 2019). Chevron and DonorsChoose.org have launched an innovative collaboration project called Fuel Your School (Chevron), that used a Google Maps and DonorsChoose software services to develop a composite service on charity funding for appropriate classrooms in public schools (Chevron Corporation, 2019).

Different IT applications are being embraced by the education sector such as social networking services, (Roblyer, McDaniel, Webb, Herman, & Witty, 2010), artificial intelligence (McArthur, Lewis, & Bishary, 2005),

smartphones (J. Kim, Ilon, & Altmann, 2013), wearable technologies (Bower & Sturman, 2015), cloud computing (Ercan, 2010), and augmented (Billinghurst, 2002) and virtual reality (Freina & Ott, 2015). Different from existing research on the adoption of IT applications in education, this dissertation considers the software service ecosystem as an example of IT. Accordingly, it investigates the current status of the education software service ecosystem and discusses its contributions to educational innovations (Chapter 5).

2.2.4 Importance of knowledge sharing in education

Importance of knowledge sharing within an organization is explained by the acceleration in generating diverse knowledge to invent and innovate faster than its competitors. Relatively, collective knowledge within an organization ensures that it has a competitive advantage over its competitors (Cabrera & Cabrera, 2002). Motivating people to share their knowledge is one concern for organizations which can be addressed through implementing incentive systems (Faith & Seeam, 2018; Hung, Durcikova, Lai, & Lin, 2011; Muller, Spiliopoulou, & Lenz, 2005). Incentive systems have to be developed to ensure that the rewards for knowledge sharing are more than the cost of knowledge and its sharing (Al-Kurdi et al., 2018; Cheng, Ho, & Lau, 2009;

Tan, 2016).

Educational institutions in underdeveloped countries generally offer a curriculum to their students without considering the demand in society and industry. Therefore, there are some challenges in providing flexible human resources which have skills and knowledge about solving various problems (for example, working in various teams and managing different projects) (Kouwenhoven, 2010). Existing research examines different challenges that education systems and institutions face within local country contexts. For instance, Odhiambo (2011) studied the problems of the higher education system in Kenya concerning quality mechanisms in the context of decreasing incomes, political interventions, and negative factors of globalization. The study highlighted that the education system needs a clear policy of awarding, supporting, and retaining capable personnel (Odhiambo, 2011).

Discussing the education system in Egypt, Louisa states that the main reason for unemployment in the country is irrelevancies between the skills of the graduates and the demands of the job market (Louisa, 2012). It is almost impossible to provide quality education when there is a deficiency in educational content (books, journals, laboratory facilities). Creation of effective educational material and content is one of the main challenges for any education system (Holohan, Melia, McMullen, & Pahl, 2005).

2.3 Aspects of the private and public sectors in innovations

2.3.1 The differences between government and consumer demands

Innovation studies mainly rely on two perspectives of development -- diffusion and adoption of innovations that are called technology push and demand pull. Technology push is characterized by advanced science and technology which can offer new innovations and further change the rates and trends of innovations in the market (Di Stefano, Gambardella, & Verona, 2012; Gallié & Legros, 2012; Nemet, 2009). From the demand pull perspective, consumer demand for certain products or services motivates market suppliers to innovate to satisfy this demand (Di Stefano et al., 2012; Gallié & Legros, 2012; Nemet, 2009). What will be more effective is if suppliers find a balance between the two perspectives if they want to strengthen and widen their positions in the market (Di Stefano et al., 2012). The next few paragraphs discuss the demand side of the market, especially how demand shapes the market and what role the government and private consumers play in this market demand.

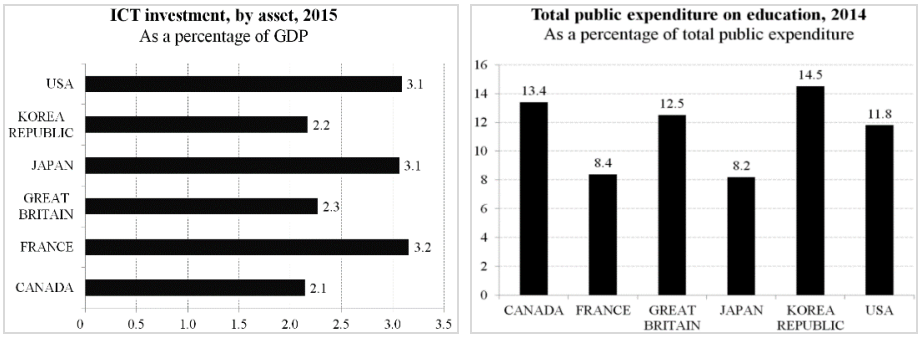
Existence of demand in the market is seen as a potential impulse for

suppliers to start innovating (Edler & Georghiou, 2007; Nemet, 2009) as this leads to innovation trajectories going to the correct market location (Di Stefano et al., 2012; Dosi, 1982; Gallié & Legros, 2012). However, demand in the market is not always stable (Adner, 2004; Priem, Li, & Carr, 2012). The demand side of the market can be divided into public (or government) and private (consumer) demand where the government can implement an innovation policy or opt for public procurement for pushing suppliers to innovate while at the same time private consumers follow their own needs to motivate suppliers to innovate.

Government demand for products and services is characterized by the emergence of a new market term called public procurement (Dalpé, DeBresson, & Xiaoping, 1992; Edquist & Zabala-Iturriagagoitia, 2012). Public procurement not only aims at executing government purchases in already existing markets but it also orders products or services that do not exist in the market making it a strong motivation for suppliers to innovate (Chicot & Matt, 2015; Edquist & Zabala-Iturriagagoitia, 2012; Hommen & Rolfstam, 2009). As classic diffusion studies tell us, demand is of great importance for innovation diffusion (Rogers, 2010). Hence, public procurement can foster the diffusion of innovations in a large group of users, generate readiness to pay higher costs (not always), and be responsible for

bringing innovations to the public sector (Chicot & Matt, 2015; Geroski, 2000). Sometimes the public sector joins the market in purchasing products and services for activating private consumers in a particular market; later suppliers gain more value from private consumers' demand (Edler & Georghiou, 2007).

Early research proves that there are particular types of products and services which the government consumes and where it drives innovation processes (for example, hospitals and electric power), while the rest of the product and service markets (for example, cars and electrical products) are mostly activated by private consumers (Dalpé et al., 1992). There are heterogeneous consumers in the market with their own needs for products and services and addressing their needs requires suppliers to invest in research and faster innovating (Priem et al., 2012). At the same time, private consumers can also join the innovation cycle in the market by creating end-user innovations (de Jong, Gillert, & Stock, 2018; De Jong, von Hippel, Gault, Kuusisto, & Raasch, 2015; Halbinger, 2018; Von Hippel, De Jong, & Flowers, 2012; Von Hippel, Ogawa, & de Jong, 2011), or a supplier can create an environment for properly communicating with consumers to get information about existing trends in consumer demand (Di Stefano et al., 2012).



a) **b)**

Figure 2.2 a) IT investments, by assets in 2015 as a percentage of GDP[2], **b)** Total public expenditure on education, 2014, as a percentage of total public expenditure[3]

Countries which correctly estimate the value of IT and the education sector for economic growth invest in the development of both sectors. Figure 2.2 shows IT investments as a percentage of GDP in 2015 and the total public expenditure on education as a percentage of total public expenditure in 2014 for seven OECD countries. Considering these countries as the biggest economies in OECD we argue that all countries targeted an increasing role for IT and the education sectors in their economies and for further development.

The great potential that IT has in the education sector has led governments to spend sizable amounts on IT adoption in education (Blignaut, Hinostroza,

[2] OECD Report. *OECD Science, Technology and Industry Scoreboard 2017*. Available athttps://doi.org/10.1787/9789264268821-en

[3] OECD Report. *Education at a Glance 2017*. Available at https://doi.org/10.1787/eag-2017-en

Els, & Brun, 2010; Livingstone, 2012; Machin, McNally, & Silva, 2007). However, most of the projects on adopting IT in education have not been successful due to the complexity of government policy being implemented in practice (Younie, 2006). Accordingly, global society is still finding a gap between the efficiency of investments in IT and the positive outcomes of the education process (Buabeng-Andoh, 2012). Early literature emphasizes that despite significant investments in IT, the education sector lagged behind industry in IT adoption (Leidner & Jarvenpaa, 1995), and did not achieve expected transformations in the sector (OECD, 2016).

Existing literature highlights the importance of the government`s role in the well-being of the education sector and the implementation of various technology solutions for improving the sector. Sánchez et al. stress that public policy in educational reforms is a fundamental factor in creating a knowledge enhanced society (J. Sánchez et al., 2011) as greater government investments and efforts in OECD countries led to better technology bases in educational institutions in the last few decades. But there are still concerns about less integration of technologies with the teaching and learning process which IT should serve (OECD, 2016). Despite great efforts by governments to improve IT adoption in education, experts argue that the education sector is weak in implementing innovations and leading educational technologies (Foray &

Raffo, 2014). This is probably driven by skill deficient teachers when it comes to IT adoption in education and integrating IT into everyday practices in schools (OECD, 2016).

Niemi et al. (2013) discuss Finland's experience of IT integration in education for improving its education sector where government plans and strategies played a crucial role in developing an information society and providing technology-enhanced education. Stevenson (2013) emphasizes The British government's expenditure on forming a technology base for modern education, and training of staff on IT integration in teaching and learning. Discussing IT adoption in education, literature shows the Korea Republic as one of the leading countries. Existing research pays attention to the efforts and investments of the Government of Korea Republic in IT adoption in education which made the country one of the leaders at the global level in implementing e-learning and IT integrated education (J. Sánchez et al., 2011). In the Korea Republic, most of the initiatives in education are driven by the government and they are focused on developing digital educational content and bridging the educational divide by implementing smart education solutions using modern innovations in teaching and learning (Grzybowski, 2013). These examples show that for developing a technology-savvy society, using IT for education and innovative learning and teaching can be done if there are strong

policy and investments by the government.

2.3.2 Innovations in the public and private sectors

When distinguishing the public and private sectors, scholars pay attention to the business and operational targets of entities in the private sector whose purpose is making profits and the public sector where the aim is providing services with not-for-profit objectives (Lachman, 1985). Such a difference between the public and private sectors also shows distinct dissimilarities in the innovation activities undertaken by both the sectors. Innovation studies on the private sector discuss providing goods and services to the market with profit associated commercialization. However, the public sector innovates for improving public services and performance (Arundel, Bloch, & Ferguson, 2019; Nugroho, 2011). Following the core ideas of innovation and commercialization, the private sector is more intent on advancing R&D activities and protecting intellectual property rights which are less appropriate for the public sector (Arundel et al., 2019).

The reasons for innovating in the private sector include business owners' motivation for attaining more profits while for employees these include improving productivity and efficiency (Demircioglu & Audretsch, 2017). Both employees and business owners' motivations for innovation are driven by

market competition where to survive in the market all participants fight for more innovation adopters (Hartley, Sørensen, & Torfing, 2013). Organizational survival for private players in the market depends on innovation development and knowledge creation. To improve innovation development private organizations focus on bundling local methods and technologies to bring viable innovations to the market while simultaneously they also get involved in knowledge creation by using both local and external sources to create the seeds for future innovations (Miller, Fern, & Cardinal, 2007).

In the public sector, the main reasons for innovations are the need for new or elaborate public services and financial issues (Hartley et al., 2013; Walker, 2006). The motivation to innovate in the public sector is driven by an aspiration for acquiring a good reputation and growth. Further, the desire to be re-elected pushes the elected members in the public sector to run innovation-related programs (Hartley et al., 2013). Accordingly, internal changes, external effects, and independent decisions in developing innovations create an environment for public sector innovations which ensures improved service delivery and functional improvements in their organization (Walker, 2006). At the employee level, innovations in the public sector can be built on trust (in organizational strategies and interpersonal trust), availability of an

environment for experimenting, feedback, and the motivational mechanisms used by the top managerial level in the performance of the employees (Demircioglu & Audretsch, 2017).

Understanding the value of innovations in economic growth, the public sector encourages the private and non-profit sectors to innovate by providing regulations, R&D subsidies, following tax cut policies, and providing infrastructure for science and technology which are some of the examples of public sector innovations (Aschhoff & Sofka, 2009). The role of the public sector is significant in developing regulations and the national innovation policy. In developing countries, in particular, the public sector plays a pioneering role in creating an industry active environment using which the private sector can prosper (Hu & Mathews, 2005). By implementing innovative policies, the governments tend to drive both the private and public sectors to increase their innovation capabilities and produce competitive products or services which can strengthen the position of the country in the global economic space (Kuhlmann, 2001).

The public sector is more sensitive to policy and regulations on innovation activities so some of the policy implementations are also seen as government innovations while it is impossible to find these in the portfolio of innovations of any business entity (Arundel et al., 2019; Arundel, Casali, & Hollanders,

2015). The distinguishing characteristics of innovations in the public sector include less innovation capabilities, barriers of bureaucracy, reluctance to changes, and risk-taking (Arundel et al., 2019, 2015). Discussions on innovations in the literature show that the basic concept of innovations in the public sector is technology adoption (Arundel et al., 2019; Bretschneider & Wittmer, 1993). The public sector's demand for products and services is characterized by the emergence of a new market term called public procurement (Dalpé et al., 1992; Edquist & Zabala-Iturriagagoitia, 2012), which has been discussed in the previous subchapter.

Chapter 3. Value Co-creation Models for Improving Educational Services

3.1 Stakeholders' interactions for educational services

Delivering up-to-date and high-quality educational content is a big topic in the education sector. Existing literature argues that the lifetime of the syllabi for technology programs is 3.5 years but computer engineering programs are advised to update educational content every 1.5 years (Kalanidhi, 2016) otherwise the education system will have to deal with poor syllabi and outdated content which will lower the quality of learning outcomes (Giannikas, 2013). Poor learning outcomes as a result of outdated syllabi and content can negatively impact further economic development in a country (Asikhia, 2010; Ghaffarzadegan et al., 2017).

Figure 3.1 gives interactions among stakeholders for educational content exchange. The rectangular blocks show the stakeholders and the oval-shaped blocks represent a certain function of the stakeholders. The arrow lines between stakeholders show the interactions on value among the stakeholders and the lines between the functions show the functional relatedness of the

stakeholders. In general, a teacher creates educational content and shares it with his/her colleagues; simultaneously other teachers also do the same thing. System holders encourage all teachers with various kinds of incentives to share educational content and use others' content (if necessary) to create up-to-date and better educational content.

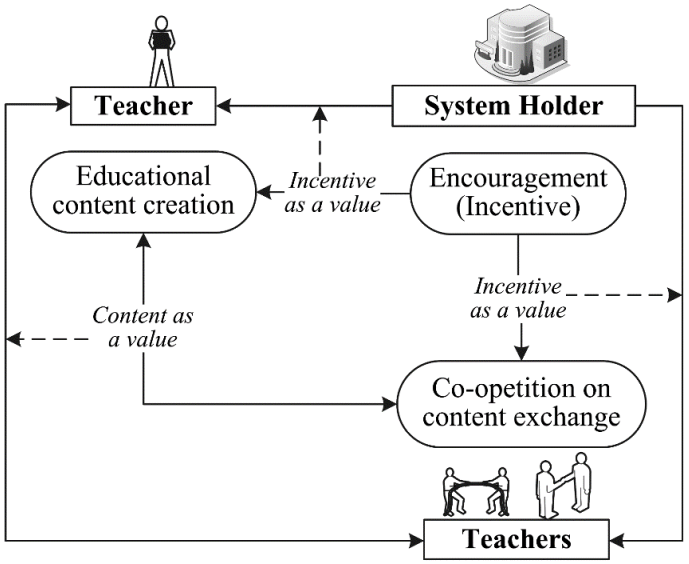


Figure 3.1 Model for the stakeholders' interactions on educational content exchange

An interaction model for improving the adoption of software service innovations in the education sector is given in Figure 3.2. The model is considered as a part of the software service ecosystem and its stakeholders' interactions.

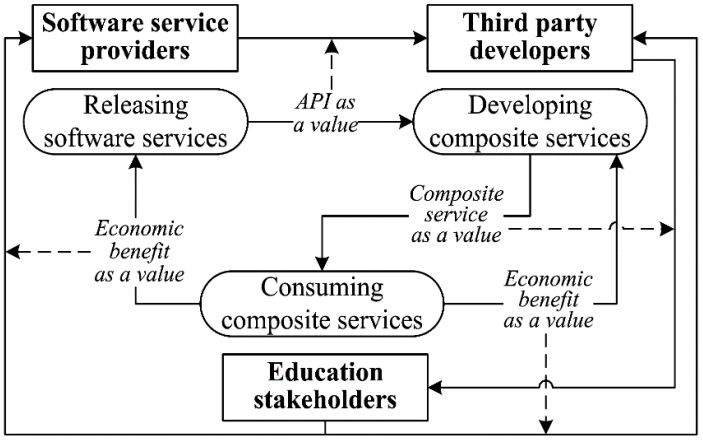


Figure 3.2 Model of interactions in the software service ecosystem and education stakeholders

Stakeholders in the ecosystem are described in rectangular shapes while the ovals include the main functions of each stakeholder in Figure 3.2. Software service providers open their APIs, that is, open value for third-party developers to create composite services (Koohborfardhaghighi & Altmann, 2015). New innovations emerge when a third-party developer adds new value to a software service. Education stakeholders consume composite services and at the same time, they provide software service providers and third-party developers with economic benefits. This interaction and value exchange between the parties in the software service ecosystem is shown with arrow lines and they clearly represent the flow of value among stakeholders.

3.2 Description of the proposed model for educational content sharing

This section addresses SRO1, that suggests a model of educational content exchange.

Specific research objective 1 (SRO1): Suggesting an educational content creation model for teachers' collaboration in knowledge exchange enhanced by a stimulation policy by system holders.

The following research questions are considered for organizing the studies around the suggested model of collaborative educational content creation:

- Research question 1 (RQ1): How to design an educational environment that supports collective knowledge creation and sharing?

To address RQ1, Figure 3.3 gives a model that develops an environment of educational content sharing among teachers by using the theoretical framework of knowledge sharing. Different from earlier research on knowledge sharing among academia (Al-Kurdi et al., 2018; Cheng et al., 2009; Dee & Leisyte, 2017; Faith & Seeam, 2018; Kezar, 2005), we formulate and experimentally analyze the possibility of sharing educational content. Educational content sharing among teachers can be seen as a part of knowledge sharing within the academia.

Education is not a process following which a teacher comes to class, delivers a couple of hours of lectures, and gives assignments. This is a long path and education stakeholders (teachers, principals, and students) face different challenges during this journey. In the overall context, heterogeneous stakeholders interact with each other within an education system (Aimin & Rizen, 2014; Smith & Palmberg, 2009). These interactions drive the emergence of new system behaviour (Newell, 2008).

We consider interactions between two stakeholders -- 'system holders' and 'teachers'. System holders can be the government, local governments, or educational institutions which are responsible and capable of regulating and managing the education process. If the suggested model (Figure 3.3) is applied at a countrywide level, then the government or education ministry is the system holder. If it is implemented within a single organization, then the educational institution is the system holder. 'Teacher' is shown at the left of the 'creation' segment and 'teachers' (under the 'co-opetition' segment) are shown in different places in the model. However, their activities are similar, and all of them create educational content and share it with other teachers. The reason for showing them separately is to describe teachers' workflow from the perspective of a single teacher. But, the reader has to realize that in practice all teachers (under the 'co-opetition' segment) do the same things.

Many forms of knowledge can be exchanged among teachers. As a general notion, it can be seen as knowledge sharing if one person delivers a couple of sentences containing useful information to another person. The model shows different types of content that can be used in educating students but we limit the scale of the educational material. At a certain level, we classify the educational content that is shared among teachers as syllabi, study programs, educational material (textbooks, papers, and media files), and teaching methods (Banzato, 2012). In general, we consider that any chunk of information which is used in a class by a teacher can be shared through the suggested model. From a technical point of view, we do not classify the format of the information (.doc or pdf); this can be the system holders' task.

The proposed model is enhanced by IT, and all business processes in educational content creating and sharing are formulated on the ground of technologies. The element 'technology support for the model' and dash lines surrounding the model show that all activities and operations within the model are done using IT solutions.

The model highlights four segments, (1) 'creation', (2) 'execution', (3) 'co-opetition', and (4) 'encouragement'. Each segment includes some sub-systems with specific functionalities. Sub-systems are connected by arrow lines, showing the directions of the workflow and type of content delivered to

the next sub-system. The functions of the sub-systems of (1) ‘creation’ and (2) ‘execution’ are existing practices in educational institutions such as the teacher creates the syllabus, the educational material, and student evaluation objects to deliver a class. By employing educational content, he/she teaches students and evaluates their learning outcomes.

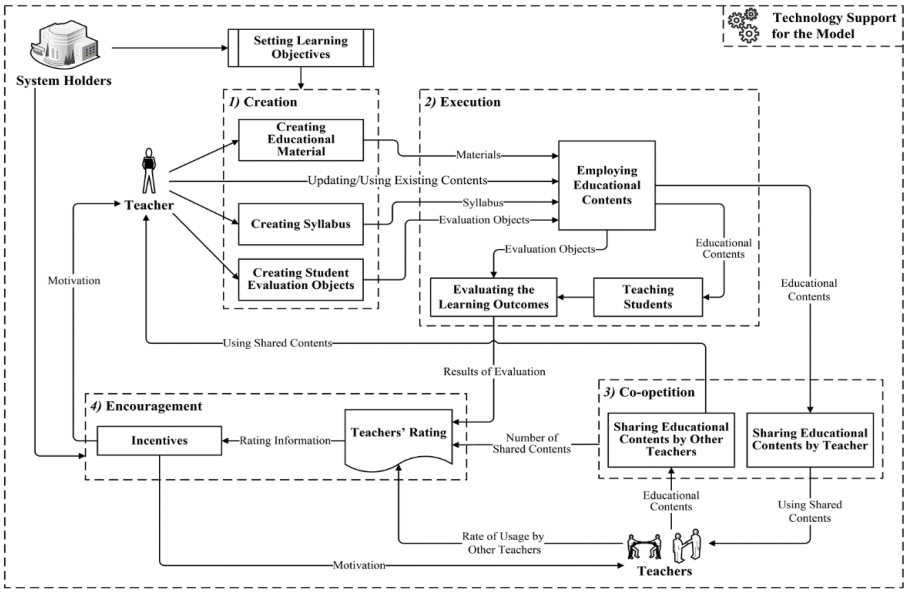


Figure 3.3. Model for educational content creation and sharing

Our suggestion for this general practice is the creation of an environment where teachers cooperate for improving the curricula by sharing their own educational content. At the same time, the system holder encourages them by rating the teachers and providing different incentives. The model contributes to teachers’ general practice by discussing the business process of sharing

educational content and using encouragement mechanisms.

In our model, system holders set the learning objectives which define what students have to obtain by enrolling in a specific course. Taking into account the learning objectives, the teacher creates educational material, the syllabi, and student evaluation objects. We use the expression ‘educational content’ to describe all these together. A teacher who does not create any new educational content can use existing content or update his/her own content by directly addressing the sub-system ‘employing educational content’. ‘Employing the educational content’ sub-system collects all educational content from the teacher by providing ownership of the content to the teacher. As further steps, the teacher can share this content with other teachers, use it while ‘teaching students’ in class, and for ‘evaluating the learning outcomes’ to test knowledge absorption among students. This shows the (2) ‘execution’ of the main responsibilities of the teacher in knowledge transmission to students.

Segment (3) ‘co-opetition’ includes sub-systems which have similar functionalities but these are shown separately to better explain the co-opetition in educational content sharing among a group of teachers. The ‘sharing educational content by a teacher’ sub-system shows that the content provided by a teacher is accessible to other teachers. Similarly, the ‘sharing educational content by other teachers’ sub-system shows the availability of

educational content to the teacher which is shared by other teachers. As explained above, a teacher is one of the members of the teachers' community, and all teachers have the same opportunities and functionalities.

While teachers participate in educational content sharing, system holders encourage them to perform better to achieve collective value co-creation. System holders develop and provide the policies and real applications of incentive mechanisms to motivate teachers involved in educational content sharing (or (4) 'encouragement' segment). Teachers' ratings are defined by the shared educational content, the rate of usage of this content by other teachers, and the results of the evaluations (incoming arrow line to the 'teachers' rating' sub-system). According to periodic ratings, teachers who contribute more can get incentives from system holders which motivate them further to be active in educational content sharing among colleagues.

Chapter 4. An ABM Analysis of Exchanging Educational Content among Teachers

4.1 Introduction

Recent literature shows that human capital can be empowered with an advanced educational system which in turn increases labour productivity and the high equilibrium level of output (Benos & Zotou, 2014). Further, economic growth can be achieved through 1) endogenous growth, 2) the innovative capabilities of the economy, and 3) modern science and technology for the new paradigm of production (Benos & Zotou, 2014; Hanushek & Woessmann, 2008). All societies are interested in improving their economies. However, not all of them pay attention to the underlying educational processes (Adetula et al., 2017). The education system demands new thinking and appropriate approaches to be more effective and productive.

Education is a long journey on which stakeholders (teachers, principals, and students) face different challenges. Heterogeneous stakeholders interact with each other to find solutions to these challenges (Aimin & Rizen, 2014; Smith & Palmberg, 2009), and consequently, new system behaviour emerges (Newell, 2008). The task for all stakeholders is how to manage the issues

around the creation of relevant and up-to-date knowledge sources. Knowledge sharing is crucial for new knowledge creation (Al-Hawamdeh, 2003), and recent studies prove the existence of a research gap in knowledge sharing in academia (Al-Kurdi et al., 2018). However, existing literature does not discuss the design, structure, and processes of knowledge sharing within an educational institution and instead addresses the issues around knowledge sharing among academia and external stakeholders (industry) (Dee & Leisyte, 2017).

This scenario motivated us to analyze teachers' behaviour towards the adoption of an educational content sharing model (of the environment) discussed in Chapter 3. Our specific research objective for this part of the analysis is:

Specific research objective 2 (SRO2): Analyzing the stimulation policies in the education ecosystem for teachers' acceptance of collaborative knowledge creation and exchange.

Our design follows a game theoretic approach in modelling the effects of incentive by the system holders. We capture the differences in teachers' perceptions about the obtained payoffs during their strategic interactions in collective educational content creation and sharing. For this we address the following research questions:

- Research question 2 (RQ2): How do teachers behave towards educational content sharing in case there are different payoffs in the environments?
- Research question 3 (RQ3): How do incentive mechanisms affect teachers' behaviour on educational content sharing?

We present a game theory approach in modelling the incentive effects for the teachers' knowledge sharing behaviour. For the experimental analysis, we used the agent-based modelling methodology applying iterated games (prisoner's dilemma, the snow-drift game, and the stag-hunt game). Our simulation analysis includes 36 types of scenarios with different combinations of simulation parameter configurations that cover a wide range of possible environments (or payoff sets), teachers' behaviour sets, and available incentive mechanisms.

The main contribution of this study to existing research and for educational system holders is that it highlights ways in which teachers' content sharing behaviour within different environments can be shaped. We discuss issues around behavioural aspects of knowledge sharing among teachers and the motivational mechanisms that drive overall system behaviour which is considered a set of individual behaviours. The findings of the simulation analysis show that it is important to have a proper incentive system

for increasing cooperation on knowledge sharing within educational institutions. The results also show the high probability of teachers' acceptance of ego-centred behaviour if educational institutions do not introduce incentives. This means that ego-centred teachers will not share their educational content with their colleagues.

Our results also show that providing incentives helps teachers' adopt altruistic behaviour which is the most productive in educational content sharing. However, it is suggested that education system holders need to find optimum solutions for launching incentive mechanisms related to teachers' behaviour. Teachers' rational interest in gaining more payoffs should not drive the collective irrationality that will raise the issue of system misuse. In general, the suggested model Figure 3.3 (discussed in Chapter 3) can serve as an alternative to educational content exchange between teachers with the aim of improving the curricula offered by an educational institution.

4.2 Literature review on knowledge sharing in education

4.2.1 Examples of knowledge sharing in the education sector

The emergence of modern technologies in the last decades, such as the web provided great potential for educational shifts. One of these new paradigms is the collaborative learning approach (Tsai, Li, Elston, & Chen, 2011). Students use Wiki websites for partnership and publishing course assignments and also distributing it to other students. For instance, the educational server Deutsche Bildungsserver (www.eduserver.de) for primary and secondary education in Germany helps link content providers (that is, education material). This system connects 16 German states for sharing educational material among teachers. The idea behind it is providing an environment for cooperation among teachers which leads to the enrichment of open education resources (Kerres & Heinen, 2015).

Nowadays the educational communities consider two main platforms when it comes online and free sharing of educational material: OpenCourseWare and Open Educational Resources. Open Educational Resources are defined as any digitalized free and open educational material for teachers, students, self-learners, and researches. Education material on

OpenCourseWare is arranged in a particular course format, whereas Open Educational Resources can accept any digitalized format (Caudill, 2012; Hylén, 2005; Koohang & Harman, 2007; Terrell & Caudill, 2012). Massive Open Online Courses (MOOCs) are defined in existing research as open web-based courses that are available for everyone (García-Peñalvo, Johnson, Alves, Minović, & Conde-González, 2014; Liyanagunawardena, 2015; Martin, 2012; Yuan & Powell, 2013). High enrolments (McAuley, Stewart, Siemens, & Cormier, 2010; Siemens, 2013; Wulf, Blohm, Leimeister, & Brenner, 2014) and designing courses around the goals of various study fields through a special platform provides an environment for establishing online education communities (Liyanagunawardena, 2015; Siemens, 2013).

Students are attracted to MOOCs due to the educational institutions and educators associated with them as they hope to have access to high-quality education which was traditionally provided by these institutions and educators. However, the quality of education may be an illusion for learners (Margaryan, Bianco, & Littlejohn, 2015). It needs to be highlighted that MOOCs are oriented towards offering online courses only. However, a new paradigm of open online education should help strengthen and improve the quality of education and help in preparing skilled graduates for job markets as well. There is no strong movement to completely shift traditional education to an

online education system. It is also still not clear whether demand for traditional education will decrease since learners still dream of sitting in classrooms in high ranked universities which have their platforms on online education.

The success of such technological paradigms depends on how users accept and utilize them. Banzato (2012) examined if Italian teachers who participated in online courses were willing to share their educational material in a digitalized format with not only students but also other colleagues. The study showed that only 20.45 per cent of the participants shared their material openly and 18.18 per cent did not. Also, 61.36 per cent of the teachers responded that material could be accessed by making it password protected (Banzato, 2012). Early research shows that the willingness to share and the frequency of sharing were the main drivers of the online knowledge sharing process (Lin & Chen, 2009). This means that if there is a system for knowledge sharing but users do not use it, then the system remains useless.

4.2.2 Theories around the management of knowledge sharing and human behaviour

Different theories in economic and social sciences are applied to understand the backend of knowledge sharing behaviour in practice. The economic exchange theory addresses people's behaviour from the perspective of ego-centric interests, that is, if the provided reward is higher than the cost of the knowledge, then people start sharing costly knowledge (Cheng et al., 2009; Constant, Kiesler, & Sproull, 1994; Hung et al., 2011). The knowledge market theory shows that knowledge can be sold from suppliers to consumers if the moderator of the market properly directs incentive mechanisms to make a dynamic market for the knowledge (Davenport & Prusak, 1998). People have a lot of interest in benefit maximization and cost minimization and the social exchange theory ties these interests with people's periodic interests (Molm, 1997). This theory talks of people's interest as social costs, loss of knowledge power, relative advantages, effort, and social benefits such as reputation, recognition and altruism (Hung et al., 2011; X. Zhang, Chen, Vogel, Yuan, & Guo, 2010).

Some incentive systems focus on direct economic gains though these are not the only mechanisms of managing knowledge sharing among employees

as the reputation of the employees is also a factor that influences knowledge sharing (Hung et al., 2011; Muller et al., 2005). Reputation can be described as promotions on the career track (Muller et al., 2005), recognition in the community (Faith & Seeam, 2018), and others. An experimental analysis of intrinsic (altruism) and extrinsic (reward, reputation) motivation found that reputation feedback mechanisms were crucial for healthy knowledge sharing environments (Hung et al., 2011). In general, the goal of knowledge management within organizations has been emphasized in the creation of new knowledge (Koohborfardhaghighi & Altmann, 2017).

4.2.3 Features of education as a knowledge sharing environment

It is necessary to take into account employee behaviour while using incentive mechanisms which should foster positive dynamics of knowledge sharing (Tan, 2016). A balance between personal interests and incentives is important for controlling social dilemmas where people trying to increase their payoffs can decrease the overall benefits for the organization (Cabrera & Cabrera, 2002; X. Zhang et al., 2010).

Existing research does not discuss the design, structure, and processes of knowledge sharing within an educational institution. Most of the research

addresses issues related to external knowledge sharing among academia (Dee & Leisyte, 2017). It considers academia as a stage for disseminating ideas and knowledge, where intellectual capital can be increased as a guarantee for competitive advantage (Al-Kurdi et al., 2018). An educational institution which properly identifies the strength of knowledge sharing for its progress can motivate teachers to achieve success together by internally exchanging their knowledge and experiences (Cheng et al., 2009). Recent literature also emphasizes that an educational institution's progress along with improved value by its teachers can drive improved knowledge sharing in the teachers' community (Faith & Seeam, 2018).

Lack of proper connections prevents knowledge sharing among education participants (Dee & Leisyte, 2017) which can lower the creation of new knowledge and innovations. Hence, using different solutions for knowledge sharing within academia may create a medium where the integrity of knowledge is under risk (Kezar, 2005). Setting knowledge sharing as a compulsory activity for teachers is also not an appropriate way of building a healthy climate in academia. Instead of this, addressing incentives and teachers' expectations can be more useful (Cheng et al., 2009). Besides incentive mechanisms, the climate and culture of the organization in knowledge sharing are also discussed in the literature (Al-Kurdi et al., 2018)

which shows the entire behaviour of the system. The remaining issue for academia is properly dealing with the barriers and finding the optimum way of implementing the solutions to reach successful knowledge sharing practices.

4.3 Methodology

4.3.1 Reasons for using Agent-Based Modelling

Analyzing educational content sharing environments and teachers' actions within such an environment, existing studies have been done in a particular context, demography, and cultural aspects (Tseng & Kuo, 2014; Van Acker, Vermeulen, Kreijns, Lutgerink, & Van Buuren, 2014). All these facets of existing research also discuss very specific environments and teachers' context-dependent behaviour. The findings and implications of these studies are important for taking precise decisions in certain contexts, especially if the educational content sharing system has been already launched and there is a need to analyze the performance of the teachers and the outcome of the system. We are far from criticizing the way these analyses have been done in existing research but we want to highlight the need for comparing different environments, teachers' behavioural diversity, and various motivational factors for education system holders.

The education system includes numerous teachers who engage in content sharing; all these teachers have unique behaviour. Teachers try to maximize their own utility or benefits by acting within a system (H.-L. Yang & Wu, 2008) following their own behaviour. But a system including n number of teachers (agents), having m types of behaviour cannot be analyzed using any linear methods. Some existing studies argue that available qualitative and quantitative research methodologies are not sufficient for explaining the dynamics and behavioural changes in the education system (Jacobson, 2015).

Considering these points, this dissertation did a simulation analysis using Agent-Based Modelling (ABM) (Macal & North, 2005), assuming education stakeholders as agents in the system. Agent-Based Modelling is a simulation technique that focuses on the agents who perform in competitive interactions and take individual decisions on the basis of certain rules and behaviour representing a real system (Bonabeau, 2002; Koohborfardhaghighi, Romero, Maliphol, Liu, & Altmann, 2017). Besides behavioural conflicts and teachers' consent for educational content sharing, dynamic interactions among teachers have to be carefully studied. In each time period, behavioural conflicts and consent lead agents to use a strategy that maximizes their utility which can be studied by following the game theory approach (H.-L. Yang & Wu, 2008; X. Zhang et al., 2010). In general, using ABM in educational content sharing

allows us to understand how the system works, patterns of agents' interactions with each other, and the emergence of complex system behaviour (Furtado, Sakowski, & Tóvolli, 2015) which is hard to observe in other methodologies.

Education is a complex system (Davis & Sumara, 2006) which includes various stakeholders, their behaviour, different forms of interactions, and the emergence of the feedback mechanism. Besides, education as a complex adaptive system has complicated patterns of connectivity among its elements and stakeholders (Koohborfardhaghighi, Altmann, & Tserpes, 2017). Educational content sharing is a global paradigm in the education sector and is the result of teachers' performance. But this performance does not happen easily and continuously though some factors are related to the occurrence and the longevity of the process. These factors can shape the behaviour of each teacher, altruistic commitment, performance expectations, self-efficiency (Tseng & Kuo, 2014), the value of their knowledge, incentive mechanisms (H.-L. Yang & Wu, 2008), interpersonal relations, mutual trust, and the types of resources that are shared.

Due to the system's complexity, analyzing educational content sharing in different environments including various teachers' behaviour and incentive mechanisms, this analysis uses Agent-Based Modelling (ABM) with certain simplifications. It simplifies real-world cases to simulate them in different

scenarios including different strategies, decisions, and environments (Roudsari, Shariatpanahi, Ahmady, & Khoshnevisan, 2016). These opportunities provided by ABM enable us to create an artificial world including a limited number of teachers with their behaviour that shape interactions within given time periods.

We apply the simplifications to stress the impact of the major parameters of the simulation in the processes within the complex system (Sabzian et al., 2019), namely, features of the environment, teachers' behavioural aspects on interactions, and teachers' behaviour towards incentive mechanisms. As these parameters have complex system phenomena understanding social mechanisms in a targeted system is difficult. Accordingly, our simplification logic helps reduce the complexity of the targeted system to properly build our cognition and knowledge about particular changes in the system (Helbing, 2012).

4.3.2 Simulation setup

As each agent has a specific behaviour on sharing educational content the analysis has to be carefully designed considering the dynamic interactions between agents on the ground of conflict and consent between different behaviours. Behavioural conflicts and consents push agents to come up with strategies for winning in a situation which refers to apply the well-known game theory approach (H.-L. Yang & Wu, 2008; X. Zhang et al., 2010). A few studies use the game theory approach for behaviour analysis of the players in knowledge sharing environment, but there is a need for research on inter-behavioural effects and the mechanisms of their manipulations (X. Zhang et al., 2010). Most of the analyses using iterated games among agents focus on overall knowledge sharing strategies and incentives within an organization (H.-L. Yang & Wu, 2008).

Educational content sharing is a consequence of (a) teachers' behaviour, (b) differences between the cost and benefits, (c) teachers' capabilities for sharing and using shared educational content, (d) and incentive mechanisms of system holders to regulate the overall climate in the system. In the literature review part, we discussed different factors impacting knowledge sharing behaviour. Due to the complexity of human behaviour and interactions among

people, and the emergence of system behaviour, we apply some simplifications in our simulation. For example, the simulation scenario focuses only on teachers' ratings and the economic incentive mechanisms, whereas in theory, this involves reputation, recognition, and other motivation factors.

When the environment cannot reject the economic exchange and social exchange theories, the agents in the environment practically perform using their own perspectives: maximizing benefits and minimizing costs (Cheng et al., 2009; Constant et al., 1994; Hung et al., 2011; Molm, 1997). Then each agent gets involved in the global game with his/her own strategies to get optimum payoffs at the end of the game. Accordingly, our simulation scenario includes three types of payoffs and five types of strategies used by agents. The term strategy is interchangeable with the term 'behaviour' as we focus on teachers' behaviour.

Another simplification in the simulation is that all educational content shared by the teachers has a similar value. However, in a real scenario, the value of a book and of a research paper is not equal. Hence, the simulation does not include a classification of educational content. We consider all educational content to have a relative advantage over the others.

We consider the following factors as influencing teachers' decisions on

knowledge sharing which show whether a teacher won the game or lost:

- U - utility can be the new knowledge sources, the relative advantage of the content, and ways of applying different teaching methods of the educational content for the receiving teacher; $U \geq 0$;
- L is the value of loss (time, effort, money, and health) or cost of educational content for the teacher who is sharing educational content. $L_i \geq 0$ (Ba, Stallaert, & Whinston, 2001);
- C is the cooperative value (co-creating collective knowledge, co-improving educational content, and a collective solution to the challenges of the syllabi) that teachers get when they mutually share educational content; $C \geq 0$ (X. Zhang et al., 2010);
- P is the penalty for teachers in case they mutually decide not to share educational content $P \geq 0$. But as penalty has a negative meaning, it decreases the overall utility of the teacher despite having a positive value;
- As there is the loss factor (time, effort and money), each contribution has to be recompensed for fostering active knowledge sharing (X. Zhang et al., 2010). We add an incentive factor I which is $I \geq 0$.

As we have different types of incentive mechanisms, we discuss them in the next subchapters. We do not add the value of the incentives in the default

case of the payoff matrix (Table 4.1).

Table 4.1 Payoff matrix for teachers

		Teacher *j*	
		Share	Not share
Teacher *i*	Share	*i)* $U+C+I-L_i$ *j)*$U+C+I-L_j$*;*	*i)* $I-L_i$ *j) U*
	Not share	*i) U* *j)* $I-L_j$	*i) P* *j) P*

Let us assume that the condition of the game is between teacher *i*, who does 'not share' and teacher *j* who 'shares'. These are values in the box (Table 4.1), highlighted with a grey background. By 'not sharing' educational content, teacher *i* does not have any loss (*L*), instead, he/she gets the utility (*U*) from obtaining the educational content from teacher *j*. As teacher *j* shares educational content with teacher *i*, he/she has a loss (*L*) but as a teacher *i* does not have a reciprocal response, teacher *j* cannot obtain any utility (*U*). To maintain the 'sharing' behaviour of teachers, the system holder provides an incentive (*I*) to compensate for the loss to teacher *j*, ($I-L_j$).

4.3.3 Simulation parameters

4.3.3.1 Payoff sets

One way in the strategic game for analyzing cooperation or defect among agents is by changing the payoff matrices (Cabrera & Cabrera, 2002; Muller et al., 2005). While giving the values for each factor of the payoff matrix (*U, L, C, P, I*), we try to configure three payoff sets which address three types of games: prisoner's dilemma, the snow-drift game (game of chicken), and the stag-hunt game (collective inaction) (Dixit & Skeath, 2015; Szolnoki & Perc, 2009). Each game represents the features of a certain educational environment in which teachers get different payoffs while performing. The reason for using these games in the simulation is because games have different ways of providing payoffs to a teacher related to his/her actions (share or not share). Thus, the environments in the simulation differ as per the games.

Generally, these games differ from each other because of the different values of the rewards for mutual cooperation (*R*), punishment for mutual defection (*P*), sucker's payoff for the cooperator, when the opponent chooses to defect (*S*), and temptation to defect (*T*) (Szolnoki & Perc, 2009). The characteristics of the environments and payoff sets are:

- A knowledge sensitive environment or Payoff Set 1 uses the prisoner's dilemma game which does not include the cooperative value (C=0) for educational content sharing, U=6, L=3, C=0, P=0. The game satisfies the condition $T>R>P>S$ (Szolnoki & Perc, 2009). We define the environment as knowledge sensitive because the sucker's payoff for the cooperator (when the opponent chooses to defect) has the lowest value.
- A defect-restrictive environment or Payoff Set 2 is characterized by the application of the snowdrift game. There is no cooperative value (C=0) for mutual educational content sharing and less value of the loss: U=6, L=1, C=0, P=2 (the values of P have to be accepted as P=-2 for the teachers, as 'penalty' has a negative meaning). The game follows the condition $T>R>S>P$ (Szolnoki & Perc, 2009), and due to punishment for mutual defection, we call the environment defect restrictive.
- A cooperation-oriented environment or Payoff Set 3 applies the stag-hunt game. There is an assumption that cooperation among teachers on educational content sharing will increase the overall quality of the curricula thanks to the increased variety in the content, then: U=6, L=3, C=6, P=0. The game satisfies the $R>T>P>S$ condition (Szolnoki & Perc, 2009), and according to the high value for mutual cooperation (R), we set the environment as cooperation-oriented.

As shown in Table 4.2, the payoff matrices can be denoted by calculating each payoff set while considering a no incentive situation (that is, I=0).

Table 4.2 Payoff matrices for payoff sets 1, 2, and 3

		Teacher *j*					
		Payoff Set 1		Payoff Set 2		Payoff Set 3	
		Share	Not share	Share	Not share	Share	Not share
Teacher *i*	Share	*i)* 3 *j)* 3*;*	*i)* -3 *j)* 6	*i)* 5 *j)* 5*;*	*i)* -1 *j)* 6	*i)* 9 *j)* 9*;*	*i)* -3 *j)* 6
	Not share	*i)* 6 *j)* -3	*i)* 0 *j)* 0	*i)* 6 *j)* -1	*i)* -2 *j)* -2	*i)* 6 *j)* -3	*i)* 0 *j)* 0

4.3.3.2 Behaviour sets

The existence of a loss (time, effort, money, and health) parameter within the environment influences teachers' decisions about knowledge sharing. The results of the teachers' decisions reflect their strategy or behaviour about the knowledge sharing process. Usually, educational content is composed of open knowledge that places almost no restrictions on sharing. Of course, copyright, ownership, and property rights of the original sources of knowledge have to be followed. But in general, teachers who compose educational content and the syllabi do not suffer any big loss by sharing their content. This is the difference between knowledge sharing in education and in other organizations.

To select the strategies (teachers' behaviour) for the simulation, we considered the aspects discussed in the previous paragraph. There are more than 100 strategies on 'cooperation' or 'defection' in the game but we selected five strategies to represent the diversity of teachers' behaviour including actions as 'cooperation', 'defection', and choosing one of them according to the opponents' actions. Generally, we justify the selection of the strategies to represent teachers' behaviour in educational content sharing by following the logic:

- Teachers spend their resources (time, effort) in composing educational content and they have to be compensated;
- The teachers' mission is educating people which is an example of building and disseminating knowledge;
- Educational content is not to be hidden even from colleagues;
- Educational content does not provide a strong basis for defining the relative power of a teacher.

Based on this logic we define five types of teachers' behaviour to find the overall knowledge sharing among teachers. The behaviour of each actor in our simulation shows the choice made by a teacher whether to share educational content or not. Going with existing research on strategic games, we select 'Always Cooperate (AllD)', 'Tit-For-Tat (TFT)', 'Always Defect (AllD)',

‘Suspicious Tit for Tat (STFT)’, and ‘Tit for Two Tats (TFTT)’ strategies for composing behaviour sets (Kendall, Yao, & Chong, 2007; H.-L. Yang & Wu, 2008). Each strategy defines the behaviour of a teacher about educational content sharing which he/she can perform. Table 4.3 shows the types of teacher behaviour and relative strategies for our simulation parameters.

Table 4.3. Teachers’ behaviour regarding game strategies

Behavioural type	**Name of strategy**	**Description**
Altruist teachers	Always Cooperate (AllD)	teachers are always ready to share their educational content regardless of opponent teacher’s strategy (behaviour);
Responsive teachers	Tit-For-Tat (TFT)	teachers start their actions by sharing educational content but in the next stages they try to follow the last strategy (behaviour) of their opponent teacher;
Ego-centred teachers	Always Defect (AllD)	these teachers never share their educational content;
Debatable teachers	Suspicious Tit for Tat (STFT)	in the initial round of the game, teachers do not share their content but in the next iterations they follow the strategy (behaviour) of their opponent teacher;
Disappoint teachers	Tit for Two Tats (TFTT)	these teachers start their performance by sharing educational content but defect if their opponents defect two times in a row;

To avoid using technical names of the strategies, we classify the teachers by their behavioural types (altruist, ego-centred, etc.) that are appropriate for

one particular game strategy. Yang and Wu (2008) address knowledge sharing within an organization by distinguishing mutual trust among employees by their strategies. As trust is significant in the environment, there should be a high risk of leaking the information or losing relative power. All strategy sets in Yang and Wu's research (2008) include strategies as always defecting and one in which the agents start with defection and then later follow the opposite of their opponents' strategies.

Different from other organizations (industry or government), the education sector is more flexible on knowledge dissemination. Hence, we keep behaviour sets which reflect a more cooperative environment. Considering this, we compose all behaviour sets including altruistic and responsive teachers but some of them exclude ego-centred, debatable, and disappointed teachers. In this way, we show the differences between teachers' behaviour and inter-employee trust in an organization.

Our current simulation analysis uses the following behaviour sets of teachers formed by a combination of different strategies in the game theory:

- Behaviour Set 1: Altruist teachers, responsive teachers, ego-centred teachers, debatable teachers, disappointed teachers;
- Behaviour Set 2: Altruist teachers, responsive teachers, ego-centred teachers, debatable teachers;

- Behaviour Set 3: Altruist teachers, responsive teachers, ego-centred teachers, disappointed teachers;
- Behaviour Set 4: Altruist teachers, responsive teachers, debatable teachers, disappointed teachers.

In the first iteration, the share of all behaviours is equally assigned among the teachers in each behaviour set. For example, in the initial setting, the share of teachers having the same behaviour is 20 per cent of the total in Behaviour Set 1, while in Behaviour Sets 2, 3, and 4 teachers' behaviour is 25.

4.3.3.3 Incentive mechanisms within an environment

Knowledge sharing systems mostly address the issue of motivating participants for active performance by providing different kinds of incentives (Faith & Seeam, 2018; Hung et al., 2011; Muller et al., 2005). Existing literature discusses different kinds of incentives: (a) compensation for individual contributions and (b) an incentive for a successful knowledge sharing activity (Cabrera & Cabrera, 2002). To set the incentive mechanisms for simulation, we apply these two incentive types by adjusting for the parameters mentioned here.

In general, we estimate the impact of incentive mechanisms on teachers' behaviour and the behaviour of the entire system in different scenarios. We

assume that incentives can be provided to compensate for the loss of sharing since educational content creation requires time, effort, and financial spending by the teacher. Three types of incentive mechanisms are used in our simulation, including the case of 'not providing an incentive' and two other incentives mentioned earlier: (a) compensation for individual contributions and (b) an incentive for a successful knowledge sharing activity. Then the incentive mechanisms for the simulation are:

- Miser: there are no incentives for teachers who share their educational content.
- Spendthrift: compensation for each shared educational content is provided, regardless of whether it is useful for others or not. But it is more than the loss for the teacher while sharing his/her own educational content. We set the spendthrift incentive amount as 4.
- Balanced: the usefulness of knowledge in knowledge sharing environments is important (X. Zhang et al., 2010). Otherwise, there is no benefit in making a repository of useless contents. The current incentive is provided on the basis of usage of the content by other teachers. We use the normal probability distribution with mean $\mu = 3$ and standard deviation $\sigma = 0.3$ to define the amount of incentives for the teachers who have shared educational content. By using others'

educational content, teachers can absorb the relative advantage of the educational content. Due to the complexities of defining the accepted relative advantages by teachers when using others' educational content, we apply this mechanism of incentive for only rewarding the real contribution of a teacher who is sharing current educational content. Let us assume that there is an already defined amount of reward R for providing an incentive for teachers. However, reward *Ri* is provided to the teacher *i* which is equal to the share of his/her educational content *Ai* used (equal to the proportion of the real contribution) by teacher *j*. This incentive type is related to the usage rate for defining a teacher's real contribution to his/her colleagues.

4.3.4 Simulation scenario

For our simulation, we set the population of teachers at 100. With respect to the introduced parameters (that is, three payoff sets or environments -- knowledge sensitive, defect-restrictive and cooperation-oriented), four behaviour sets (Behaviour Sets 1, 2, 3, 4), and three incentive mechanisms (Miser, Spendthrift and Balanced) we generate 36 simulation scenario configurations. To avoid the negative effects of assumptions and generated parameters using the normal distribution, each scenario is run five times. Each

run of the simulation scenarios includes 10 time periods, where each teacher meets all the other teachers 10 times during a game. Teachers have information about the last behaviour of each other that is used for selecting the game strategy regarding the previous behaviour of the opponent.

Teachers can observe the changes in other teachers' payoffs. This helps compare their own payoffs with others which could be a reason for further changing their own behaviour. The most productive behaviour that gets the highest payoff can be adopted by the teachers who are getting the least payoffs. The frequency of the behaviour settings is collected in each iteration to answer the research questions.

4.4 Analysis results

The results of the simulation analysis are given in figures (Figure 4.1, Figure 4.2, Figure 4.3 and Figure 4.4) which show the dynamics of behavioural changes by teachers. This means how teachers engage in more beneficial behaviour according to the environment and incentives in a given time period. The dynamics of the teachers' behavioural changes depend on the payoffs which each teacher can get according to the environment and his/her own behaviour about educational content sharing with others. We present the

results of teachers' behavioural changes grouped from the perspective of teacher behaviour sets, that is, figures are grouped around each behaviour set but in different environments and incentive mechanisms.

Figure 4.1 gives the dynamics of behavioural changes among the teachers in Behaviour Set 1 in different environments and with different incentives. The main feature of these results is the existence of all types of teachers' behaviour in the set. It is characterized by the emergence of the mutual and multilateral impact of different behaviours on teachers' decisions about educational content sharing. In all environments when there are no incentives (incentive = miser), the behaviour that is favourable to 'not sharing' dominates. Figure 4.1 a, d, and g show that teachers accept ego-centred, disappointed, and debatable behaviour during the simulation period. This can be explained by the causality of getting fewer payoffs by the teachers, who have a behaviour supporting 'sharing' than teachers who do 'not share'.

In this case, an educational institution which is not focusing on motivating teachers to share their educational content by providing incentives and recognition will have difficulties in implementing such a system. In all environments, if high incentives (incentive = spendthrift) are ensured, more teachers change their behaviour towards 'sharing', and most accept altruistic behaviour (Figure 4.1 b, e, and h). When the system holder offers incentives

per usage (by others) of shared content (incentive = balanced), then most of the teachers prefer to have altruistic, responsive, or debatable behaviour which can also contribute to the system by actively involving in knowledge exchange.

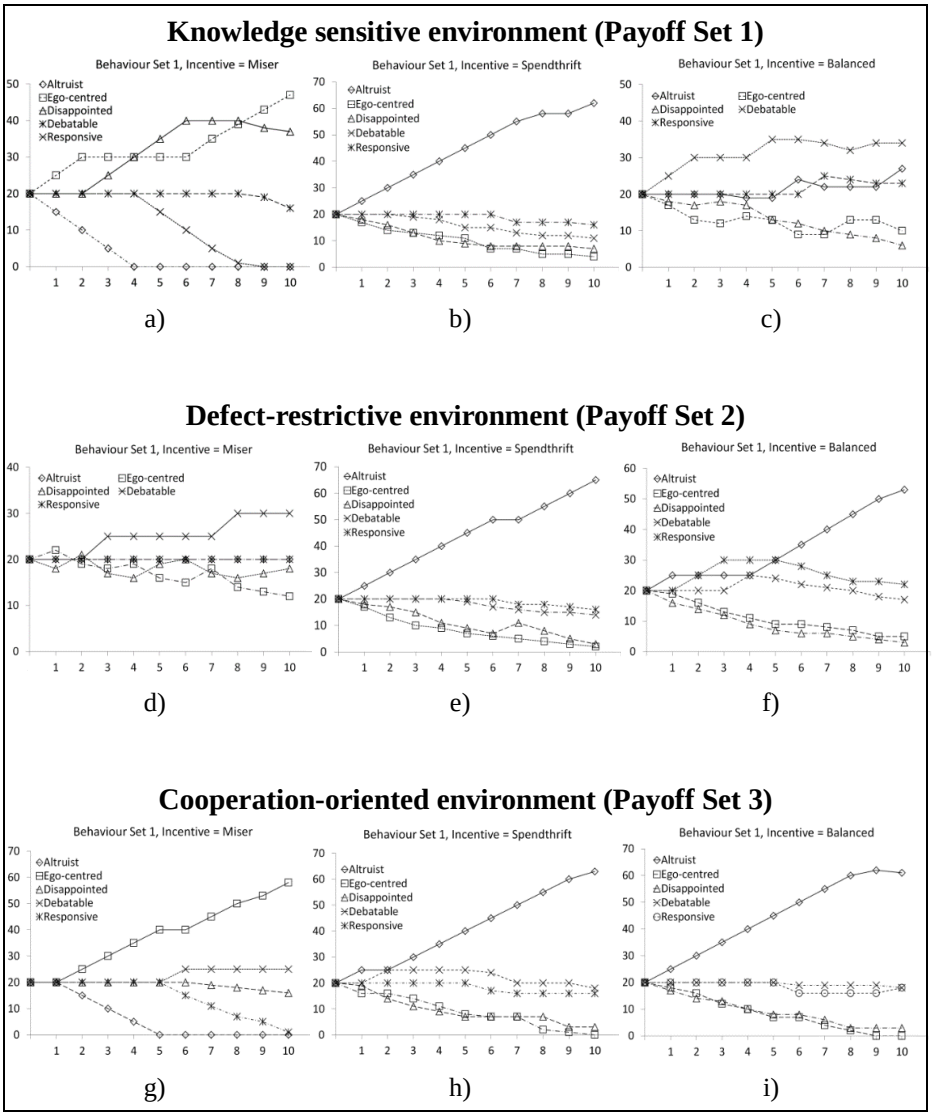


Figure 4.1. Dynamics of behavioural changes in teachers in Behaviour Set 1

In general, if an incentive is given for used educational content, then the initial time periods can be beneficial for the teachers who are debatable and responsive (Figure 4.1 c, f, and i). This is explained through the possibility of not getting incentives even by sharing educational content if his/her colleagues find the material useless. Conversely, the behaviour of teachers who share sometimes and get a number of usages can be interesting for others until some of the behaviours become more beneficial. In a knowledge sensitive environment, debatable behaviour is the most preferred as it observes the strategies used by the others and acts correspondingly in the next time periods. The rest of the environments are emphasized by growing demand for altruistic behaviour which is attractive for gaining more payoffs than the others.

Mainly, in all environments if an incentive is given then teachers try to adopt altruistic behaviour and this system can be utilized as teachers get more payoffs for their ‘sharing’ and increase the cooperative value within the system. An educational institution should be concerned about the risk of improper utilization of the system and incentives when providing high incentives (incentive = spendthrift). This can raise the risk of sharing any material by the teachers to increase their own payoffs. Simply, the system may get an enormous quantity of useless content. It is better to properly set the

incentive policy according to teachers' behaviour towards usage either for the system's well-being or self-well-being.

Figure 4.2 gives the results of the simulation scenario configurations with the difference that it excludes teachers who have disappointed behaviour. In the case of no incentives (incentive = miser) for teachers, the results shaped interesting curves that not only ego-centred or debatable behaviour dominates. In a knowledge-sensitive environment (Figure 4.2 a) altruistic teachers are discriminated because of less payoffs after sharing material. Accordingly, from the early time periods, altruistic teachers start accepting ego-centred behaviour to reduce their losses in sharing the content. This is a potential risk for the educational institution if it is implementing a system which is ignored by the teachers.

Teachers in a defect-restrictive environment (Figure 4.2 d) do not show significant changes in behaviour; in the second time period some of the debatable teachers decide to shift to ego-centred behaviour and everybody keeps their behaviour constant till the end of the period. An almost similar pattern of behavioural dynamics is observed in the context of the cooperation-oriented environment (Figure 4.2 g) but here ego-centred and debatable teachers do not have any behavioural changes. From the fourth tick, some of the responsive teachers start acting as altruistic teachers. These slight changes

can be explained by the disappearance of the disappointed teachers. According to the characteristics of disappointed behaviour, teachers can easily ignore sharing forever if their colleagues have defected two times in a row.

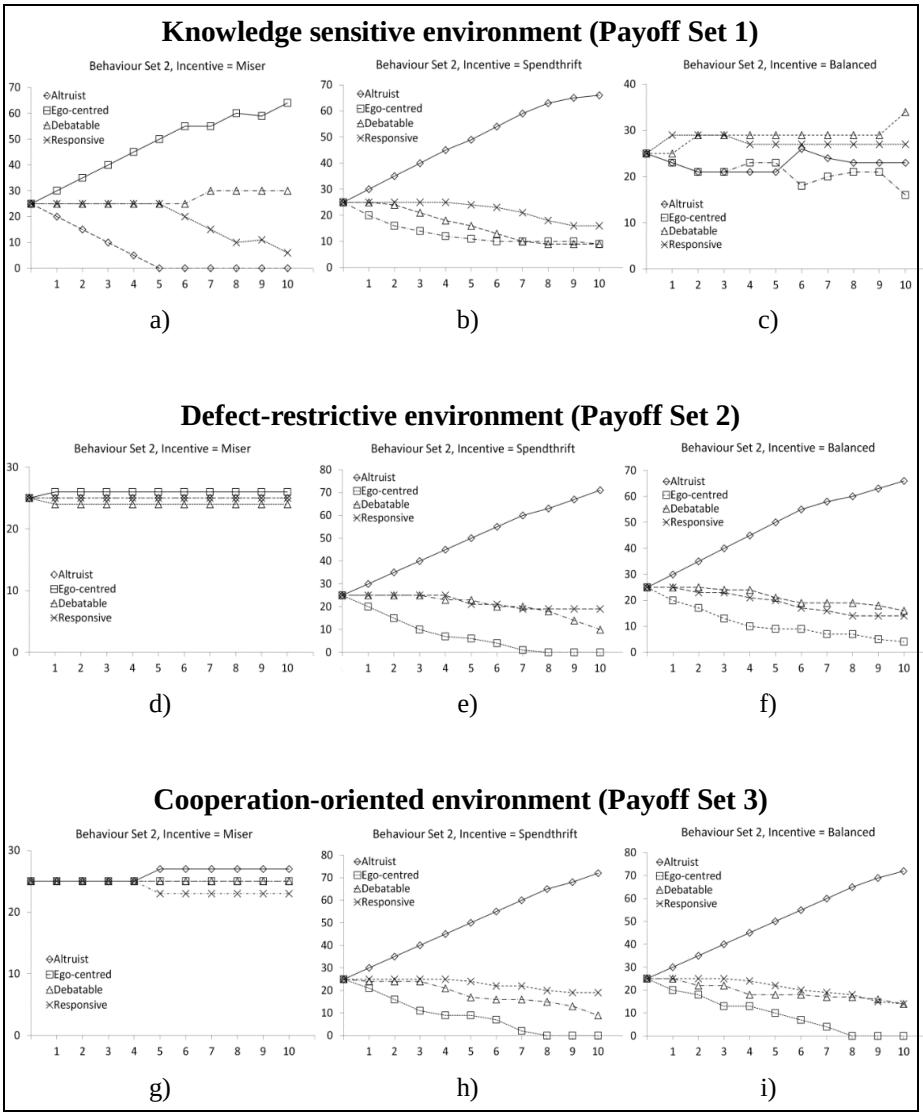


Figure 4.2. Dynamics of behavioural changes in teachers in Behaviour Set 2

When an educational institution starts providing incentives to the teachers,

altruistic behaviour becomes dominant. In all the three environments, an incentive mechanism motivates teachers to become altruistic which shows that it is the most beneficial behaviour for getting more payoffs (Figure 4.2 b, e, h, f, and i). The number of teachers who have ego-centred behaviour declines until 0 (Figure 4.2 e, h, and i) in the later periods of the simulation runs in defect-restrictive and cooperation-oriented environments. However, some of the ego-centred behaviour remains in a knowledge sensitive environment (Figure 4.2 b, c, and f) even until the end of the simulation time periods. This means that teachers who estimate their relative advantage on the basis of their knowledge to deliver particular classes can refuse better payoffs, while in the other environments this does not work. Figure 4.2 c shows that during the early periods ego-centred behaviour competes with others in a knowledge sensitive environment.

Responsive and debatable behaviour decreases slightly (Figure 4.2 f and i) from the early periods in defect-restrictive and cooperation-oriented environments when an incentive is given on the basis of usage by others (incentive = balanced). Of course, it is logical to think that if the shared material is more, then the probability of its being used is also high. No doubt, this can work for altruistic behaviour, so the generally accepted behaviour remains altruistic. There is a possibility that some of the rare material shared

by the teachers having responsive and debatable behaviour can also be used by their colleagues. This is an interesting point of the behaviour analysis that the system influences different behaviour to increase positive outcomes for teachers.

In the case of the 'no incentive' (incentive = miser) scenario's configurations, responsive behaviour is accepted as beneficial behaviour (Figure 4.3 d and g), followed by ego-centred behaviour. As is seen altruistic behaviour disappears in almost all simulation configurations where an incentive is not provided, so a cooperation-oriented environment (Figure 4.3 g) also loses altruists from the seventh tick. But a defect-restrictive environment manages to have around 25 per cent altruists in the total sample set but still, there is the hope that someone will share the content and make others also share (besides ego-centred).

The incentives that are provided keep pushing the teachers to accept altruistic behaviour, followed by responsive behaviour. The difference in some of the simulation configurations from the previous results is that responsive behaviour is demanded a bit more (Figure 4.3 b, e, and h), or there is almost no decrease in the number of teachers who initially had the same behaviour (Figure 4.3 c, f, and i). All ego-centred and disappointed teachers prefer to shift to altruistic behaviour (Figure 4.3 b, e, h, f, and i), some of them even

disappear as their initial behaviour is no longer beneficial. In knowledge sensitive environments, when the incentive is usage-based (Figure 4.3 c), then ego-centred behaviour dominates from the second half of the time periods but altruistic behaviour is defined as less beneficial behaviour.

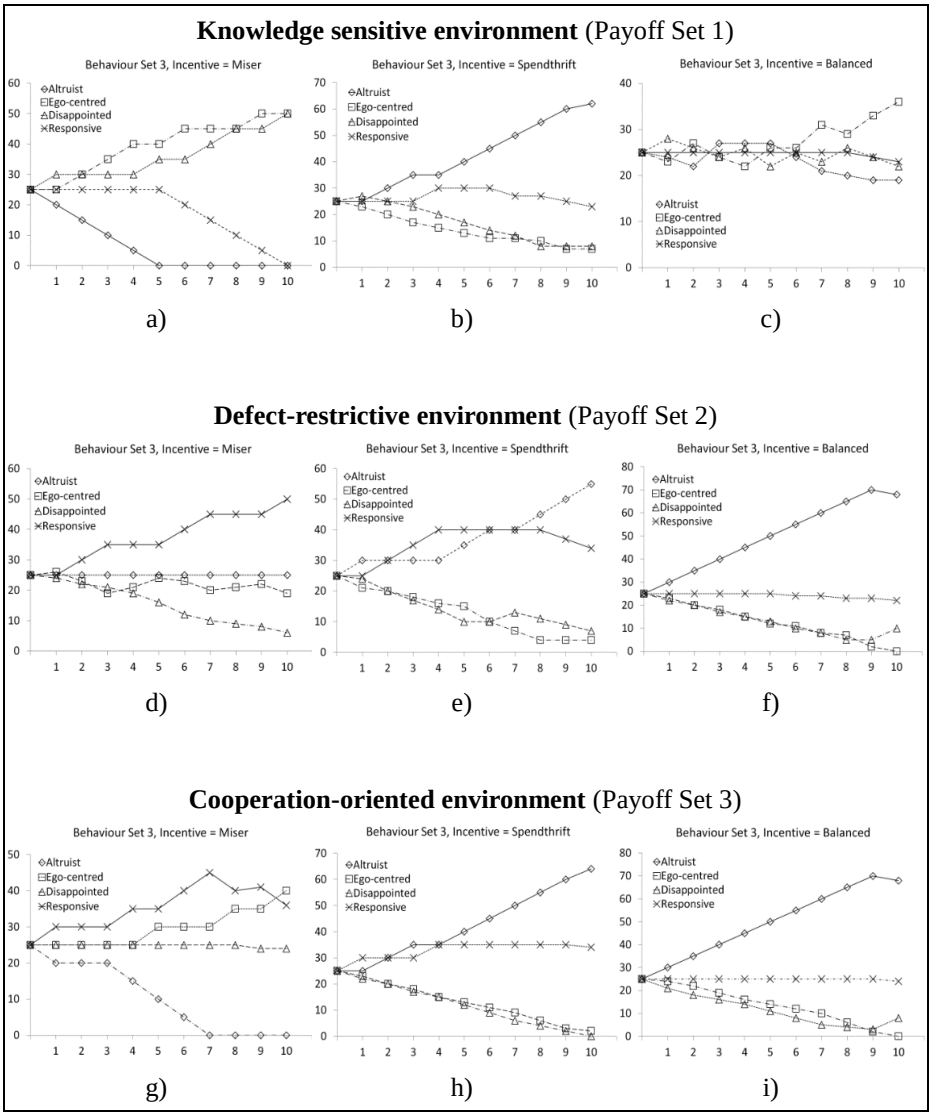


Figure 4.3. Dynamics of behavioural changes in teachers in Behaviour Set 3

In these results demand for responsive behaviour increases slightly as compared to the results in Figure 4.1 and Figure 4.2. According to the characteristics of responsive behaviour, teachers start their activities with sharing, until one of their colleagues does not share. If ‘no share’ moves to responsive, then next time responsive will not share or opposite otherwise. The number of altruistic teachers increases when incentives are provided. Accordingly, there is hope that responsive teachers share more than in the previous time periods. Disappointed and ego-centred behaviour only has a competitive character when the environment is knowledge sensitive and incentive is not provided per usage (Figure 4.3 a and c). The rest of the simulation configurations show that they are not commonly accepted.

The results of the analysis on the dynamics of teachers’ behavioural changes excluding ego-centred teachers from the set are given in Figure 4.4. These results are different from those given earlier in Figure 4.1, Figure 4.2, and Figure 4.3 with the possibility of more sharing by teachers, as there is only debatable behaviour which starts the activities by ‘not sharing’. In general, debatable, responsive, and disappointed teachers do ‘not share’ their content but of course, a sharing or not sharing strategy used by responsive and disappointed teachers depends on debatable teachers. When the set of teachers tends to exclude ego-centred behaviour, the productivity of the system can

increase with more sharing. Almost all the graphs in Figure 4.4 show a slight decline in less beneficial behaviour which highlights that any behaviour can be beneficial before meeting a debatable colleague.

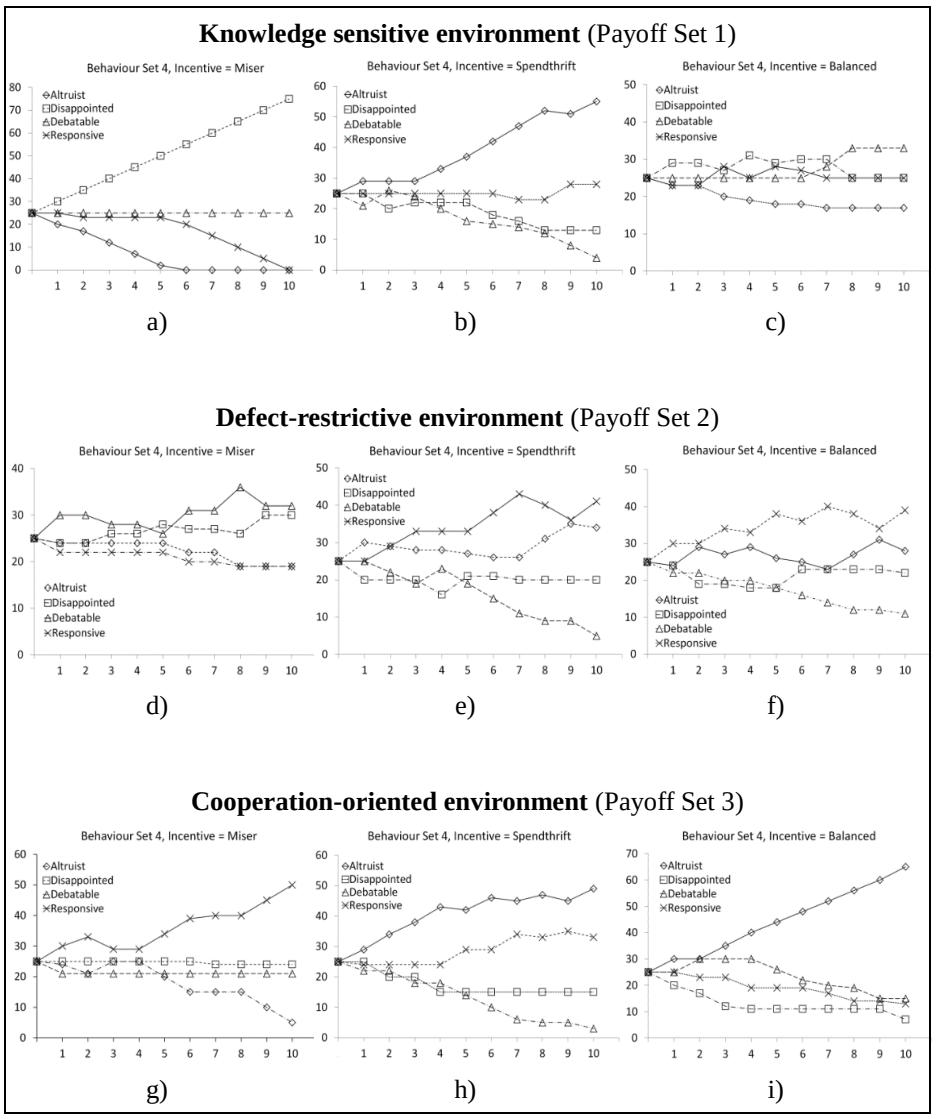


Figure 4.4. Dynamics of behavioural changes in teachers in Behaviour Set 4

A knowledge sensitive environment keeps teachers ‘not sharing’ their materials if there are no incentives (incentive = miser). As shown in Figure 4.4 a, disappointed behaviour increases dramatically with a proportional decrease in the number of altruistic and responsive teachers. Debatable behaviour which is the main source of ‘not sharing’ is constant till the end of the simulation periods. If there is no incentive, then debatable and disappointed behaviour dominates responsive and altruistic behaviour (Figure 4.4 d) in a defect-restrictive environment. In a cooperation-oriented environment, responsive behaviour has a growing shape of a trace which is fed mostly by altruists (Figure 4.4 g), Hence, debatable and disappointed behaviour remains and has an almost constant pattern.

The strong dominance of altruistic behaviour is observed in environments but depending on the type of incentives. In a knowledge-sensitive environment when incentives are high (incentive = spendthrift), altruistic behaviour has a dramatic increasing pattern after the third tick (Figure 4.4 b). In a defect-restrictive environment, responsive teachers are productive by gaining more payoffs when any type of incentive is given (incentive = spendthrift and balanced). But there is no big difference in follower behaviour which is altruistic (Figure 4.4 e and f). A cooperation-oriented environment motivates most of the debatable and disappointed teachers to shift to altruistic

behaviour when an incentive is given per shared content (incentive = spendthrift) so much so that almost half of the teachers become altruistic at the end of the time periods (Figure 4.4 h). When the incentive has a usage base character, then all teachers try to accept altruistic behaviour (Figure 4.4 i).

Graphs e and f in Figure 4.4 do not show a strong dominance by one behaviour, rather mostly altruistic and responsive behaviour has higher indications as compared to debatable and disappointed behaviour whereas in graphs d and c this is the opposite. In Figure 4.4 e disappointed teachers demonstrate an almost constant shape which means responsive and altruistic behaviour in a defect-restrictive environment increases due to the disappearance of debatable behaviour when an educational institution gives high incentives (incentive = spendthrift). In general, it can be assumed that excluding ego-centred teachers can increase the efficiency of the system from the perspective of more content sharing if disappointed teachers do not meet those colleagues who have rejected sharing two times in a row.

Table 4.4. Summary of surviving behaviours after the 10th tick

Behav. Sets	Payoff types	Incentive	Surviving behaviour	Behav. Sets	Payoff types	Incentive	Surviving behaviour
Behav. Set 1	Knowledge sensitive	Miser	*Ego-centered*	Behav. Set 3	Knowledge sensitive	Miser	*Ego-cen ./ Disap.*
		Spendthrift	*Altruist*			Spendthrift	*Altruist*
		Balanced	*Debatable*			Balanced	*Ego-centered*
	Defect-restrictive	Miser	*Debatable*		Defect-restrictive	Miser	*Responsive*
		Spendthrift	*Altruist*			Spendthrift	*Altruist*
		Balanced	*Altruist*			Balanced	*Altruist*
	Cooperat.-oriented	Miser	*Ego-centered*		Cooperat.-oriented	Miser	*Ego-cent. / Resp.*
		Spendthrift	*Altruist*			Spendthrift	*Altruist*
		Balanced	*Altruist*			Balanced	*Altruist*
Behav. Set 2	Knowledge sensitive	Miser	*Ego-centered*	Behav. Set 4	Knowledge sensitive	Miser	*Disappointed*
		Spendthrift	*Altruist*			Spendthrift	*Altruist*
		Balanced	*Debatable*			Balanced	*Debatable*
	Defect-restrictive	Miser	*Ego-centered*		Defect-restrictive	Miser	*Debatable*
		Spendthrift	*Altruist*			Spendthrift	*Responsive*
		Balanced	*Altruist*			Balanced	*Responsive*
	Cooperat.-oriented	Miser	*Altruist*		Cooperat.-oriented	Miser	*Responsive*
		Spendthrift	*Altruist*			Spendthrift	*Altruist*
		Balanced	*Altruist*			Balanced	*Altruist*

Notes:

- Environment types are defined according to the value of the payoffs in the matrices of each game, namely, prisoner's dilemma, snow-drift, and the stag-hunt game.
- Behaviour Set 1 includes teachers having altruistic, responsive, ego-centred, debatable, and disappointed behaviour. Behaviour Set 2 excludes disappointed teachers, Behaviour Set 3 excludes debatable behaviour and in Behaviour Set 4 ego-centred teachers are not included.
- Incentive mechanisms are defined as 'miser' – there is no incentive; 'spendthrift' – the incentive is higher than the loss of sharing; and 'balanced' – incentive per use (by others) of the content.

Table 4.4 gives a summary of the surviving behaviour after the 10th time period of the simulation runs. Even though an equal number of behaviours was distributed at the start of the simulation runs, the end of the simulation time periods is interesting. In most of the cases, different environments (payoffs) led teachers to adopt ego-centred behaviour when an incentive was not provided. Even in a knowledge sensitive environment without any incentives, 64 per cent of the teachers chose ego-centred behaviour.

When the simulation scenario uses Behaviour Set 4, 75 per cent of the teachers found disappointed behaviour as beneficial. Incentive mechanisms could affect teachers' behaviour towards the acceptance of altruistic behaviour. Implementing incentives in a 'defect-restrictive' and a 'cooperation-oriented' environment shows that in most scenarios 50-72 per cent of the teachers can be attracted to share their educational content by adopting altruistic behaviour. Other behaviours (debatable, disappointed, and responsive) are demanded if ego-centred teachers do not exist in the environment (Behaviour Set 4).

4.5 Discussion and conclusion

4.5.1 Summary and implications

Existing research states that not all teachers want to openly share their educational content through the knowledge disseminating systems of educational institutions (Banzato, 2012), and to some extent they are right. Creating educational content is not an overnight job, and it is costly in terms of time, effort, and money. Understanding that sharing something that one has dedicated resources to is difficult, our model (Figure 3.3 in Chapter 3) focused on the encouragement mechanisms used by system holders to establish a healthy environment of collaboration on educational content sharing. Accordingly, the model included elements of defining teachers' ratings and appropriate incentives depending on their performance within a system. Since the contribution of internal knowledge sharing is significant for the system's well-being, system holders motivate teachers for reciprocal collaboration in knowledge sharing (Cheng et al., 2009).

The main philosophy of the motivation mechanism of providing different incentives is increasing the teachers' willingness to reveal their educational content to the community. Willingness has been found to be a crucial factor for knowledge sharing in an online environment (Lin & Chen, 2009). The

challenge of motivation can be addressed by implementing incentive mechanisms (Faith & Seeam, 2018; Hung et al., 2011; Muller et al., 2005). We delivered the conceptual approaches in an incentive mechanism in the suggested model (Chapter 3). Our simulation analysis covered different types of incentive mechanisms for studying behavioural changes in teachers on educational content sharing related to incentives and payoffs.

One of the main contributions of this study for academia is that it discusses the ways in which educational content sharing behaviour among teachers within different environments can be shaped. Existing research highlights the lack of a design for the structure and processes of knowledge sharing in an educational institution (Dee & Leisyte, 2017). Therefore, we touched on issues around the behavioural aspects of knowledge sharing among teachers and the motivational mechanisms that drive the overall system behaviour considering a set of individual behaviours.

We did a simulation analysis using the ABM methodology by applying iterated games in three types of environments (knowledge sensitive, defect-restrictive, and cooperation-oriented), four types of behaviour sets, and three different incentive mechanisms (miser, spendthrift, and balanced); the results of all the simulation configurations have specific characteristics. In general, these results suggest that educational institutions maintain active knowledge

sharing according to the behaviour of the teachers and the value of the knowledge to the owners. By considering these parameters, education system holders define the overall behaviour of the environment, if the knowledge has high value and cost in the environment or not.

If teachers' educational content or knowledge is up-to-date, is of high quality, and gets relative advantages to a teacher, then education system holders have to make the right decision about incentive and motivation mechanisms. Otherwise, such a knowledge sensitive environment can openly reject sharing the knowledge that has high value for the owner due to lack of an incentive mechanism. In such an environment, strong monetary incentives that exceed losses to teachers for sharing content have to be provided to activate teachers' willingness. Summing up, using the economic exchange theory it can be highlighted that in a knowledge sensitive environment, providing rewards that are higher than the cost of knowledge to teachers will help them avoid their own interests in keeping their knowledge hidden (Cheng et al., 2009; Constant et al., 1994; Hung et al., 2011).

If the knowledge and educational content of each teacher does not have a critical value, and the teacher does not benefit more by keeping, then the probability of sharing without incentives is higher than in a knowledge sensitive environment. In a defect-restricted environment, debatable and

responsive behaviour is demanded more than the others in case there are no incentives for sharing. It is quite easy for system holders to define the extent of incentives depending on teachers' behaviour. As knowledge market theory states, system holders have to take on the brokering role to help teachers by providing motivation through recognition, cost compensation, reciprocity of sharing, and altruism (Davenport & Prusak, 1998).

Educational institutions can be considered as a stage in the long-term relations between teachers on knowledge co-creation and sharing and co-working on research. Related to this, we included a third environment -- cooperation-oriented -- where teachers frequently cooperate to create an educational knowledge base. The simulation results show that according to the behaviour set of the teachers in this environment, the overall system's behaviour on knowledge sharing is positive even in case incentives are not provided. In general, the environment is favourable for responsive teachers while the incentive is a miser configuration.

The main philosophy for system holders can be applying the social exchange theory for boosting teachers' behaviour on educational content sharing. As people try to maximize their own benefits and reduce the costs within the community it leads to the start of long term relations, properly recognizing altruism, reputation, and social benefits for the teachers according

to their performance. This will serve the overall well-being of the system (Hung et al., 2011; Molm, 1997; X. Zhang et al., 2010).

The findings of the simulation analysis highlight that it is significant to have a proper incentive system for increasing cooperation in knowledge sharing within educational institutions. However, the results also show that if education institutions do not launch incentives (incentive = miser), the probability of accepting ego-centred or disappointed behaviour by teachers is high. This means ego-centred teachers will never share their educational content with colleagues, and disappointed teachers will also prefer following ego-centred teachers.

In general, when an education system holder introduces incentives to motivate teachers to work more productively on educational content sharing, teachers' behaviour changes to altruistic or responsive that can influence the overall system behaviour by focusing on knowledge exchange. The figures that give the results (Figure 4.1, Figure 4.2, Figure 4.3 and Figure 4.4) highlight the strong dominance of altruistic behaviour if there is an incentive mechanism that visually imagines this situation and can create some illusion for trust in the absolute effectiveness of the system's behaviour. In other words, if altruistic teachers dominate in the environment, then this does not mean that the overall education system is doing well because everybody is

sharing their content. The issue that arises is the type of incentive that is provided to the teachers for their performance within a suggested model.

A big task for education system holders remains defining teachers' personality and behaviour for incentives (Tan, 2016). The system should not become a medium for teachers to encourage their own interests related to the payoffs that they get for sharing their content. The function of the system holder is to keep in control the changes in teachers' interest towards getting more payoffs by contributing less. The importance of this suggestion is seen in case teachers try to share educational content that is useless for colleagues but brings some incentives to the owner. This is the reason why after a couple of years any system can be less useful to the community because its main focus is only directed towards fulfilling one's own interests.

In case high incentive mechanisms (incentive = spendthrift) provided in all environments for just sharing educational content independent of its usability and usefulness this can lead to a social dilemma. While the intentions of the teachers about increasing their own payoffs regarding their own interests can decrease the overall benefits to the educational institution (Cabrera & Cabrera, 2002; X. Zhang et al., 2010), it can also disrupt the behaviour and productivity of the system. Incentive per usage by others can be an appropriate solution for avoiding this social dilemma. But if it is a knowledge sensitive environment,

then the quantity or extent of the incentive should be carefully designed because revealing costly knowledge should be compensated with incentives for keeping a balance between teachers' behaviour, the productivity of the system, and the expenditure incurred on the stimulations.

4.5.2 Limitations and future outlook

The first limitation of this study is that the suggested model considers only educational content sharing as the main activity of the teachers. However, teachers can share the results of their research that is not included in their syllabi. This is a future research target for us to enlarge the possible area of knowledge sharing in academia.

The next limitation is related to the analysis part of the study which despite covering a wide range of simulation scenario configurations, needs further steps to focus on some targeted environments in real practices. Nevertheless, the implementation of a real scenario in existing systems helps us draw conclusions about existing educational systems and teacher communities. These limitations motivate us to continue extending and widening the current study with more practical and narrow analysis.

Chapter 5. Innovations of Educational Services in a Software Service Ecosystem

5.1 Introduction

A new trend of innovations in software is providing software services as a platform to the public so that third-party developers can create new composite services on top of it (Campbell-Kelly, 2009; M. Cusumano, 2010a; K. Kim et al., 2015). Keys to these innovations are aggregating third-party developers to create various services thus attracting end-users and gaining economic benefits from the user base (Gambardella et al., 2016). Existing studies suggest ways of triggering this positive feedback system by separating core services to keep inside and peripheral services to commit outside (Ceccagnoli et al., 2012), adjusting openness of software services (Gawer, 2014), and separating the money side from the subsidy side (Eisenmann et al., 2006).

Our motivation for this research is finding out whether these strategies are sufficient to trigger the positive-feedback system. If they are sufficient, all categories should passionately adopt this way of innovating at the same level as the innovations around mapping and social networking (K. Kim et al., 2015). Education is a good case to consider. A long history of IT adoption

shows that the education sector is aiming at expanding the volume of classrooms by embracing students who live far away from classrooms (Alavi et al., 1995) and are not comfortable moving near classrooms (Piccoli et al., 2001) and those who have limited cognition (Leidner & Jarvenpaa, 1993). The education sector is also familiar with publishing content for the public over a long period from Johannes Gutenberg to the recent web services' MIT OpenCourseWare (https://ocw.mit.edu).

This research underlines the consistency between market demand and the areas that the software services cover. End-users rally to a software service which fulfils their demand; composite service developers respond to this demand (Eisenmann et al., 2006). Attracting composite service developers and end-users, therefore, depends on covering market demand for software services. We consider three cases of market demand coverage. First, a composite service expands the demand area for a software service by adding its own value to it. Second, combining a pair of software services creates new demand in the overlapping demand area. Third, a cluster of software services or a group of software services densely connected with each other drives innovations in the overlapping area.

In this framework, we address the specific research objective of finding innovations in software services in the education category to discuss market

demand for software services and their competitiveness:

Specific research objective 3 (SRO3): Studying stimulation strategies for the adoption of software service innovations in the education sector through supply and demand adjustments.

For this we discuss the following research questions:

- Research question 4 (RQ4): How frequently is a software service in education re-used to create composite services?
- Research question 5 (RQ5): Does a software service in education lead to any relations among the software services?
- Research question 6 (RQ6): How many software services in education are embedded in clusters of software services?

We implement our research model in empirical data for 127 composite services and 425 software services in education aggregated from www.programmableweb.com. We highlight the results for the education category by comparing them with those from the social networking category, one of the most active categories in software service innovations (944 composite services and 1,308 software services aggregated in the same way as the education category).

Our findings have both academic and managerial implications. First, consistency is necessary between market demand and the coverage of

software service to stimulate innovations by third-party developers. Second, according to these academic implications, the market demands knowledge dissemination, administrative support, and plentiful content on and experience in education. In conclusion, the education category looks snooping around a fence and waiting for relevant software services before reaping to its prosperous innovation.

5.2 Literature review on software service innovations

5.2.1 From IT adoption to user innovations

Information technologies have transformed education. A traditional way of providing education is through physical communication, that is, face-to-face talking in a certain place at a certain time (Alavi, 1994; Leidner & Jarvenpaa, 1995; Piccoli et al., 2001). This was a feature of classrooms from ancient Greek to modern schools until education practitioners and experts suggested that IT adoption in education could address physical constraints in communication (Alavi, 1994; Alavi et al., 1995; Gupta & Bostrom, 2013; Leidner & Jarvenpaa, 1993; Söllner et al., 2017).

This transformation is happening within as well as outside classrooms.

First, a multimedia system supports active communication in a classroom (Jonassen, 1996; Leidner & Jarvenpaa, 1995; Santhanam et al., 2008; Webster & Hackley, 1997; Xu et al., 2014). An interactive simulation environment in a multimedia system provides students with cognitive experiences in the subject to be learned but which is hard to bring to the classroom such as the shape of the galaxy and the movement of electrons around a nucleus (Leidner & Jarvenpaa, 1995; Webster & Hackley, 1997). This way of communication in the classroom reduces inequalities in learning capabilities (López, 2010; Xu et al., 2014) and stimulates creative thinking (Tezci, 2011).

Second, the Internet eliminates spatial and temporal restrictions in communication (Anohina, 2005; Aparicio et al., 2016; Ozdemir & Abrevaya, 2007; Piccoli et al., 2001; Wan et al., 2008; D. Zhang et al., 2004). Education services can be provisioned for disabled people (Seale & Cooper, 2010) and in the distant area such as the Australian Outback (Anohina, 2005; Ozdemir & Abrevaya, 2007; D. Zhang et al., 2004). Lectures on podcasts have opened up a bigger market which is larger than 50 students in a traditional classroom (Evans, 2008; D. Zhang et al., 2006) and is spread through social networking services through which students learn through interactive and collaborative communication (Hamid et al., 2015).

As a result, today's classrooms are mostly equipped with multimedia and

remote conference systems (Alavi, 1994; Alavi et al., 1995; Leidner & Jarvenpaa, 1993) and have moved to cyberspace that connects teachers and students through the Internet such as Technology, Entertainment and Design (TED) (Gupta & Bostrom, 2013; Söllner et al., 2017). If the public sector (educational organizations and the government) and the private sector with a public goal for education have driven IT adoption so far, the education sector is adopting a new trend of innovations that have emerged in the IT sector -- they are inviting users of education services for their innovations (Gambardella et al., 2016).

Many software vendors who have constructed data on maps, photos, and video clips, as well as functions for web browsing and geocoding, decompose their data and functions to provide them to the public through the open Application Programming Interface (Open API) (Campbell-Kelly, 2009; Ogrinz, 2009). This data and its functions are called ‘software services’ (K. Kim et al., 2015). Third-party vendors and consumers develop new services, or the so-called ‘composite services’, on top of one or more software services which usually require an abundance of capital to construct thus preventing the new services from appearing in the market (K. Kim et al., 2015).

Some of the leading educational organizations have made modules and opened their content to third parties. The University of California Berkeley,

one of the foremost leading organizations in education, for example, is open to third-party agents for some of its administration tasks such as registration status check and class information (Berkeley University of California, 2019). The issue that remains is what and how do end users use these services as well as other services in other categories such as Google Maps and YouTube.

5.2.2 Motivations for innovations in an ecosystem of software services

Software service providers, composite service developers, and consumers build an ecosystem which involves their intertwined relationships (Haile & Altmann, 2016b; K. Kim et al., 2015). The agents in the ecosystem achieve innovations on the grounds of their stratified heterogeneous motivations to innovate in the ecosystem of software services. Table 5.1 depicts the agents' give and take in the ecosystem, to support the discussion on their heterogeneous motivations.

First, a software service provider constructs a software such as mapping and video streaming services that require intensive capital (K. Kim et al., 2015). The strategic goal is attracting end-users who become the potential market for composite services (Kapoor & Agarwal, 2017). Various composite services again tempt end-users to visit software services and the network

effect between the two sides leads to their growth (Parker et al., 2017). However, wasting their capacity in less beneficial innovations has a negative impact on their competitiveness (M. Cusumano, 2010b). Therefore, a software service provider should define its boundary and concentrate on innovations in its own services to attract both composite service developers and end users (Gambardella et al., 2016).

Table 5.1 Relations among agents in an ecosystem of software services

	To Give	**To Take**
Software Service Providers	Software service providers allow third-party developers to access their software as a service through open API.	They extend innovations in software services to composite service developers so that they can get a large group of end-users whom they can rely on for developing economic schemes.
Composite Service Developers	Composite service developers create composite services on the basis of software services and release them in the market for end-users to fulfil demand at long-tail.	They access innovation resources that require intensive capital and attract end-users to their sites designed for supporting their economic schemes.
End-Users	End-users visit the sites of composite services and hence software services' sites by referring to composite services so that composite service developers and software service providers can use these for designing their economic schemes.	They fulfil the demand from the heads of software services to the long-tail of composite services with high quality and variety as they develop the composite services themselves.

Second, a composite service developer extends the variety of complementary services around a software service. As the basic software service lowers the cost of innovation, various composite services at the 'long-tail' are able to enter the market even if there are no reasonable returns (Miric, Boudreau, & Jeppesen, 2019). A developer can also release composite services without any commercial purpose because software services remove all initial costs except third-party developer's time, skills, and ideas (de Jong et al., 2018). With no initial costs, a composite service developer invites end-users to his/her site for economic and altruistic purposes.

Finally, end-users fulfil their heterogeneous demand for a group of various services provided by third-party developers (Jansen, Brinkkemper, Souer, & Luinenburg, 2012). Using software and composite services does not usually levy any fee, and the pricing has provisions for deepening activities from the services (M. A. Cusumano, 2008; Haile & Altmann, 2016b). Furthermore, their demand can be satisfied through adding their own ideas to the existing software services with low or almost no initial costs as composite service developers work (Franke & Von Hippel, 2003). In other words, end-users in the ecosystem seamlessly switch their roles between consumers and producers in the process of fulfilling demand.

Releasing software services in the ecosystem of software services fits the

business model of the education sector. Let us consider the classroom as a platform on which students and teachers meet like end-users and composite service developers meet on a platform of software services. The classroom has increased its receptive capacity for students by adopting multimedia systems (Muir-Herzig, 2004) and the Internet for distance learning (Ozdemir & Abrevaya, 2007) and the web such as TED (TED, 2019), and can hence invite more teachers to this business. By extension, opening up capital-intensive institutional functions and educational content can stimulate the development of various services fulfilling students' demand at the long-tail.

Education embraces public interest which distinguishes it from other sectors. The motivation to improve the quality of education and removing the digital divide makes the government lead IT adoption in education according to its long-term country-wide plans (Skryabin et al., 2015). Following public interest, leading universities have also opened their educational content such as the MIT OpenCourseWare (https://ocw.mit.edu), and administrative information such as UC Berkeley's API (Berkeley University of California, 2019) to the public as a service through the web with no direct economic benefits to them. Accordingly, the education sector's public interest lowers the barriers in opening up software as a service to the public.

What remains in the education sector is software service providers actively

opening their software as a service so that composite service developers and end-users are attracted to the software services. If the composite service developers extend the coverage of education services on the ground of software services in the education category, end-users will be able to fulfil their demand for education services at the long-tail by visiting the sites of composite and software services. The education category is expectedly embedded in the ecosystem of software services as it diffuses information across heterogeneous composite service developers and end users.

5.2.3 Relations, clusters, and the longevity of software services

A software service has a lifecycle from birth to death through prosperity as the market is segmented by the demand for services (Bass, 1969; Rogers, 2010). In other words, the scale of the prosperity of a software service increases proportionally to the number of people in the market demanding the service and it fades out as the demand is exhausted (Rogers, 2010). The time of withdrawal of a software service from the market moves forward if a new service substitutes the existing one and advances it further in the market (Jovanovic & MacDonald, 1994) and the incumbent service does not flow to a larger segment of demand from small early adopters (Moore, 2014). In summary, the longevity of a software service is finite and depends on its

fitness with market demand.

Participating in an ecosystem increases the scale of prosperity and extends the longevity of a software service's lifecycle by expanding market demand (Figure 5.1). First, composite services expand demand for a software service into the long-tail by adding their value to the software service (left column of Figure 5.1) (Oestreicher-Singer & Sundararajan, 2012). The expansion of demand then makes more end-users rally towards a software service than it can attract on its own. Due to low initial costs and innovations by users, it is easier to re-steer the direction of the expansion (Franke & Von Hippel, 2003). Therefore, in a market with changing demand a software service can attract longer than it would otherwise.

Second, combining software services creates an area of demand that has not been covered by the software services individually (middle column of Figure 5.1). This new area of demand does not require additional costs; what it needs are time, skills, and ideas of third-party developers to combine them with a software service (de Jong et al., 2018; Haile & Altmann, 2018). Therefore, bridging software services yields higher competitiveness in the market, that is, a large scale of prosperity and more longevity as compared to what would happen if a service was solely reused for developing composite services (Papazoglou & Spanos, 2018). Empirical research supports the theory

that frequently reused software services have a lifecycle with a high peak and a long span (K. Kim et al., 2015).

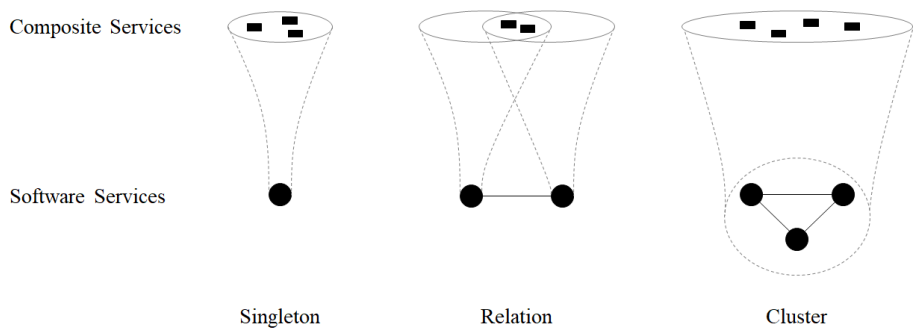


Figure 5.1 Projection of demand of software services on composite services for singleton, relation, and a cluster of software services

Note: Slide circle and solid box represent a software service and a composite service respectively.

Third, a cluster of software services in which they are intensively recombined with each other strengthens their lifecycle (right column of Figure 5.1). Software services in a cluster share overlapping areas of demand so more agents are locked in the area than in one of the pair of software services (Haile & Altmann, 2016b). Moreover, software services that are not yet combined are proximate through their common neighbouring services through which they potentially create new overlapping demand areas. Therefore, a cluster of software services has the potential to peak at higher prosperity and has wider

longevity in their lifecycles. This is like a social networking cluster in which its unique characteristics are more sustainable as they are shared by its members than those for an individual on his/her own (Festinger, Back, & Schachter, 1950; Girvan & Newman, 2002).

5.2.4 Market place for software services

A software service is a software that is provisioned as a service to support interactions between a person and a machine, and/or among a group people on the web (S. Baek, Kim, & Altmann, 2014; K. Kim et al., 2015). For example, end-users access Google Maps' server that has map data and related functions through a web browser to read a map of, for example, Waco in Texas. These end-users do not need to install a standalone package with a map on their personal devices (Yoo et al. 2010). Amazon even provides computation as a service which was previously provided as a product (that is, a personal computer and a shared server); a user does not need to know the location of the computer and pays for the service on demand (Chen and Wu 2012). In this way, the software business has turned to the services paradigm from product development by considering the following market issues: potential consumers, the risk of a price-free competitor, the longer lifecycle of software services, fast innovation adoption, and less expenditure on R&D than for developing a

product sample for an abstract consumer market (M. A. Cusumano, 2008).

An advanced way of using software services is accessing data repositories and computation resources through a standardized interface which is generally called an Open Application Programming Interface (Open API) (Zang, Rosson, & Nasser, 2008). 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 (K. Kim, Altmann, & Lee, 2013). Access to software services through an open API leads to promoting innovations in an open manner, that is, a third-party user creates a new service which is called a composite service by adding his own data and functions to one or more software services shared through the Internet (K. Kim, Altmann, & Kim, 2019; K. Kim et al., 2015; Zang et al., 2008). In this way, various services in a 'long-tail' can be released reducing the burden of a huge amount of investments in basic functions such as map data, search engine, data storage, and servers for computation (Oestreicher-Singer & Sundararajan, 2012). Enabling software reusability and modularity can bring timely and cost-effective project fulfilment (Banker & Kauffman, 1991) but it is sensitive to a firm's business vision. However, firms looking at a long-term business vision prefer re-using software service modules, while a short-term business vision focuses on delivering software related projects in a limited time (Sherif & Vinze, 2003). If a firm promotes

third-party developers for creating a new product or service which is tightly composed with internal re-usable modules of core products then it can increase the benefits for the developer and enhance the position of the firm in the market (Tiwana, 2018).

Smaller players in the software service ecosystem can win the market with strong relationships directed at finding optimum solutions for specific requirements and rapid adoption of innovations than large rival producers (Jansen et al., 2012). Partnerships on a platform ecosystem can be beneficial for software vendors for increased consumption of services and an increased number of initial public offers but only in case of strong marketing, service capabilities, and an intellectual property rights policy (Ceccagnoli et al., 2012). A technological shift by the platform provider can disrupt the positions of market leaders who contribute significantly but it also simultaneously ensures the new potential for other players to create more value (Kapoor & Agarwal, 2017). The entry of a platform provider in a complementary market can drive higher innovation growth that increases service consumption and feedback from users which other players can also benefit from (Foerderer, Kude, Mithas, & Heinzl, 2018). The correlation among the number and variety of services and service usage activates the cross-side network effects in a market (Haile & Altmann, 2016a). Relatively, an increased number and variety of services

drive short-term consumption by end-users, and this increased usage by end-users magnifies the number and the variety of services in the long term (Song, Xue, Rai, & Zhang, 2018).

Early literature on user innovations highlights individuals as a promising source for the creation of new modifications or changes to existing products or services (Nambisan, Agarwal, & Tanniru, 1999; Urban & Von Hippel, 1988; Von Hippel, 1986), especially in the IT sector. The heterogeneity of consumer demand in the market motivates users to seek solutions to fulfil their own needs by modifying existing products when market supply is lacking (Franke & Von Hippel, 2003). These solutions by the users provided for by personal investments for satisfying their own needs leads to the emergence of the user (consumer) innovation paradigm (de Jong et al., 2018; De Jong et al., 2015; Franke & Von Hippel, 2003; Gambardella et al., 2016; Halbinger, 2018; Hienerth, Von Hippel, & Jensen, 2014; Morrison, Roberts, & Von Hippel, 2000).

The heterogeneity of consumer demand leads us to argue that there is a possibility that individuals who also have the same needs for goods or services provided by user-innovators also exist. Recent literature shows that individuals are investing a great amount in their innovations (De Jong et al., 2015; Von Hippel et al., 2012, 2011) but are rarely willing to commercialize

them (de Jong et al., 2018; Gambardella et al., 2016; Hienerth et al., 2014; von Hippel, DeMonaco, & de Jong, 2017). By initiating the diffusion of their own innovations user-innovators can contribute to social welfare when others get value from their innovations (De Jong et al., 2015; Gambardella et al., 2016), or sometimes these user-innovations can drive the emergence of a new service or product in the market (Morrison et al., 2000).

The software service ecosystem applies the concepts of the user-innovation paradigm by revealing open APIs of the services and calling individual developers to innovate by creating composite services (mashups) (K. Kim & Altmann, 2013). This also supports users to exchange and diffuse their own solutions (Halbinger, 2018) which are not market-oriented but maybe for their own needs or for altruism (de Jong et al., 2018; Hienerth et al., 2014) in the software services sector. Investments for sharing composite services by user-innovators can decrease potential adopters' costs for seeking innovations thus increasing social welfare (De Jong et al., 2015; Gambardella et al., 2016). However, a new issue of investing in externalities also emerges here.

The free availability of software service codes (or APIs) does not mean that they will be successfully adopted (De Jong et al., 2015) as they still need potential users. Open software services are provided for promoting a user-

complemented market (de Jong et al., 2018) which further leads to mashups by users that can bring additional profits for the provider (Gambardella et al., 2016). The current approach to technological co-evolution by providers and users has motivated even closed platforms to open some product interfaces by keeping the core products proprietary (M. Cusumano, 2010b). Before calling users to innovate together, providers should properly define the extent of openness and a healthy environment for interactions with user-innovators (Gambardella et al., 2016) to push user innovations. The efforts made by the providers of the software service ecosystem on the diffusion of user innovations can reduce innovators' costs of revealing new composite services (innovations).

5.2.5 Diffusion of software service innovations

The market needs time to adopt technology but technology has limited longevity in the market. A technology shows a bell-shaped curve from its birth to death through prosperity as inventors and imitators in a limited population adopt the technology (Bass, 1969; Rogers, 2010). Although an old technology fades out from the market at the end of its longevity, a successive technology replaces the old one to continue the growth of the industry as long as the market demands it (Jovanovic & MacDonald, 1994). However, all

technologies do not move through this lifecycle successfully. Even advanced technologies can fail to attract most of the consumers if they do not satisfy market demand in front of the 'chasm' between early adopters who respond to technological opportunities, and the early majority which fulfills its own demands (Moore, 2014). The longevity of innovations depends on size and maintenance efforts as large systems can live longer than smaller ones due to coverage by large processes but their maintenance efforts are also relatively higher (Swanson & Dans, 2000).

During the longevity of innovation in the market, it is expected that not only the adopter's characteristics will change but the scale of adoption can also influence the evolution of functionality and complementarity of the innovation with other innovations and technologies (Freitas, 2008). The potential market failure of innovation can be detected because of more expenditure in diffusion when the net benefits of each adopter increase proportionally with the expenditure on innovation diffusion (De Jong et al., 2015). A way of avoiding market failure and increasing the breadth of the diffusion is leaning on information from past adopters about the innovation and reaching wide acceptance among potential adopters (Greve, 2011).

Some software services show a bell-shaped curve for the lifecycle of connectivity in the software service ecosystem (K. Kim et al., 2015). The

market responds to a software service in two ways. End-users directly use a software service through web pages on demand (K. Kim, Altmann, & Hwang, 2011). And third-party developers reuse the software services to create composite services that satisfy end-users. In both the scenarios, innovative products that cross the boundaries of technological domains are developed on the basis of strong knowledge that goes beyond a single domain which increases their competitive advantages in different domain markets (Papazoglou & Spanos, 2018).

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. The issues that remain are how actively the market responds to education software services, whether they complete their lifecycle like successful software services or snoop around the chasm to be finally declined. Here one of the main factors could be knowledge about the innovation which increases awareness among potential adopters, as a result of which there is more likelihood of the innovation being adopted (Gibbons, 2004).

5.2.6 Innovations' market failure

According to the literature on innovations, market failure occurs primarily because of improper commercialization activities by the providers (Chiesa & Frattini, 2011; Henkel & Von Hippel, 2004) and rarely because of poor manufacturing. Market failure is described as the inefficiency of staying in the market when an alternative service or product makes consumers better-off without making others worse off (de Jong et al., 2018). Recent studies have found a new shape of market failure in the user innovation market. The market failure of user innovations can emerge if the user-innovator invests more in the diffusion of the innovation and the adopter gets proportionally more net benefits by adopting this innovation (De Jong et al., 2015). From the perspective of the user-innovator, adoption by others is characterized as an externality which can lead to the issue of free riders (De Jong et al., 2015; von Hippel et al., 2017).

Classic theories of diffusion explain the chasm where most innovations fail to attract an early majority of adopters because they cannot satisfy their demand (Moore, 2014). Then if any innovation by the user is involved in the diffusion there is a probable risk of diving into the chasm or simply meeting market failure. Diffusion of user innovations can be beneficial if there are

potential adopters who get value from the innovations (De Jong et al., 2015). However, a task for the user-innovator is accurately addressing the needs of adopters (Henkel & Von Hippel, 2004) and managing the adoption network precisely (Chiesa & Frattini, 2011) to avoid failure. The question that arises here is if the user-innovator wants to diffuse an own-needs oriented innovation which can be valuable for other adopters (de Jong et al., 2018).

The adoption of innovations in the education sector is quite a challenging process because of the system's complexity of education settings, as is evident from a few innovative projects that can live longer because of this reason (Bocconi, Kampylis, & Punie, 2013). Innovation adoption in education is characterized by the emergence of changes at the practical level (bottom up) and promoting practitioners roles in decision making and risk taking (Ellison, 2009). In this case, teachers can be seen as lead users of innovations at the practical level of education. Then the innovations can probably start if the teachers' communities have unique demands (Morrison et al., 2000) according to their teaching methods and models and these innovations can be considered as user innovations. A factor that can hamper the occurrence and adoption of user innovations in education is that the output of the innovation cannot be estimated as in the market (Scupola & Zanfei, 2016).

5.3 Methodology

The data for our analysis is aggregated from http://www.programmableweb.com. The website provides information on software services that open their APIs and composite services (mashups) that use those software services. The record starts in May 2005 and is still being updated and has more than 18,600 software services and 7,900 composite services in 482 service categories. We selected the services belonging to the education category released between the beginning and end of August 2018, and social networking services released in the same period for the analysis and comparison. As a result, 425 (1,308) software services and 127 (944) composite services are used for the analysis in education (and social networking) (Table 5.2).

An analysis of the relationships and clusters of software services is done using the social network analysis with our empirical data. We define a network of software services as a set of software services (representing vertices) and the concurrent use of a pair of software services for developing a mashup (representing edges). The edges are undirected and binary, that is, an edge just designates the existence of recombination of software services but does not give information on the frequency of recombination. The network

contains 106 software services and 127 composite services that combine software services in education, and 596 software services and 944 composite services in social networking (Table 5.2).

Table 5.2. Number of software and composite services

		Number of software services	Number of composite services
Software services and composite services released during the study period	Education	425	127
	Social Networking	1,308	944
Software services and composite services used for analysis	Education	106	127
	Social Networking	596	944
Software services and composite services that refer to more than one software service	Education	85	59
	Social Networking	480	594
Software services and composite services that refer to only one software service	Education	21	68
	Social Networking	116	350

We analyze the network at three levels. First, we analyze the reuse of software services at the level of singletons. We explicitly analyze the appearance of software services in the ecosystem and count the number of times the software services are reused for creating composite services, measured by the frequency of their appearance in composite services.

Second, considering the relationships between software services we

measure the position of a software service with two centrality indicators, degree centrality and betweenness centrality (S. Baek et al., 2014; K. Kim et al., 2015). Degree centrality of a vertex is the number of edges that are attached to the vertex (Estrada & Rodriguez-Velazquez, 2005). The former means how deeply a software service is involved in developing composite services. Betweenness centrality is the number of shortest paths between any pairs of vertices that pass by the focal vertex, divided by the number of all shortest paths connecting the pairs of vertices(Estrada & Rodriguez-Velazquez, 2005).

Third, we analyze the services at the cluster level according to the definition given by Wasserman and Faust (1994) as a group of vertices connected with each other more densely than the other vertices in the group. If the market demands agile innovations of composite services with specific features, then the innovations lead to gathering those software services around the demanded features. We implement the leading eigenvector algorithm to detect clusters in networks of software services. The algorithm calculates the modularity of the edges among the vertices and then the eigenvectors that yield the leading eigenvalue for the modularity matrix. The output identifies the clusters that contain the most densely connected vertices within them (Newman, 2006).

5.4 Analysis results

5.4.1 Growth of the software service ecosystem

A software service ecosystem grows as new software services are released and reused for developing composite services. Figure 5.2 depicts the annual growth in the number of software and composite services in education between 2006 and 2017. We removed the years (2005 and 2018) with incomplete data from the study period. The results show that annual growth in software services peaked at 93 in 2012, around which time from a monotonic increase the growth started decreasing. On the other hand, the growth of composite services dropped in 2011 and remained at a low level thereafter. These patterns suggest that education services do not experience active innovations in composite services during the lifecycle of the software services.

Comparing this growth to the growth in social networking services shows inactive innovations in education (Figure 5.3). Like in education services, the annual growth in software services in the social networking category monotonically increased initially and decreased after touching a ceiling of 350 in 2012. The growth of composite services in the social networking category also shows a monotonic increase and decrease around a peak of 305 in 2011. The peak for composite services preceded the one for software services by

one year. In other words, education services and social networking services both experienced the same lifecycles in feeding software services but composite services did not frequently appear during the period of active innovations in the education category.

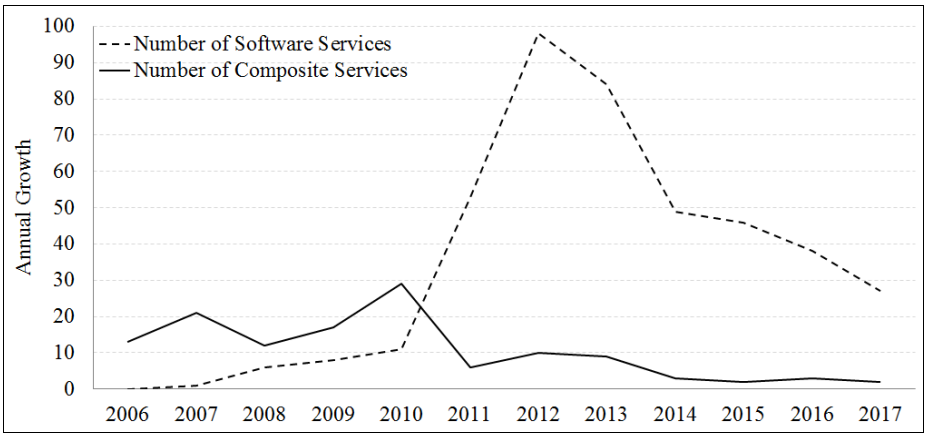


Figure 5.2. Annual growth in the number of software and composite services in the education category

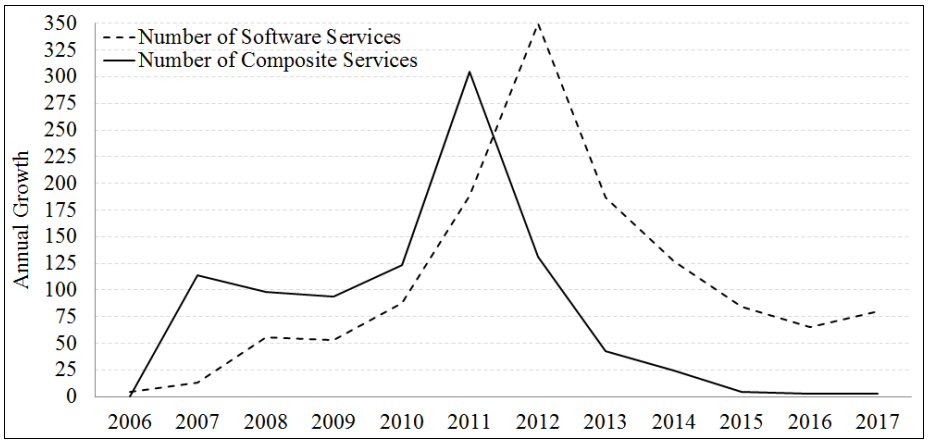


Figure 5.3. Annual growth in the number of software and composite services in the social networking category

5.4.2 Reuse of software services for creating composite services

The analysis' results at the singleton level show that composite services in education mainly refer to software services out of the education category (Table 5.3). Five of the six services belong to the mapping category (Google Maps), the social networking category (Facebook and Twitter), and image and video category (Flickr and YouTube). DonorsChoose, an online charity service that promotes students who need support (DonorsChoose.org, 2019; "ProgrammableWeb," 2018a), is the only software service in the education category. These results suggest that innovations in education were led by feeding software services out of the education category.

On the other hand, in the social networking category, the software services most frequently reused in composite services belong to the same category (Table 5.3). Facebook and Twitter were reused for 242 and 312 composite services respectively, while Google Maps was used for 223 services. Google Maps is the most frequently reused software service in the entire ecosystem (K. Kim et al., 2015). Software services in the social networking category look at leading innovations in social networking composite services. This is contrary to education in which dominant software services that appear in

education composite services do not belong to the same category and follow the pattern of the entire software service ecosystem (K. Kim et al., 2015).

Table 5.3. Representative software services that were reused most frequently during the study period

Service name	Release date	Provider	Service category	Reuse in all categories	Reuse in the education category	Reuse in the soc.net. category
Google Maps	Dec. 2005	Google	Mapping	2,577	66	223
Flickr	Sep. 2005	Yahoo	Photos	635	11	77
YouTube	Feb. 2006	Google	Video	707	9	83
Facebook	Aug. 2006	Facebook	Social	451	9	242
Twitter	Dec. 2006	Twitter	Social	827	7	312
DonorsChoose	Mar. 2009	Donors Choose	Education	16	14	--

5.4.3 Relations between software services through creating composite services

Baek et al. (2014) distinguish between the roles of a vertex into a hub (high degree and high betweenness centralities), core (high degree and low betweenness centralities), bridge (low degree and high betweenness centralities), and periphery. By capturing the role of each software service in a

network, we define their influence on composing and managing the entire network.

Software services become more influential in a network if they are located in a hub and connect other software services through co-reuse for releasing composite services. The core position shows the strength of the software service in a cluster which assembles the rest of the software services to create value around a certain demand. The bridge node in a network links different clusters that can be interpreted as a software service forming a bridge between demand areas around the composite services. Peripheral software services contribute to the creation of composite services around limited demand by consumers.

Figure 5.4 shows the position of software services in a map of degree centrality and betweenness centrality of 85 software services in which 21 isolated services are removed. The most frequently reused software services (Google Maps, Facebook, Twitter, and Flickr) are located in the centre of the education service network and Google Maps is a hub that connects the other software services in the ecosystem. Education software services including DonorsChoose, the most frequently reused software service in education are located in the periphery.

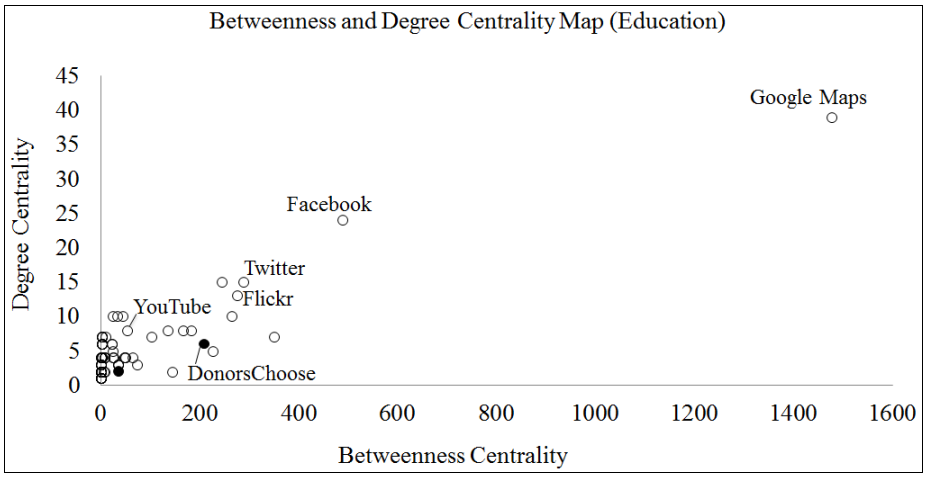


Figure 5.4. Degree and betweenness centralities map for the education category

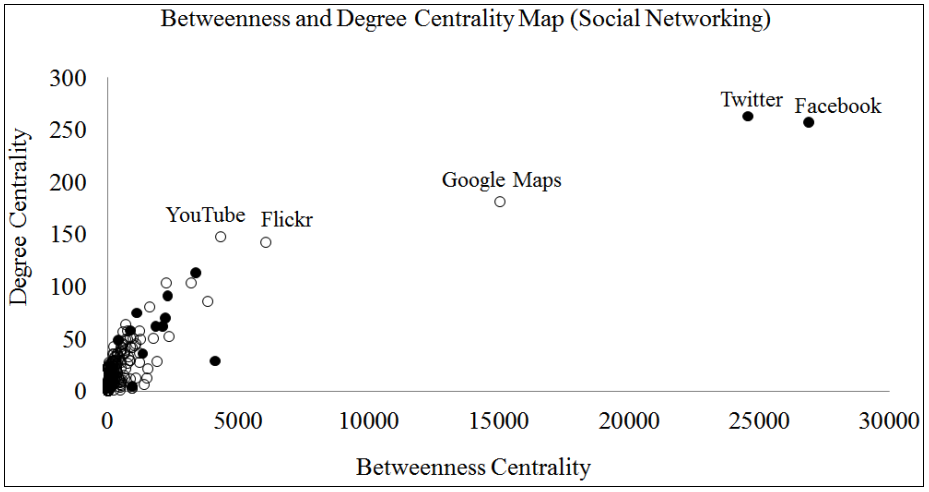


Figure 5.5. Degree and betweenness centralities map for the social networking category

Software services that act as hubs exist in the social networking category too (Figure 5.5). Social networking services, such as Facebook and Twitter act

as hubs in the social networking services network which is different from educational services. The central position is occupied by Google Maps, Flickr, and YouTube which are also hubs in the entire ecosystem (K. Kim et al., 2015). Because deleting hubs destroys the entire ecosystem, creating composite services in the social networking category relies on software services in the same category. On the other hand, it is hard to say that innovations in education composite services require software services in the education category.

5.4.4 Clusters of software services that densely create composite services

We detected 11 and 6 clusters in the networks of education services and social networking services respectively. We selected enough clusters which consist of more than three software services because one and two software services are isolated singletons or dyads instead of being a cluster and a cluster with three software services is built by creating only one composite service. Table 5.4 gives four clusters in the network of education services (E1 – E4), and four clusters for social networking services (S1 – S4) which are filtered by this process.

The clusters in the education category do not usually consist of software

services belonging to the education category. Two clusters (E2 and E4) have no software services of the education category. Rather, cluster E2 consists of three software services of the advertisement category among 14 software services and cluster E4 has nine software services belonging to the mapping and two software services of the social networking category. The remaining two clusters E1 and E3 embrace one and four education services respectively among 13 software services in E1 and 24 software services in E3. In other words, education composite services can emerge even from non-education software services.

The clusters in the social networking category show a composition that is contrary to the education category. All four clusters contain considerable software services of the social networking category such as Facebook and Twitter. That is, 36 of 110 software services, 14 of 42 software services, five of eight software services and one of eight software services belong to the social networking category for S1, S2, S3, and S4 respectively.

In summary, the results mean that social networking composite services like services for strengthening the use of giant social networking services in case of S1 appear in the demand area around social networking services according to our consideration in the right column of Figure 5.1.

Table 5.4. Clusters of software services in education and social networking categories

ID	Entire srvs.	Educat. srvs.	Social netw.	Description	Software services
E1	15	1	4	Online communities of learners are useful for knowledge dissemination	Alexa Site Thumbnail; Facebook; Google AJAX Language, Pay Pal; …
E2	14	0	0	Instantly finding the books in need	Amazon Product Advertising; Google Search; YouTube; Yahoo Maps; …
E3	24	4	3	Making knowledge content available to everyone	DonorsChoose; Flickr; UC Berkeley Registration Status Check; Twitter; …
E4	21	0	2	Locations of good schools	Dropbox; Google Maps; Yahoo Geocoding; Bing; …
S1	110	0	36	Dominating social networking services pull software service giants	Facebook; Google Maps; Twitter; Amazon S3; …
S2	42	0	14	Enabling the rapid distribution of video and music content	YouTube; Flickr; Amazon Product Advertising; Bing; …
S3	8	0	5	Capture, store, and share photos via social networking platforms	GitHub; Burstn; SlideShare; Tumblr; …
S4	8	0	1	E-commerce with social networking services	Yahoo Image Search; iTunes; Google Custom Search; LinkShare; …

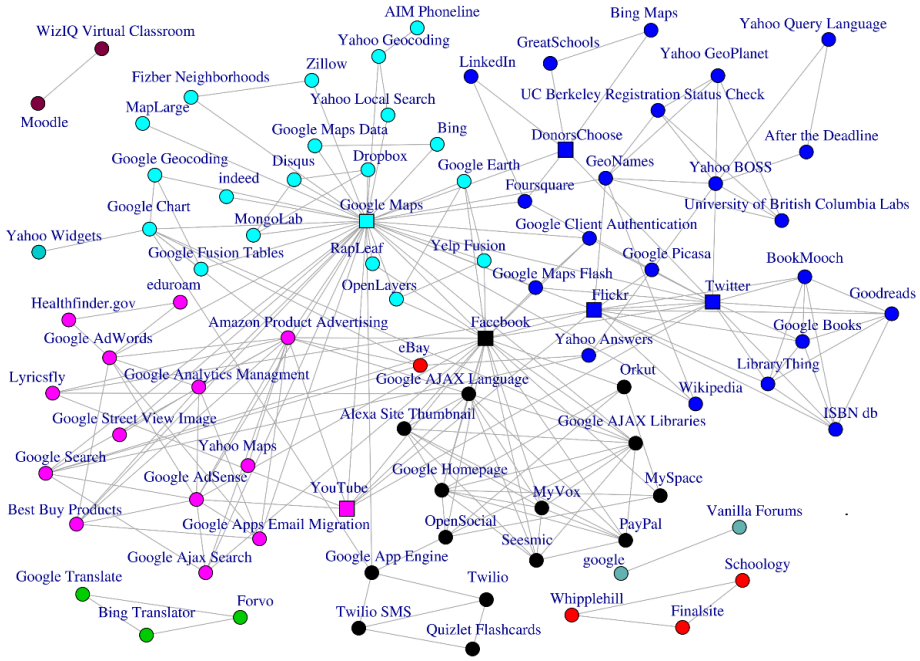


Figure 5.6. Network map of the education software service ecosystem

Figure 5.6 shows the network of software services connected through concurrent reuse for developing composite services in the education category. The colours of the vertices represent membership in clusters and the rectangle shape of the vertices shows the selected software services. Four clusters are detected in the main components, four clusters in the small independent components, and a cluster including only eBay software service. The six representative software services belong to each of the clusters in the main component which are distinguished by different colours. However, no education software service contributes to the connectivity of each cluster to the main component. Only a small independent component consists of

education software services: Finalsite, Schoology, and Whiplehill formed the cluster by developing one composite service (CustomSync for The Education Edge).

Figure 5.7 shows the network map of software services co-reused to create new social composite services. The entire network in the social category is big with hundreds of node and thousands of links between them. For avoiding this complexity and showing a visually well-represented network map, we deleted the links with weight equal to 1. As a result, we reduced the number of software services on the map which co-reused only once with others. The software service network map for the social category includes two big clusters and two small clusters connected to them, and there are two isolated clusters connecting only two nodes each. The most important software services (Facebook, Twitter, and Google Maps) in the network ensure the rigidity of the giant cluster by connecting more nodes. YouTube and Flickr pull other software services to make a cluster which is smaller than the giant one. Other social software services like Foursquare, LinkedIn, and FriendFeed also have more links to other nodes because of frequent co-reuses.

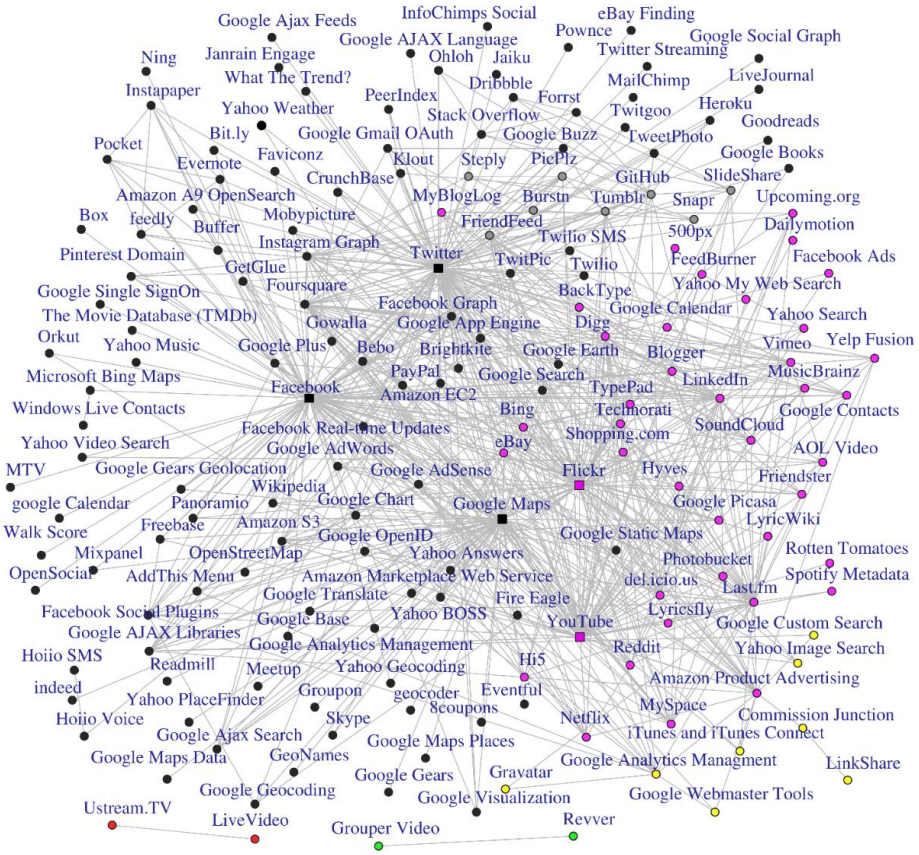


Figure 5.7. Network map of the social networking software service ecosystem

5.5 Discussion and conclusion

5.5.1 Summary

The findings of this research show that supplying software services might be insufficient for initiating growth in the ecosystem of software services. The education category supplies software services with the motivation of attracting end users to classrooms by extended the long history of its IT adoption (Leidner & Jarvenpaa, 1993). However, third-party developers do not actively join in the innovations in composite services of education (Table 5.3). Moreover, education services do not lead innovations through recombination in the education category as we see patterns of relations among software services (Figure 5.4). A comparison of the results of social networking services emphasizes this pattern in education (Table 5.3 and Figure 5.5).

Our findings also suggest that demand is correlated to the lack of innovations in composite services even though there is enough motivation for innovations and there is a relevant supply of software services. Education software services rarely appear in the clusters of software services that create composite services in the education category (Table 5.4). DonorsChoose, the most frequently reused software service in education, appears in 14 education composite services, while Google Maps appears in 66 composite services of

the total 127 education composite services (Table 5.2 and Table 5.3). Let us consider that composite services are developed in an area where demand expands from the point of software services (Figure 5.1). In this sense, our findings imply that software services could not satisfy the demand of end-users which reflects in composite services.

5.5.2 Implications

Our findings have four implications for academia and managers. First, our approach opens a new way of applying network analysis to the management of information systems. Existing studies that use a network analysis consider a network as a conduit of knowledge flow among individuals that affects their performance (Chellappa & Saraf, 2010; Sasidharan, Santhanam, Brass, & Sambamurthy, 2012). Another stream in existing studies shows the complex patterns in the communication structure between entities in a system (Cha, Kwak, Rodriguez, Ahn, & Moon, 2009; Yun, Lee, & Jeong, 2016). On the other hand, our approach shows that market demand around software services emerges in the singletons, relations, and clusters that a network consists of (Figure 5.1).

This approach to a network analysis connects the diffusion of a software service with its relations and clusters through its market demand. An edge

between software services through composite services creates value even if no knowledge flows over the edge and their cluster does so even if it contains common characteristics of software services, that is, demand around a software service is expanded by composite services. The way of expanding demand for a software service affects its lifecycle as the diffusion of a software service depends on market demand (Rogers, 2010). To our knowledge, this is the first study that connects a network of software services and demand related to the network and the diffusion of the software services.

Second, our findings suggest that theories on software services in an ecosystem should consider the coincidence between demand covered by a software service and the demand that end-users have. Existing studies highlight inviting third-party developers in a software service as a platform and strategies to attract end-users who prefer free services while keeping the returns with the software service provider (M. Cusumano, 2010b; Gambardella et al., 2016; Parker et al., 2017). Existing studies also assume that an ecosystem needs market demand for third-party developers to innovate and invite end-users in innovations. They explain the growth of an ecosystem on the ground of this demand leading to the participation of third-parties in innovations (K. Kim et al., 2015).

If existing studies assume that there is market demand in an ecosystem,

our study examines the relationship between demand among agents in the ecosystem. Composite services rally to a software service once the market demands it. And the coverage of a composite service should be relevantly proximate to one of the software services to expand it due to the cognitive limitation of distant services (Nooteboom, Van Haverbeke, Duysters, Gilsing, & van den Oord, 2007). Therefore, a software service should cover market demand or at least proximate to it to attract third-party developers. We conclude that inconsistencies between market demand and the coverage of software services lead to the failure of education services in reaping the prosperity in the lifecycle of software services.

Third, our findings contribute to the platform theory as they have managerial implications for developing an ecosystem of software services. The number considerably surpassed 12 million developers of mobile applications (Evans Data Corporation, 2016) and reached 2.32 billion mobile phone users (Simms, 2017). Around 2017, the world had 2 billion education participants who communicated in classrooms (Max Roser, 2017). That is, education has a demand that potentially creates a market that is larger than the mobile phones market. If innovations by third-party developers and end users are not very active in the education category it is not because of lack of demand.

According to our findings as there are inconsistencies between market demand and the coverage of a software service, a software service should be carefully designed so that its coverage helps meet market demand. Table 5.4 gives a clue to the design of educational software services. Market demand for education is located in the effective dissemination of knowledge (E1, E2, and E3) and administrative support for education (E4). A software service that will lead innovations in education can also emerge for providing educational content (for example, MIT OpenCourseWare: https://ocw.mit.edu) through support from other software services in searching and social networking categories as well as comprehensive administrative information about and experiences in education that support the education of third-party developers. This is the role that Facebook and Twitter perform in cluster S1 (Table 5.4) and Google Maps in the entire ecosystem of software services.

Fourth, public interest in education might be related to inactive innovations in an ecosystem of education software services. A long history of IT adoption in education and its public interest make it easy to release software services. However, these features of the education sector might miss comprehensive strategic thinking. Introducing a software service requires balancing the risk of losing competitiveness through sharing the core service and the benefits of obtaining more end-users by expanding market demand

(West, 2003). On the other hand, public interest allows a software service to be introduced although it does not gain benefits that are larger than its risk or even there is no any market demand.

We do not maintain that education should be privatized involving a strong public interest. Instead, the education sector is already familiar with sharing with end-users and inviting third-parties to a platform as we can see in MIT OpenCourseWare (https://ocw.mit.edu) and TED (https://www.ted.com). The market looks at demanding software services with the content on and experience in education that can lead and/or support disseminating knowledge and administration for education (Table 5.4). The next step is matching the coverage of software services with market demand and striking a balance between the benefits of a strategic decision and its risk in competitiveness before introducing a software service. We are confident that proper software service will boost the education category.

5.5.3 Limitations and future outlook

Although our study has academic and managerial implications, it has several limitations that give us a chance of doing further research. First, a lot of the composite services are created on the ground of single software services and a network approach excludes these singletons. Further research needs to design a frame that includes both singletons and relations (and clusters).

Second, in the analysis we use the categories of software services without modifications which are defined by the platform - ProgrammableWeb (https://www.programmableweb.com) and this pre-defined category could be different from what is really used. For example, Wikipedia might be in education but we omitted it in the analysis because it belongs to the wiki category. Further research needs an algorithm identifying the actual categories of software services.

Chapter 6. Concluding Remarks

6.1 Summary of the results

The purpose of this dissertation was studying the ecosystem strategies and policies for improving the quality of educational services by stakeholders' value co-creation for knowledge building and innovating for education (general research objective). To find answers to this general research objective, the dissertation focused on the following streams of research:

1. designing an alternative model for collective educational content creation and sharing as a value co-creation among teachers;
2. studying teachers' behaviour towards the adoption of the collaborative value creation model;
3. analyzing the adoption of software service innovations in education from the perspective of improvements in educational services.

Three specific research objectives were finalized to meet the general research objective of the study. Each specific research objective included relevant research questions. The dissertation has three main chapters, each addressing one of the specific research objectives. To answer the research questions (RQ2 – RQ6), two well-known methodologies, namely, social network analysis and Agent-Based Modelling by applying iterated games

were used. The results of the analyses were presented and discussed and their implications highlighted in the relevant chapters. This chapter summarizes the results of the earlier three chapters and underlines the noticeable results of the study.

Summarizing ideas around the suggested collective educational content creation and sharing model (of the environment) in Chapter 3, we come to the following conclusions. Existing studies discuss the provisioning of the most relevant and up-to-date knowledge sources and educational content as an important topic in educational institutions (Eames et al., 2003; Van Driel & Berry, 2012). Following Research Question 1, this dissertation introduces a new approach to educational content sharing among teachers as a way of delivering up-to-date and quality curricula to learners.

The study suggests a model that supports creating educational material, syllabi, and student evaluation objectives by teachers for the purpose of educating students, simultaneously feeding other colleagues in need of educational content. The main concept behind the model is encouraging teachers to get involved in improving educational content through sharing with each other and keeping themselves up-to-date as effective educational content creation is still a contentious issue for education system holders (Holohan et al., 2005).

The model covered some of the existing practices of teachers' activities in educational content creation and how it is used in classes such as creating syllabi and educational material for building the students' knowledge set in a classroom and evaluating their knowledge in exams. However, sharing and using educational content with/of other teachers is carefully designed in a new and simple approach. The suggested model not only focuses on building such a system using information technologies but also considers how the business model of the system could be developed with strong relations with stakeholders. The intention of the stakeholders on value co-creating and strong cooperation is a central concern of this research.

The suggested model (Figure 3.3) can serve as an alternative to educational content exchange between teachers with the aim of improving the curricula offered by educational institutions. As a consequence, a country's risk of slowing down economically because of poor learning outcomes which are a result of outdated educational content and poor syllabi is reduced (Asikhia, 2010; Ghaffarzadegan et al., 2017).

The model considers incentive mechanisms as a crucial source for behavioural changes among teachers for sharing educational content with their colleagues. This is the reason we came up with this model and investigated it with simulation experiments that suggest that the system holders manipulate

teachers' behaviour towards cooperation. As a logical and practical continuation of the work in Chapter 3, Chapter 4 analyzed the behavioural aspects of accepting an educational content sharing environment. For this analysis, we used ABM by employing iterated games. An artificial world of the study was built in a wide range of possible simulation configurations. We now highlight some important points of the simulation analysis.

Diversity of environments is emphasized depending on the payoffs for the teachers. In different environments, the utility and loss of certain strategies of 'sharing' and 'not sharing' have different values for the same teacher. To answer Research Question 2, we discuss the results of the simulation scenarios in which incentives have not been provided (incentive=miser). The results indicate that teachers tend to move towards ego-centred behaviour in a knowledge sensitive environment. But, a defect-restrictive environment leads teachers towards debatable and responsive behaviour. Teachers in a cooperation-oriented environment tend to have altruistic, responsive, and ego-centred behaviour. All these behavioural changes in the teachers depend on behaviour sets which characterize the behaviour of the teachers' community.

Teachers' behaviour within a community can be different so coming from this behavioural diversity we conducted a simulation analysis covering multiple sets of teachers' behaviour. As an answer to Research Question 3, the

results show that providing incentives cultivates acceptance of altruistic behaviour among teachers (Table 4.4) which is the most productive behaviour in educational content sharing. But it is suggested that education system holders should find optimum solutions for launching incentive mechanisms related to teachers' behaviour. Teachers' rational interests in gaining more payoffs should not drive collective irrationality that will lead to the problem of system misuse.

Based on the research in Chapter 5, we draw the following conclusions. Market demand for a software service determines its lifecycle (Rogers, 2010). Inviting third-party developers to innovate helps struggling software services to strengthen their lifecycles by expanding their coverage to meet market demand. The success of this invitation needs consistency between market demand and the coverage of a software service; lack of this consistency prevents it from reaping to the prosperity period. Education has a long history of IT adoption and having public interest and so it is suitable for introducing software services to join their ecosystem (Leidner & Jarvenpaa, 1993, 1995). Our findings suggest that the education category is still snooping around a fence and waiting for relevant software services before it crosses the fence to widely adoption of innovations in the market.

Related to Research Question 4, the findings of the analysis show (Figure

5.2) that releasing software services maybe not sufficient for triggering improvements in the software service ecosystem. Even though IT has provided many opportunities in education, the software service ecosystem of the education category is not as mature as was expected.

Software service providers have supplied open interfaces (API) to attract end-users to bring innovations into classrooms. However, third-party developers have not reacted to fulfilling end-users' demands by introducing composite services. As an answer to Research Question 5, Figure 5.4 shows that education software services do not lead the relations among other software services in the ecosystem. This indicates passive innovation creation in the education software service ecosystem.

The findings for Research Question 6 suggest that demand can be correlated more with the lack of innovations in software services even though there are a number of software services and there is motivation for innovations. This can be seen in education software services being inactive within clusters (Table 5.4) in the education software service ecosystem. The clusters are formulated from the perspective of creating innovations through supplying education composite services where mapping and social networking software services dominate (Figure 5.6). This implies that innovations (composite services) are developed around expanded demand.

6.2 Major contributions

This dissertation has both theoretical and managerial implications of the suggested model of educational content sharing and the analyses that it conducts. A major academic implication of the dissertation is proposed effective methodologies to answer the research questions and its suggestion that these methodologies can be alternatives to related research objectives in the future. The managerial implications are emphasized with strategic guidelines on considering the behaviour type with educational content sharing among teachers and on the diffusion of software service innovations for improving educational services.

6.2.1 Contributions to educational content sharing among teachers

To understand the inter-relatedness of the suggested model for educational content sharing in Chapter 3 and the analysis in Chapter 4, this section discusses the contributions of both the chapters together.

The first contribution of the study related to Specific Research Objective 1, is the possible approach for educational content creation and sharing within the teachers' community that this dissertation discusses. The research suggests

a model (Figure 3.3) supporting the creation of educational content by the teachers for their own purposes of educating students, while simultaneously also providing it to other colleagues in need of some educational content. The main concept behind the model is encouraging teachers to get involved in improving educational content through sharing it with each other and remaining up-to-date since effective educational content creation still remains a key concern for education system holders.

The second contribution of this research (SRO2) for academics is that it discusses an alternative approach for triggering behavioural changes in teachers towards educational content sharing within the different environments as there is a demand in existing literature for the design of an entire structure and processes of knowledge sharing within the academia. To design the possible scenarios appropriate for real-life cases of educational content sharing, the dissertation includes different sets of environments, teacher behaviours, and incentives for its simulation analysis.

The third contribution of the study is (SRO2) for education system holders as it defines the value of knowledge for the owner, namely how knowledge defines the relative advantages for a teacher. Accordingly, different incentive mechanisms can be implemented to achieve behavioural changes among teachers towards sharing their educational content. For example, in an

environment where knowledge has a high value for the owner, teachers prefer following a strategy of 'not sharing' (Figure 4.1 a, g; Figure 4.2 a, d; Figure 4.3 a, g) if the system holder does not compensate the teachers for their losses in sharing their knowledge. On the other hand, providing high incentives within the environment where knowledge has less value for the owner, leads to a social dilemma. The dissertation suggests that education system holders should keep a balance between the knowledge sensitivity of the environment and providing different incentives.

The fourth contribution of this dissertation is that it explains the relationship between teachers' behaviour and incentive mechanisms in different environments. This will increase the risk of accepting 'not sharing' behaviour when providing less incentives in an environment in which teachers obtain more payoffs by using others' shared content (Table 4.4). Or encouraging teachers regardless of the usability of their educational content raises the issue of promoting self-interest among teachers for gaining more from the incentive mechanisms. The suggestion for the educational system holders is to carefully design incentive mechanisms regarding teachers' behaviour as this will prevent system misuse for cultivating self-interest or rejecting collaborations on educational content sharing.

Besides these environmental and incentive mechanisms for educational

content sharing, there is plentiful research on interpersonal connectivity patterns on knowledge sharing (Koohborfardhaghighi, 2017; Koohborfardhaghighi & Altmann, 2016; Koohborfardhaghighi, Lee, & Kim, 2014, 2017). In order to enrich the stream of our further studies, we will consider the connectivity patterns among teachers and investigate their effects on the obtained outcome within educational content sharing environment.

6.2.2 Contributions to the software service ecosystem

The results of the analysis related to Specific Research Objective 3 make the following contributions.

The first contribution is related to the application of social network analysis. Our approach highlights a new way of using the current methodology in innovation and information systems' management. Existing research applies the social network analysis to examine knowledge flows among individuals or for shaping the complex patterns of the communication structure. Considering singletons, relations, and clusters of software services (Figure 5.1), this dissertation concludes the importance of the market demand for software services in the education sector.

The second contribution is related to the consistency between market demand for software services and the demand that the software services cover.

As per our knowledge, this is the first work on the relationship between demand among the ecosystem's agents (software and composite services). Existing research also stresses market demand in the software service ecosystem but that is different from this dissertation as it focuses on the demand relationship among parties within the ecosystem. If there is demand for a software service in a market, then composite services emerge around this software service. To increase demand for the software service, the composite services' coverage has to be appropriate to that software service. We highlight that the inconsistency between the market demand and the demand coverage of software services leads to market failure of educational composite and software services.

The third contribution is a suggestion for using the platform theory for managerial aspects of the evolution of the software service ecosystem. There are more than 2 billion education participants and their potential demand is almost equal to the market size for smartphones; demand for educational innovations can be proportionally big as smartphones have. Inactive innovations in the education software services category do not show a lack of demand for innovations in the education sector. Instead, they show the mismatch between market demand and the coverage of software services. Hence, this dissertation suggests that software services need to be carefully

designed so that their coverage meets market demand.

The fourth contribution is that it highlights the possible causality between the education sector's public interest and the passive innovations in the education software service ecosystem. Software services introduced in the education category can be motivated by IT adoption and public interest but this could be just an illusion for complex strategic thinking. By supplying software services, a provider tries to balance the risk of losing competitive advantages and obtaining benefits by expanding the market demand for an increased number of end-users. But public interest can allow the introduction of software services even if it is hard to obtain a benefit from them or there is the risk of lack of demand in the market.

6.3 Implications for education stakeholders

6.3.1 Implications of the knowledge exchange model for education stakeholders

Distinguishing between core and peripheral services in education allows the conceptualization of ideas on service improvements in academia. This section discusses the benefits of a knowledge sharing environment for education stakeholders, especially for improving the quality of knowledge for the core service (educating). When organizing a knowledge sharing environment for teachers, the dynamic movement of content among peers is ensured. This is a way of adding each peer's value to the content thus creating better knowledge sets. This dissertation defines the main stakeholders as a learning environment, managers, teachers, students, and educational content.

For the learning environment. The suggested knowledge sharing model (of the environment) can be taken into consideration at the back-end but it is influential in the well-being of the learning environment. This influence can be observed in learners' motivation for getting quality educational content combined with effective teaching methods. Another facet of the knowledge exchange model in the learning environment is the merger of the educational content in the local context and adoption of globally recognized knowledge

sources by a few teachers which is then spread through their colleagues.

For content. The quality of educational content defines the employability skills of the graduates. Exchanging educational content collected by each teacher improves the dissemination of knowledge and meets frequent updates. Through circulation, a particular piece of knowledge gains an additional value that is added by each teacher. The range of applications in knowledge creation expands into different areas through the visions of different teachers and their classes. This helps students realize how things are inter-related in this complex world and makes them aware of a broad way out of a single course framework. In this way, knowledge exchange and quality assurance are useful for making bundled educational content following a wide vision and philosophy.

For managers of education. An educational content exchange environment can be an alternative way for managers to incorporate quality issues into value co-creation among teachers. For this, the managers need to properly define the learning objectives and encourage teachers who are contributing to knowledge building and sharing. Managers' concerns about the quality of educational content will reduce and their efforts can be directed towards provisioning better peripheral services (learning management and extracurricular activities).

For teachers. Teachers have an opportunity to become aware of different

knowledge sets and pull them for improving their educational content. Teachers can update their syllabi and their reference material in each semester with the aim of keeping them in sync with rapid developments in society. By sharing educational content, teachers can gain incentives for their contributions. This will compensate them for their investments in time and effort. Feedback from colleagues will lead to further improvements in content, syllabi, and teaching methods.

For students. The students' mission is getting knowledge and becoming ready for highly competitive job markets. The model makes the most significant contribution for students on accepting relevant and up-to-date knowledge sources. All kinds of syllabi, knowledge, and information which positively responds to quality requirements enhance students' knowledge absorption and improves their learning outcomes.

6.3.2 Implications of software service innovations for education stakeholders

Applications of software service innovations for improving educational services can accelerate the emergence of new ways of knowledge dissemination and strategic management of the education process. Regarding specific tasks, objectives, and missions of each stakeholder, we discuss certain

guidelines and positive inputs of innovations of the software service ecosystem.

For the learning environment. Facilitating the learning environment with software service innovations leads to an improvement in the physical setting in which communication between the teacher and learners takes place. This can also accelerate the emergence of new educational approaches and cultures that are useful for improving cognitive activities and knowledge building exercises among the learners. Overall, implementing software service innovations for teaching and learning can change the context of the educational philosophy and help education participants move to new stages.

For content. Software services allow educational content to be systematically collected, processed, and utilized. While transmitting content to learners, teachers can use more visualized forms of disseminating knowledge that improves understandability and acceptance of the content by learners. Supplementary educational content can be disseminated through informal channels in the knowledge community. Relevant and up-to-date educational content can be built on well-organized content sharing systems that ensure improved quality of the main education services.

For managers of education. The results of the analysis show that software service innovations that have been introduced so far are favoured for

knowledge sharing and educational administration. Hence, management of educational processes can be organized better by applying different solutions provided by software service innovations. Later, organizational changes from the management's perspective can help maintain the quality of educational services. Here, diverse learning management systems will facilitate different functions and a wide range of services can be enabled by software services. New ways of optimum administration through innovations reduce teachers and learners operational time as they respond to requests by managers. From the perspective of providing quality education services, managers can rapidly disseminate and collect information, systematically process the data, and achieve better decision making.

For teachers. Opportunities for software service innovations in knowledge sharing enhance the value and volume of the knowledge that is transmitted from the teachers to the learners. This helps teachers explain the learning material in a convenient way in a classroom that is understood by all the learners. Outside the classroom, a teacher has an informal community with learners for exchanging supplementary knowledge. Innovations of software services allow teachers to shift the peripheral activities to online systems and keep more time for their core service of teaching in a classroom. By building their own online spaces, teachers economize their time spent on interacting

with students after classes and use it for building new knowledge sets.

For students. As the main consumers of education services, students want service quality in their schools. We have discussed the positive aspects of applying software service innovations directly related to the students' daily activities in the classroom. While interacting with other stakeholders of education, students can benefit from:

- Improved learning environments motivate students to absorb more knowledge and change their habits towards the learning process;
- Visualized knowledge content enhances cognitive knowledge construction among the learners;
- Well managed services increase students' active engagement in interactions with education managers.
- An extended (anytime and anywhere) communication medium between teachers and learners guarantees flows of quality knowledge.

6.4 Limitations and future outlook

This dissertation discussed its objectives around collective educational content creation and sharing among the teachers' community and adoption of software service innovations for improving educational services. The research was done to fill the gap in the existing literature. However, the dissertation has some limitations that provide an opportunity for a further extension of the research.

The first limitation is that the study assumes that teachers' behaviour is appropriate for the five selected strategies among hundreds of strategies suggested in the iterated games. In each simulation scenario configuration, the proportion of teachers' behaviour was set equally. But in a real situation, this proportion can be different. For setting teachers' behaviour within the environment for simulation analysis, simple interviews can be useful for learning teachers' behaviour towards sharing their knowledge sources with their colleagues in a real environment. In future research, possible teachers' behaviour can be studied through real cases.

The second limitation is related to the research in Chapter 5. In general, IT adoption in education can have patterns which are different from those in the adoption of other software and composite services. This thesis defines

composite services as innovations. However, innovations can be in diverse shapes, for example, built-in technologies that may be easier to adopt widely and online services that do not require extra effort for developing composite services. Future research can address these issues for strengthening the theories and practical implications around innovation adoption in education.

The third limitation is related to the market failure of innovations. This thesis focuses on consistency between demand and the coverage area of the software services on the ground of innovation adoption. If we consider composite services as user innovations, then further research has to tie the prosperity of categories within the software service ecosystem with diffusion and market failure of user innovations.

These limitations are a motivation for carefully extending this study in future research.

Reference

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Glossary of terms

Altruistic teacher / Always cooperate

- The behaviour of teachers who are always ready to share their educational content regardless of the strategy (behaviour) of the opposing teacher

Balanced (incentive)

- An incentive given to teachers on the basis of per usage of his/her content by other teachers

Behaviour sets

- A particular group of teachers including different teacher behaviour

A cluster of software services

- A group of software services that are densely connected to each other in a network

Composite services (mashup)

- New software or service released by third-party developers by adding value to one or more software services

Cooperation-oriented environment

- An environment that is characterized by the payoff set providing the highest gains to teachers who ‘share’ mutually

Debatable teacher / Suspicious tit for tat

- The behaviour of teachers referring to the following logic: ‘in the initial stage teachers do not share their content but in the next iterations they follow the strategy (behaviour) of opposing teachers’

Defect-restrictive environment

- An environment that is characterized by a specific payoff set penalizing teachers if they mutually do 'not share' their educational content

Disappointed teacher / Tit for two tats

- Teachers' behaviour type showing their actions according to the following logic: 'teachers start by sharing educational content but then defect if their opposing teachers defect two times in a row'

Education stakeholders

- Education managers, teacher, students, learning environment, and content

Educational content

- Bundle of syllabi, educational material, student evaluation objects, and teaching methods

Ego-centred teacher / Always defect

- A type of teacher behaviour that refers to 'never sharing' educational content

Incentive

- Compensation given to teachers for the losses that they incur when sharing educational content

Knowledge sensitive environment

- An environment that is characterized by a specific payoff set in which sharing educational content leads to high losses for teachers

Learning environment

- The place where knowledge transfer occurs from teacher to students; refers to educational approaches, the cultural context, and the physical setting

Miser (incentive)

- A type of setting for the simulation analysis which highlights that system holders never provide incentives to teachers for their knowledge sharing activities

Payoff

- A teacher' gain in a system by 'sharing' or 'not sharing' educational content

Payoff set

- A set of payoffs for the all possible cases of teachers' specific actions in a system

Peripheral educational services

- Any service provided by academia to improve or support the teaching and learning process and the management of education

Relations of software services

- Conjoint use of any software services to create new composite services

Responsive teacher / Tit for tat

- Teachers' behaviour type following the rule: 'starting actions by sharing educational content but in the next stages follows the last strategy (behaviour) of opposing teachers

Singleton

- A software service that is used alone to create a new composite service

Software service (API)

- Application Programming Interface which is a specifically opened function of existing software or service

Software service ecosystem

- The intertwined relationship between software and composite services

Spendthrift (incentive)

- An incentive provided for compensating the loss of each shared education content regardless of whether it is useful for others or not

System holder

- A managerial group or organization of the education system, for example, principal, managerial board, and education ministry

Teachers' behaviour

- Certain actions of the teachers for educational knowledge sharing on the basis of analyzing its benefits and losses

Value co-creation

- Collaboratively creating value through mutual interactions

Abstract (Korean)

교육은, 지속 가능한 사회를 건설하고 경제적 번영을 달성하기 위해 중요한 부문을 차지한다. 고대 그리스 학교에서 중세의 대학으로 그리고 근대 교실에 이르기까지, 교육은 특정 물리적 공간에서 제공되었습니다. 각 시대에는 저마다의 교습법과 교육관행이 있었는데, 20세기 후반에 정보 및 통신 기술이 발달함에 따라 이를 수용하는 교육기법이 발달했습니다.

정보통신기술은 학습자에게 지식을 전달하는 새로운 방식을 소개했다. 예를 들어, 멀티미디어 기술은 지식 표현 방식을 향상시켰고 인터넷은 학습자와 교육 기관 간의 공간적, 시간적 구분을 줄였다. 그러나 이러한 모든 기회는 전 세계 교육계가 당면한 어려움을 해결하는 데 아직 도움이 되지 못하고 있다. 따라서 까다로운 취업 시장에서 경쟁력 있는 인력을 양성하는 것은 여전히 어려운 임무로 여겨진다. 신기술에 대한 부정적 반응, 그리고 교육 콘텐츠 및 인적 자원의 부족은 국가의 지속 가능한 발전을 저해한다.

본 논문은 교육 분야에서 제기되는 이러한 문제를 이해하기 위해 다음의 두 가지 연구 문제를 다룬다.

1. 교육 컨텐츠의 품질을 향상하고 다양한 맥락에서 첨단 교육 서비스 채택 유인을 제공하는 지식 교환 서비스를 구현한다.

2. 소프트웨어 서비스 생태계에서 교육 서비스 품질 향상을 위한 혁신을 유발하도록 교육 수요와 공급 사이의 차이를 해소한다.

본 논문은 교육의 이해 관계자와 교육 외부의 당사자 사이에서 발생하는 가치 창출을 분석한다. 이를 통해, 지식 창조와 교육 혁신에 관한 이해 관계자들이 공동으로 가치를 창출하여 교육 서비스의 질을 높일 수 있는 생태계의 조성 전략 및 정책을 연구한다.

학습자가 원하는 교육 콘텐츠를 최신 지식 소스에서 받아서 학습자에게 제공하는 것은 교육 기관에게 여전히 큰 과제이다. 따라서, 본 논문의 제1 세부연구목표(SRO1)에서는, 교사 간의 교육 내용 공유를 지원하는 개념적 모델을 제시한다. 본 연구의 모델은 교육 콘텐츠 공유에 대한 교사의 동기 부여를 위한 인센티브 메커니즘을 포함한다.

제2세부연구목표(SRO2)는, 동료 간의 교육 내용 공유에 관한 교사의 행동을 연구하는 것이다. 이에 따라, 죄수의 딜레마, 눈 드리프트 게임 및 사냥 게임에 착안한 반복 게임 모형을 세우고, 에이전트 기반 모델링을 사용한 시뮬레이션 분석을 수행한다. 여기에는 3 가지 환경유형(보수 매트릭스), 4 가지 교사행동양상 및 3 가지 인센티브 메커니즘을 가정한 시나리오를 구성한다. 이 유형들을 조합한 36 가지 시나리오에 따라 지식 컨텐츠의 공유가 확산되는 조건을 찾는다.

시뮬레이션 분석결과는 교육 컨텐츠가 소유자에게 적절한 유인을

제공하지 않으면 그 지식의 공유가 거의 불가능하다는 것을 보여준다. 따라서, 지식 공유 협력을 증진시키기 위해서는 적절한 인센티브 시스템을 갖추는 것이 필수적임을 알 수 있다. 아울러, 분석결과는 교사에게 인센티브 메커니즘을 전달하기 위한 방안이 필요함을 제기하며, 교사의 자기 복지에 대한 관심이 시스템을 오용하게 만드는 집단적 비합리성을 유발하지 않도록 해야 함을 제기한다. 본 연구 모형은, 교육 기관이 제공하는 교과 과정 개선을 위한 교육 콘텐츠 교환의 대안으로 사용될 수 있다.

제3세부연구목표(SRO3)는, 소프트웨어 서비스, 서비스 사이의 결합 및 서비스 클러스터에 대한 시장의 수요와 수명주기를 조사한다. 생태계를 개발하기 위한 기존의 전략이 시장 수요의 중요성을 간과하고 있음을 지적하고, 최종 이용자가 소프트웨어 서비스 주변에 모일 수 있도록 안내하는 것이 중요함을 제기한다.

이 연구에서는 공개된 소프트웨어 서비스 플랫폼(www.programmableweb.com)에서 수집 한 데이터를 사용하고, 소셜 네트워크 분석 방법론을 적용하여 소프트웨어 서비스의 결합관계를 분석한다. 소프트웨어 서비스 생태계에서 각 소프트웨어 서비스가 차지하는 위치를 정의하기 위해 디그리 중심성과 사이 중심성을 측정하고 주요고유벡터 알고리즘을 적용하여 소프트웨어 서비스 클러스터를 판별한다.

교육 부문의 소프트웨어 서비스 및 복합 서비스에 대한 실증자료에 대한 본 연구의 결과는, 현재 교육 부문의 소프트웨어 서비스가 시장 수요를 반영하지 못하고 있음을 지적하고, 풍부한 교육

컨텐츠를 지닌 소프트웨어 서비스가 지식 전파를 진흥할 수 있음을 보여준다. 이러한 분석 결과는, 소프트웨어 서비스 생태계 관련 이론이 시장의 수요를 고려하여 논의될 필요가 있음을 제기한다.

본 논문의 결과물은 학계와 경영계에 이론 및 실용적 기여를 제공한다. 본 연구의 학술적 기여는, 소셜 네트워크 분석과 게임이론이 교육 서비스 활성화를 위한 연구에 적용될 수 있음을 보여줬다는 것이다. 경영적 관점에서는, 교육에 지식 공유를 도입하여 교육의 품질을 높이기 위해서는, 교사의 행동 및 시장의 수요를 이해하는 것이 중요함을 지적한다. 이를 통해, 교육계의 혁신과 교육 서비스의 개선을 실현하기 위한 관리 지침을 제공할 것으로 기대한다.

주요어 : 교육에서 IT 채택, 소프트웨어 서비스, 교육 생태계, 교육 콘텐츠 공유, 에이전트 기반 모델링, 네트워크 분석

학 번 : 2016-32108