Creating Added Value for Smart Card Applications: The University as a Case Study

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***Abstract*—Studies on smart card applications, in addition to focusing on instrumentality and practicality, should also consider the importance of social construction. The implications of actors with different roles on technology directly influence the developmental direction of smart card applications. This study examines smart card applications, using a private university in Taiwan as a case study. It attempts to understand and interpret how the university handles problems arising from smart card applications, from the perspective of schools and suppliers, during the planning and design phases of implementation. Additionally, it uses the Social Construction of Technology (SCOT) as an analytic lens. The results of this study show that when the university developed a new interpretation of smart card applications, it focused on value-added e-services. This emerged and unexpected consequences arose from actual work-practice situations; smart student ID cards were not merely tools for identification and payment, but also the means to shape student lifestyles.**

Keywords - smart card application, SCOT, e-service, university

I. INTRODUCTION

Smart card technology is widely applied within our daily lives, from electronic payments, transportation, and telecommunications to healthcare, entertainment, and education [1, 3]. Smart cards are capable of accessing, storing, and calculating data, as well as providing an immediate exchange of necessary information to facilitate data security, identification, and authentication.

This study discusses the application of smart cards within a university setting. Existing studies on smart card applications in schools [5, 6] and students' technological acceptance of smart cards [1, 7] focus primarily on users and usage. Villano [8] claims that between 1997-2002, there were nearly 50 schools implementing smart card programs in the U.S.; however, only a few actually benefited from their advantages [4, 5].

Holmstrom & Stalder indicated that the drifting of technologies depends on actor interactions. Implementation of technologies do not always follow the original plans [2]. In schools with smart card applications, although students are the primary users, the perspectives of schools, designers, and suppliers should also be considered. During the planning and designing stages of smart card applications, schools and suppliers play particularly important roles. Past research focuses primarily on technological aspects of implementation, especially the instrumentality and practicability of smart cards in schools, without considering the importance of social construction. For example, smart cards could be implemented in a variety of ways, based on the interests and implications of technology on actors with different roles. Some researchers tend to neglect the interpretation of design and configuration of technology, and thus fail to consider certain practical relations [12].

The questions posed by this study are: why do schools issue smart cards? What are the obstacles? How should schools adjust to their implementation and take advantage of their added-value? In answering these questions, this study examines the first case of smart student ID cards at a Taiwanese university. Discovering three different rollouts of student ID cards, it explains how the university treated and coped with the problems arising from the smart card applications. Furthermore, this study uses tools of Social Construction of Technology (SCOT) as an analytic lens.

The paper is organized as follows. Section II reviews the literature related to smart cards in university applications. Section III describes the data collection strategies and introduces the analytic lens -- SCOT. Section IV explains case background. Section V analyzes the case and discussion follows in section VI, and then conclusions are offered.

II. SMART CARD IN UNIVERSITY APPLICATIONS

Smart cards are commonly applied within universities [1, 5, 6], which often provide the best opportunity for promoting smart card technology. For universities, smart cards can enhance administrative efficiency [1], reduce administration costs, and increase incomes [9]. Mirza & Alghathbar [5] and Flwler, Swatman & Welikala [6] investigated smart card applications in universities around the world, including North America, West Europe, and Asia. They surveyed 20 universities with 34 applications, and developed four categories for the most popular applications: student ID cards,

 ISBN: 978-1-61208-117-5

book borrowing, and access to library and printers [5]. Related applications can be generalized into three categories: (1) student ID cards as identification; (2) entrance cards for libraries, buildings, parking lots, etc.; and (3) e-purses for consumption (e-purse [3] is a prepaid card which can be used for payment or small retail instead of coins).

Schools adopt different types of smart cards, such as magnetic stripe cards, contact-less cards, or hybrid-cards, each with different versatilities [6]. Services also vary, as some function as debit cards, have store-value, or other payment types [5]. Clark [9] discussed the key successful factors of e-purse smart card applications, and concluded that cost, interoperability (applications outside of schools to replace coins, or to be integrated with other cards), and a critical mass of users and merchants are most important.

There are many examples of both successful and failed micropayment applications with university smart cards. Mcard of the University of Michigan was launched in 1995, but suffered from poor promotion and was suspended in 2001. Smart cards at the University of Central Florida, first issued in 1998, provide valuable discounts and benefits to students on campus [9].

In some cases, schools use more than one smart card system. The library of the City University of Hong Kong introduced the Octopus card (one of the most successful debit cards in the world [2]) as a payment mechanism for copying, laser printing, and overdue fines, rather than use the existing student CitySmart card. On one hand, the CitySmart system was plagued by a non user-friendly interface and limited numbers of debit devices on campus. And on the other hand, over 98% of the students at the City University of Hong Kong possess the Octopus card [4].

Beyond the focus on the university perspective, other studies [1, 7] examine this issue in terms of student acceptance of technology. In sum, the promotion and development of smart card applications in universities are not simple technical issues, but rather involves social and economic factors, as well as users' behaviors and preferences.

Although these studies have provided an understanding of smart card applications in universities, they have neglected the purpose of schools implementing such cards. Purpose may influence both the functional design of smart cards, as well as the appearance of potential problems and corresponding solutions during implementation [4]. In fact, smart card application has different meanings to different users and usage stages. Different visions for smart card application by schools influence the developmental direction of these cards on campus.

III. RESEARCH METHOD

A. Strategy of data collection

This study focuses on one case study, allowing the researcher to connect research phenomenon with actual situations [11], in order to recognize the dynamics of these phenomenon. The main methods for data collection include participant observation, semi-structural interviews, conference records, and file data (see Table I). One of the authors works at SCE, he has completely participated in the development of smart card applications. We conducted interviews and collected secondary data from March 2006 to May 2010. Through these multiple sources of data collection, the authenticity of the data was repeatedly validated.

TABLE I. THE TYPES AND ILLUSTRATIONS OF EMPIRICAL DATA

Data type	Illustrations
Participation observation	Observation period: 1998.5-2010.5. One of the authors works at SCE.
Semi-structure interview	There are ten person-interviews. Each interview lasts 90 to 120 minutes. Some of the interviewee is interview twice depends on situation.
Meeting minutes	There are 32 minutes, such as cooperation and negotiation of enterprises, technology discussion meeting, managers' meeting, and technology group meeting.
Documents	There are 54 files like project reports, technical documents, memorandums, official documents, presentations, and historical data.

B. Analytic lens—Social Construction of Technology

This research employs SCOT as the analytic lens for understanding how the interpretation of smart card applications by schools and suppliers influences the developmental direction of these cards during planning and design, and how they deal with related problems.

SCOT suggests that technology is a social structure that allows researchers to analyze technological artifacts through social situations. The developmental process is the selection of changes and eliminations. It is based on a multi-directional model, rather than a linear model. In other words, technology can have more than one developmental result. SCOT opens a "black box" of technology and examines the selection process in order to understand how people consider the problems and solutions of technological devices under different circumstances. The main concepts of SCOT are shown below [10].

- Relevant Social Groups (RSG): relevant social groups are key to understanding that technology is a social product. Each social group has a different interpretation on technological artifacts that results in different problems and solutions. For instance, young people may view bicycle riding as exercise, while mothers and older people only focus on riding safety. Thus, the development of bicycles should be versatile. The developmental direction of technology is limited to the shared implications among all members; RSG will define the technological problems and solutions.
- Interpretive flexibility: besides considering how RSG view and interpret technology artifacts, interpreting "flexibility" also refers to the design of technology artifacts; there is more than one best design. Interpretive flexibility helps to explain how different RSG treat and construct the problems and solutions arising from technology in order to expose the "black box" of technology.

 ISBN: 978-1-61208-117-5

- Closure & stabilization: with regard to technology, closure includes artifact stabilization and problem-solving. It refers to whether RSG are certain about problems being solved or whether main problems have been redefined by RSG (indicating that RSG have given a meaning to the solution of a technology artifact). For instance, use of pneumatic tires on bicycles was originally intended for solving problems with vibration, but later contributed to faster bicycle speeds. Higher wheels are used on high-speed bicycles, but are less safe for women or the elderly. For different groups, the development process of bicycles involves different dimensions, and their chosen artifacts vary. Thus there are degrees of artifact stabilization. Relevant social groups will form the regulation and values of artifacts, and further influence the meaning and development direction of artifacts.

IV. CASE BACKGROUND

This study examines a private university in Taiwan (anonymous: CU) as the subject, and ascertains how the IT department developed smart cards to provide on-campus services and position the university as a pioneer of information technology innovation in Taiwan. Since 1995, CU has actively pursued the goal of "lifelong education," particularly within the School of Continuing Education (SCE). There are eight teaching centers in SCE, located in the center of the city with convenient transportation. In order to attract students and provide multiple learning services, the dean of SCE set "*e-campus*" as a major goal of SCE organizational development.

CU issued smart student ID cards to enhance campus service efficiency and quality, as well as school resource management. Since SCE operates independently, smart card applications were first implemented by the teaching centers of SCE, under the planning of the SCE IT department. The development process of CU smart student ID cards includes three stages:

A. Issue of smart student ID cards -- UPass

In 1998, CU was the first university in Taiwan to issue smart student ID cards. A local bank (Bank C) issued UPass smart student ID cards with debit card functions and a magnetic strip. In contrast to laminated paper IDs, smart cards allow data access, storage, and calculation, all of which support e-services on the CU campus. Initially, smart student ID cards (UPass) were designed for identification, entrance access to specific locations, the disbursement of fellowship money and student refunds, book borrowing in libraries, and automatic transfers of tuition. Due to financial regulations at the time, UPass could not support multi-functional transactions, but with changes to regulations in October 2001, transaction features were also added.

B. Multi-purpose multi-function of E-service (Campus's application services)

SCE attempted to develop more services for UPass. In 2002, CU was funded by Bank C to change UPass cards from simple magnetic strip cards to RFID cards with magnetic strip and Mifare standards. The SCE IT department recommended that in addition to access control to buildings and parking lots, UPass should also allow access to reserved venues. Teachers and students could directly reserve classrooms or discussion rooms online, and access these places by UPass. Such functions would save on both managerial manpower and administration costs, as well as improve the efficiency of the campus' learning environment.

SCE and entrance access suppliers cooperated and applied RFID to micropayments for photocopy, vending machines, overdue book fines, and online applications for school services, in order to provide multi-purpose multi-functional campus e-services. They also applied RFID readers to lighting, electricity, and air conditioning controls via iBOX.

C. Changes in debit smart student ID cards

In 2005, CU again served as a pioneer and cooperated with the largest transportation card system (EasyCard) in northern Taiwan. CU changed smart student ID cards(UPass) from smart debit cards into RFID smart cards, which serve as store-value cards with contact-less Mifare standards. E-purse was developed for off-line micropayments. The technical specifications of EasyCard were the same as the original smart student ID cards, thus removing potential technical problems with transferring the original services to the new student ID card system. A required pin code was established to ensure the confidentiality of the cards. Therefore, CU expanded the services of UPass beyond the campus to incorporate public transportation. There are twelve compus services of UPass, as shown in Figure 1, which can be classified into three categories, i.e., identification, administration information services, and spatial security.

CU and EasyCard held a press conference on the integration of EasyCard with campus services, and allowed participants to experience the twelve campus services of UPass (see Figure 1). After that, some schools show their great interests, and they asked CU to promote the UPass' integrative campus services for their own schools. The conference enhanced the competitiveness of service innovation at CU, and enhanced the school's reputation. Since April 2010, EasyCard has extended its services to transactions at over 10,000 locations, including four major convenience store chains, coffee shop chains, drug store chains, restaurants, fast food stores, and parking lots.

CU has actively developed innovative applications of the original RFID technique. For instance, in 2008, SCE cooperated with banks, telecommunication companies, and Austrian scholars to apply for a special government technology program, and proposed plans to incorporate mobile phone devices from plastic student ID cards in order to further facilitate e-commerce. The dean of SCE stated:, "*Our technology is ready. In the future, students can use and purchase things outside the campus through mobile phones as student ID cards, entrance access cards, and e-purse, thus creating ubiquitous services.*"

 ISBN: 978-1-61208-117-5

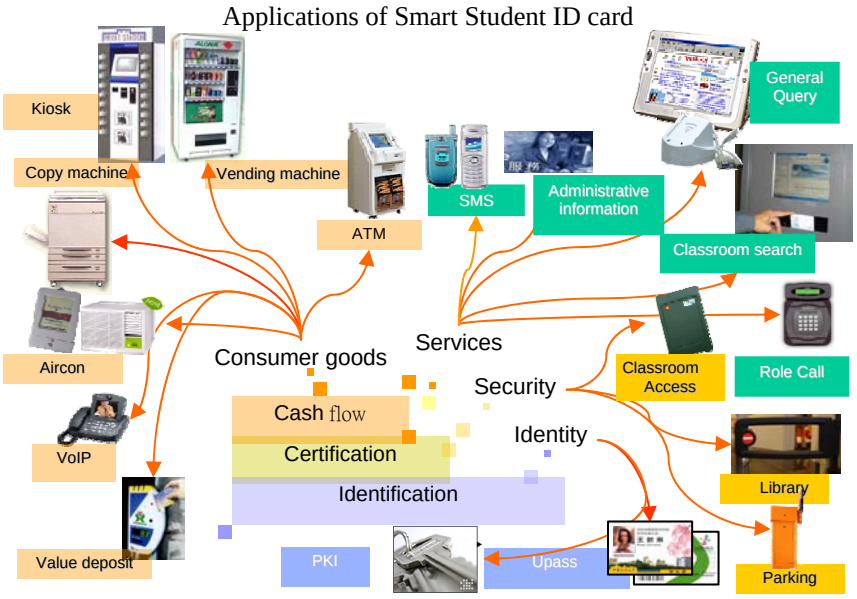

Figure 1. Applications of Smart Student ID Card for CU

V. ANALYSIS

After CU issued the first smart student ID card (UPass) system in 1998, three versions of smart cards have been used, as shown in Table II. This study focuses on the planning and designing stages of smart card applications from the perspectives of schools and suppliers. This section will analyze the development and innovation of CU smart card application using SCOT as the analytic lens.

TABLE II. SMART STUDENT ID CARDS ISSUED BY CU

Stages	Interval	Payment solution	Technical type	Forms of e-purses
1	1998-2002	Debit card	contact	--
2	2002-2005	Debit card	contact contactless (RFID, Mifare)	On-line dollars
3	2005~	Store value	contactless (RFID, Mifare)	On-line dollars Off-line dollars Pre-paid value of EasyCard

A. *Relevant Social Groups*

In order to realize that technology development is a process of social construction, SCOT prioritizes defining the major relevant social groups within technology development. Groups directly influence technology planning and design. In this case, relevant social groups involved in planning and designing smart card applications are divided into two categories:

- University: the first category includes card holders, including faculty and students; the second involves the IT Department of SCE, which was in charge of planning and implementing smart card applications. Their views on smart card application directly influence development and innovation.
- Suppliers: this includes suppliers who participate in smart card applications, including smart cards issuers such as the bank and EasyCard Company, and suppliers who provide technical support to SCE smart card applications, such as entrance access suppliers.

B. *Interpretive flexibility*

The views of the university and suppliers on smart card application directly determine planning and design, and influence the direction of development and innovation. Their views are summarized in Table III.

For CU, the issuing of smart student ID cards aimed to realize campus services by an all-in-one card, which provides multi-purpose and multi-function e-services. The IT Department of SCE thus planned and designed smart card applications. However, the IT manager stated: "*the purpose of UPass entrance access is not to control the people coming in and going out; it is about spatial management.*" Thus, e-services incorporating spatial use in teaching buildings were developed, and resulted in the integration of campus information, cash flow, and resources.

Regarding the suppliers of these services (the bank, EasyCard Company, and entrance access suppliers):

- For the bank, it could increase the number of banking customers and provide agency services on tuition, thus earning more income and developing financial transactions on campus.
- For the EasyCard Company, it can utilize EasyCard as a means to connect with campus activities, thus expanding services to fulfill their vision of "*traveling around Taiwan with one card.*"

 ISBN: 978-1-61208-117-5

- For entrance access suppliers, it is the opportunity to develop new markets in customized spatial management, in addition to standardized entrance access.

TABLE III. INTERPRETIVE FLEXIBILITY OF RELEVANT SOCIAL GROUPS FOR SMART STUDENT ID CARDS

category	Interpretive Flexibility of RSG
University	SCE: the strategy to develop application services and entrance access is interpreted as spatial management.
	Card holders: convenient; campus pass with one card
Suppliers	Bank: increase income and create new applications for financial services.
	EasyCard: a means to connect with campus activities, and expand the original application service as a transportation card, to multiple services.
	Entrance access suppliers: a way to develop new markets and redefine marketing positioning of the companies.

C. Closure and stabilization

This study aims to understand how key RSG—SCE coped with the problems encountered and redefined them when implementing smart card applications. CU originally expected that UPass could have transaction functions on campus. However, due to the limitations of financial regulations, students could initially only use their cards to pay tuition. Thus, SCE tried to develop other possibilities for smart card applications.

When SCE treated UPass entrance access as spatial management, it redefined the development of smart card applications, seeking the technical support of entrance access suppliers and developing e-services for the spatial use of academic buildings. iBOX is the main engine for entrance access systems that control lighting, electricity, and air conditioning by smart management in order to provide safety services on campus, effectively use campus space, reduce manpower, and avoid wasting resources.

SCE did not give up on the transaction functions of UPass. Since transaction amounts on campus were small and debit smart cards would be more useful, in 2005, they eliminated debit card UPass and chose EasyCard as their new UPass system. When the transaction functions of UPass extended beyond the campus, SCE redefined the ubiquity of its UPass application scope.

VI. DISCUSSION

After three issuances of smart student ID cards, CU adopted different applications and attempted to select the more suitable plan for the university. As mentioned above, SCOT plays a significant role when implementing smart cards. The development of smart cards is not simply interpreted by instrument-oriented technology viewpoint. From SCOT perspective, its social implications can also be examined.

A. Development of emerging and unexpected smart card applications

Technology development and implementation are target-oriented activities. However, when IT design cannot fulfill a goal, there will be unexpected results [15]. SCE encountered difficulties in developing the transaction functions of UPass, and treated UPass entrance access as spatial management to construct the infrastructure of campus services. This outcome was emerged and unexpected given the school's initial plans.

In comparison with the investigation of smart card applications by Mirza & Alghathbar [5] in university settings, UPass' compus services are richer and more widespread (see Figure 1). It is because SCE gives smart card applications new interpretations so that various campus services are created and unexpected results emerge.

The findings of this study verify the situated change model proposed by Orlikowski, who indicated that organizational chage emerges in work-practice situations; it is not a planned or technology-oriented change[13]. Likewise, the development of CU smart student ID cards was not an original goal, and was not led by technology, but rather was an emerging and unexpected result of practical adjustments made by SCE.

B. Creating value-added e-services

Porter suggested that the competitiveness of companies is based on the creation of customer values. One strategy is to develop internal activities of companies through technological development in order to coordinate activities, create value, and realize cost advantages [14].

The findings of this study support Porter's ideas. SCE redefined the meaning of smart card applications as spatial management, cooperated technically with entrance access suppliers, integrated spatial use and managerial activity, and further created value-added e-services, as shown in Figure 2. In addition, for SCE, the planning and design of smart card applications was cost-oriented. They suggested that "*in campus application, managerial costs rather than service costs are high.*" The development of smart card application integrated campus information, cash flows, and resources, thus saving managerial manpower and administration costs for CU. While SCE interprets the function of UPass' entrance access, it means not only to control member's entrance, but also to manage classroom usage, and venue reservations. It enables threefold IT application developments so that SCE further applies the technique of entrance access (e.g., iBOX) to provide safety services on campus and keep creating more value-added e-services.

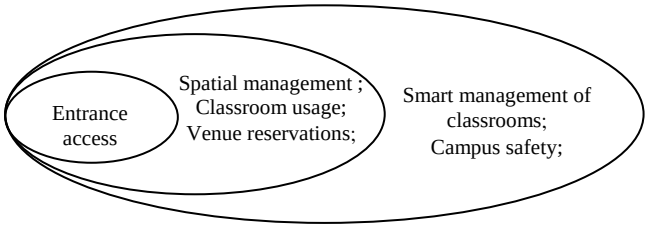

Figure 2 The creation of the value-added e-services from entrance access, spatial management, to campus safety

C. Smart student ID cards: from identification to forms of life

Regarding technological artifacts, Winner suggested that artifacts are not neutral in values, and their design and construction imply specific social intentions. They are treated as forms of life and regulate people's behaviors [12]. Smart student ID cards at CU support this argument [12].

After transforming from paper student ID cards to smart cards, SCE endowed meanings to smart card applications. Besides providing campus services, the smart cards have shaped students' activities, learning, and consumption, both inside and outside of the campus, thus reflecting students' lifestyles. Smart student ID cards are not simply tools for identification and payment, but also could regulate students' disciplines and behaviors. With more services made available by the university and smart card issuers, the regulation of card holders' daily living will continue to expand. Smart ID cards also influenced the work of staff, such as safety control on campus, by helping monitor important systems.

VII. CONCLUSION

Smart cards application in schools is not only for implementing all-in-one card and convenient services. As this case study shows, after the university encountered difficulties in providing transaction services, it redefined the direction of smart card application to spatial management. It further integrated campus information, cash flow, and resources, in order to save managerial manpower and administration costs, thus creating value-added e-services:

- Smart card application is not completely motivated by instrumental characteristics and practicality of technology, rather it is the process of social construction. When relevant social groups give new meanings to smart card application, services emerge from practical situations and result in unexpected outcomes.
- Regarding technology artifacts, smart student ID cards provide campus services, and shape students' lifestyles and behaviors.

Future development strategies of smart card application are as follows. The first is to enhance the mobility of smart card applications, such as technical development of mobile devices and increasing self-service machines on campus for added values and information searches. The second is to develop services upon the activities [17], such as planning daily activities for students and staff on campus; applications for specific locations, such as libraries, gymnasiums, and academic buildings; or socio-spatial dimensions, such as considering urban form, consumer preference, and cultural attributes [18].

Although this study used a university campus as a case study, the findings can also serve as reference to some large corporations that issue smart cards for identification and entrance access. Future studies can discuss how relevant social groups, such as schools (or enterprises) and suppliers, interact with each other to form network relationships by in-depth case analysis in order to contribute to the development of smart card applications.

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 ISBN: 978-1-61208-117-5