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UNDERSTANDING THE ROLE OF KNOWLEDGE CO-PRODUCTION BETWEEN USERS AND DEVELOPERS IN ISD PROJECT: AN INTELLECTUAL CAPITAL PERSPECTIVE

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Abstract

Information system development (ISD) has long been treated as that process that system developers craft an artifact to support business operation based on their special expertise. However, a significant portion of projects still have failed because the developed outcome cannot fit users' needs. An emerging internal service concept indicates that, by treating ISD as one type of service, the requirement definition can be viewed as a co-production process in which users and developers integrate their own knowledge. By incorporating this concept into research design and taking intellectual capital perspective into account, this study proposed a model to examine the antecedents and consequences of knowledge co-production between users and developers. Data collected from 267 developers confirmed our hypotheses that knowledge co-production can benefit ISD outcomes, and common knowledge, relational capital and participative decision-making between these two parties increase the effectiveness of knowledge co-production effectively. Lastly, the implications toward academic and practitioner are also provided.

Keywords: Knowledge Co-production, Project management, Intellectual capital.

1. INTRODUCTION

Management information system department has long been considered as a supporting function in the organization and the information system development (ISD) is treated as crafting artifact to support business operation. It is a process that developers transform user requirements into system design and then develop system to fulfill these requirements. However, a lack of user engagement in the development process reduces the effectiveness of development outcome. The consequence is that extra cost and time have to be entered when the final systems do not ultimately meet users' required functionality and requirements (Procaccino & Verner 2009). Based on the emerging internal service perspective, ISD is treated as one of service types, and the requirement definition process can be viewed as a valuable co-production process in which users and developers work closely to determine the system requirements and carry out the final system to support users' daily work. In addition, since ISD itself is knowledge intensive and requires both business and technical knowledge, the process can be regarded as a knowledge co-production process. The combination of these two perspectives implies that the quality of final system and project outcome should be affected by the extent to which these two parties can blend individuals' expertise and co-produce a new knowledge to develop system to support business operation.

Given that the knowledge co-production plays an important role on ISD outcome, understanding its antecedents is then critical. Several research streams deal with the interaction between users and developers separately. For example, Tesch et al. (2009) emphasized the importance of having common knowledge, Jiang et al. (2006) and Wang et al. (2006) highlighted the critical role of user-IS interaction, and He and King (2008) confirmed the effect of user participation in the requirement determination process (He & King 2008). In this study, we adopted intellectual capital perspective and classified variables into relational, human, and structural three dimensions to investigate their impacts on knowledge co-production between users and developers.

Therefore, based on the above discussion, the purposes of this study include: (1) understand the importance of user-IS knowledge co-production in ISD project team by examining its impact on system quality and project outcome; (2) explore the critical role of common knowledge (human capital), relational capital and participative decision-making (structural capital) on user-IS knowledge co-production from an intellectual capital perspective; (3) we also attempted to highlight the importance of user-IS knowledge co-production in ISD by examining its mediating role between the proposed antecedents and consequences. We argued that the common knowledge, joint decision-making and smooth interaction affect project outcomes indirectly through user-IS knowledge co-production. The rest of this paper is organized as the following. In the next section, related literature is reviewed and hypotheses are provided. Research method is introduced in the third section. Data analysis and discussion are followed by conclusion.

2. LITERATURE REVIEW AND HYPOTHESES

2.1. Requirement Definition As A User-IS Knowledge Co-production Process

One of the important steps, maybe the most important, in ISD is to elicit, document, define, and refine the user requirements (Sage & Rouse 2009). Unable to manage requirements increases residual risks during ISD process and erodes process performance through increasing the difficulty in planning and control (Nidumolu 1996; Wallace et al. 2004). Therefore, it is critical to eliminate uncertainty caused by requirements problem, and one possible answer is to determine the actual requirements as early as possible and control the change during the development process.

Basically, system design largely depends on system developers' ability to craft out a system which can support business operation. However, how well the system design can capture the business operating process can not be solely determined by developers only. From a knowledge management perspective, ISD is a series of activities in exchanging, integrating, and utilizing knowledge to counter challenges. Therefore, to develop an ideal information system, it is critical for the project team to integrate different types of knowledge, such as programmers, managers, users and analysts throughout various stages (Curtis et al. 1988). Based on this perspective, we viewed requirement definition as a knowledge co-production process between users and developers. In this early stage of ISD process, there are, at least, two types of knowledge involved: business knowledge and ISD knowledge. Users need to contribute their business domain knowledge in order to facilitate developers carrying out the system design. Through transferring and exchanging process, users and developers blend their owned knowledge and the blended results serve as basis for system design. The input, output, and system functions are then determined which serve as the blueprint of the final system. The quality of this blueprint is highly correlated with the effectiveness of development work. Evidences showed that the exchange of knowledge between users and developers increases the clarification of requirements and therefore, reduces the impact of requirements uncertainty (Hsu et al. 2008).

2.2. Consequences of Effective User-IS Knowledge Co-production

While studying ISD project management, researchers often split the outcome of project into product and process two dimensions (Nidumolu 1996). Product performance refers to the successfulness of the system that was developed, whereas process performance refers to the successfulness of the development process, such as the extent to which the project was delivered on schedule and within budget (Wallace et al. 2004). In the following, project outcome and system quality literatures are reviewed and the hypotheses are developed.

2.2.1. System Quality

System quality refers to the systems' reliability, response time, ease of use, ease of learning (Belardo et al. 1982), access convenience, systems integration (Bailey & Pearson 1983) and resources using, etc. (Swanson 1997). In general, it represents the capability of the system to maintain its level of performance when used under specified conditions, the capability of system to be transferred from one environment to another, the capability of the system to be modified, the capability of the system to be understood, learned, used and liked by the users, and the capability of the system to provide the outputs which meets the users' needs (Bevan 1999).

Ives and Olson (1984) indicated that system quality is a function of user participation. They argued that actual requirements can be better identified when users engage in the development process. As a result, the developed systems are able to response to users' needs. In this study, we follow this concept and argue that the main purpose for users to engage in the development process is to contribute their knowledge to determine the actual requirements (He & King 2008). In addition, to assure that user requirements can be effectively incorporated into system design, developers need to blend users' knowledge with their own (Robillard 1999). According to Patnayakuni et al. (2007), when a common base of knowledge has been captured, shared and formalized, knowledge can be integrated, and the resulting solution will more likely satisfy what end users' intended needs. Therefore, we predict that, during ISD process, user-IS knowledge co-production facilitates efficient development of a software solution that is more likely to reflect its intended objectives. The higher levels of user-IS knowledge co-production should enhance the final system better satisfying users' functional expectations.

Hypothesis 1：The user-IS knowledge co-production positively affects the system quality.

2.2.2. Project Outcome

Project management literature defined project outcome as the ability to meet project goals, budget, schedule, and quality (Schwalbe 2002). A lack of sufficient knowledge increases risks (Nidumolu 1995; Gemino et al. 2007), increases uncertainty (Iacovou & Wording 2009), and inhibits learning process (Ramasubbu et al. 2008), which inhibit project team to achieve predefined goal. In addition to insufficient knowledge, unable to integrate existing knowledge is also cited as one barrier in achieving high performance (Patnayakuni et al. 2007; Mitchell & Nicholas 2006). Bassellier et al. (2003) and Nissen and Jennex (2005) indicated that the successful integration of the differentiated knowledge during the ISD project is a critical factor for project success. Many projects cannot adhere to predefined schedules or budgets because development teams fail to identify serious problems, such as failing to identify true requirements in the early stages. In fact, many systems are first presented to end users or senior managers during testing or even implementation stages, in which case flaws and inappropriate functions are first identified in these late stages. The rework cost for flaws found in the later stages is much higher (40 to 100 times) than in the early stages (Boehm & Turner 2003). Therefore, to reduce unnecessary cost, actual requirements should be identified as early as possible. We predict that successful requirements definition can assure the project to be accomplished on time and within budget. Thus, in this study we hypothesize:

Hypothesis 2：The user-IS knowledge co-production positively affects the project outcome.

2.3. To Enhance the Capacity of User-IS Knowledge Co-production

Knowledge co-production process is a valuable co-creation process which includes individuals' in-depth knowledge and understanding of the nature of the use of organizational structure in coordinating, creating, and utilizing knowledge. In other words, new knowledge is created through integration of different knowledge to solve countering problems (Grant 1996). Although the integration of specialized knowledge across different domain knowledge of developers and users is necessary, it is always a central challenge in ISD (Patnayakuni et al. (2007). From the resource-based view (RBV) perspective, available resources determine capabilities. In this study, based on intellectual capital perspective, resources which can be used to enhance the capacity of user-IS knowledge co-production are classified into human, relational, and structural three dimensions.

2.3.1. Human Capital

Human capital in ISD context can be viewed as the sum of developers' and users' knowledge. In addition to the owned domain knowledge, common knowledge is required for effective user-IS knowledge integration (Grant 1996). How well developers and users can blend their owned knowledge is determined by the extent to which they understand each other (Tesch et al. 2009). Shared understanding or common knowledge facilitates learning and reduces miscommunication (Mohammed & Dumville 2001). This implies that the possession of business knowledge for developers and the possession of ISD knowledge for users enable both parties to understand and to participate in the others' key processes and to respect each others' unique contribution and opinion (Tiwana & McLean 2005). In other words, given that the amount of common knowledge between users and developers is a fundamental factor to achieve mutual understanding for successful system development, the ISD knowledge of users and business knowledge of developers thus play an important human capital role to improve user-IS knowledge co-production. Thus, we hypothesize:

Hypothesis 3：The human capital positively affects user-IS knowledge co-production.

2.3.2. Relational Capital

In the context of ISD, the more developers and users work together, communicate, coordinate and negotiate, the stronger the partnership develops and both of them become more effective at planning and developing new applications (Ross et al. 1998). During ISD process, to integrate developers' and users' knowledge into the project-related activities requires each other's trust and respect (Tiwana & McLean 2005). Higher levels of relational capital enhance the likelihood that developers and users are willing to exchange and combine their domain knowledge during the ISD process (Szulanski 1996; Tiwana & McLean 2005). According to strong-tie theory, closed relationship is required for both parties to contribute their knowledge to project level. When there are strong and trusting relationships between developers and users, the costs of communication, coordination and combination of each other's knowledge will decrease, and in turn, facilitate the effectiveness of user-IS knowledge co-production (Robert et al. 2008). Thus this study suggests that relational capital is an important component enhancing the user-IS knowledge co-production process. We hypothesize that:

Hypothesis 4：The relational capital positively affects user-IS knowledge co-production.

2.3.3. Structural Capital: Participative Decision-Making

Structural capital refers to the organizational capability that involves routines and structures which enhance effectively interactions among stakeholders (Okhuysen & Eisenhardt 2002). Even though the employees possess a high level of intellect, if the organization has poor systems and procedures to support their needs and actions, the overall intellectual capital will not reach its fullest potential (Bontis 1996). Participative decision-making is one of the mechanisms representing the structural capital. It provides the organizational context to understand and clarify different knowledge and skills held by different stakeholders. In our study, participative decision-making is viewed as the sharing of decision-making authority among users and developers. In the IS literature, user participation has long been believed as one effective mechanism to facilitate users to contribute to the project work. Users are able to provide business domain knowledge to help determine system requirements through the formal engagement (He & King 2008). Empirical studies also indicated that participative decision-making is one effect means to enhance user-IS knowledge co-production within ISD context (Patnayakuni et al. 2007). Based on the above discussion, we hypothesize that:

Hypothesis 5：The structural capital positively affects user-IS knowledge co-production.

3. RESEARCH METHODOLOGY

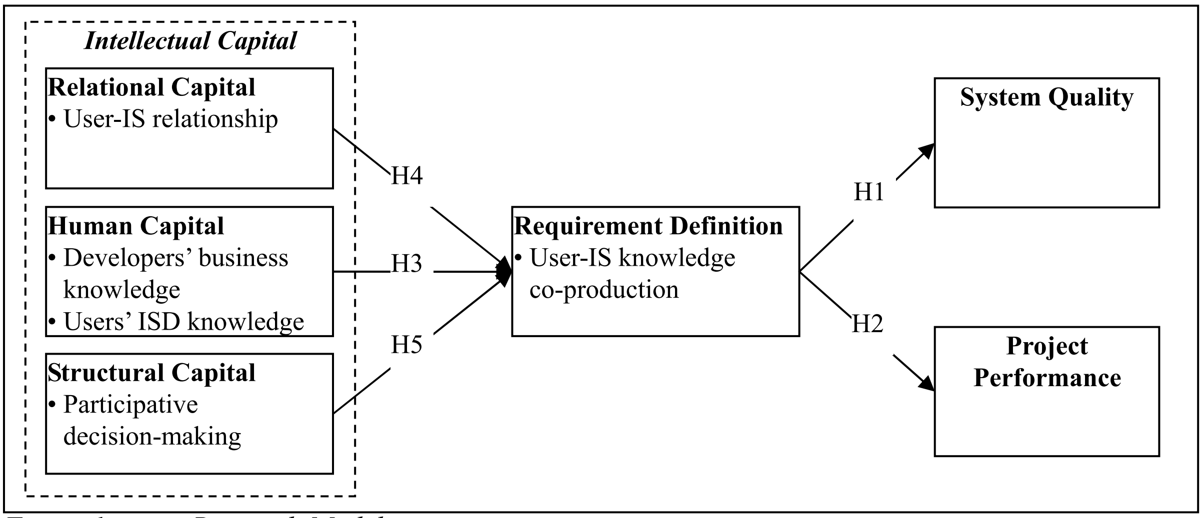

Figure 1. Research Model

3.1. Sample and Data Collection

The research model is showed in Figure 1. Data collected from practitioners was then used to examine the proposed model. Data collection was conducted in a two-stage approach: a pilot test phase and questionnaire survey phase. We adopted a two-step approach to collect the required data. First, we sent a letter to all 359 institute members of the Information Management Association (IMA) in Taiwan. IMA is an organization that aims at improving IT usage and enhancing communication among IS professionals. Almost every member of this organization is an IS department manager. Members who were willing to participate in our study were then contacted by telephone. On the phone, we introduced the major purpose of this study and detailed data collection procedures. The number of project team in each member's organization is then recorded. In the second stage, we delivered the survey package to 750 project managers, team leaders, or senior members with their contact information collected from the previous stage. A total of 267 people returned the survey package, yielding a valid response rate of 35.6 percent.

Measure	Categories	#	%	Measure	Categories	#	%
Tenure	Less than 4 years	54	20.2	Duration in project	Less than helf	101	37.8
	4-10 years	132	49.4		Helf-1 year	85	31.8
	11-20 years	71	26.6		1-2 year	49	18.3
	More than 21 years	8	3.0		2-3 year	14	5.3
	Missing	2	0.7		More than 3 years	17	6.4
					Missing	1	0.4
Age	21-30	75	28.1	Gender	Male	195	73
	31-40	160	59.9		Female	70	26.2
	41-50	28	10.5		Missing	2	0.7
	More than 51	4	1.5				
Team size	< 5	102	38.2	Educational background	Less than college	14	5.2
	6-10	94	35.2		Bachelor	156	58.4
	11-20	55	20.6		Master	93	34.8
	21-30	5	1.9		Doctor	1	0.4
	More than 31	11	4.1		Missing	3	1.1
Position	Programmer	115	43.0	Industry type	Manufacturing	107	40.1
	SA	48	18.0		Service	51	19.1
	Project leader	51	19.1		Education	11	4.1
	CIO	23	8.6		Finance	20	7.5
	Other specialists	28	10.4		Others	43	16.1
	Missing	2	0.7		Missing	35	13.1

Table 1. Sample demographics (N=267)

3.2. Constructs and Measurements

Measurement items were developed based on a comprehensive review of the literature as well as on experts' opinions. A review of literature was undertaken to identify construct definitions and any existing measures. To the extent possible, previously published items were adopted or adapted. This study adopted the Likert Scales, letting the participants choose from one to seven levels of agreement, with anchors ranging from 1 (strongly disagree) to 7 (strongly agree). Please see Table 2 for sources of items. Validity and reliability of our measurement are assured since all related indices meet or exceed the minimum requirement. Detail information is provided in Table 3 and Table 4.

Variables	Source	Variables	Source
User-IS knowledge Co-production	Developed by the authors	***Human Capital***	Lior Fink & Seev Neumann, (2009); Tesch et al. (2009)
Relational Capital	Tiwana & Mclean (2005)	***Structural Capital***	Patnayakuni et al. (2007)
System Quality	Wallace et al. (2004); Hartwick & Barki (2001); Patnayakuni et al. (2007)	***Project outcome***	Tesch et al. (2009); Jones & Harrison (1996); Wallace et al. (2004)

Table 2. Operational Definition and Source of Measurement

Constructs	Items	Factors		Items	Factors	
		Loadings	ITC		Loadings	ITC
User-IS Knowledge Co-production	1	0.813	0.601	3	0.849	0.667
CR=0.909, Alpha=0.866, AVE=0.714	2	0.847	0.702	4	0.870	0.720
Human Capital:	1	0.870	0.669	3	0.899	0.726
Developers' Business Knowledge *CR=0.913, Alpha=0.872, AVE=0.723*	2	0.848	0.634	4	0.782	0.593
Human Capital:	1	0.788	0.649	4	0.868	0.779
Users' ISD knowledge	2	0.871	0.788	5	0.823	0.717
CR=0.926, Alpha=0.904, AVE=0.676	3	0.814	0.697	6	0.765	0.641
Relational Capital	1	0.793	0.597	4	0.983	0.828
CR=0.943, Alpha=0.924, AVE=0.769	2	0.908	0.826	5	0.846	0.775

	3	0.927	0.857			
Structural Capital *CR=0.924, Alpha=0.876, AVE=0.803*	1	0.831	0.562	3	0.914	0.704
	2	0.940	0.792			
System Quality *CR=0.955, Alpha=0.946, AVE=0.754*	1	0.876	0.701	5	0.880	0.775
	2	0.847	0.708	6	0.814	0.625
	3	0.846	0.721	7	0.914	0.823
	4	0.898	0.780			
Project outcome *CR=0.923, Alpha=0.896, AVE=0.708*	1	0.876	0.663	4	0.836	0.747
	2	0.859	0.702	5	0.746	0.631
	3	0.882	0.707			

Table 3. The Result of Factor Analysis

Variables	Mean	Std. Dev.	M3	M4	Correlation Matrix						
					CP	**BSK**	**UIK**	**RC**	**SC**	**SQ**	**PP**
User-IS Knowledge Co-production	5.246	0.832	-0.409	-0.160	**0.845**						
Human Capital: Developers' business knowledge	5.336	0.837	-0.383	-0.256	0.367	**0.850**					
Human Capital: Users' ISD knowledge	4.461	1.060	-0.206	-0.064	0.420	0.264	**0.822**				
Relational Capital	5.208	0.936	-0.418	0.213	0.520	0.182	0.410	**0.877**			
Structural Capital	5.274	1.012	-0.667	-0.038	0.442	0.301	0.361	0.405	**0.896**		
System Quality	5.239	0.817	-0.404	-0.311	0.564	0.438	0.398	0.497	0.440	**0.868**	
Project Outcome	5.188	0.991	-0.736	0.635	0.401	0.287	0.317	0.368	0.337	0.708	**0.841**

Table 4. Descriptive Statistics and Correlation Matrix

3.2.1. Common Method Variance

Since we collected both independent and dependent variables simultaneously from the same respondents, common method variance (CMV) might be a concern in this study. The Harman's single factor test was implemented to ensure that there was no significant method effect on the predefined causal relationship. In addition, the impact of method variance was tested by creating one method variable (with all used indicators) and linking it to both independent and dependent variables (Pavlou & Gefen 2005; Podsakoff et al. 2003). The impact of this method variable is insignificant which suggests that the common method bias problem should not be problematic in this study.

3.3. Hypothesis Test: The Structural Model

Hypothesis test was conducted through partial least squares (PLS) regression analyses using SmartPLS. All the path coefficients and explained variances for the model are shown in Figure 2.

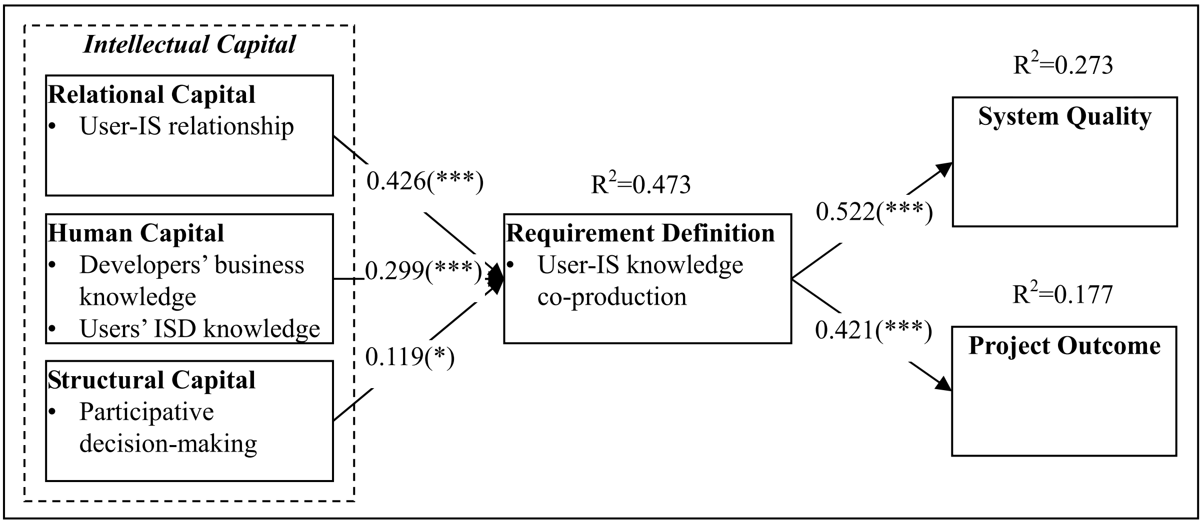

Figure 2. Structural Model and Paths Coefficient

As indicated, human capital (β= 0.299, $p < 0.001$), relational capital (β= 0.426, $p < 0.001$) and structural capital (β= 0.119, $p < 0.05$) affect user-IS knowledge co-production positively. This result confirms our expectation and provides support for H3, H4 and H5. In addition, the path from user-IS knowledge co-production to system quality and project outcome are all significant (β= 0.522, $p < 0.001$; β= 0.421, $p < 0.001$) which shows that H1 and H2 are supported.

Variables	**System quality**		**Project outcome**	
	Model 0	**Model 1**	**Model 0**	**Model 1**
Structural capital	0.280(**)	0.251(*)	0.205(+)	0.184
Relational capital	0.295(***)	0.190(**)	0.235(**)	0.160
Human capital	0.177(+)	0.103	0.182(*)	0.133
User-IS knowledge co-production	--	0.246(**)	--	0.173(*)
R^2	0.353	0.384	0.240	0.257

Table 5. Analysis of Mediating Effect

3.3.1. Analysis of Mediating Effect

This study proposed that "user-IS knowledge co-production" is an important mediator between its antecedents and system quality, project outcome. We followed procedures suggested by Baron and Kenny (1986) to test the mediating effect of user-IS knowledge co-production. The results show that user-IS knowledge co-production transfers the impacts of three types of capital to system quality and project outcome. Specifically, after joining user-IS knowledge co-production as a mediator, the explained variance of system quality and project outcome significantly increases from $R^2 = 0.353$, $R^2 = 0.240$ to $R^2 = 0.384$; $R^2 = 0.257$. In sum, these results prove the argument of this study, which indicates that user-IS knowledge co-production is an important mediator between relational capital, human capital, structural capital and system quality, project outcome.

4. DISCUSSION AND CONCLUSIONS

The foci of this study are: (1) to understand how user-IS knowledge co-production affects system quality and project outcome; and (2) to explore the antecedents of the co-production process from the intellectual capital perspective. Our survey of 267 ISD practitioners confirms all proposed hypotheses that human capital, structural capital, and relational capital have positive impacts on the co-production process, which, in turn, leads to better system quality and project outcome.

This study generates several implications to academics and practitioners. For academics, we successfully show that requirement definition can be viewed as user-IS knowledge co-production between users and developers. We also confirmed its importance on project development outcome, including system quality and project outcome. By applying the concept of intellectual capital here, we proposed three antecedents of user-IS knowledge co-production, including human capital, relational capital and structural capital. Finally, we demonstrated the mediating role of user-IS knowledge co-production between intellectual capital and system quality, project outcome. The results show that user-IS knowledge co-production fully mediates the impacts of intellectual capital on project outcome and partially mediates the impacts of intellectual capital on system quality.

For practitioners, the results of this study highlight the importance of cultivating common knowledge. Project managers or team leaders should try to enhance developers' business knowledge and users' ISD knowledge. In addition to fostering common knowledge, it is critical to form mechanisms to enhance requirement definition. Project managers should include users in the decision making process or improve their relationships with users.

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