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We Are in the Same Boat: The Effect of Social Interdependences on Knowledge Boundary Spanning in Interdisciplinary Collaboration

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Abstract

Purpose – As organizations emphasize cross-functional team to leverage knowledge across disciplines for providing better services to customers, it is important to note the challenge due to knowledge boundaries within the collaboration among members who are trained by different disciplines. Knowledge is like a double-edged knife that can drive innovative solutions as well can hinder knowledge creation across functions because of its tacit and stickiness nature. The different assumptions, interpretations, and value schemes embedded in individual discipline make the team members have inconsistent interpretations and interests even when they use common terminologies. The raising misunderstandings and conflicts highlight an important issue called knowledge boundary problem.

Design/methodology/approach – This study investigates knowledge boundary spanning by perceived goal, task and reward social interdependences under the interdisciplinary collaborative context where members have different professional backgrounds. Taking e-learning content development that engages different professions as an example, this study conducted a survey to empirically examine how social interdependences facilitate the effectiveness of knowledge boundary spanning, and subsequently influenced the project performance. In a project level, we collected totally

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70 pair of data, each of which was represented by the answers of two team members with different professional backgrounds.

Findings – Applying the Partial Least Squares (PLS) analysis, our findings highlighted that effective knowledge boundary spanning could predict product and process qualities. The findings also showed that perceived goal and task interdependences had significant and positive impacts on the effectiveness of knowledge boundary spanning, but perceived reward interdependence did not.

Research limitations/implications – This study contributes current research by demonstrating the importance of knowledge boundary spanning for making a successful interdisciplinary collaboration. This study also extends previous research findings by showing the way where effective knowledge boundary spanning can be proactively managed through social interdependences perceived by team members who have different professions.

Practical implications – To practice, our findings provide a solution to manage knowledge boundary problems that might rise problems and conflicts across professions. For effectively applying the tacit, sticky and localized practical knowledge constructed by members from other discipline, team members have to extensively concentrate on the effectiveness of lexicons transfer, interpretations translation, and interests transformation. When working on an interdisciplinary collaboration project, managers can increase the perceived goal interdependence by designing a share goal which can be accomplished when the subgroups pressure their individual goals. And, manager can make the task intertwined to increase the perceived task interdependence.

Originality/value – Our findings highlight knowledge boundary issue in a collaboration evolved with members who have different professions. Our finding contributes service science and knowledge management research by making aware of the impact of knowledge boundary spanning, as well as by suggesting a way for managing knowledge boundary spanning proactively.

Keywords: interdisciplinary collaboration, social interdependence, knowledge boundary spanning, project performance, e-learning content development.

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同舟共濟：多重學域合作中社會互賴關係對知識疆界跨越之影響

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摘要

當組織組成跨領域團隊並期望藉助多重學域的知識來提供顧客更好的服務時，我們必需留意由於成員各自相異的專業知識而形成的合作障礙。知識就像是個雙面刃；它雖然可能促成創新的解法，但也由於知識具備高度的內隱與情境黏著性，它也可能使得跨領域的知識創造失靈。在此，即使團隊成員使用同一個術語，但由於各個專業領域所內嵌的假設、詮釋與價值觀各異，使得成員們可能對此術語產生不一致的解釋與關注重點，進而產生許多誤解與衝突。此種因為知識而產生的合作障礙，即為知識疆界問題。

本研究探討在多重學域合作的情境中，團隊成員所感知的社會互賴關係（social interdependences）如何影響知識疆界的跨越。社會互賴關係提供成員橋接知識疆界的動機，好讓彼此能達成各自的目標、完成自己的工作、並獲得獎賞。以數位學習內容開發專案（其本質上需要不同專業領域的成員合作）為例，本研究調查社會互賴關係如何促進有效的知識疆界跨越並進而提高專案績效。以專案為資料分析的基礎，本研究收集了 70 組資料，每一組資料皆由二位具有不同專業背景的成員填寫。運用 Partial Least Squares（PLS）分析，我們發現有效的知識疆界跨越可以提昇專案產出與過程的品質。而在社會互賴關係中，當成員們感知到目標與任務的互賴將可促成知識疆界跨越，但感知獎賞互賴則無此效應。我們於文後也討論此研究發現對學術與實務可能帶來的意涵。

關鍵詞：多重學域合作、社會互賴、知識疆界跨越、專案績效、數位學習內容開發

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1. INTRODUCTION

Collaborations among individuals from different professions are promoted by organizations in order to leverage knowledge for providing better solutions and services to customers (Brown & Duguid 2001; Brown 2008). Such collaborations, also referred as interdisciplinary collaborations (Haythornthwaite 2006; Daley 2009; Garman et al. 2006), is beneficial because it brings multiple perspectives to broaden context and to address the complexity of a problem (Haythornthwaite 2006; Lay and Mol 2002). It also can merge disciplinary knowledge to generate a wide variety of ideas (Humphreys et al. 2008; Sharp et al. 2006), and to produce more creative designs (Humphreys et al. 2008; Sharp et al. 2006). Applications of interdisciplinary collaborations are constantly found in many areas, such as service design (Brown 2008), healthcare (Garman et al. 2006), public administration (Daley 2009), and education (Kruck and Teer 2009).

Although many benefits are proposed, to success an interdisciplinary collaboration can be a challenge because of knowledge boundary problems (Carlile 2002, 2004). The knowledge boundary problem refers to the difficulties on delivering knowledge across professional boundaries (Brown and Duguid 2001; Carlile 2002, 2004). Like a double-edge knife, knowledge is critical to drive innovative problem solving within a function, but it may actually hinder problem solving and knowledge creation across functions (Nonaka 1994; Szulanski 1996). Because of its tacit and stickiness nature, knowledge is a usually localized, embedded, and invested knowing in practice (Bourdieu 1990; Lave 1988). Such kind of practice-based knowing varies among functions (or professions), therefore knowledge from one function (or one profession) does not readily fit into the "lived world" of another (Yanow 2004). This specialization of knowledge in practice makes it difficult to collaborate across functional (or professional) boundaries, as well as to accommodate the knowledge developed in another practices (Carlile 2002).

The evidences of knowledge boundary problem are proposed by research in many areas. In public sector, for example, Daley (2009) reported that the effectiveness of interdisciplinary collaboration was contingent to the structural incentives and the previous experiences. In healthcare, for another example, Garman et al. (2006) described that the collaboration could be dysfunctional because of the qualitatively distinct sets of goals and professional values represented in each disciplines. Conflicts were constantly emerged as healthcare professions are trained by fundamentally distinct perspectives on how care should be provided and how processes should be improved (Garman et al. 2006). Furthermore, in communities of practices context, Oborn and

Dawson (2010) suggested that learning under an interdisciplinary context was more than to share each other's knowledge, rather it was a 'learn to talk' process where participants figured out the knowledge gaps and rephrased their knowledge for the others. Since most organizational innovation happen at the boundaries between professions (Leonard-Barton 1995), working across knowledge boundaries is a key for organization's competitive advantage (Carlile 2004).

Previous research addresses the knowledge boundary spanning issue by regarding resources and interactive mechanism. The resource-based research considers that what resources are important to cope with knowledge boundary. For example, intellectual capitals and social capitals are suggested important toward IS-user collaboration in IS development project (Hsu et al. 2014; Lin 2014). These capitals, such as human capabilities, interactive mechanisms, and social relationships, can facilitate the process of knowledge co-creation and prompt better project performance (Hsu et al. 2014). The interactive-mechanism-based research emphasizes particular activities, individuals and artefacts that work on the boundary for improving the effectiveness of interaction (Evans and Scarbrough 2014; Huang and Huang 2013; Star and Griesemer 1989). Brought the idea from boundary spanning studies (Star and Griesemer 1989), these research investigates which boundary spanning approach and boundary object that can smoothly facilitate knowledge delivery (Evans and Scarbrough 2014). An implication brought by these studies is that knowledge boundary can be systematically managed by particular capitals and with appropriate interactive mechanisms. However, most of the capital measurements are post hoc and reflect what has been already happened. It remains unclear about how to articulate these resources by proactive managerial design of interactive mechanisms.

In this study, we extend our previous research to explorehow social relationship influences knowledge boundary spanning. In our previous study, relational capital was proved to be more important than interactive mechanism on the impact on knowledge boundary spanning (Hsu et al. 2014). However, it is hardly proactively manipulated by managers because relational capital is usually emerged and developed upon the on-going interaction experiences. For better managerial intervention, social interdependences can provide a mechanism for mangers to facilitate relational capitalamong participating parties for bridge knowledge boundary. In addition, as previous investigations draw much of attention on knowledge boundary between developer and external partners (e.g., IS and users), coping with knowledge boundary problems within a project team is needed to be highlighted and investigated. As team

members work intensively for accomplish project outcomes, the knowledge boundary problems could bring much of conflicts and misunderstandings which make the knowledge co-creation inefficient. The problems could be worse on interdisciplinary collaboration team since the members hold fundamentally distinct goals and value schemes in their knowledge system.

Specifically, we apply a social interdependence perspective to examine knowledge boundary spanning within the context that the collaboration is participated by members having different professions. We assume that social interdependence among team members can increase the effectiveness of understanding and applying the practical knowledge developed by the other professions. Anchored on e-learning content development project which is usually work by members with education, media design, programming and subject-matter knowledge, our research questions are (1) How does effective knowledge boundary spanning help improve e-learning development performance? (2) How and which do social interdependences influence knowledge boundary spanning effectiveness?

2. LITERATURES

2.1 E-learning Development as an Interdisciplinary Collaboration

Collaboration across disciplines has become popular in service and product design and development. This kind of collaboration works among professional boundaries in order to bring multiple perspectives to bear on a problem, to provide broader context for what is happening (Haythornthwaite 2006), to address the complexity of current phenomena (Lay and Mol 2002), and then it can merge knowledge across disciplinary boundaries to generate a wide variety of ideas and more creative designs (Humphreys et al. 2008; Sharp et al. 2006). Therefore, interdisciplinary collaboration can be found in many areas, such as healthcare (Garman et al. 2006), public administration (Daley 2009), education (Kruck and Teer 2009; Sanner and Deis 2009), and business (Brown 2008).

E-learning content development is a typical example of interdisciplinary collaboration. The e-learning content developing team is usually organized by professions of subject-matter, education, media design, and programming to provide the service of creating online learning contents for increasing learners learning effectiveness. During the developing process, the team members acquire subject-matter knowledge from subject-matter experts (SMEs) to extract the learning needs (Lynch and Roecker

2007; Nicholson and Ngai 1996). And, an instruction designer analyzes the learning materials to conclude the learning objectives, instructional agenda and methods for better knowledge construction (Lynch and Roecker 2007; Yusoff and Salim 2012). Then, a media designer and a programmer work with the instruction designer and SMEs for realized the instructional design with appropriate media presentation and interactive control program. In such collaboration, team members need not only to share individual knowledge but also to adopt and apply others' knowledge to create the final learning contents. In other words, working among knowledge boundaries is essential and critical for the success of an e-learning content development project.

2.2 Knowledge Boundary Problems

Knowledge boundary refers to the boundary caused by knowledge that embedded in functions and professions (Bourdieu 1990). The knowledge boundary perspective reminds that knowledge is critical to drive innovative solutions but it may actually hinder problem solving and knowledge creation across functions (Brown and Duguid 2001; Carlile 2002, 2004). Because of its localized, tacit, and embedded nature, the local knowledge from one profession may not properly fit into another "lived world" (Yanow 2004). This specialization of knowledge makes it difficult to be understood across functional boundaries, and accommodate the knowledge developed in another practices (Carlile 2002).

It is important to distinguish knowledge boundary problem form communication issues caused by motivation (Gagné 2009; Gupta and Govindarajan 2000), organizational structure (Hustad 2007; Laxton and Applebee 2010), transfer channels (Alavi and Leidner 2001; Gupta and Govindarajan 2000; Zhuge 2002), and culture differences (Li 2010; Wang 2011). Knowledge boundary problem focuses on the ineffective knowledge delivery caused by underlining presupposition and preconception held by the participants, rather than caused by the participants' poor motivation or interest conflicts during communication process.

Knowledge boundary can create problems in interdisciplinary collaborations where the participants work across professional boundaries. For example, Garman et al. (2006) described that such collaboration can be dysfunctional because each of disciplines represents qualitatively distinct sets of goals and professional values. Conflicts were emerged as healthcare professions had fundamentally distinct perspectives on how care should be provided and how processes should be improved (Garman et al. 2006).

Without consistent terminologies, goal and value systems among disciplines, the collaboration may be dysfunctional and ineffective because it involves with a long process of clarification and negotiation (Hsu et al. 2014).

Carlile (2004) integrates previous literature and suggests a comprehensive framework for knowledge boundaries and knowledge boundary spanning. Three knowledge boundaries arise depend on different extents of novelty, specialization, and dependence (Carlile 2002)(Figure 1).

First, ***syntactic knowledge boundary*** refers to the syntax barriers and concerns about the improper information processing across a given boundary (Hsu et al. 2014). This knowledge boundary emphasizes the need for participants to establish a shared and stable syntax to insure accurate information processing within the communication across a boundary (Carlile 2002). *Knowledge transfer* is the main purpose of syntactic knowledge boundary spanning, and it can be improved through the creation of shared lexicon, that involving the storage and retrieval of knowledge (Davenport and Prusak 1998).

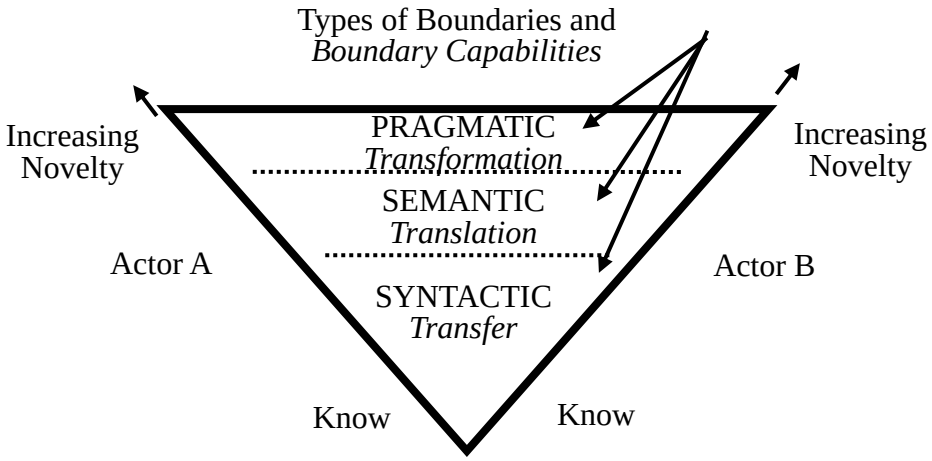

Figure 1: Framework of knowledge boundaries Adapted from (Carlile 2004)

Second, ***semantic knowledge boundary*** refers to interpretation differences that make collaboration difficult although shared lexicons are presented (Carlile 2002). It exists when knowledge increased on a certain level in novelty, specialization and dependence. Despite they use the same word, different meanings are usually generated by the members with different profession (Hsu et al. 2014). As ‘quality’ means ‘reliability’ to engineers, for example, it might be interpreted as ‘good user experience’

to user-interface designers. Instead of information-processing, knowledge boundary problems moves to learn about the sources that create interpretive differences (Carlile 2002). Therefore, to span the semantic knowledge boundary, the members have to deal with the tacit and contextual knowledge issues that creating the inconsistent interpretations on a lexicon (Leonard-Barton 1995). *Knowledge translation* is the way to span semantic knowledge boundary (Carlile 2004). In this process, the members have totranslate local knowledge into the way that can be understood by the counter parts in order to insure an accurate interpretation for generating mutual understandings (Hsu et al. 2014; Nonaka 1994).

Third, ***pragmatic knowledge boundary*** refers to a challenging condition in which a common interest has to be achieved when collaborators negotiate about scope, consequences and conflict resolutions of knowledge delivery with each other (Yuanyue et al. 2010). It exists when the novelty, specialization and dependence of knowledge rise to a high level. The members with different profession usually hold distinct assumption and value systems which drive distinct concerns on what would be done. The team members need to transform their existing knowledge adaptively, therefore their knowledge can be used by the others (Hsu et al. 2014). In a motor design project, for instance, an engine group intent to put a powerful engine into a new car model, but it failed because the engine is too big to fit the styling group's design of car case (Carlile 2004). For the engine group's assumption, a bigger size is essential for making a powerful engine. But, it makes the care bulky which contradicts the styling group's instinct of being fashion. Conflicts erupt when the team members' interests contradict each other (Yuanyue et al. 2010), and the knowledge accumulated in one function generates negative consequences in another (Carlile 2004). To resolve the negative consequences, *knowledge transformation* is needed (Carlile 2004). In a process of knowledge transformation, collaborators need to represent current knowledge by a new way, and validate it within and across functions (Carlile 2002).

2.3 Knowledge Boundary Spanning

Previous research suggests that knowledge boundary problem can be systematically managed by appropriate resources and interactive mechanisms (Hsu et al. 2014; Lin 2014). For resources, research emphasized particular capitals that can facilitate knowledge delivery and co-creation. Taking IS-user collaboration on requirement definition as a research context, Hsu et al. (2014) propose intellectual

capitals are effective for knowledge boundary spanning. The intellectual capitals, such as human capabilities, interactive mechanisms, and social relationships, improve the results of knowledge co-creation between IS and users, then prompt better project performance (Hsu et al. 2014). Among these capitals, social relationship is the most important, followed by human capabilities and interactive mechanisms. In addition, Lin (2014) extends the above research by exploring the effect of social capitals to knowledge boundary spanning. Her research findings proposed that, among the sub-constructs of social capital, the effect of relational capital (i.e. the quality of relationship) is significant but the effects of cognitive capital (i.e. common language and shared mental model) and structural capital (i.e. channels for accessing resources) do not reach to the significant level in ISD project (Lin 2014).

Research that draws on knowledge boundary spanning mechanisms brings the idea from traditional boundary spanning studies (Evans and Scarbrough 2014; Star and Griesemer 1989). These studies consider how boundary spanning approach and boundary object that can smoothly facilitate knowledge delivery across knowledge boundaries. Boundary spanning approach refers to the process and designed activities that work on boundaries to increase interaction and communication effectiveness (Du and Pan 2013; Evans and Scarbrough 2014). Knowledge boundary bridged by particular person (i.e. boundary spanner) or distributed among team members are two typical boundary spanning approaches (Du and Pan 2013; Evans and Scarbrough 2014). In addition, boundary spanning research also concerns about boundary objects which refers to “an analytic concept of those scientific objects which both inhabit several intersecting social worlds and satisfy the informational requirements of each of them” (Star and Griesemer 1989, p. 393). The focus of boundary object research is on how artefacts function in spanning intersecting practices (Akkerman and Bakker 2011).

To sum up, current research concerns on resources and interactive mechanisms for coping with knowledge boundary. Among the effects, studies indicate that relational capital is more important than interactive mechanism (Hsu et al. 2014; Lin 2014). However, it remains unclear about how to improve the relationship among the participants. In addition, as relational capital is embedded in the interactions among external partners that an organization (or a team) experienced (Hsu et al. 2014), it is hard to be proactively managed by managers. This study seeks Pee et al. (2010)’s study on knowledge sharing for the implication to bridge the gap. Pee et al. (2010) shows that social interdependences can provide structural incentives to promote the knowledge sharing between IS and users. With careful design of social interdependences, manager

may proactively manipulate the construction of relational capital.

2.3 Social Interdependence

Social interdependence theory describes how subgroups interact with each other. Social interdependence exists when the outcome of individual behavior affects and is affected by other subgroups' behaviors (Johnson and Johnson 2005). The interdependencies in goals, tasks and rewards between subgroups promote the interactions that may influence immediate and future outcomes of each other (Pee et al. 2010; Johnson and Johnson 2005). These interactions can include providing each other with assistance and exchanging needed information and resources to fulfill the interests of each other (Pee et al. 2010).

Previous studies emphasize the effect of perceived social interdependences rather than the objective assessments (Johnson and Johnson 2005). Only when the objective social interdependences are perceived by people, these social interdependences can prompt the corresponding actions. In other words, when higher social interdependences are perceived, individuals are more likely to work jointly with others to pursue the desirable outcomes together.

In organization, three perceived social interdependences are identified, including goal, task, and reward interdependences. *Perceived goal interdependence* refers to the degree to which a subgroup believes that its goals can be achieved only when the goals of the other subgroup are also met (Weldon and Weingart 1993). Perceived goal interdependence requires the subgroups' goal be compatible and reliant on the goal attainment of one another. *Perceived task interdependence* refers to the degree to which a subgroup believes that it depends on the other subgroups in order to carry out its work (Vegt and Vliert 2005). Although task interdependence and goal interdependence may be highly correlated, they are distinct concepts (Pee et al. 2010; Wageman 1995). For the e-learning content development, subgroups may perceive an interdependent goal (e.g., develop a learning material that can adequately address learning needs) without perceived high task interdependence during the project (i.e., the instructional designer might be experienced to carry out most task of the project without much involvement from the SMEs). *Perceived reward interdependence* refers to the degree to which a subgroup believes that its rewards depend on the performance of the other subgroups (Wageman 1995). Rather than linking the reward to individual performance, rewards interdependence considers to link the rewards to a subgroup according to the

performance of the other subgroups.

Many studies suggest task interdependences drives group performance (Allen et al. 2003; Wageman and Baker 1997). Groups that work on high task interdependence exert more helping behaviors and improve performance over time (Allen et al. 2003). However, the impact of reward interdependence varies. Although studies show that reward interdependence has a positive impact on performance through the mediation of knowledge sharing (e.g., Pee et al. 2010; Lin 2014), some studies show an interaction effect that reward interdependence affect group performance only when task interdependence is high (Allen et al. 2003; Wageman and Baker 1997). Although group reward enhances performance for interdependent task, it shows no significant impact on the independent task (Wageman and Baker 1997). When examining the effect of reward interdependence over time, in addition, Allen et al. (2003) find that the groups in high reward interdependence condition exert more effort in the beginning, but devote comparative less effort than groups in low reward interdependence condition in the end. Their findings also indicate that helping behaviors increased when high level of task interdependence combine with low level of reward interdependence. Group members display more helping behavior in an attempt to overcome the potential performance difficulties (Allen et al. 2003).

3. RESEARCH FRAMEWORK AND HYPOTHESES

Based on previous discussion, we build a research framework on social interdependence perspective. We attempt to examine how social interdependences affects knowledge boundary spanning among team member to increase performance (Figure 2).

3.1 Impact of Effective Knowledge Boundary Spanning to Performance

As e-learning content development always involves with interdisciplinary collaboration, the team members have to integrate their knowledge to accomplish the project deliveries. However, integrating knowledge cannot happened spontaneously as the team members hold different assumptions, interpretations and value schemes toward what knowledge is about and how knowledge can be represented (Carlile 2004; Garman et al. 2006). Conflicts are emerged and make the collaboration dysfunctional when there is no effectiveness on syntactic transfer, semantic translate, and pragmatic transformation (Hsu et al. 2014). In other words, when the team members can

effectively share their knowledge through building common lexicons, understandings and interests, they can improve project performance (Hsu et al. 2014; Leonard-Barton 1995; Pee et al. 2010). Thus, this study proposes the hypothesis H1.

H1: Effective knowledge boundary spanning is positively correlated to project performance.

Previous studies suggest project performance involving both product and process qualities (Hsu et al. 2014; Lin 2014; Pee et al. 2010). Product quality refers to how well the product deliveries are while project quality refers to the successfulness of development process (Hsu et al. 2014). In e-learning content development context, product quality refers to the quality of the developed e-learning content, and it can be evaluated by the content, navigation mechanism, instructional design, and media presentation dimensions (eLQSC 2013). When team members can effectively span knowledge boundaries, they can create an e-learning content with appropriate instructional design, suitable media presentation and smooth navigation control to realize the expected learning objectives. Thus, we propose the sub-hypotheses H1a:

H1a: Effective knowledge boundary spanning is positively correlated to product quality

Process quality refers to the extent to which development task is executed efficiently (Hsu et al. 2014). Specifically, it focuses on the quality of goal achievement, schedule, and budgetary control of development work (Wallace et al. 2004). If team members cannot effectively transfer terminologies, translate interpretations, and transform interests, they will spend lots of time on clarifying terms, explaining misunderstanding, and dealing goal conflicts. As a result, the project performance decreased as project schedule may delay, budget may exceed, and the deliveries fail to satisfy the expected need (Wallace et al. 2004). Therefore, this study proposes the sub-hypothesis H1b.

H1b: Effective knowledge boundary spanning is positively correlated to process quality

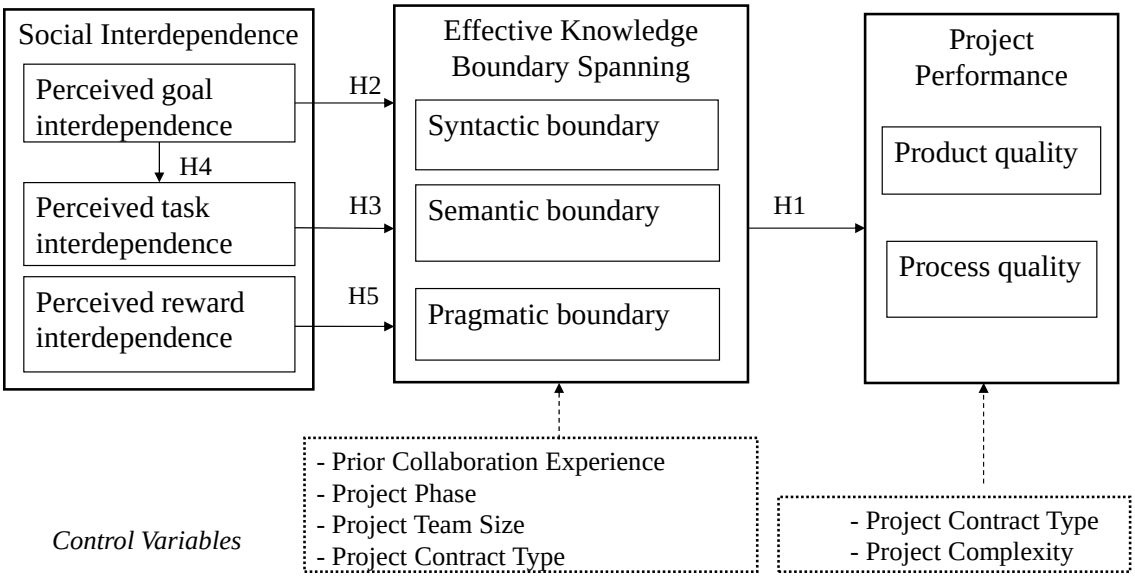

Figure 2: Research framework

3.2 The Impact of Social Interdependences to Effective Knowledge Boundary Spanning

Social interdependence is a structure of interdependencies among individuals and it affects the extent to which individuals interact with others (Ghobadi and D'Ambra 2011). Social interdependence arises when individuals perceive that their outcomes affect and are affected by each other's behaviors (Johnson and Johnson 2005).

3.2.1 Perceived goal interdependence

Goal interdependence are perceived as individual goals can be achieved only when the goals of the others are also met (Weldon and Weingart 1993). Despite having a project goal, team members also have individual goals and interests when they participate in project development (Andres and Zmud 2001-2002). When the individual goals are perceived interdependent, team members find their goals are compatible and reliant on the goal attainment of one another. In this situation, team members will exchange information more accurate (Amason and Schweiger 1997), and they are more likely to provide each other with assistance and resources to prevent the unexpected consequences due to goal conflicts, as well as to fulfill their individual interests (Pee et al. 2010). In e-learning content development project context, the instructional designers may expect a quality learning materials that have rich and up-to-date media

presentations to satisfy learning needs. But the media designer may expect to work with familiar tools for making the development efficient. In this situation, the goals between instructional designer and media designer is conflict since using the up-to-date technology that support rich presentations might be expensive and time consuming. The potential goal conflicts may lead to a lose-lose consequence that instructional designer dissatisfy the quality of project delivery and the media designers spend more time and effort on continuously modifying it. When the instructional designer and media designer perceived and realize their goals are interdependent, they could coordinate a shared goal by transforming individual interests, and provide each other with assistance to share interpretations and lexicons to fulfill the individual interests of each other. Thus, we proposed the Hypothesis H2:

H2: Perceived goal interdependence is positively correlated to the effectiveness of knowledge boundary spanning.

3.2.2 Perceived task interdependence

Task interdependence increased when the members believe their work depends on how well the other subgroup carry out its work (Vegt and Vliert 2005). When the members perceive higher task interdependence with others, they would increase cooperation, helping each other, so as to improve the quality of their work (Allen et al. 2003). Task interdependence among team members can be found in the analysis, design, development, implementation and evaluation stages of e-learning content development. In analysis stage, for example, instructional designer relies on SMEs to share domain knowledge while SME depends on instructional designer to identify the learning objectives and needs. In design and development stages, for another example, the performance of the media designer and programmer depend on the quality of storyboard which is a output of instructional design while instructional designer rely on media designer and programmer‘s technical support on producing the learning materials. These task interdependences create a campaign for exchanging and integrating members’ practical knowledge in order to accomplish the intertwined tasks. The extent to which knowledge sharing and exchange increase along with the increase of task interdependence (Pee et al. 2010). When team members find the quality of their work depend on how well the others’ tasks are performed, they will work on span knowledge boundaries by improving the effectiveness of exchanging terminology and clarifying misunderstanding, as well as coordinating individual interests. Thus, we proposed the

hypothesis H3:

H3: Perceived task interdependence is positively correlated to the effectiveness of knowledge boundary spanning.

Although task interdependence and goal interdependence are distinct concepts, they are highly correlated (Weldon & Weingart 1993; Wageman 1995; Pee et al. 2010). When subgroup perceive their goal accomplishment relies on that of other subgroups, they may develop a collaboration strategy that plan, coordinate and execute task efficiently to accomplish mutual goal. Thus, we proposed the hypothesis H4:

H4: Perceived goal interdependence is positively correlated to the perceived task interdependence.

3.2.3 Perceived reward interdependence

Rewards interdependence increases when the reward to a subgroup depends on the performance of the others. As reward is a strong incentive for prompting employees' expected behaviors, it can enhance members' commitments to team success by facilitating interactions and knowledge sharing (Aladwani et al. 2000; Siemsen et al. 2007). When a team member believes that their rewards depend on the performance of the other members, he or she will increase knowledge exchange interactions to improve the effectiveness of knowledge boundary spanning to prompt each other's performance in order to maximize collective rewards (Abdel-Hamid et al. 2000; Hackman 1987). Thus, we propose the hypothesis H5.

H5: Perceived reward interdependence is positively correlated to the effectiveness of knowledge boundary spanning.

3.3 Control Variables

This study encompasses other factors that may influence effective knowledge boundary spanning and e-learning development project performance as the control variables. ***Prior collaboration experience*** may influence effective knowledge boundary spanning. As well-established project teams may have built common understandings on many issues and continue to assume these common understandings in future interactions,

it is essential to control the effect of prior collaboration experience on effective knowledge boundary spanning (Mennecke and Valacich 1998). ***Project team size*** may also influence the effectiveness of knowledge boundary spanning because of communication complexity (i.e. n(n-1)/2 for the team with n team members) (Pee et al. 2010). In large teams, therefore, communication and collaboration among team members are much harder than that in small teams (Curtis et al. 1998). Misunderstandings among members may also increase as team size grows and challenge the effectiveness of knowledge boundary spanning. ***Project phase*** is controlled because it may require different levels of knowledge boundary spanning. For instance, the analysis phase often involves more knowledge boundary spanning than the implementation phase since extensive knowledge exchange between developers and SMEs is needed in order to clarify the learning needs of course and to evaluate technical feasibility. ***Project complexity*** may influence e-learning development performance. The overall performance decreases when project complexity increases (Roberts et al. 2004-5). That is, the more complex a project, the more challenges the project must overcome (Pee et al. 2010). ***Project contract type*** may disturb project performance by the measurement emphasized on reporting performance (Misra 2004; Pee et al. 2010).

4. RESEARCH METHODOLOGY

A survey was conducted to empirically investigate the proposed hypotheses. The instrument was developed from previous literature and verified by three academic experts and one practitioner. The potential subjects of the survey were the team members who provided e-learning content development service to an organization. The unit of analysis in this study was an individual project each of which had two members responding to the questionnaire. A pretest was held by analyzing fourteen projects conducted by undergraduate students.

4.1 Construct Measurements

The measurements of the constructs were adapted from previous literature to fit the research context of this study. Most items, excepting prior collaboration experience, project phase, project team size and project contract type, were evaluated by seven-point Likert scales ranging from 1 (strongly disagree) to 7 (strongly agree).

As that suggested in Pee et al. (2010), the scales of social interdependence comprised both general and multiplicative measures. The items with general measure

asked a subject evaluate the overall social interdependence among team members. For such measures, responses of two members were aggregated for generating the score of the items for representing the situation of an individual project. In this study, effective knowledge boundary spanning, product quality, process quality, and project complexity were general measures. The items with multiplicative measure asked a subject to evaluate her dependency on the other members, as well as the other members' dependency on her. For such measures, the responses of two members were multiplied to represent the mutual dependences of an individual project. The similar manipulation was reported in Pee et al. (2010) and Nelson and Cooprider (1996).

Social interdependence. Social interdependence was operationally defined as the extent to which team members perceived goals, task, and rewards interdependent on each other during the particular project phase. Social interdependence contained three sub-constructs, including perceived goal interdependence, perceived task interdependence, and perceived reward interdependence.

Perceived goal interdependence. Perceived goal interdependence was operationally defined as the extent to which team members depend on each other to reach individual goals during the particular project phase. One general measure and two multiplicative measures adapted from Pee et al. (2010) were used to measure this construct.

Perceived task interdependence. Perceived task interdependence was operationalized in terms of the extent to which team members rely on each other to accomplish individual tasks during the particular project phase. One general measure and three multiplicative measures adapted from Pee et al. (2010) were used to measure this construct.

Perceived reward interdependence. Perceived reward interdependence was operationally defined as the degree to which team members rely on each other to have rewards, credit and recognition during the particular project phase. One general measure and two multiplicative measures adapted from Pee et al. (2010) were used to measure this construct.

Effective knowledge boundary spanning. Effective knowledge boundary spanning was operationalized as the extent to which team members effectively fulfilled syntactic knowledge transfer, semantic knowledge translation and pragmatic knowledge transformation during the particular project phase. Eight items adapted from Hsu et al. (2014) were used to measure this construct.

Product quality. Product quality was operationally defined as the successfulness

of the developed e-learning material in quality dimensions. The eLQSC (2013) proposed five dimensions of e-learning courseware quality checklist, including content, learning navigation mechanism, instructional design, and media design. Accordingly, we developed five items to evaluate the qualities the e-learning delivery during the particular project phase.

Process quality. Process quality was operationally defined as the successfulness of the process of e-learning development project in terms of goal, schedule and budgetary control during the particular project phase. Process quality involved five reflective construct adapted from Hsu et al. (2014) and Pee et al. (2010).

Control variables. For the control variables, ***project phase*** was measured as a nominal scale to report the latest completed phase of a project (i.e., analysis, design, development, implementation, and evaluation). ***Prior collaboration experience*** was measured as a nominal scale to indicate whether team members had worked together before starting the project. ***Project team size*** reported the number of team members in a project team. ***Project contract type*** was a nominal scale to report the contract type used for a project. ***Project complexity*** presented the extent of unfamiliarity of domain knowledge and technology. It was measured by four items adapted from Pee et al. (2010).

4.2 Sampling and Data Collection

The potential subjects were the team members who worked on an e-learning content development project. We acquired our sample via theoretical sampling based on two criteria. First, the multiple responses from a team would be collected to represent the social interdependences in a project level (Nelson and Cooprider 1996; Pee et al. 2010). As the concept of social interdependence indicated how people “mutually depend” on each other for a particular work (Pee et al. 2010), the appropriate unit of analysis should be in a project level, rather than in an individual level. Therefore, we should acquire responses from at least two team members for each project. Second, the respondents of a project should be with different professional backgrounds in order to fit our research interest of knowledge boundary.

We followed three steps for recruiting the subjects. First, the researchers developed a list of potential e-learning development projects. It was a challenge since e-learning projects were widely distributed among organizations, and there was no formal association for the e-learning industry in Taiwan. To cope with the problem, researchers

contacted more than 40 organizations to identify the ongoing e-learning development projects. These organizations were e-learning vendors and organizations that might receive e-learning services.

Second, we applied two criteria to screen the projects for identifying the potential valid subjects: (1) the project had at least two team members with different expertise; and (2) the project should be processed after analysis phase to have adequate interaction among team members.

Third, the researchers contacted the organizations that responded a willing to participate in surveys, and distributed the instrument to project team members with the support of representative from the responded organizations. Two team members were required to response survey instrument individually, and then the two responses would be calculated to represent the situation of the project. The two respondents in each project were also required to specify their job titles and educational background to ensure that they had different professions.

To minimize a retrospective bias, furthermore, all constructs were measured based on the current phase in ongoing projects (or just closing projects). This was because respondents' perceived of interdependence might be biased by the project's final achievement, and these perceptions might differ from what they were. For instance, project team members might not consciously perceive reward interdependence during the project development. And they did not work out enough knowledge integration during the project development, thus the quality of e-learning material development was not good. Consequently, as the team members could not get the expected reward, they finally realized that their rewards were in fact interdependent. When they responded to our survey retrospectively, they might report the retrospective result (i.e., high-reward interdependence) rather than what was perceived during the collaboration (i.e., low-reward interdependence), and that brought bias into data analysis.

5. RESEARCH FINDINGS

5.1 Subjects

After more than three months of data collection, we acquired 161 responses from 91 projects although 101 project teams agreed to participate in surveys. Among these responses, 21 projects were discarded because they had only a single response that could not fulfill the requirement of two members as representatives of a project. Finally, we identified 70 pairs of response (from the remaining 140 valid responses) that

represented the situation of 70 projects for the following analysis.

The 70 projects came from 19 organizations, including nine business companies, five e-learning vendors, three elementary schools, one educational institution, and one medical institution. Table 1 presented the description of the subjects.

Table 1: Demographics of the 70 projects

Characteristic	Freq.	%	Characteristic	Freq.	%
Objectives of E-learning Development			Last Completed Project Phase		
Basic training	26	37.1	Analysis	2	2.9
Professional training	18	25.7	Design	5	7.1
Skills training	11	15.7	Development	11	15.7
Personal-development	10	14.3	Implement	29	41.4
Others	5	7.1	Evaluation	23	32.9
Project Team Size (People)			Company scale (People)		
>3	9	12.9	< 10	2	2.9
3-4	37	52.9	10-29	21	30.0
5-6	12	17.1	30-99	10	14.3
>7	12	17.1	100-299	7	10.0
Type of Material Presentation			> 300	30	42.9
Video material	25	35.7	Schedule Duration (Months)		
PowerPoint material	23	32.9	>3	17	24.3
Screencast material	3	4.3	3-6	20	28.6
Interactive animation	14	20.0	7-12	28	40.0
Others	5	7.1	13-23	4	5.7
Sponsor’s industry			24 or more	1	1.4
Finance	21	30.0	Project Contract		
Service	26	37.1	Fixed-cost basis	35	50.0
Manufacturing	2	2.9	Time-and-material basis	9	12.9
School	12	17.1	Self-development	26	37.1
Educational Institutes	2	2.9	Prior Collaboration Experience		
Medical institutions	4	5.7	No	19	27.1
Others	3	4.3	Yes	51	72.9

The objective of the e-learning materials included 37.1% in basic training, 25.7% in professional training, 15.7% in skills training, and 14.3% in personal-development. For project team size, about half of the projects (52.9%) had 3 to 4 team members, 17.1% were 5 to 6 team members, 17.1% had more than 7 project team members. The media presentations of learning material were video (35.7%), PowerPoint (32.9%) and interactive animation (20.0%). Most projects were contracted on a fix-cost basis (50.0%). The industries that sponsored these projects included 37.1% in service, 30.0% in finance, and 17.1% in school. About the latest completed project phase, 41.4% had completed the implement phase, 32.9% ad completed the evaluation phase and 15.7% had completed the development phase. The majority of projects were scheduled in 7 to 12 months (40.0%). More than half of the projects (88.1%) had prior collaboration experience.

5.2 Reliability and Validity

We used the 140 individual responses to assess construct reliability and validity. The preliminary examination indicated a poor measurement of the perceived task interdependence construct. For making PLS findings could be interpreted, researchers had to dealt with those items that were unacceptable by the criteria of measurement model (Hair et al. 2014). Therefore, we fix the measurement problem by deleting the item TI2 and had an acceptable measurement model for the structure model estimation. Table 2 presented the results.

Convergent validity was evaluated through factor loadings. As shown in Table 2, most of item loadings were greater than 0.7 (Hair et al. 2014), while TI1 was acceptable as its value was above 0.60 (Hair et al. 2014). With regard to AVE, all constructs' value of AVE exceeded 0.50, excepting perceived task interdependence.

Discriminant validity was presented in Table 3. As the construct correlations coefficients (non-diagonal elements) were much lower than the corresponding square root of AVE (diagonal elements), indicating an acceptable discriminant validity. In addition, the variance inflation factor (VIF) was applied to assess the multicollinearity among the constructs. The resultant VIF scores ranged from 1.195 to 2.332 (Table 4). These scores were below the suggested threshold value 3.3 (Diamantopoulos and Winklhofer 2001) excluding the potential multicollinearity concern of our data.

Table 2: Reliability and validity

Constructs	Item	Mean	Loading	Constructs	Item	Mean	Loading
Perceived Goal Interdependence (Alpha=0.858, CR=0.913 AVE=0.778)	GI1	6.174	0.866	**Knowledge Boundary Spanning** (Alpha=0.965, CR=0.970, AVE=0.804)	SYN1	5.907	0.857
	GI2*	35.000	0.887		SYN2	5.879	0.869
	GI3*	35.343	0.893		SYN3	5.729	0.918
Perceived Task Interdependence (Alpha=0.604, CR=0.761, AVE=0.515)	TI1	5.129	0.760		SEM1	5.721	0.899
	TI3*	23.557	0.680		SEM2	5.821	0.889
	TI4*	22.000	0.710		SEM3	5.893	0.882
Perceived Reward Interdependence (Alpha=0.744, CR=0.854, AVE=0.661)	RI1	5.693	0.820		PRG1	5.879	0.939
	RI2*	25.060	0.770		PRG2	5.871	0.915
	RI3*	27.829	0.847				
Product Quality (Alpha=0.967, CR=0.974, AVE=0.883)	PDQ1	5.814	0.943	**Process Quality** (Alpha=0.948, CR=0.960, AVE=0.829)	PCQ1	5.814	0.932
	PDQ2	5.593	0.932		PCQ2	5.721	0.940
	PDQ3	5.800	0.960		PCQ3	5.807	0.852
	PDQ4	5.907	0.917		PCQ4	5.829	0.945
	PDQ5	5.879	0.946		PCQ5	5.786	0.878

Alpha: Cronbach's α; CR: Composite Reliability; AVE: Average Variance Extracted.

*: multiplicative measure items

Table 3: Discriminant validity

	EKBS	GI	RI	TI	PDQ	PCQ
EKBS	0.896					
GI	0.574	0.882				
RI	0.585	0.671	0.813			
TI	0.608	0.551	0.637	0.718		
PDQ	0.737	0.463	0.413	0.357	0.910	
PCQ	0.756	0.490	0.473	0.406	0.869	0.940

Note: EKBS: Effective knowledge boundary spanning; GI: Perceived goal interdependence; RI: Perceived reward interdependence; TI: Perceived task interdependence; PDQ: Process quality; PCQ: Product quality

Table 4: VIF test

	EKBS		PDQ	PCQ
GI	1.931	EKBS	1.357	1.357
RI	2.332	TYP	1.256	1.256
TI	2.130	CPX	1.496	1.496
His.	1.411		TI	
TYP	1.440	GI	1.000	
PHA	1.195			
T-Size	1.192			

Note: EKBS: Effective knowledge boundary spanning; GI: Perceived goal interdependence; RI: Perceived reward interdependence; TI: Perceived task interdependence; PDQ: Process quality; PCQ: Product quality; His: Project collaboration history; TYP: Project contract type; PHA: Project phase; T-Size: Project team size; CPX: Project complexity

5.3 Hypothesis Testing

We applied partial least squares (PLS) with SmartPLS 3.0 software to examine the research framework. PLS was a structural equation modeling technique that concurrently describes the strength and direction of relationship among constructs (structural model) and represent the psychometric properties between constructs and their corresponding measurement scales (measurement model) (Hair et al. 2014). Using a bootstrap sampling method with 2000 subsamples, results of the structural model estimation were shown in Figure 3.

In Figure 3, the effective knowledge boundary spanning was significantly and positively correlated to product quality (β=0.62***, $p<0.001$) and process quality (β=0.68***, $p<0.001$), indicating a support on H1a and H1b. It implied that both product quality and process quality increased when knowledge boundary spanning was effective.

In addition, both perceived goal and reward social interdependences were significantly and positively correlated to the effectiveness of knowledge boundary spanning (β=0.33*, $p<0.01$; β=0.32*, $p<0.01$), but the influence of perceived reward interdependence was not significant (β=0.11, $p>0.05$). Those results demonstrated supports on H2 and H3, but rejected H5. The correlation between goal and task interdependences were significant positive, indicating a support on H4 (β=0.55***, $p<0.001$). And, all of the control variables did not have significant effects.

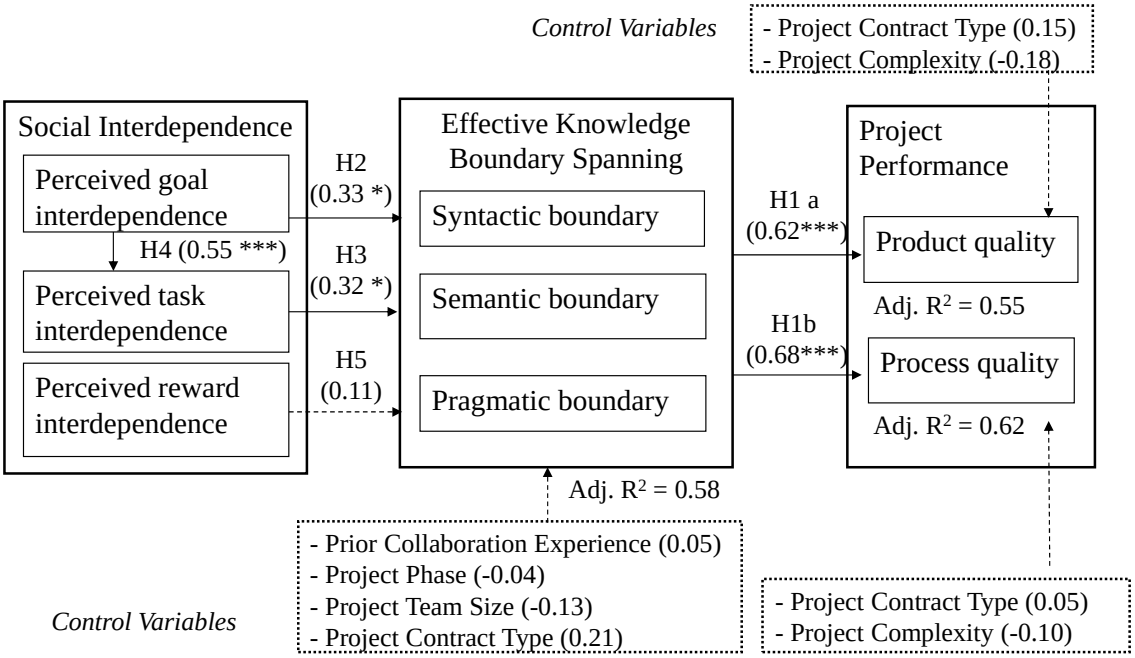

Figure 3: Structure model

6. DISCUSSIONS AND IMPLICATIONS

This study investigates the relationships among social interdependence, effective knowledge boundary spanning and project performance in e-learning content development context. Our findings indicated that the effectiveness of knowledge boundary spanning can improve both product and process quality. And perceived goal and task interdependences are significantly correlated to the effectiveness of knowledge boundary spanning. However, perceived reward interdependence showed no significant impact.

Our results are consistent with previous knowledge management literature highlighting the importance of knowledge boundary (Carlile 2004) and the way to facilitate knowledge boundary spanning (Hsu et al. 2014). As e-learning content development project needs intensive collaboration among team members from different disciplines, our investigation on the relationship between social interdependences and knowledge boundary spanning can contribute insights to both research and practice.

6.1 Implications on Research

This study contributes **service science** research by demonstrating the importance of knowledge boundary spanning for the collaboration that is made by team members with distinct professions. As interdisciplinary collaborators are emphasized to replace 'lone genius inventor' for creating service innovation (Brown 2008, p. 86), to cope the potential barriers brought from knowledge itself is highly critical. Team members might not understand and apply the others' knowledge even they have high motive on interaction and sharing. The tacit and stickiness natural of knowledge block understandings by syntactic, semantic, and pragmatic knowledge boundaries (Carlile 2002; Yanow 2004). When the team members effectively span the three knowledge boundaries, they can increase project performance with better process and product qualities.

In addition, our findings can contribute **knowledge management** research in two ways. First, we extend previous research focus on investigating knowledge boundary spanning within team boundary. Knowledge boundary issues may be easier being noticed among department or organization boundaries that developing team collaborate with subgroups from other subunits or from external organizations. Thus, it is not surprise that previous investigations pay much of attention to knowledge issues on collaboration with external partners, such as IS-user (e.g., Hsu et al. 2014) and business-external IT consultant (e.g., Pee et al. 2010). It is still not enough research to highlight the knowledge boundary issues within a team that members are trained by different disciplines. In e-learning content development context, SMEs, instructional designer, media designer and programmer are usually trained by different disciplines with distinct assumptions and value scheme, the boundary caused by knowledge itself is inevitable and cannot be ignored for having satisfied project performance. Our findings indicate the importance of effective knowledge boundary spanning by proving positive relations among effective knowledge boundary spanning, product and process performance.

Second, this study also extends knowledge management research by showing that effective knowledge boundary spanning can be proactively managed by social interdependences. Previous research suggests that knowledge boundary problem can be significantly managed by relational capital without showing how to improve the relationship among the participants. (Hsu et al. 2014; Lin 2014). As relational capital is a resource embedded in the on-going interactions among participant, it is a post hoc and reflective metric and is hard to be proactively managed by managers. Our findings

bridge the gap by confirming that knowledge boundaries could be effectively spanned when team members perceived goal and task interdependences. By establishing these interdependences, team members not only increase the motive of knowledge sharing (Pee et al. 2010) but also work jointly to increase the effectiveness of syntactic transfer, semantic translation, and pragmatic transformation in order to accomplish their goals and tasks.

However, our findings show that the effect of perceived reward interdependence on knowledge boundary spanning is not significant, indicating an inconsistent to Pee et al. (2010). Seeking for possible explanations on this inconsistency, we cluster our sample into two groups based on the three items of reward interdependence measurement. While comparing the effectiveness of knowledge boundary spanning between the high and low reward interdependence groups, we found that the high reward interdependence group reported the greater effectiveness of knowledge boundary spanning (mean=6.16, n=37) than the low reward interdependence group did (mean=5.47, n=33) ($F=13.7^{***}$, $p<0.00$). It indicates that the effect of reward interdependence might be unstable due to the statistical estimation approach applied. Therefore, future studies might pay more attention to the statistical approaches while they attempt to conclude the effect of reward interdependence from previous literatures. In addition, the inconsistent finding about the effect of reward interdependence reminds us a need on exploring potential variables. For example, effort expand on knowledge boundary spanning might be one of the variables (Wageman 1995; Wageman & Baker 1997). The effectiveness of knowledge boundary spanning would be altered by the effort that team members devote to bridge the knowledge boundary problems. Despite perceived lower level of reward interdependence, the team members might display more knowledge spanning efforts in an attempt to overcome the potential performance difficulties, and then improve knowledge boundary spanning effectiveness. This idea can be supported by Allen et al.'s (2003) suggestion that low reward interdependence group increase efforts on helping others by time. The further research may include the effort construct into investigation in order to clarify the unstable effect of reward interdependence.

6.2 Implications for Practice

To practice, our findings emphasize the importance of knowledge boundary spanning for team members with different professions. Problems and conflicts will rise if we ignore the fundamental differences on assumption, interpretation and value

scheme embedded in different disciplines. For effectively applying the tacit, sticky and localized practical knowledge constructed by members from other discipline, team members have to extensively concentrate on the effectiveness of lexicons transfer, interpretations translation, and interests transform. Increase perceived goal and task interdependences can be helpful to facilitate knowledge boundary spanning effectiveness. When working on an interdisciplinary collaboration project (such as e-learning content development), managers can increase the perceived goal interdependence by designing a share goal which can be accomplished when the subgroups pressure their individual goals. And, manager can make the task intertwined or increase the perceived task interdependence. Although manager may also consider providing group reward to encourage knowledge boundary spanning, its effect are still unconcluded by current research.

7. CONCLUSIONS

This study investigates the importance of knowledge boundary spanning under interdisciplinary collaboration conditions. Taking e-learning development as an example, this study empirically examines how social interdependences facilitates effective knowledge boundary spanning, and subsequently influences e-learning development performance. Our findings highlight an important role of effective knowledge boundary spanning in predicting product and process quality. This finding contributes service science and knowledge management research by making aware of the impact of knowledge boundary spanning within a team that members are with distinct professions. Our findings also show that perceived goal and task social interdependence have significantly positive impact on the effectiveness of knowledge boundary spanning, but the effect of perceived reward interdependence is unstable. It reminds the need to further exploration of the effect of reward interdependence, in terms of considering statistical methods and exploring the hidden variables. These findings can contribute knowledge boundary studies by suggesting a way for managing knowledge boundary spanning proactively by designing goal and task interdependences among team members who are with different professions.

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Appendix I

Construct	Item		Adapted
Perceived Goal Interdependence	GI 1	The goal attainment of team members are highly interdependent.	Pee et al. (2010)
	GI 2*	The goal accomplishment of you (the other members) depends very much on the goal accomplishment of the other members (you).	
	GI 3*	The achievement of goals of you (the other members) subgroup greatly influences the achievement of goals of the other members (you).	
Perceived Task Interdependence	TI 1	Team members often work together concurrently to accomplish the project's tasks.	Pee et al. (2010)
	TI 2*	You (the other members) often accomplish the own tasks independently from the other members (you).	
	TI 3*	Your (the other members') task completion often depends on the other members' (your) tasks in a sequential direction.	
	TI 4*	Your (the other members') task completion often depends on the other members' (your) tasks in a reciprocal "back and forth" manner.	
Perceived Reward Interdependence	RI 1	The rewards/credit/recognition received by the team members are highly interdependent.	Pee et al. (2010)
	RI 2*	You (the other members) often receives rewards/credit/recognition only when the other members (you) performed well.	
	RI 3*	The rewards/credit/recognition received by You (the other members) are greatly influenced by the performance of the other members (you).	
Syntactic Knowledge Transfer	SYB 1	Team members use shared terminology to transfer their own knowledge to each other.	Hsu et al. (2014)
	SYB 2	Team members build shared lexicon toward each other's expertise/knowledge.	
	SYB 3	Team members are able to accurate communicate and transfer what each other say into e-learning materials development.	
Semantic Knowledge Translation	SEB 1	Team members are capable of translation their expertise to each other.	Hsu et al. (2014)
	SEB 2	Team members are able to describe knowledge in the way that each other can understand it clearly.	
	SEB 3	Team members used the way that each other can understand correctly to help them to exhibit the design of e-learning materials.	
Pragmatic Knowledge Transformation	PGB 1	Team members are proficient at combining and exchanging ideas to solve problems in e-learning development project's goal, scope and consequence.	Hsu et al. (2014)
	PGB 2	Team members did a good job of sharing their individual goals and interests of new e-learning material.	
Product Quality	PDQ 1	Material content meets the expected quality at this phase.	eLQSC (2013)
	PDQ 2	Learning navigation mechanism meets the expected quality at this phase.	
	PDQ 3	Instructional design meets the expected quality at this phase.	
	PDQ 4	Instructional medi meets the expected quality at this phase.	
	PDQ 5	Overall, this project developed the e-learning materials to meet the quality expected at this stage.	
Process Quality	PCQ 1	Expected amount of work completed.	Hsu et al. (2014), Pee et al. (2010)
	PCQ 2	Project team's adherence to schedule.	
	PCQ 3	Project team's adherence to budget.	
	PCQ 4	Project team's achievement of project objectives.	
	PCQ 5	High quality of work completed.	
Project Complexity	PC 1	There are very clear known ways to perform the project work.	(Pee et al. (2010))
	PC 2	There are very little established practices can follow to complete the project tasks.	
	PC 3	The technology involved in developing the targeted e-learning material is brand new to our project team.	
	PC 4	Our project team has very little prior experience with the technology involved in developing the targeted e-learning material.	

* means multiplicative measure.