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The Relationship between Incentives, Explicit and Tacit Knowledge Contribution in Online Engineering Education Project*

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Knowledge contribution is a very important issue in online engineering education. This study investigates how to encourage knowledge contribution in a large Asia online engineering education project. Based on long-term empirical research, we found economic incentive is more critical to facilitate explicit knowledge contribution, while social incentive is more important in encouraging tacit knowledge contribution. Moreover, we also found incentives may have different effects due to students' individual difference, e.g., personal value. That is, economic incentive may have positive effect on some students, but none or negative to others. These findings provides some theoretical contributions on e-learning and knowledge management, and also provides some implications for choosing technology in online engineering education system, and designing incentive mechanism.

Keywords: incentives; explicit knowledge contribution; tacit knowledge contribution; online engineering education project

1. Introduction

In 'learning 2.0' era, online engineering education systems become more and more popular. Students can access the online resource and discuss with instructors or members in any location, at any time. Within IT-based systems, students not only download materials, but share relevant experiences and information with other classmates [1, 2]. Knowledge sharing, or knowledge contribution, is one of most salient issue in online engineering education systems [1]. As engineering education focuses on the students' innovation, engagement, and team work, without effective knowledge sharing, student teams might not integrate their knowledge and skills to accomplish innovative work [2]. Most of virtual engineering education fails due to ineffective knowledge contribution.

Many prior studies investigate the knowledge sharing in different background, such as distributed work within real organizations [3, 4]. Some research found individuals to share knowledge not only for economic benefits (e.g. pay) but for social benefits (e.g. reputation) [5]. Other studies suggested social exchange theory can be useful to understand knowledge sharing in the virtual teams [6]. However, few studies have focused on the relationship between incentives and tacit, explicit knowledge sharing within engineering education system background. In engineering education research, students' personal value and difference are important variables which may influence on the knowledge sharing [7]. Numerous empirical studies confirmed the positive relationship between individual perception of benefits and knowledge sharing behavior [8]. Moreover, this relationship is also influenced by individual difference [9–11]. Thus, it is important to investigate incentive-knowledge sharing relationship in the online engineering education systems.

This study focuses on the case of BOHKNET, one of largest online engineering education systems in Asia. First, we examine which incentives are effective on encouraging knowledge sharing. Second, we test the effects of students' personal indifference on the knowledge sharing. The findings may have implications for the incentive mechanisms design.

The remainder of this article is constructed as follows. In section 2, a brief introduction of the BOHKNET project is given; in section 3, theory background and research model are provided; then, instrument and data collection are introduced; in section 5, data are analyzed; and finally, discussions are presented.

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2. Engineering education system background: BOHKNET

Data collection was conducted in a virtual engineering education project among universities, conducted by City University of Hong Kong, called BOHKNET, from 2006–2012. The goal of the BOHKNet project is to offer students the opportunity to work together in a virtual team for problem-based collaborative learning. BOHKNet involves several universities from different countries, i.e., City University of Hong Kong (Hong Kong), Beijing University of Technology (Beijing), Eindhoven University of Technology (Netherlands) and Tilburg University (Netherlands).

Several part-time engineering postgraduate students in four universities with different backgrounds applied to join the teams of HKNet to work together on different research questions. Each BOHKNet team consisted of 10 to 12 students in 3 locations. There were 13 teams with each team assigned a software-related topic (e.g., 'policy programs for e-service', 'identity theft' or 'trust models and trustworthy systems/services for the Internet') to be addressed from different geographical perspectives. In other words, all teams needed to discuss their topics from a European and Asian perspective, and then write their report in an integrated framework, rather than simply connecting different parts within the timeframe of 8 weeks.

Several technologies were encouraged to be used in the course to support the knowledge sharing process. Members could upload and download documents and post progress reports through off-the-shelf learning management system (electronic blackboard) developed by City University of Hong Kong that supports forums for each team. BOHKNET also encourages members to communicate with each other in direct ways, such as using e-mail, google.doc, instant messengers (e.g., MSN) and VoIP technology (e.g., Skype). Videoconferencing system was thus used at the start of the project, the fourth week to report the progress, and at the end of the project.

An incentive scheme for encouraging KS was also introduced. Team members received points and gifts based on the evaluation of their team performance on KS process. The details of incentives are described in the following:

(1) There were four deliverables assigned in the eight weeks with four deadlines. Every deliverable was to be discussed in electronic blackboard or group meeting of MSN. Each team needed to finish the deliverable and upload the report in the electronic blackboard before the deadline, with the incentive of receiving points for matching the deadline. For example, for the first deliverable which was to 'do a risk assessment and describe your research questions,' each team discussed the research plan and research questions, and uploaded their decision. If they uploaded their work successfully, they would get the points for this deliverable.
(2) Instructors accessed the online forum of each team in the electronic blackboard system, and evaluate whether members in this team were discussing and sharing knowledge with each other frequently. Because instructors could evaluate the knowledge sharing process only in the online forum but other communication tools (e.g., MSN), team members were encouraged to record their group meeting logs in MSN and upload them to the online forum. At the end of project there was a celebration where instructors awarded the teams and members with best practice of knowledge sharing. The rewards included points and small gifts.

3. Research model and hypotheses

The research model is illustrated in Fig. 1.

3.1 Economic incentive

Knowledge can be defined as different types. Nonaka et al. [12] classify knowledge into explicit knowledge and tacit knowledge. Explicit knowledge is codified knowledge that has been articulated in symbolic form; tacit knowledge includes two elements: 1) the cognitive element referring to mental models (e.g., beliefs and viewpoints), and 2) the technical element referring to skills that can be applied in a special context (e.g., know-how). According to Alavi et al. [13], IT is more useful for supporting explicit KM rather than for tacit KM.

In online engineering education systems, knowledge contribution can be defined as individual sharing work relevant experiences and information with other students. Knowledge contribution can be explained by economic exchange theory and social

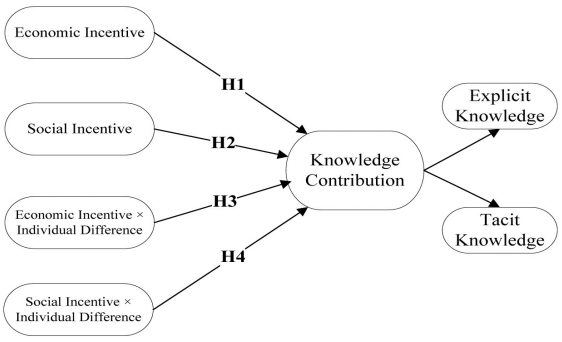

Fig. 1. Research model.

exchange theory. Based on economic exchange theory, economic incentives are critical benefits for contributing knowledge, such as bonuses, improved payment and job security [5]. In this study, perception of economic incentive can be defined as the belief that one can receive extrinsic rewards for one's knowledge sharing. Numerous empirical studies examined the positive relationship between perception of reward and knowledge sharing [8]. In virtual environment, some studies argued the lack of incentive scheme lead them unwillingness to share knowledge, and suggested to introduce a reward system for valuable postings [14]. It is supposed that if the individuals' perceived reward is sufficient high, they will share their tacit and explicit knowledge.

Thus, we propose hypothesis 1a and 1b:

Hypothesis 1a: Economic incentive is positively related to explicit knowledge contribution.

Hypothesis 1b: Economic incentive is positively related to tacit knowledge contribution.

3.2 Social incentive

Social exchange theory posits that individuals engage in social interaction for social incentives, such as approval and respect [15]. In knowledge sharing, social incentive can be seen as the relational and reciprocal outcomes by the organization [5]. Prior studies argued several social benefits, especially respect may contribute the knowledge contribution in the virtual work groups [16].

In this study, social incentive refers to the recognition of knowledge contribution to the virtual team by other members. In the working environments of organizations, employees can show others that they possess valuable expertise through helping other and then receive the respect from others.

Furthermore, some studies found that appropriate feedback is critical in knowledge sharing [4]. If knowledge contributors think they can obtain good feedbacks from others, they earn the respect from others [17]. In the online engineering education system, fear of receiving negative feedback and reducing image in the teams may lead to team members' unwillingness of sharing knowledge [16]. It is supposed that if team members perceived to obtain good feedback and enhanced reputation in the team, they will share their knowledge to others. The hypothesis 2a and 2b are proposed:

Hypothesis 2a: Social incentive is positively related to explicit knowledge contribution.

Hypothesis 2b: Social incentive is positively related to tacit knowledge contribution.

3.3 Individual difference

In social exchange, the relationship between incentives and contribution behaviors also depends on individuals' difference [18]. Eisenberger et al. [9] proposed a variable, called 'exchange ideology', to measure the individual difference on this relationship. Exchange ideology is a personal value, which can be defined as the individual's likely response to the incentive-contribution exchange.

Previous studies confirmed the positive interactive effects of individual difference and social exchange relationships [9, 10]. For example, Lin [19] examined the exchange ideology in the knowledge sharing relationship in the organization, and found that it has positive moderating effect on the relationship between participative decision-making and knowledge sharing. Ladd and Henry [20] reported the exchange ideology has moderating effect on the relationship between perceived organizational support and organizational citizenship behaviors. This finding helps us to examine the exchange ideology influences on the sharing behaviors among team members. That is, given that a team expects economic or social incentives to affect knowledge contribution, individuals with high exchange ideology are very concerned about these incentives, and therefore will to share knowledge beyond the group's normal expectations.

Considering economic and social incentives have the similar logics in the virtual learning environment, it is supposed that exchange ideology has a positive interactive effect on the incentive on knowledge contribution. Thus, we propose hypotheses 3 and 4 as:

Hypothesis 3a: Individual difference will have positively interactive effect with the relationship between economic incentive and explicit knowledge contribution.

Hypothesis 3b: Individual difference will have positively interactive effect with the relationship between economic incentive and tacit knowledge contribution.

Hypothesis 4a: Individual difference will have positively interactive effect with the relationship between social incentive and explicit knowledge contribution.

Hypothesis 4b: Individual difference will have positively interactive effect with the relationship between social incentive and tacit knowledge contribution.

4. Research method

A cross-sectional survey instrument was designed to get information about all of the variables. One construct for knowledge contribution was measured by the frequency of 'never' to 'very frequently.' All the other constructs were measured

through seven-point scales anchored from 'strongly disagree' to 'strongly agree.' We adapted existing scales to enhance validity. Seven items for 'knowledge contribution' (KC) were adapted from the work of Lee [21], four items for explicit knowledge contribution, and three items for tacit knowledge contribution. The specific knowledge was replaced with that related to work in the context of the virtual project, e.g. 'I share work reports and documents with members of my virtual team'. Five items for individual difference (ID) were adapted from the work of Eisenberger [9] (e.g. 'How hard a team member works should be affected by how well the team treats him or her'). Items for 'economic incentive' (EI, e.g. 'I can get higher grades when I share my knowledge'), and 'social incentive'(SI, e.g. 'Sharing my knowledge improves other team members' recognition of me') were adapted from the work of Kankanhalli et al. [5]. Some questions were modified to match the background of this study.

The field study was conducted in BOHKNET (www.BOHKNet.com). The period of data collection is over 3 months. Several part-time engineering education postgraduate students joined in the teams of BOHKNET and work together for solving different research questions.

5. Results

5.1 Descriptive statistics

The participants were comprised of 80.5% males and 19.5% females. Out of the 113 respondents, 10 were between 18–21 years of age (8.8%), 80 in the 22-25 age group (70.8%), 12 in the 26-29 age group (10.6%), 5 in the 30–33 age group (4.4%), 3 in the 34–37 age group (2.7%), 1 in the 38–41 group (0.9%), and 2 were older than 41 (1.8%). For work experience, the distribution is: <1 year 34.5%, 1–4 years 46.0%, 5-8 years 10.6%, 9–12 years 4.4%, and >=13 years 4.4%. Regarding nationalities, 26 respondents came from Mainland China (23.0%), 53 from Hong Kong (46.9%), 23 from The Netherlands (20.4%), and 11 from other countries (e.g., Canada and Portugal, 9.7%).

All the Cronbach's alpha values were found to be greater than 0.7. Knowledge contribution's alpha is 0.85, explicit knowledge contribution is 0.72, tacit knowledge contribution is 0.85; Exchange ideology is 0.73; Economic incentive is 0.80; Social incentive is 0.92.

5.2 Hypotheses tests: model 1 and model 2

In this study, moderated multiple regression (SPSS 13) was used for testing interaction effects. Interaction terms are computed by multiplying two independent constructs. We tested research model with two dependent variables, explicit knowledge contribution (EKC, model 1), and tacit knowledge contribution (IKC, model 2). Table 1 summarizes the results of hypotheses tests. In model 1, the R^2 value of 0.213 and adjusted R^2 value of 0.16 indicated the explanatory power of model was satisfactory ($F = 5.24$, $P < 0.01$). The main effect of economic incentive on EKC is significant, H1a is supported. And interactive effect of economic incentive and exchange ideology is negatively significant, which is contrary to H3a. In model 2, the R^2 value of 0.180 and adjusted R^2 value of 0.125 indicated the explanatory power of model was satisfactory ($F = 6.126$, $P < 0.01$). The main effect of social incentive on IKC is significant, H2b is supported. And interactive effect of economic incentive and exchange ideology is negatively significant, which is contrary to H4a.

Table 1. Results of hypotheses tests

Moderated Multi-Regression	Model 1: Explicit Knowledge Contribution	Model 2: Tacit Knowledge Contribution
Step 1: Control Variables		
Gender	0.201*	0.067
Age	–0.120	0.004
ΔR^2	0.038	0.004
Step 2: Main Effects		
Economic Incentive (EI)	0.239*	0.037
Social Incentive (SI)	–0.035	0.271*
Individual Difference (ID)	0.181	–0.025
ΔR^2	0.056*	0.037*
Step 3: Interaction Terms		
EI*ID	–0.300**	–0.268*
SI*ID	0.036	–0.095
ΔR^2	0.066*	0.084**
R^2	0.213	0.180
Adjusted R^2	0.16	0.125

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

6. Discussion

Based on our results, the first interesting finding is that explicit and tacit knowledge contribution was affected by different types of incentives. That is, economic incentive affected participants' explicit knowledge contribution; while social incentive affected tacit knowledge contribution in online engineering education project. In BOHKNET, each project consisted about 8 to 10 weeks. During this period, members would like to code their experience and homework, and upload documents into electronic knowledge repository for economic incentives (e.g., bonus, and points). However, the social incentive is also very critical in facilitating participants to share tacit knowledge. Before the project, members of virtual teams had not known with each other, but after the project they will be the friends and keep the discussion. Thus, during the project, they may build mutual trust and communicate with each other via instant messenger, in this IT-based engineering education project, social incentive will encourage students to share their experience and conduct face-to-face communication via MSN, but code knowledge and upload.

The second interesting findings are interactive effects of individual difference (i.e., exchange ideology) and economic incentives are significantly negative, regardless explicit or tacit knowledge contribution. These findings are contrary to our hypotheses. That is, engineering students with strong EI show little or no knowledge contribution as the response to the economic incentive. We may find a reasonable explanation for this negative moderating effect in the free-riding theory. In free-riding theory, the basic free-rider problem is 'individual will fail to participate in collectively profitable activities in the absence of coercion or individually appropriable inducements' [22]. Based on this theory, a rational actor will have the free-riding tendency to gain outcomes of collective incentives with little or no effort on knowledge sharing. The free-riding tendency is related to several characteristics of work group, such as group size [23]. Some characteristics of virtual teams in BOHKNET may lead to the free-riding tendency of individual with strong exchange ideology. In the BOHKNET, the reward to encourage knowledge sharing is team-based and each virtual team has 10 to 12 members which is larger than most of studies in work groups with no more than 8 people [24]. In these large and distributed teams, team members can not notice if a member contributes knowledge to the whole work. Thus, individuals with strong exchange ideology may prone to gain benefits with sharing little or no knowledge.

7. Conclusions

The findings have several implications for practice. First, for facilitating explicit knowledge contribution in online engineering education systems, economic incentive is critical. Especially in the early stage of project, instructors should apply the economic incentive to encourage students to code and upload their formal knowledge and homework. Second, in the middle stage of project, tacit knowledge contribution and sharing via instant messenger is more important, and social incentive must be applied. For example, instructors may provide 'Best sharing award' or 'Ranking of contributors' to enhance the reputations of active contributors, it will be very helpful to maintain knowledge sharing culture within project. The third, individual difference should be considered when instructors design the incentive mechanism and select team members. In contrary to long-term project, virtual learning project dealing with short-term teams may balance the individuals with low and high exchange ideology. For reducing the negative effect of free-riding, instructors should encourages members to establish longer social relationship through informal ways, such as communicating and adding friend through software such as MSN and Skype. Several strategies could be considered to avoid the free-riding behaviours in the virtual teams, like limiting the group size. Project may also consider assigning a group manager in online learning system. A group manager can review the process of knowledge sharing, give the feedback to each member and distribute outcomes to individuals based on the evaluation of effort on sharing knowledge.

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