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# Coping knowledge boundaries between information system and business disciplines: An intellectual capital perspective

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ABSTRACT

Information system development can be considered a collaboration between users and developers. The inability to leverage the localized knowledge embedded in these two stakeholders hinders software development work to achieve high performance. Exploring the ways to counter this difficulty is then critical. This study applies an intellectual capital perspective to address the issues around spanning the knowledge boundary between developers and users. Our findings highlighted how important effective knowledge boundary spanning is to both product and project quality. Furthermore, three dimensions of intellectual capital increased the degree to which knowledge boundary spanning was effective.


## 1. Introduction

Multidisciplinary collaboration, such as cross-functional teams within an organization [11], or collaboration among organizations with different expertise [49], has become common in organizations for leveraging multiple knowledge bases to create innovations. Benefits are expected from multidisciplinary collaboration, including addressing the complexity of current phenomena [45], extending the solution space by bringing multiple perspectives [35], generating a wide variety of ideas and producing more creative designs [72,40]. However, challenges appear, especially when such collaborations cross the boundaries between specializations. For example, conflicts arise and collaboration may be dysfunctional when goal and value diversity are driven by professional differences [27], and communication can be ineffective as it always involves a long process of term definition negotiation in multidisciplinary collaboration [59]. These examples collectively highlight the not-to-be-ignored effect of the "knowledge boundary" in multidisciplinary collaboration [11,12]. *Knowledge boundary* refers to the knowledge delivery problems in which the tacit and sticky nature of localized knowledge may actually hinder problem solving and knowledge creation across functions [57,9]. In practice, this specialization of knowledge increases the difficulty of collaborating across functional boundaries and accommodating knowledge developed in other practices [11].

In the information system (IS) area, a typical example of multidisciplinary collaboration is the IS development (ISD) process in which users and IS developers work together to counter requirements risks and generate better outcomes [38]. *Requirements risk* is the possibility that the elicited requirements will be of low quality, such as incorrect or invalid requirements [84,70]. Failing to elicit correct requirements in the design stage could increase the difficulty in the late stages of IS development [28,56]. Project teams may need extra resources and time to achieve predefined goals, and the developed system may not fully support users' daily work [64]. Studies have proposed ways to improve the quality of requirements elicitation, including development methodologies, tools and design paradigms [61,31]. In addition, empirical studies also emphasized the importance of including users in the requirements elicitation process to ensure success [36].

However, simply involving users in the system development process is far from sufficient. After decades of studying, academic researchers show inconsistent results on the effect of user participation [36,42]. Project performance may still be low even when users are included [47]. Even though contingency theory is widely adopted to explain the inconsistent findings [39], few studies attempt to answer this question from the process of or

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activities in user participation. This suggests the need to investigate this issue from a different perspective. For example, from a boundary spanning perspective, to obtain higher quality requirements, developers have to understand users' needs, translate user requirements into system features, and even negotiate with users about what the system should be and how processes could be improved. Since users and IS developers have different expertise and interests in their working domains, quality requirements can be created only when the knowledge boundary is successfully overcome.

Information system development is a knowledge intensive process in which business knowledge from users and technical knowledge from developers are considered the most critical resources. By viewing the elicited requirements as new knowledge jointly created by users and developers, the interaction process between these two parties for requirement elicitation can then be regarded as a knowledge boundary spanning process. Ineffective knowledge boundary spanning between users and developers may result in inadequate requirements and hinder final performance. This also highlights the importance of identifying what must be available within the organization or project team for effective knowledge boundary spanning. Since an ISD project is a knowledge intensive process and knowledge is counted as the most critical resource, intellectual capital serves as a good starting point for investigating this issue. Current research suggests that user–IS interactions can be better achieved with mutually shared knowledge, a smooth relationship and appropriate mechanisms for collaboration [78,86]. These concepts are aligned with the intellectual capital theory which suggests that the intellectual materials (e.g., knowledge, information, intellectual property, and experience) allows the organization to produce a higher-valued asset [74]. Distinguishing human, relational and structural types of capital [8], the intellectual capital theory has been adopted to understand knowledge contribution [87] and the quality of knowledge sharing [82,81].

Applying the intellectual capital perspective, this study examines how the various types of intellectual capital between users and IS developers contribute to overcoming knowledge boundaries. The research questions include: (1) "Can effective knowledge boundary spanning between users and IS developers help improve ISD performance?" and (2) "Can intellectual capital facilitate effective knowledge boundary spanning between users and IS developers?" By answering the above questions, this study contributes to the ISD project management area by showing the importance of knowledge boundary spanning. Past studies largely adopted the participation concept and examined the positive and negative effects of user engagement on project performance. We introduce the knowledge boundary concept into this research stream and argue that, in order to better utilize expertise, both developers and users need to cross the knowledge boundary between them. In addition, we also identify possible approaches that can be used to facilitate knowledge boundary spanning. Those identified approaches may serve as guidance for managers to overcome knowledge boundaries in practice.

The rest of this paper is organized as follows. In the next section, related literature is reviewed and hypotheses are provided. The research method is introduced in Section 3. Data analysis and discussion are then followed by the conclusion.

## 2. Literature

### 2.1. Knowledge boundaries and boundary spanning

A knowledge boundary is a kind of barrier or gap that prohibits effective knowledge delivery across functions and among experts [9,10]. In contrast to current research, which suggests such factors as motivation [88,2,32], cultural issues [51], transfer channels [2,32] and absorptive capacity [32,14], studies of knowledge boundaries are specifically concerned with the barriers caused by local knowledge itself in the process of knowledge delivery and sharing [11,12]. Past literature addresses knowledge boundaries from three main perspectives. The first stream of research regards knowledge as something to be captured, stored and retrieved [11,24]. This stream takes an *information processing perspective* (*or engineering approach* [24]) and puts emphasis on developing a common lexicon for effective knowledge delivery [24,44,26]. The second stream of research concerns the tacit, sticky and situated nature of knowledge. Therefore, this stream stands on the *interpretive perspective* and focuses on common meanings to share knowledge between actors [83,43]. The third stream of research stresses the *social perspective* and acknowledges how different interests impede knowledge sharing and, therefore, emphasizes the importance of goal consensus building to facilitate knowledge delivery [24,50,29].

Carlile integrated these three streams and developed a comprehensive framework to manage knowledge boundaries [11,12]. The basic argument of this framework is that knowledge within a function actually hinders problem solving across functions because knowledge is localized, embedded and invested in practice [11], as well as socially constructed among professionals [21]. The specialized, socially constructed and embedded nature of knowledge increases the difficulty of working across functional boundaries and accommodating knowledge developed in another practice [21].

Carlile further suggests that knowledge boundaries can arise in different degrees of novelty, specialization and dependence. *Novelty* refers to the degree to which the circumstances are unusual [12]. *Specialization* is the difference of the amount and type of domain-specific knowledge. It determines the amount of effort needed to adequately share and assess each other's knowledge [12]. *Dependence* refers to "a condition in which two entities must take each other into account if they are to meet their goals" [12]. Carlile [11,12] also identified three knowledge boundaries: syntactic, semantic and pragmatic, as shown in Fig. 1.

First, a *syntactic knowledge boundary* occurs when knowledge is low in novelty, specialization and dependence. This knowledge boundary refers to the lack of a shared syntax and creates the concern that information may not be processed properly across a given boundary. This boundary highlights the need for actors to establish a shared and stable syntax to ensure accurate communication across a boundary and to solve challenging communication and information processing problems [11,71]. *Knowledge transfer* is the major purpose of syntactic boundary spanning. A common lexicon created by the storage and retrieval of knowledge can facilitate knowledge transfer across the syntactic boundary [16]. When the created common lexicon sufficiently specifies the differences and dependencies of consequence at the boundary, it can function as a boundary object to facilitate knowledge transfer

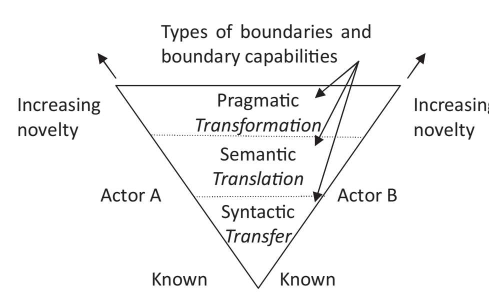


**Fig. 1.** Framework of knowledge boundaries.
Adapted from [12].

and information processing between senders and receivers. In general, having more information, more communication and more teamwork strategies improves information processing quality, thus spanning the syntactic knowledge boundary [11].

Second, a *semantic knowledge boundary* occurs when the novelty, specialization and dependence of knowledge rise to a certain level. This knowledge boundary refers to a condition that, even when a common syntax is present, different interpretations of the common syntax make communication and collaboration difficult [11]. It is not unusual for the same word to have different meanings in different functional settings. This knowledge boundary concerns learning about the sources that create interpretive differences in a boundary [11]. Therefore, collaborators need to consider the tacit, individual, and context-specific aspects of knowledge creation and transfer in order to span the semantic boundary [58,46]. This implies that *knowledge translation* is needed to cope with a semantic boundary. Translation aims at dealing with semantic differences among actors. Error-free knowledge translation is required in order for actors to grasp and convey the actual meaning of knowledge delivered from their counterparts, and to avoid misinterpretation [3]. Effective translation relies on the existence of a mutual understanding which can make tacit knowledge explicit across a boundary [57]. Common or shared meanings ensure accurate translation and interpretation of the knowledge across the semantic boundary and, therefore, provide an adequate means of sharing and assessing knowledge at a boundary. Collocation, shared tools or methodologies, boundary spanners [34], transactive memory [2,1] and community of practices [10,43] are suggested by previous literature as useful ways to developing shared meanings [12].

Third, the term *pragmatic knowledge boundary* refers to the challenges in which a common interest has to be achieved when participants negotiate with each other on the scope, consequences and conflict solutions of knowledge delivery [20]. The interactions across functions are not inconsequential. Individuals from each function may have to alter their own knowledge and influence or transform the knowledge used by the other function. Conflict may erupt when interactions are consequential. When differences, dependencies and novelty are high, conflicts among the actors will surface when their goals of knowledge delivery contradict each other [11,20]. To solve the conflicts that potentially generate negative consequences, the actors have to engage in a process of presenting current knowledge, creating new knowledge, and learning the consequences within and across functions, and then they have to transform knowledge accordingly [11]. This process is the so-called *knowledge transformation*. Shared artifacts, such as drawings and prototypes, acting as boundary objects, have proven effective in providing a concrete means of representing different functional interests and facilitating negotiation and transformation [12].

### 2.2. Requirements definition as user–IS developer knowledge boundary spanning

In ISD, requirements definition is an important stage in which to elicit, document, define, and refine user requirements [69]. Incomplete, unclear and inadequate requirements may result in information system failure [48] and cause significant difficulties during the subsequent ISD process [15]. For example, inadequate requirements increase residual risks and difficulties in planning and control, thus decreasing IS performance [85,56]. Thus, determining the actual requirements and eliminating the uncertainty caused by requirements problems as early as possible are critical to controlling the process and quality of IS development.

Effective requirements definition is a collaborative behavior that relies on effective communication and interaction between different stakeholder groups such as users and IS developers [54]. It involves integrating business knowledge with IS knowledge to accurately design the system and completely fulfill users' needs [79,37,19]. In this light, how well the system design can capture the business process cannot be determined solely by the IS developer's ability to craft a system to support business operations. Users need to contribute their business domain knowledge to help IS developers carrying out of the design. By transferring knowledge to each other, users and IS developers can blend their own knowledge with the transferred one for clarification of the requirements, thus reducing requirements uncertainty and achieving a better system design [39].

From a knowledge boundary spanning perspective, the requirements definition process involves a series of activities in exchanging, integrating and utilizing knowledge from users and IS developers to solve business problems. It requires IS developers to understand and elicit information from the application domain, and to generate requirement specifications by transferring, representing and detailing the accumulated information [69]. Final system performance is determined by how effectively specialized knowledge possessed by the participants is integrated [61]. This kind of knowledge integration includes establishing shared syntax, semantics, and interests in the ISD process so that specialized knowledge can be transferred, translated and transformed [12,61].

We therefore regard requirements definition as a typical process of knowledge boundary spanning. At the syntactic level, users and developers have to build common lexicons and increase communication with their counterparts [11]. In the requirements determination stage, these two parties need to interact with each other frequently to share data, information, workflows, reports and technical terms, and improve communication and information processing quality. These interactions can facilitate knowledge transfer and decrease the uncertainty of requirements definition. At the semantics level, while developers and users hold different interpretive schemes and mental models, different interpretations and distinctive meanings of the details of the IS application may be observed. Those semantic level differences include requirements, system architecture, technology feasibility, and process design. To bridge the semantic knowledge boundary, users and IS developers need to build a mutual understanding to facilitate mutual learning. As a result, they can grasp and translate the actual meaning of knowledge delivered from their counterparts to avoid misunderstandings [12]. At a pragmatic level, users and IS developers need to negotiate with each other regarding the scope of the IS application, and resolve conflicts so as to construct common goals and interests for the IS development. For example, a prototype is usually used by IS developers as a boundary object to negotiate system features, project objectives and scope in order to achieve effective knowledge transformation. The above discussion indicates that the requirements definition process is a typical example of knowledge boundary spanning in which users and IS developers collaborate with each other to create accurate requirements through effective knowledge transfer, translation and transformation.

### 2.3. Bridging knowledge boundaries via intellectual capital

As indicated, in order to produce an IS which can satisfy business needs, the users and IS developers have to share individual knowledge, as well as to assimilate what has been shared by their counterparts. That is, they have to cope with the knowledge boundaries in order to create new knowledge to solve business problems [30]. Previous research has dealt with the interaction between users and IS developers from various perspectives. For example, Grant [30] proposed that the mutual understanding that existed between participants determined the efficiency of knowledge integration; Tiwana and McLean [80] emphasized that stakeholder relationships were key to effective knowledge integration; Swanson [75] confirmed that user participation was critical to enhancing requirements acquisition. Since these concepts align with the premise of intellectual capital, we therefore consider intellectual capital to be our foundation as we attempt to understand its effects in facilitating knowledge boundary spanning between users and IS developers.

*2.3.1. Intellectual capital*

Introduced by John Kenneth Galbraith in 1969 [7], with a major breakthrough made subsequently by Stewart [74], intellectual capital refers to intellectual materials (e.g., knowledge, information, intellectual property, and experience) which can be formalized, captured and leveraged to give an organization a competitive edge by producing a higher-valued asset [74]. Similarly, Bontis considered an organization's intellectual capital to be the wealth of ideas and innovative ability which could contribute to the competition [8]. Extending from Stewart [74], Bontis [8] further proposed intellectual capital as a second order construct comprised of human capital, structural capital and relational capital.

*Human capital* refers to an organization's members' ability to provide solutions for customers and creating innovation [74]. It includes the competencies (i.e., knowledge and skills), attitude (i.e., motivation and leadership) and intellectual agility (i.e., innovation and entrepreneurship) of an organization attempting to provide innovative solutions for customers [74,68]. Human capital is regarded as a source of innovation and strategic renewal which generates value and gives an organization a competitive advantage [18].

*Structural capital* refers to the mechanism which allows human capital to be used repetitively and then create value [74]. According to Bontis [8], structural capital deals with organization mechanisms and structures that support members in order to achieve business performance. Specifically, structural capital can be organizational routines and structures capable of enhancing effective interactions among stakeholders [60].

*Relational capital* is the intangible resources that an organization holds, including knowledge embedded in the interactions among customers, suppliers, the government and related industry associations [8]. Stewart [74] defined relational capital as the value of an organization's relationships with the people with whom it does business.

Intellectual capital was shown to have a positive impact on an organization's performance [7]. In this study, we apply it at the project level and argue that intellectual capital is critical for final project outcomes as well, based on the following two reasons. First, an ISD team can be viewed as a small organization in which the team members act on their intellectual resources to produce an information system. Second, it is well known that ISD is a knowledge intensive process in which knowledge and expertise residing within different stakeholders are the most important resources [52]. This aligns with what the original intellectual capital studies indicated: that expertise or knowledge is the most critical resource for enhancing an organization's performance and achieving a competitive advantage. Therefore, at a project level, similar to the operation of an organization, better project performance can be achieved when a team possesses sufficient intellectual capital.

## 3. Research framework and hypotheses

Based on the discussion above, we structured our study on the basis of the intellectual capital perspective and attempted to examine how intellectual capital within an organization affects knowledge boundary spanning between users and IS developers to achieve successful outcomes. Although past intellectual capital research indicates that intellectual capital has a direct effect on firm performance, we include the knowledge boundary concept in this study and further argue that knowledge boundary spanning serves as one critical mediator between intellectual capital and final performance. Past intellectual capital research treats intellectual capital as the sum of expertise and knowledge resources residing within an organization. They ignore the need for the diverse expertise and knowledge possessed by different stakeholders to be integrated in order to generate a better effect. Therefore, the research models of past studies did not include possible barriers that may prohibit distributed intellectual capital from functioning properly. However, users and developers are distinct stakeholders who possess needed but diverse expertise for effective system development. It is then reasonable to understand that final performance is contingent on the effectiveness of knowledge integration or knowledge boundary spanning. Therefore, we propose that effective knowledge boundary spanning should be achieved in order for a project team to perform well.

In this research, effective knowledge boundary spanning is defined as the users' and IS developers' interaction with each other to reach effective syntactic knowledge transfer, semantic knowledge translation and pragmatic knowledge transformation. With a high degree of effective knowledge boundary spanning, users and IS developers have a shared syntax lexicon with which to communicate and transfer knowledge, semantic meaning with which to interpret and translate knowledge, and a common interest in the IS scope, consequences and conflict solutions for IS development. Here, we suggest that the outcome of the IS project can be improved when knowledge boundary spanning between users and IS developers is effective. The research model is shown in Fig. 2 and corresponding hypotheses are discussed thereafter.

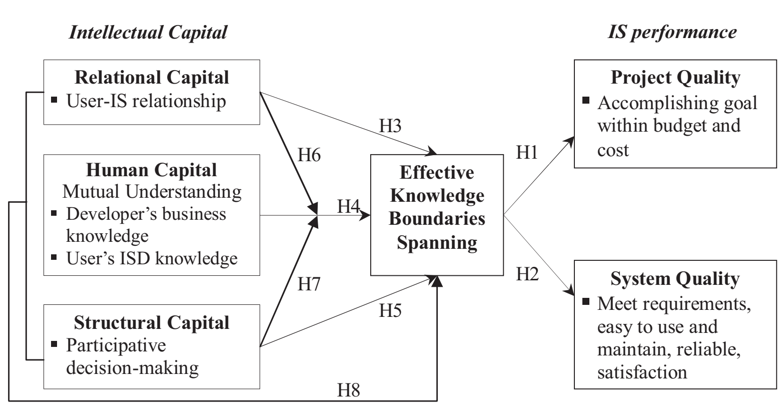


**Fig. 2.** Research framework and hypotheses.

### 3.1. Consequences of effective knowledge boundary spanning

We expect that effective knowledge boundary spanning can improve the performance of an IS project. While evaluating the performance of an IS project, researchers argue that both process and product outcomes should be taken into consideration [86,56]. Although these two concepts are related, they can be distinguished from each other. While *process* outcome focuses on the extent to which development work is carried out efficiently, *product* outcome represents the quality of the developed system. An IS project with low process outcomes (e.g., failure to accomplish a predefined goal within the allotted time or budget) may or may not have a high product outcome. For example, in order to accomplish the project on time, a project team may take a compromised approach such as excluding some minor functions. As a result, the process outcome may be acceptable but the product outcome would be low. In this study, we include both concepts and refer to the process outcome as project quality and the product outcome as system quality, specifically.

In IS development, system quality can be improved when requirements are better identified [42]. System quality refers to the successfulness of the developed system [85]. It represents the capability of the system to maintain its performance level under specified conditions and meet user needs, and its capability to be modified, understood and used by users [76,5]. When knowledge boundary spanning is highly effective, users and developers are more likely to have a shared lexicon, shared interpretation and common interests regarding the IS development. Thus, the users can smoothly deliver their knowledge to help IS developers identify the actual requirements [36]. At the same time, the IS developers can better understand and blend users' knowledge with their own to create an information system that can fulfill user needs [61,67]. In other words, user requirements can be effectively incorporated into the system design when users and IS developers can effectively bridge the knowledge boundary and integrate knowledge across the professions. Thus, we propose the following hypothesis.

**Hypothesis 1.** System quality increases when knowledge boundary spanning is highly effective.

Project quality can be improved when knowledge boundaries are effectively spanned. Project quality refers to the degree to which a project meets its goals, budget, schedule, and quality criteria [85]. Knowledge boundaries between users and IS developers cause communication problems and misunderstandings, thus increasing the risks and uncertainty within the IS development process [28,55,41]. Without a shared lexicon, shared interpretation and common interest, users and IS developers may spend considerable time on clarifying and negotiating requirements rather than developing the system to support users' needs. Schedules extend and costs increase greatly when the team fails to identify requirements, requiring rework in the later stages of IS development [6]. In contrast, with more highly effective knowledge boundary spanning, users and IS developers can help each other identify actual requirements in the earlier stage, and make sure that the project would be accomplished on time and within budget [61,52]. Thus, we propose another hypothesis.

**Hypothesis 2.** Project quality increases when knowledge boundary spanning is highly effective.

### 3.2. The antecedents of effective knowledge boundary spanning

Effective knowledge boundary spanning (EKBS) refers to the degree to which participants can effectively transfer their own knowledge, translate what is shared by their counterparts, and transform the knowledge to meet the common interests in an IS development project. In this light, new knowledge is created through grasping and integrating different knowledge to solve business problems [30]. Therefore, understanding how to bridge the knowledge boundary and achieve successful knowledge integration is particularly important. Prior IS research addresses this issue by emphasizing mutual understanding [30], the user–IS relationship [80] and user participation [75]. Although these studies have merit, they lack an integrated and comprehensive framework to understand the antecedents of EKBS in the IS development context. In this study, we include the three elements of intellectual capital (i.e., the human, relational, and structural dimensions) to achieve a comprehensive investigation.

#### 3.2.1. Relational capital: user–IS relationship

Relational capital refers to the value of the relationships among the stakeholders of an ISD project. Since we view developers and users as two major stakeholders, relational capital in this study describes the interaction, mutual respect and trust, personal friendship, and reciprocity between them. Relational capital is critical because a stronger partnership helps to bridge knowledge boundaries. Partnership is developed when users and IS developers frequently work together, communicate, coordinate and negotiate with each other [68]. Strong trust and respect facilitate the process of effectively spanning knowledge boundaries between users and developers [80]. When users and IS staff are in a reciprocal and friendly relationship, the costs of communication and coordination decrease, and in turn, the effectiveness of knowledge boundary spanning increases [66]. Users and IS developers are willing to share their own knowledge, and to understand and assimilate the knowledge delivered by their counterparts when they are in a better relationship [80,77]. Thus, we hypothesize the following.

**Hypothesis 3.** The user–IS relationship has a positive influence over the degree to which knowledge boundary spanning is effective.

#### 3.2.2. Human capital: mutual understanding

Human capital focuses on the capabilities of members within an ISD project. Since developers and users are two major players within the ISD process, human capital within an ISD project can be viewed as the ability of these two players to generate an effective outcome. Therefore, the degree to which they possess the necessary knowledge to carry out the whole process can be used to represent the level of human capital within ISD. Human capital in the ISD context includes both developers' and users' knowledge. When users and IS developers have a clearer concept of the knowledge of their counterparts, over and above their own knowledge, they are more capable of providing innovative solutions [30], indicating a higher level of human capital. When developers have business knowledge and users have IS knowledge, they can both better understand and respect each others' unique contributions [80]. When users and IS developers have a mutual understanding, they have an easier time blending their own knowledge to further IS development [78], reducing misunderstandings and facilitating knowledge integration [53]. That is, the degree of mutual understanding between users and IS developers is fundamental to improving the degree of effectiveness of knowledge boundary spanning. Thus, we hypothesize the following.

**Hypothesis 4.** Mutual understanding can increase the degree to which knowledge boundary spanning is effective.

#### 3.2.3. Structural capital: participative decision-making

Structural capital refers to the organizational capability that involves routines and structures which effectively enhance the interactions among stakeholders [60]. Even though the employees are intelligent, if the organization has poor mechanisms to support their needs and actions, the overall intellectual capital will not reach its expected potential [8]. In an information system development context, participative decision-making has been widely adopted to represent the existence of formal mechanisms to facilitate knowledge exchange or integration between stakeholders [61]. We follow this stream and view participative decision-making as a mechanism representing structural capital in an IS development context. Participative decision-making provides the opportunity for all to understand and clarify different knowledge held by different stakeholders. In this study, participative decision-making refers to user participation and shared decision-making in the IS development process. In the IS literature, user participation has long been believed to be an effective mechanism to facilitate user contributions. Users are able to provide business domain knowledge to help determine system requirements through formal engagement [36]. Empirical studies also prove that participative decision-making is effective in enhancing the degree of effectiveness of knowledge boundary spanning within an IS development context [61]. Thus we hypothesize the following

**Hypothesis 5.** Participative decision-making has a positive influence over the degree to which knowledge boundary spanning is effective.

### 3.3. The interaction effects of paired types of capital

#### 3.3.1. Relational capital and human capital

Human capital and relational capital may jointly affect knowledge boundary spanning between users and developers. According to Faraj and Sproull [19], users and developers are motivated to contribute, share and exchange knowledge with each other when they have a close relationship. When relational capital is high, users and developers may care less about gains and losses; instead, they demonstrate more altruistic behavior toward their counterparts. Users and developers can trust and respect each other, and are more engaged in collaboration when relational capital is high. In addition, with good relationships, users and developers may have more opportunities to interact, communicate and negotiate with each other. If users and developers have positive relationships, higher cohesion will exist between them, eventually improving the process of using mutual understanding to create new knowledge. Therefore, we propose the following hypothesis.

**Hypothesis 6.** The interaction between human capital and relational capital positively affects effective knowledge boundary spanning.

#### 3.3.2. Structural capital and human capital

Human capital and structural capital may jointly affect knowledge boundary spanning between users and developers. The structural design of user participation can facilitate greater and richer interactions among participants in the ISD process [65]. To IS developers, even if there is a mutual understanding, user participation can shorten the time spent on capturing the terminologies and the tacit knowledge embedded in the problem domain. With formal user participation, the developers can have certain and specific support when they try to understand the syntax, semantic and pragmatic meaning of the requirements. Similarly, through formal participation, users can enhance their understanding of the ISD process, and have concrete expectations of the IS project. The formal structure provides users and IS developers with a mechanism to make joint decisions, helping the two parties to have a mutual understanding and effectively bridging the knowledge boundaries. We thus hypothesize the following.

**Hypothesis 7.** The interaction between human capital and structural capital positively affects effective knowledge boundary spanning.

#### 3.3.3. Structural capital and relational capital

Structural capital and relational capital may jointly affect knowledge boundary spanning between users and developers. While structural capital allows users to engage in the system development process and facilitate knowledge boundary spanning between these two parties, a strong relationship allows the knowledge boundary spanning to be more effective. It is not unusual for users and developers to have different expectations of the system since they possess different technological frames [17]. Conflicts may take place under this condition. A strong relationship can ease possible conflicts and allow the two parties to reach consensus more easily. Therefore, we hypothesize the following.

**Hypothesis 8.** The interaction between structural capital and relational capital positively affect effective knowledge boundary spanning.

## 4. Research methodology

We conducted a survey in this study to test the research framework empirically. The survey instruments were adopted for the research context from previous literature. A pretest was conducted to validate the measurements.

### 4.1. Sample and data collection

The potential subjects of this study were practitioners who engaged in information system development. We took a two-step approach to collecting the data. We first contacted all 251 information systems department managers in Taiwan's Information Management Association (IMA). Via telephone, we introduced the major purpose of this study to the mangers and determined their willingness to participate in this study. Those who were willing to participate were asked to provide the contact information of project managers, team leaders, or senior members within their organization (one member for each recently completed project). For those companies which had two or more recently completed projects, the information of each contact was recorded. A total of 750 projects were identified. In the second stage, we delivered the survey instrument to the 750 project managers, team leaders, or senior members who were identified in the first stage. A total of 279 responses were collected, indicating a 35.6% response rate. Among the responses, a total of 12 cases with more than 50% missing values were discarded [33], and the remaining 267 responses were used for the following analysis. Note that our 267 respondents represented a total of 113 companies. Since more than two samples might be drawn from one company, there is a need to exclude possible interferences caused by "company," a higher-level influencer. We performed several additional tests, by using Stata with a corrected standard error, to exclude the impact of company. Since all path coefficients were exactly the same and also were significant at the same level, we were confident to conclude that company should not be a concern in our study.

To ensure the sample representativeness, in addition, two separated analyses were conducted. We first compared those companies which were willing to participate in this study with those which were not. No differences between these two groups were found, in terms of company size and industry type. The second comparison was to ensure there was no significant

**Table 1**
Sample demographics ($N = 267$).

| Measure | Categories | # | % | Measure | Categories | # | % |
|---|---|---|---|---|---|---|---|
| Tenure | <4 years | 54 | 20.2 | Duration in project | < half year | 101 | 37.8 |
| | 4–10 years | 132 | 49.4 | | Half-1 year | 85 | 31.8 |
| | 11–20 years | 71 | 26.6 | | 1–2 year | 49 | 18.3 |
| | >21 years | 8 | 3.0 | | 2–3 year | 14 | 5.3 |
| | Missing | 2 | 0.7 | | >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 |
| | >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 |
| | >31 | 11 | 4.1 | | Missing | 3 | 1.1 |
| Authority position | Programmer | 115 | 43.0 | Industry | Manufacturing | 107 | 40.1 |
| | SA | 48 | 18.0 | | Service | 51 | 19.1 |
| | Project leader | 51 | 19.1 | | Education | 11 | 4.1 |
| | CIO[a] | 23 | 8.6 | | Finance | 20 | 7.5 |
| | Others[b] | 28 | 10.4 | | Others[c] | 43 | 16.1 |
| | Missing | 2 | 0.7 | | Missing | 35 | 13.1 |

[a] CIOs serve as managers of certain projects.
[b] Network maintainer, DB maintainer, QA engineer and maintainer.
[c] Public utilities, transportation, retail and government.

difference between those which returned our survey and those which did not. Since we did not collect the project characteristics in the first stage, an earlier-late comparison was made instead. We compared the first and fourth quartiles of the samples based on the return date. Since no significant differences were found, we were then assured that our sample did not suffer the non-response issue.

Table 1 shows the demographic information of the respondents. Most of the respondents were male (73%) and were well educated (58% had a bachelor degree and 35% had a master degree). As for their authority levels, 43% were programmers, 18% were system analyst and 19% were project leaders. The demographics were aligned with the distributions in the Taiwanese ISD context noted by previous studies [25,73], demonstrating a satisfactory sample representation.

### 4.2. Constructs measurements

Measurements were developed by adopting previously published items. Each item was measured by a 7-point Likert scale, with values ranging from 1 (strongly disagree) to 7 (strongly agree). The contents of the survey instrument were verified by 3 academic domain experts and 5 practicing developers. A pre-test involving part-time MBA students was conducted to validate the instrument. The measurement items are shown in Appendix A.

#### 4.2.1. Effective knowledge boundary spanning (EKBS)

EKBS was operationalized as the degree to which users and IS developers' interactions effectively accomplished syntactic knowledge transfer, semantic knowledge translation and pragmatic knowledge transformation. We developed 8 reflective items, based on conceptual and empirical studies by Carlile [11] and Tiwana and McLean [80], to measure this construct. We treated EKBS as a second-order construct that contains three first-order constructs (i.e., transfer, translation and transformation). Doing so was considered appropriate because the correlation coefficients among those three first-order constructs ranged from 0.62 to 0.8, and their loadings values ranged from 0.85 to 0.95.

#### 4.2.2. Human capital (mutual understanding)

Although human capital can broadly refer to organization members' knowledge, skills, attitude and intellectual agility [74,68], we focus on users' and IS developers' shared knowledge which is required for effective knowledge integration [30]. In this study, this construct was operationally defined as mutual understanding which referred to the capabilities that both users and developers should have in the ISD process to ensure the correctness of requirements elicitation and the success of the final outcome. Two capabilities were required: developers' business knowledge and users' ISD knowledge. The former related to developers' knowledge of the new application's business functions and the latter was users' overall knowledge of the ISD methods and processes. This construct was manipulated as a second order formative construct formed by developers' business knowledge and users' ISD knowledge. Principal component factor analysis was applied to calculate the loading of each indicator. The factor loadings were used as weights of the two indicators for generating the value of mutual understanding. A total of 10 items (4 for developers' business knowledge and 6 for users' ISD knowledge) adopted from Fink and Neumann [22], and Tesch et al. [78] were used to measure this construct.

#### 4.2.3. Relational capital (user–IS relationship)

Relational capital refers to the level of mutual trust, respect, reciprocity and closeness in the relationship between users and developers during the ISD project [80]. In this study, this construct was operationally defined as the user–IS relationship. A total of 5 items adapted from Tiwana and McLean [80] were used to measure relational capital.

#### 4.2.4. Structural capital (participative decision-making)

Structural capital refers to the organizational routines and structures which effectively enhance interactions between stakeholders [60]. In this study, this construct was operationally defined as participative decision-making, which refers to the sharing of decision-making authority between users and developers. A total of 3 items adapted from Patnayakuni et al. [61] were used to measure participative decision-making.

#### 4.2.5. System quality

System quality was operationally defined as the successfulness of the developed system in terms of its reliability, ease of maintenance, ease of modification, and its ability to meet users' requirements. A total of 7 items adapted from Patnayakuni et al. [61], and Wallace et al. [85] were used to measure product performance.

#### 4.2.6. Project quality

Project quality referred to the successfulness of the development process itself (i.e., the extent to which the project was delivered on schedule and within budget) [85]. The 5 items used in this study were adapted from Tesch et al. [78], and Wallace et al. [85].

## 5. Research findings

### 5.1. Reliability and validity

Reliability could be ensured through composite reliability (CR) and Cronbach's alpha. These two values should be greater than 0.7, which could be viewed as highly reliable. Convergent validity should be tested when multiple indicators are used to measure one construct, and it can be examined via item-total correlation (ITC), factor loading, and average variance extracted (AVE) [23]. To achieve the required convergent validity, ITC should not be less than 0.3, factor loading should be greater than 0.7, and AVE should be greater than 0.5. The results of reliability and validity are shown in Table 2.

To achieve adequate discriminant validity, the correlation coefficients among variables should be less than 0.90, and the square root of AVE should be greater than the inter-construct correlation coefficients [23]. Descriptive statistics and the correlation matrix are shown in Table 3.

#### 5.1.1. Common method variance

Since we collected both independent and dependent variables simultaneously from the same respondents, common method variance (CMV) could 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. With all indicators entered, 7 factors were extracted. The variance explained by the first factor was 37%. In addition, the impact of method variance was tested by creating one method variable (with all used indicators) and linking it to indicators of both independent and dependent variables [62,63]. Most paths from this method variable to indicators were found to be insignificant (80%) which suggests that common method bias should not be problematic in this study.

**Table 2**
The results of reliability and validity.

| Constructs | Items | Factors | |
|---|---|---|---|
| | | Loadings | ITC |
| **Effective knowledge boundary spanning** *CR = 0.938, Alpha = 0.925, AVE = 0.656* | 1 | 0.860 | 0.795 |
| | 2 | 0.811 | 0.692 |
| | 3 | 0.785 | 0.682 |
| | 4 | 0.840 | 0.758 |
| | 5 | 0.757 | 0.639 |
| | 6 | 0.795 | 0.663 |
| | 7 | 0.829 | 0.772 |
| | 8 | 0.797 | 0.733 |
| **Relational capital** *CR = 0.943, Alpha = 0.924, AVE = 0.769* | 1 | 0.793 | 0.597 |
| | 2 | 0.908 | 0.826 |
| | 3 | 0.927 | 0.857 |
| | 4 | 0.983 | 0.828 |
| | 5 | 0.846 | 0.775 |
| **Structural capital** *CR = 0.924, Alpha = 0.876, AVE = 0.803* | 1 | 0.831 | 0.562 |
| | 2 | 0.940 | 0.792 |
| | 3 | 0.914 | 0.704 |
| **Human capital: developers' business knowledge** *CR = 0.913, Alpha = 0.872, AVE = 0.723* | 1 | 0.870 | 0.669 |
| | 2 | 0.848 | 0.634 |
| | 3 | 0.899 | 0.726 |
| | 4 | 0.782 | 0.593 |
| **Human capital: users' ISD knowledge** *CR = 0.926, Alpha = 0.904, AVE = 0.676* | 1 | 0.788 | 0.649 |
| | 2 | 0.871 | 0.788 |
| | 3 | 0.814 | 0.697 |
| | 4 | 0.868 | 0.779 |
| | 5 | 0.823 | 0.717 |
| | 6 | 0.765 | 0.641 |
| **System quality** *CR = 0.955, Alpha = 0.946, AVE = 0.754* | 1 | 0.876 | 0.701 |
| | 2 | 0.847 | 0.708 |
| | 3 | 0.846 | 0.721 |
| | 4 | 0.898 | 0.780 |
| | 5 | 0.880 | 0.775 |
| | 6 | 0.814 | 0.625 |
| | 7 | 0.914 | 0.823 |
| **Project quality** *CR = 0.923, Alpha = 0.896, AVE = 0.708* | 1 | 0.876 | 0.663 |
| | 2 | 0.859 | 0.702 |
| | 3 | 0.882 | 0.707 |
| | 4 | 0.836 | 0.747 |
| | 5 | 0.746 | 0.631 |

### 5.2. Hypothesis tests

Hypotheses were tested via partial least squares (PLS) regression analyses using SmartPLS. All path coefficients and explained variances for the model are shown in Fig. 3.

Our analysis showed that the paths from effective knowledge boundary spanning to both system quality and project quality were significant ($\beta = 0.600$, $p < 0.01$; $\beta = 0.474$, $p < 0.01$), which supported H1 and H2. For the antecedents, human capital ($\beta = 0.254$, $p < 0.01$), relational capital ($\beta = 0.422$, $p < 0.01$), and

**Table 3**
Descriptive statistics and correlation matrix.

| Variables | Mean | Std. Dev. | M3 | M4 | Correlation matrix | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | EKBS | DBK | UIK | RC | SC | SQ | PQ |
| Effective knowledge boundary spanning (EKBS) | 5.290 | 0.813 | −0.387 | −0.350 | **0.845** | | | | | | |
| Human capital: developers' business knowledge (DBK) | 5.336 | 0.837 | −0.383 | −0.256 | 0.367 | **0.850** | | | | | |
| Human capital: users' ISD knowledge (UIK) | 4.461 | 1.060 | −0.206 | −0.064 | 0.420 | 0.264 | **0.822** | | | | |
| Relational capital (RC) | 5.208 | 0.936 | −0.418 | 0.213 | 0.520 | 0.182 | 0.410 | **0.877** | | | |
| Structural capital (SC) | 5.274 | 1.012 | −0.667 | −0.038 | 0.442 | 0.301 | 0.361 | 0.405 | **0.896** | | |
| System quality (SQ) | 5.239 | 0.817 | −0.404 | −0.311 | 0.564 | 0.438 | 0.398 | 0.497 | 0.440 | **0.868** | |
| Project quality (PQ) | 5.188 | 0.991 | −0.736 | 0.635 | 0.401 | 0.287 | 0.317 | 0.368 | 0.337 | 0.708 | **0.841** |

M3: skewness; M4: kurtosis.
The diagonal line of correlation matrix represents the square root of AVE.

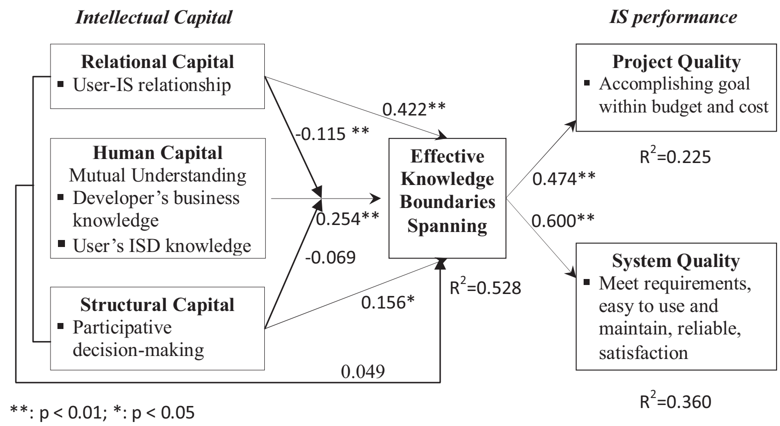


**Fig. 3.** Structural model and paths coefficient.

structural capital ($\beta = 0.156$, $p < 0.05$) had positive effects on effective knowledge boundary spanning. This result confirmed our expectation and provided support for H3, H4 and H5.

For the interaction effect between paired types of intellectual capital, we first created three interaction terms by using the product indicators approach suggested by Chin [13]. Among the three created interaction terms, only one was found to be significant. A negative coefficient ($\beta = -0.115$, $p < 0.05$) between HC*RC and EKBS was found. Therefore, H6, H7 and H8 were all not supported.

*5.2.1. Analysis of the mediating effect*

This study proposed that EKBS was an important mediator between intellectual capital and ISD performance. We followed procedures suggested by Baron and Kenny [4] to test the mediating effect of effective knowledge boundary spanning. The results, as shown in Table 4, indicated that EKBS transferred the impacts of three types of capital to system and project quality. Specifically, EKBS fully mediates the effects of structural and human capital types and partially mediates the effect of relational capital on system quality and project quality. In addition, after joining EKBS as a mediator, the explained variance of system quality and project quality significantly increased from $R^2 = 0.407$ and $R^2 = 0.269$ to $R^2 = 0.453$ and $R^2 = 0.290$. In sum, these results proved the argument of this study, indicating that EKBS was an important mediator between all types of capital (relational, human and structural) and both types of quality (system and project).

Furthermore, since there were three independent and two dependent variables, we conducted six Sobel tests to examine the mediating effect of EKBS. According to the results, the mediating effect for the structural capital and project quality link was significant only at the $p < 0.1$ level; the remaining five links were all significant at the $p < 0.05$ level. This evidence also endorsed our finding of the mediating effect of EKBS between intellectual capital and project outcomes.

**Table 4**
Analysis of mediating effect.

| Variables | System quality | | Project quality | |
|---|---|---|---|---|
| | Model 0 | Model 1 | Model 0 | Model 1 |
| Structural capital | 0.173* | 0.127 | 0.148* | 0.117 |
| Relational capital | 0.348** | 0.244** | 0.295** | 0.203* |
| Human capital | 0.228* | 0.144 | 0.199* | 0.142 |
| EKBS | – | 0.310** | – | 0.206* |
| $R^2$ | 0.407 | 0.453 | 0.269 | 0.290 |

* $p < 0.05$.
** $p < 0.01$.

## 6. Discussion

This study examines knowledge boundary spanning from an intellectual capital perspective, and it empirically tests the hypotheses in the context of IS development. In this light, we seek to reveal the antecedents of effective knowledge boundary spanning and the influence of effective knowledge boundary spanning on IS performance. Survey data collected from 267 IS practitioners were used to verify the developed concept. There are four noteworthy findings.

First, our findings show that effective knowledge boundary spanning can significantly influence system and project quality. User participation studies indicated that including users in the system development process may or may not generate the expected effect [36,42]. Our study provides a plausible explanation in that the inability to span the knowledge boundaries effectively between users and developers limits the effect generated from including users in the system development process. Similar to how the software development process can be improved when knowledge among IS developers can be successfully shared, formalized and integrated [61], project performance can surely be improved when users and developers can effectively cross the knowledge boundaries between them.

Second, the findings prove that knowledge boundaries can be effectively spanned when strong intellectual capital exists within the organization. Human capital and relational capital have proved to have significant influence over the degree to which knowledge boundary spanning is effective; structural capital has a marginal effect. These results can be supported by previous research which puts emphasis on the importance of interaction, mutual respect and trust, friendship and reciprocity between users and developers during the ISD process [80]. Among the three dimensions of intellectual capital, the comparison of the path coefficients provided an empirical basis by which to suggest that relational capital and human capital are more influential in facilitating EKBS in the ISD process, while structural capital has only marginal influence.

Third, the results reveal the mediating role of EKBS between intellectual capital and IS performance. Despite the fact that the three dimensions of intellectual capital directly influence system and project quality, our findings indicated the improvement of $R^2$ when using EKBS as a mediator. Specifically, EKBS partially mediates the effect of structural and relational capital types on system quality, and it fully mediates the effect of the same two

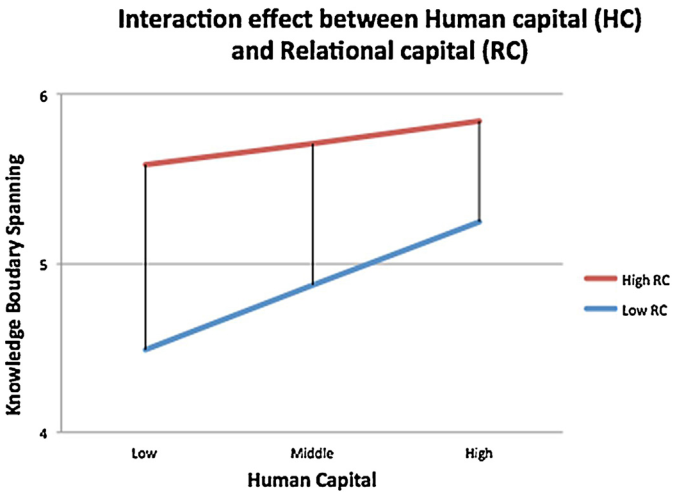


**Fig. 4.** The effect between HC*RC and EKBS.

capital types on project quality. This result extends previous arguments that highlight the effect of intellectual capital on performance [61,78,8] by showing that intellectual capital can influence the effectiveness of knowledge transfer, translation and transformation between users and IS developers before it promotes final IS performance.

Fourth, surprisingly, the interaction between human capital and relational capital is found to negatively impact the effectiveness of knowledge boundary spanning. This is in contrast to our expectation that a positive coefficient would be observed. The negative coefficient indicates that a better user–IS relationship may reduce the impact of human capital on EKBS. Fig. 4 illustrates the interaction between these two types of capital. First, when human capital is low, the level of relational capital is critical. Projects with sufficient relational capital can still achieve effective knowledge boundary spanning when human capital is low. However, the importance of relational capital decreases as the level of human capital increases. The difference between the effects of high and low levels of relational capital is limited when human capital is high. Second, based on the slope between human capital and EKBS, the importance of human capital to EKBS varies as the level of relational capital changes. Even though a significant main effect of human capital is found, the interaction effect diagram shows that human capital has a limited effect when relational capital is high. The importance of human capital is much higher when relational capital is low. Generally, this finding shows that the user–IS relationship helps to ameliorate the weakness created when users and IS developers lack sufficient mutual understanding, thus facilitating more effective knowledge boundary spanning. This may be because a better user–IS relationship allows users and IS developers to maintain intensive communications, coordination and interactions, smoothing the subsequent syntax transfer, semantics translation and pragmatic transformation between the users and IS developers.

However, different from our expectation, the empirical results show that the moderating effects of structural capital on both human capital-to-EKBS and relational capital-to-EKBS are not significant. Participative decision-making may not contribute to an increase in EKBS when there is a lack of mutual understanding or a poor relationship between users and IS developers. These findings potentially suggest the need for caution in order to avoid overemphasizing the value of user engagement which is touted by current literature. It also highlights that, in the countries with relationally based culture (e.g., Taiwan), people demonstrate more effective interactions with those whom they already know and those with whom they have closer friendships. The formal structural mechanism becomes less important, especially when there is sufficient human and relational capital to support interactions and communication between users and developers.

Based on the findings above, this study generates several implications for academia and practitioners. For academia, this study can contribute to both knowledge management and project management research. For knowledge management, this study identified and successfully demonstrated the impact of knowledge boundary spanning on performance in multi-discipline collaboration. Using ISD as an example, we confirmed the critical role that effective knowledge boundary spanning plays in IS development performance, including its effect on both system and project quality. Therefore, this study furthers knowledge management research regarding the management of the boundaries which arise because of tacit and sticky local knowledge across different areas of expertise. Future studies are encouraged to further explore the role of knowledge boundaries based on our findings. For example, novelty, specialization and dependence are excluded from our model in order to maintain parsimony. Exploring the relative importance of each boundary spanning activity under different contexts can enrich our understanding of this issue.

In addition, we proposed that intellectual capital can facilitate knowledge boundary spanning. Three antecedents (i.e., human capital, relational capital and structural capital) prove to be important for effective knowledge boundary spanning. Leveraging the three types of intellectual capital can effectively promote syntactic knowledge transfer, semantic knowledge translation, and pragmatic knowledge transformation. However, it is notable that we did not address the effects of intellectual capital on specific knowledge boundary spanning activities (i.e., knowledge transfer, translation and transformation). Neither did we include specific boundary spanning objects in our study. Future research can further explore these issues to discover possible objects for boundary spanning facilitation.

Furthermore, this study can enhances Carlile's [12] work on knowledge boundary in two ways. Firstly, we empirically test Carlile's framework with a large sample in an IS development context. Despite Carlile adopted a case study to describe and illustrate the concept of knowledge boundaries [11,12], his framework had not been examined with a large sample. Our empirical work provides the evidence to support the concept as well as highlight its importance. Secondly, although Carlile posed three knowledge boundary spanning capabilities [12], the factors that could facilitate effective knowledge boundary spanning remained unclear in his studies. This study extends this framework by suggesting that intellectual capital can be used as the means to promote effective knowledge boundary spanning.

For project management, this study introduces the perspective of the "knowledge boundary" to resolve the inconsistent results of previous user participation research. In this light, user participation in an ISD project can be a process of delivering tacit and sticky local knowledge between people in different disciplines. With this assertion, IS development can be a complex process that involves not only creating a common terminology base, but also building shared interpretations and negotiating to support the various interests of the participants who keep qualitatively distinct sets of goals and professional values. We therefore advanced user participation literature by showing the need to investigate this issue from the perspective of knowledge boundary spanning. A significant portion of user participation studies focuses on exploring the best timing for users to engage in the ISD process.

In contrast, this study highlights that it is critical to examine the effectiveness of transferring, translating and transforming knowledge when users are involved and participate in the ISD process. In addition to understanding which stakeholders should engage in the development process (and when), more attention should be paid to understanding ways for stakeholders to cross knowledge boundaries and co-produce a high quality product.

For practitioners, the results of this study emphasize the importance of knowledge boundary spanning for users and IS developers as they co-produce the final system. Because of the tacit and sticky nature of local knowledge, IS development is far more than sharing knowledge via user participation. Instead, it must be regarded as a knowledge reproduction process in which the users and IS developers effectively transfer lexicons, translate interpretations and transform different interests in the IS project, thus coproducing a better quality system and process. To maximize co-produced value, the boundaries that are caused by local knowledge cannot be ignored when users participate in the ISD process. Otherwise, the communications may not be on the same page even when there are intensive interactions between users and IS developers.

To overcome the problems caused by knowledge boundaries, project managers can increase the effectiveness of knowledge transfer, translation and transformation by leveraging the intellectual capital between users and IS developers. Among the three dimensions of intellectual capital, the relationship with users is particularly important, especially in a relationally based culture like Taiwan. Relational capital not only contributes directly to the enhancement of EKBS, but also minimizes the disadvantages caused by insufficient mutual understanding between users and IS developers.

## 7. Conclusion

The purpose of this study is to understand the importance of knowledge boundary spanning under multidisciplinary collaboration conditions. Taking ISD as an example, this study empirically tests how intellectual capital facilitates knowledge boundary spanning and subsequently influences IS performance. Our findings suggest that effective knowledge boundary spanning plays an important role in predicting system and project quality, and it also plays a mediating role between intellectual capital and IS performance. The three dimensions of intellectual capital (human, relational and structural) significantly impact the effectiveness of knowledge boundary spanning. Furthermore, the magnitude of the impact of human capital on knowledge boundary spanning is moderated by the relationship between users and developers. In general, greater levels of relational capital held by users and developers can minimize the negative impact of insufficient mutual understanding on effective knowledge boundary spanning.

However, our study is not without limitations. First, cross-sectional data were used to examine the proposed model. However, some may argue that effective knowledge boundary spanning may inversely affect intellectual capital. Further research is recommended to adopt a longitudinal approach to address this issue. Second, opinion from one side (developers) was used to understand the effectiveness of knowledge boundary spanning. However, since boundaries are located between users and developers, opinions from both sides may be needed to represent the level of effectiveness more precisely. Future research is encouraged to collect data from both sides to verify our result. Third, to maintain parsimony, we selected specific variables to represent each type of intellectual capital, based on the literature. However, each type of capital may be represented by other variables. Future research is encouraged to extend the current study by including other meaningful variables for each type of intellectual capital.

## Appendix A. Measurement

### Effective knowledge boundary spanning [80]

**Transfer: syntactic boundary**

KBS1 Developers and users use shared terminology to transfer their own knowledge to each other.

KBS2 Developers and users build shared lexicon and meaning toward each other's expertise/knowledge.

KBS3 Developers are able to accurate communicate and transfer what users say into system design.

**Translation: semantic boundary**

KBS4 Developers and users are capable of translation their expertise to bring new concepts into system.

KBS5 Users are able to describe requirements in the way that developers can interpret and understand it clearly.

KBS6 Developers used the way that users can understand and interpret correctly to help them to express their needs.

**Transformation: pragmatic boundary**

KBS7 Developers and users are proficient at combining and exchanging ideas to solve problems in ISD goal, scope and consequence.

KBS8 Developers and users did a good job of sharing their individual goals and interests of new system.

### Relational capital [80]

RC1 There is close, personal interaction among developers and users.

RC2 There is mutual respect between developers and users.

RC3 There is mutual trust between developers and users.

RC4 There is personal friendship between developers and users.

RC5 There is high reciprocity among developers and users.

### Human capital: developers' business knowledge [22]

BS1 The developers are knowledgeable about the key success factors that must go right if the company is to succeed.

BS2 The developers understand the company's policies and plans.

BS3 The developers are able to interpret business problems and develop appropriate technical solutions.

BS4 The developers are knowledgeable about business functions.

### Human capital: users' ISD knowledge [78]

UK1 Users are not familiar with IT.

UK2 Users have little experience.

UK3 Users are not familiar with this application.

UK4 Users are not familiar with IS development.

UK5 Users are not aware the importance of their role.

UK6 Users are not familiar with their role in project.

### Structural capital: participative decision-making [47]

PDM1 Users participated in decision making broadly in this development project.

PDM2 Decision making authority rests with both development developers and users.

PDM3 Joint-decision making by users and developers is the norm in our ISD.

**System quality** [61,85]

SQ1 The system developed is reliable.

SQ2 The system is easy to maintain.

SQ3 The users perceive that the system meets intended functional requirements.

SQ4 The system meets user expectations with respect to response time, flexibility and ease of use.

SQ5 The overall quality of the developed system is high.

SQ6 The system can easily be modified to meet changing user requirements.

SQ7 Users are satisfied with the overall quality of the systems.

**Project quality** [78,85]

PQ1 Ability to meet project goals.

PQ2 Expected amount of work completed.

PQ3 High quality of work completed.

PQ4 Adherence to schedule.

PQ5 Adherence to budget.

## References

[1] A.E. Akgün, J. Byrne, H. Keskin, G.S. Lynn, S.Z. Imamoglu, Knowledge networks in new product development projects: a transactive memory perspective, Information & Management 42, 2005, pp. 1105–1120.
[2] M. Alavi, D.E. Leidner, Research commentary: technology-mediated learning – a call for greater depth and breadth of research, Information Systems Research 12, 2001, pp. 1–10.
[3] D.G. Ancona, D.F. Caldwel, Demography and design predictors of new product team performance, Organization Science 3, 1992, pp. 321–341.
[4] R.M. Baron, D.A. Kenny, The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations, Journal of Personality and Social Psychology 51, 1986, pp. 1173–1182.
[5] N. Bevan, Quality in use: meeting user needs for quality, Journal of Systems & Software 49, 1999, pp. 89–96.
[6] B. Boehm, R. Turner, Using risk to balance agile and plan-driven methods, Computer 36, 2003, pp. 57–66.
[7] N. Bontis, Intellectual capital: an exploratory study that develops measures and models, Management Decision 36, 1998, pp. 63–76.
[8] N. Bontis, Managing organizational knowledge by diagnosing intellectual capital: framing and advancing the state of the field, International Journal of Technology Management 18, 1999, p. 5.
[9] P. Bourdieu, The Logic of Practice, Stanford University Press, Stanford, CA, 1980.
[10] J.S. Brown, P. Duguid, Knowledge and organization: a social practice perspective, Organization Science 12, 2001, pp. 198–213.
[11] P.R. Carlile, A pragmatic view of knowledge and boundaries: boundary objects in new product development, Organization Science 13, 2002, pp. 442–455.
[12] P.R. Carlile, Transferring, translating, and transforming: an integrative framework for managing knowledge across boundaries, Organization Science 15, 2004, pp. 555–568.
[13] W.W. Chin, B.L. Marcolin, P.R. Newsted, A partial least squares latent variable modeling approach for measuring interaction effects: results from a Monte Carlo simulation study and electronic mail emotion/adoption study, Information Systems Research 14, 2002, pp. 189–217.
[14] W.M. Cohen, L.D.A. Absorptive Capacity, A new perspective on learning and innovation, Administrative Science Quarterly 35, 1990, pp. 128–152.
[15] B. Curtis, H. Krasner, N. Iscoe, A field study of the software design process for large systems, Communications of the ACM 31, 1988, pp. 1268–1287.
[16] T. Davenport, L. Prusak, Working Knowledge, Harvard Business School Press, Boston, MA, 1998.
[17] E.J. Davidson, Technology frames and framing: a socio-cognitive investigation of requirements determination, MIS Quarterly 26, 2002, pp. 329–358.
[18] L. Edvinsson, P. Sullivan, Developing a model for managing intellectual capital, European Management Journal 14, 1996, pp. 356–364.
[19] S. Faraj, L. Sproull, Coordinating expertise in software development teams, Management Science 46, 2000, pp. 1554–1568.
[20] Y. Feng, H. Ye, S.L. Pan, Delivering knowledge across boundaries: a process model of knowledge delivery in offshoring projects, 14th Pacific Asia Conference on Information Systems (PACIS 2010), Taipei, Taiwan, 2010.
[21] E. Ferlie, L. Fitzgerald, M. Wood, C. Hawkins, The nonspread of innovations: the mediating role of professionals, Academy of Management Journal 48, 2005, pp. 117–134.
[22] L. Fink, S. Neumann, Exploring the perceived business value of the flexibility enabled by information technology infrastructure, Information & Management 46, 2009, pp. 90–99.
[23] C. Fornell, D. Larcker, Structural equation models with unobservable variables and measurement error: algebra and statistics, Journal of Marketing Research 18, 1981, pp. 382–388.
[24] A.G. Frank, J.L.D. Ribeiro, An integrative model for knowledge transfer between new product development project teams, Knowledge Management Research & Practice 2012, pp. 1–11.
[25] J.-R. Fu, Attitude of Knowledge Sharing of Developers in the Organization – Multi-level Analysis Model Approach, Department of Information Management, National Central University, Taoyuan, Taiwan, 2005.
[26] J. Galbraith, Designing Complex Organizations, Addison-Wesley, Reading, MA, 1973
[27] A.N. Garman, D.C. Leach, N. Spector, Worldviews in collision: conflict and collaboration across professional lines, Journal of Organizational Behavior 27, 2006, pp. 829–849.
[28] A. Gemino, B. Reich, C. Sauer, A temporal model of information technology project performance, Journal of Management Information Systems 24, 2007, pp. 9–44.
[29] J. Gittell, Supervisory span, relational coordination and flight departure performance: a reassessment of post bureaucracy theory, Organization Science 12, 2001, pp. 468–483.
[30] R.M. Grant, Toward a knowledge-based theory of the firm, Strategic Management Journal 17, 1996, pp. 109–122.
[31] P.J. Guinan, J.G. Cooprider, S. Faraj, Enabling software development team performance during requirements definition: a behavioral versus technical approach, Information Systems Research 9, 1998, pp. 101–125.
[32] A. Gupta, V. Govindarajan, Knowledge flows within multinational corporations, Strategic Management Journal 21, 2000, pp. 473–496.
[33] J.F.J. Hair, W.C. Black, B.J. Babin, R.E. Anderson, Multivariate Data Analysis, 7th ed., Prentice-Hall, Upper Saddle River, 2009.
[34] A. Hargadon, R. Sutton, Technology brokering and innovation in a product development firm, Administrative Science Quarterly 42, 1997, pp. 716–749.
[35] C. Haythornthwaite, Learning and knowledge networks in interdisciplinary collaborations, Journal of the American Society for Information Science & Technology 57, 2006, pp. 1079–1092.
[36] J. He, W. King, The role of user participation in information systems development: implications from a meta-analysis, Journal of Management Information Systems 25, 2008, pp. 301–331.
[37] A. Hickey, A. Davis, A unified model of requirements elicitation, Journal of Management Information Systems 20, 2004, pp. 65–84.
[38] H. Hofmann, F. Lehner, Requirements engineering as a success factor in software projects, IEEE Software 18, 2001, pp. 58–66.
[39] J.S.-C. Hsu, C.-L. Chan, J.Y.-C. Liu, H.-G. Chen, The impacts of user review on software responsiveness: moderating requirements uncertainty, Information & Management 45, 2008, pp. 203–210.
[40] T. Humphreys, L. Leung, A. Weakley, Embedding expert users in the interaction design process: a case study, Design Studies 29, 2008, pp. 603–622.
[41] C. Iacovou, I. Wording, Selective status reporting in information systems projects: a dyadic-level investigation, MIS Quarterly 33, 2009, pp. 785–810.
[42] B. Ives, M. Olson, User involvement and MIS success: a review of research, Management Science 30, 1984, pp. 586–603.
[43] J. Lave, E. Wenger, Situated Learning, Cambridge University Press, Cambridge, UK, 1991.
[44] P. Lawrence, J. Lorsch, Organizations and Environments: Managing Differentiation and Integration, Harvard Business School Press, Cambridge, MA, 1967.
[45] J. Lay, A. Mol, Complexities Social Studies of Knowledge Practices, Duke University Press, Durham, NC, 2002.
[46] D. Leonard-Barton, Well Springs of Knowledge: Building and Sustaining the Sources of Innovation, Harvard Business School Press, Boston, MA, 1995.
[47] W.T. Lin, B. Shao, The relationship between user participation and system success: a simultaneous contingency approach, Information & Management 37, 2000, pp. 283–295.
[48] K. Lyytinen, R. Hirschheim, Information systems failures – a survey and classification of the empirical literature, Oxford University Press, New York, NY, 1988.
[49] A. Majchrzak, R. Carman, V. Lott, A. Malhotra, Radical innovation without collocation: a case study at Boeing-Rocketdyne, MIS Quarterly 25, 2001, pp. 229–249.
[50] T. Malone, K. Crowston, The interdisciplinary study of coordination, ACM Computing Surveys 26, 1994, pp. 87–119.
[51] R. McDermott, C. O'Dell, Overcoming cultural barriers to sharing knowledge, Journal of Knowledge Management 5, 2001, pp. 76–85.
[52] R. Mitchell, S. Nicholas, Knowledge creation in groups: the value of cognitive diversity, transactive memory and open-mindedness norms, Electronic Journal of Knowledge Management 4, 2006, pp. 67–74.
[53] S. Mohammed, B. Dumville, Team mental models in a team knowledge framework: expanding theory and measurement across disciplinary boundaries, Journal of Organizational Behavior 22, 2001, pp. 89–106.
[54] M. Newman, D. Robey, A social process model of user–analyst relationships, MIS Quarterly 16, 1992, pp. 249–266.
[55] S. Nidumolu, The effect of coordination and uncertainty on software project performance: residual performance risk as an intervening variable, Information Systems Research 6, 1995, pp. 191–219.
[56] S.R. Nidumolu, Standardization, requirements uncertainty and software project performance, Information & Management 31, 1996, pp. 135–150.

[57] I. Nonaka, A dynamic theory of organizational knowledge creation, Organization Science 5, 1994, pp. 14–37.
[58] I. Nonaka, I. Takeuchi, The Knowledge-Creating Organization, Oxford Press, Oxford, UK, 1995.
[59] E. Oborn, S. Dawson, Learning across communities of practice: an examination of multidisciplinary work British, Journal of Management 21, 2010, pp. 843–858.
[60] G. Okhuysen, K. Eisenhardt, Integrating knowledge in groups: how formal interventions enable flexibility, Organization Science 13, 2002, pp. 370–386.
[61] R. Patnayakuni, A. Rai, A. Tiwana, Systems development process improvement: a knowledge integration perspective, IEEE Transactions on Engineering Management 54, 2007, pp. 286–300.
[62] P. Pavlou, D. Gefen, Psychological contract violation in online marketplaces: antecedents, consequences, and moderating role, Information Systems Research 16, 2005, pp. 372–399.
[63] P.M. Podsakoff, S.B. MacKenzie, L. Jeong-Yeon, N.P. Podsakoff, Common method biases in behavioral research: a critical review of the literature and recommended remedies, Journal of Applied Psychology 88, 2003, pp. 879–903.
[64] J.D. Procaccino, J.M. Verner, Software developers' views of end-users and project success, Communications of the ACM 52, 2009, pp. 113–116.
[65] R. Purvis, V. Sambamurthy, An examination of designer and user perceptions of JAD and the traditional IS design methodology, Information & Management 32, 1997, pp. 123–135.
[66] L.J. Robert, A. Dennis, M. Ahuja, Social capital and knowledge integration in digitally enabled teams, Information Systems Research 19, 2008, pp. 314–334.
[67] P. Robillard, The role of knowledge in software development, Communications of the ACM 42, 1999, pp. 87–92.
[68] J. Roos, L. Edvinsson, G. Roos, Intellectual Capital Navigating in The New Business Landscape, New York University Press, New York, NY, 1998.
[69] A.P. Sage, W.B. Rouse, Handbook of Systems Engineering and Management, John Wiley & Sons, Hoboken, New Jersey, 2009.
[70] R. Schmidt, K. Lyytinen, M. Keil, P. Cule, Identifying software project risks: an international Delphi study, Journal of Management Information Systems 17, 2001, pp. 5–36.
[71] C. Shannon, W. Weaver, The Mathematical Theory of Communications, University of Illinois Press, Urbana, IL, 1949.
[72] H. Sharp, Y. Rogers, J. Preece, Interaction Design Beyond Human–Computer Interaction, John Wiley and Sons, Inc., Taipei, Taiwan, 2006.
[73] J.C.-W. Shih, Conflict, Communication, and Performance in IS Developing Team, Department of Information Management, National Central University, 2008 .
[74] T.A. Stewart, Intellectual Capital: The New Wealth of Organizations, Doubleday, 1997.
[75] E. Swanson, Management information systems: appreciation and involvement, Management Science 21, 1974, pp. 178–188.
[76] R. Swanson, TADD short! Human Resource Development Quarterly 8, 1997, pp. 193–196.
[77] G. Szulanski, Exploring internal stickiness: impediments to the transfer of best practice within the firm, Strategic Management Journal 17, 1996, pp. 27–43.
[78] D. Tesch, M.G. Sobol, G. Klein, J.J. Jiang, User and developer common knowledge: effect on the success of information system development projects, International Journal of Project Management 27, 2009, pp. 657–664.
[79] A. Tiwana, M. Keil, Functionality risk in information systems development: an empirical investigation, IEEE Transactions on Engineering Management 53, 2006, pp. 412–425.
[80] A. Tiwana, E.R. McLean, Expertise integration and creativity in information systems development, Journal of Management Information Systems 22, 2005, pp. 13–43.
[81] B. van den Hooff, M. de Winter, Us and them a social capital perspective on the relationship between the business and IT departments, European Journal of Information Systems 20, 2011, pp. 255–266.
[82] B. van den Hooff, M. Huysman, Managing knowledge sharing: emergent and engineering approaches, Information & Management 46, 2009, pp. 1–8.
[83] E. von Hippel, The impact of sticky data on innovation and problem solving, Management Science 40, 1994, pp. 429–439.
[84] L. Wallace, M. Keil, A. Rai, Understanding software project risk: a cluster analysis, Information & Management 42, 2004, pp. 115–125.
[85] L. Wallace, M. Keil, A. Rai, How software project risk affects project performance: an investigation of the dimensions of risk and an exploratory model, Decision Sciences 35, 2004, pp. 289–321.
[86] E. Wang, S. Shih, J. Jiang, G. Klein, The relative influence of management control and user–IS personnel interaction on project performance, Information and Software Technology 48, 2006, pp. 214–220.
[87] M.M.L. Wasko, S. Faraj, Why should I share? Examining social capital and knowledge contribution in electronic networks of practice MIS Quarterly 29, 2005, pp. 35–57.
[88] M.M. Wasko, S. Faraj, Why should I share? Examining social capital and knowledge contribution in electronic networks of practice MIS Quarterly 29, 2005, pp. 35–57.


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