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The impact of team knowledge on problem solving competence in information systems development team

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Abstract

Information systems development (ISD) work entails a series of problem solving activities and, therefore, knowing how to enhance problem solving competence is critical for project success. Since ISD is a knowledge intensive task, problem solving competence is largely determined whether the members can effectively utilize knowledge resources located within the team. Based on the transactive memory concept and following traditional wisdom, we hypothesized that knowing the location of knowledge allow better problem-solving competency. We also attempted to extend past studies by showing that problem-solving competency is also a function of knowledge complement and deployment. The study results, based on data collected from 215 team project managers, confirmed our hypotheses that having complement knowledge, allocating knowledge in right position, and knowing the allocation of resources are critical for problem-solving competency. In addition, the critical role of problem solving competence in project performance is reaffirmed.

Keywords: Problem solving competence; Resource-based view; Knowledge complement; Knowledge location; Knowledge deployment

1. Introduction

The highly uncertain nature of the ISD project makes it a series of problem solving processes (Cerveny et al., 1990; Jun et al., 2011; Narayanaswamy et al., 2013; Tiwana and Keil, 2009). Each project contains unique problems needed to be solved. To effectively counter challenges, team members must be able to identify sources of problems, generate and validate alternatives, implement selected solutions, and evaluate the implemented results. Such a problem solving competence, how well teams can perform the above activities during the ISD process, is highly correlated with project performance, the extent that teams can reach predefined goals within budget and on schedule (Aladwani, 2002; Liu et al., 2010). Therefore, understanding how ISD can foster their problem solving competence is a critical issue.

An ISD project is a knowledge-intensive task, which demands widely varied knowledge, including technical knowledge and application domain knowledge (Kirsch et al., 2010; Narayanaswamy et al., 2013; Rus and Lindvall, 2002). Prior research has demonstrated that a lack of knowledge resources leads to project failure (Gemino et al., 2007; Reich et al., 2014). Since ISD is a knowledge intensive task, there is a need to understand the role of problem solving competence within the ISD team from a knowledge perspective. Theorists have concluded that the availability of knowledge is critical for fostering problem solving competence (Hagemann et al., 2008; Karacapilidis et al., 2006; Park et al., 2011). Problem solving competence can be cultivated when specific types of domain knowledge are available.

However, previously largely focus on the needed domain knowledge (e.g., Atuahene-Gima and Wei, 2011). It is noticeable that problems may not always be resolved by merely collecting required domain knowledge resources. In addition to bringing

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their domain knowledge to the task level, team members also need to blend and coordinate available knowledge resources to counter the problems they face to improve the final outcome (Faraj and Sproull, 2000; Tiwana and McLean, 2005). This implies that different forms of knowledge resource are needed to foster required capability to solve problems. For example, members may also need to know who possess what knowledge and how to map available domain knowledge with tasks in hand. However, the role of other types of knowledge resources on fostering problem solving competency hasn't been investigated systemically. Therefore, the question this study attempts to answer is *what types knowledge resource are needed to foster problem solving competency in an ISD context*.

We adopt resource-based view (RBV) to address this issue. Based on RBV, performance is a function of competence which positively associates with the availability and characteristics of resources as well as the ability in leveraging those resources (Karimi et al., 2007; Teece et al., 1997). We further classified resources into experiential (knowledge complement), relational (knowledge location), and structure (knowledge deployment) three types based on the framework proposed by Gardner et al. (2011). Knowledge complement represents needed knowledge for tasks execution is available, knowledge location refers to the knowing of who knows what within the team, and knowledge deployment represents an effective matching knowledge with task.

The rest of this paper is organized as follows. The next section describes literature reviews and the theoretical framework employed that led to the model development of this study. In the following section, the methodology used to verify our theoretical framework and a data analysis of the study are presented. The final section presents the results and discussion, describes their implications for both academic and practical fields, and identifies the limitations of the study.

2. Theoretical background and hypotheses development

In this section, aligning with our research purpose, we first argue the importance of problem solving in information system development (ISD) project and build according hypothesis (Liu et al., 2010). In the following, based on resource-based view and the concept that ISD is a knowledge intensive process in which knowledge is almost the most important resource, we then construct the critical roles of different types of knowledge on forming problem solving competence.

2.1. Problem-solving competence and project performance

Achieving successful outcomes is the ultimate goal of organizational activities' operations; therefore, evaluating organizational outcomes is an important task in the management field. Such a perspective also emerges in the MIS discipline. ISD teams aim at accomplishing predefined goals within budget and at cost (Henderson and Lee, 1992). Studies based on different perspectives have been conducted to explore possible determinants of project performance. Among them, some studies adopted a problem solving perspective and view ISD as problem solving processes (Aladwani, 2002; Cerveny et al., 1990; Khatri et al., 2006). This perspective indicates that team performance is determined by whether a team can counter the problems it faces in an efficient and effective manner. Some studies show how the problem-solving process takes place in the ISD project. For example, Cerveny et al. (1990) and Kozar (1988) discussed the fundamental issues of problem solving by illustrating how different strategies are manifested in software development approaches to ISD, and recommended the application of the problem-solving model to systems development. Aladwani (2002) proposed that certain IS project design attributes (such as the use of support technology, team size, clear goals, knowledge of staff, and management advocacy) are necessary inputs for accomplishing favorable process outcomes (such as problem-solving competency), which in turn represent necessary conditions to secure the ultimately desired tasks, and psychological and organizational outcomes.

A "competence" is defined as a specialized system of abilities, cognitive skills and behavior used to complete tasks (Li et al., 2011). Furthermore, competence can be divided into two categories by different level: individual competence and team competence. Individual competence is viewed as the critical factor on job effectiveness that can help project team success. But team competence can't be viewed as the sum of individual competence because every team member should collaborate to share information, goals and decisions in project team (Kauffeld, 2006). The problem solving competence is one of the team competencies that help project team achieve goal. In the other word, ISD is viewed as the problem-solving process that every members should share information and collaborate to achieve the project goals.

A "problem" is defined as a gap between an existing state and a desired state (MacCrimmon and Taylor, 1976; Newell and Simon, 1972). Problem solving is defined as work processes for reducing the gap between the existing state and the desired state (Cerveny et al., 1990). This gap in an IS project may result from certain barriers that are related to the staff, the user, the internal organization, the external environment, the task, or technology. For example, Wallace et al. (2004) identified six category risks that might lead to a gap, which then undermines team performance directly or indirectly through reducing the quality of the developing process. One of the challenging issues for the ISD team is to completely understand and overcome problems so that a successfully functioning system can be implemented (Hickey and Davis, 2004). Therefore, it is critical to form a team which can counter risks and solve problems that emerge during the ISD process.

Since risks emerging during the development process create barriers and hydrants for project success, problem solving skills are essential for ISD team members (Whitten et al., 2000). Problem solving includes identifying problems, defining problems, generating alternative solutions, reviewing alternatives and evaluating options. For example, when progress falls behind expectations, the team has to be aware of it before it can diagnose the problem. Once the problem is identified, the team must then define how serious the problem is and the potential causes. With the understanding of potential causes, solutions can then be generated. After reviewing all possible alternatives, the best solution is then selected and implemented to counter problems.

Problem solving is an antecedent of IS project performance (Li et al., 2011). A project team that has a higher problem-solving skill level or competency can make a concerted effort with its available resources and employ an effective way to facilitate a favorable outcome. These beneficial outcomes include faster project completion, decreasing costs, and more efficient task operations. Furthermore, by solving a problem more effectively and efficiently, the clients of a project can be better served. By viewing system development as a problem solving process, Aladwani (2002) built a model to explore how different strategies can be adopted to enhance system success and team performance. The results indicate that project solving competency is highly correlated with task outcomes, psychological outcomes, and organizational outcomes. Therefore, we hypothesize that

H1. Project performance is positively associated with team problem solving competency

2.2. Antecedents of problem solving competence: a resource-based view

According to RBV perspective, resources are generally rare, inimitable, and nonsubstitutable assets which can enhance international operation by providing effectiveness and efficiency. The positive and direct relationship between *resources* and *outcome* is well recognized. Recently, an emerging explanation of the above relationship is that *resource* is one critical antecedent of *capability* which is essential for obtaining better *outcome*. For example, IS capabilities are critical for some core competencies, such as market-access, integrity-related, and functionality-related competence (Ravichandran and Lertwongsatien, 2005). Business competitive advantage are affected by the IS flexibility fostered by having business, technology and behavioral knowledge resources (Fink and Neumann, 2009). ERP literatures also illustrated that IS resources (including knowledge, relationship, and infrastructure resources) can enhance ERP capabilities which in turn lead to better process outcomes (Karimi et al., 2007). Furthermore, Tanriverdi (2006) indicated that corporate performance is a function of cross-unit IT synergies (capability) of a complementary set of IT resources and management processes.

Although the RBV perspective originated with firm level studies and, following this, some researchers extended it to lower levels. For example, Pavlou and El Sawy (2006) adopted the RBV perspective and clarified the role of the composition of IT capability in new product development level. Specifically, they indicated that the acquisition, deployment, and leveraging of resources collectively can make up the overall capability. In addition, Gardner et al. (2011)recently also argued that this theory is appropriate for team level study because teams or departments are responsible for executing activities and capabilities are needed for effective activities execution while resources are the basis of forming capabilities. Specifically, Gardner et al. (2011) demonstrated that experiential, relational, and structural resources are critical for knowledge management capabilities, which is a critical determinant of performance. Gardner et al. (2011) also demonstrates that resources for developing capability or competence can be classified into three types. *Experiential resources* refer to knowledge required to perform task; *relational resources* represent shared understanding among members; and *structural resources* indicate how resources are allocated within the team (centralized or distributed). They also empirically demonstrated that a team's knowledge integration capability is associated with the availability of these resources.

In this study, we follow this research stream and study how the team knowledge structure (resources) can lead to team performance (outcome) through enhancing problem solving competency (capability). By viewing knowledge as critical resource in ISD team, we attempt to understand team's problem solving capability is determined by the available of different resources. Knowledge complementary can be viewed as experiential resource given that it describes whether needed knowledge for task is available within the team. Knowledge deployment is considered as structural resource because it describes how needed knowledge is allocated within the team. Lastly, knowledge location is one relational resource since it is considered as a shared cognition within a team. We therefore argue that team can better solve problems in hand when (1) team has needed and complementary knowledge, (2) knowledge is well deployed based on task assignment, and (3) the individuals within the team have shared understanding toward location of knowledge. The followings present the arguments for the effects of the above three components, on problem solving competency.

2.2.1. Knowledge complement

Since teams are formed by individuals, team level problem solving competency is positively related to individual experience. Aladwani (2002) found staff knowledge has a positive impact on problem-solving capacity in an ISD project. In addition to individual capability and the relational capital of the team, knowledge resource allocation, such as knowledge heterogeneity or diversity, has received significant attention in the past (Carpenter, 2002; Hoffman and Maier, 1961; Jehn and Bezrukova, 2004; Pelled et al., 1999; Pitcher and Smith, 2001; Tiwana and McLean, 2005). For example, Hoffman and Maier (1961) proposed that knowledge diversity is an important determinant of teams' performance through providing a breadth of perspectives, skills, and knowledge.

However, some studies revealed that knowledge diversity has not always been associated with performance (Carpenter, 2002; Jehn and Bezrukova, 2004; Pelled et al., 1999; Pitcher and Smith, 2001). Researchers concluded that diversity increases conflict, which results in obstructed processes and decreased effectiveness, reduces information sharing, and slows down competitive responses (Ancona and Caldwell, 1992; Hambrick et al., 1996; Pelled et al., 1999). Faraj and Sproull (2000) indicated that knowledge should be viewed as one important resource for an ISD team and how effective it can be managed is critical for team performance. They adopted an interdependent perspective and argued that heterogeneous knowledge can generate expected effects when it functions in a coordinated manner. This implies that simply employing diversity or heterogeneity concept and examining its impact on performance may not be sound.

Unlike past studies which focus on heterogeneity only, we adopt a RBV perspective and take resource complement concepts into consideration in this study. A knowledge complement is similar to but more than knowledge heterogeneity, being defined as the diversity in the knowledge possessed by the members of a project team (Tiwana and McLean, 2005). Complementary can be viewed as an aggregation of various heterogeneous resources and competence which members require of each other while performing tasks. That is, knowledge heterogeneity is a necessary condition for a complement and a knowledge complement is impossible when all team members possess identical knowledge. Some research indicated that organizations rely on mobilizing more diverse sets of unevenly distributed knowledge resources in these years (Pangil and Chan, 2014). A complement represents an enhancement of resource values and arises when a resource produces greater returns in the presence of another resource than it does alone (Clemons and Row, 1991; Koch, 2011; Zhu and Kraemer, 2003). Thus, in this study, we define a knowledge complement as the enhancing presence of the heterogeneous capability, experience, knowledge, and skill possessed by various experts in a complementary manner such that greater returns can be obtained.

The concept of the complement originates from the resource-based view (RBV) proposed by Wernerfelt (1984). Theorists suggested that firms should focus on their core competence and make alliances with other firms with complementary assets in order to increase their competitive advantage (Badaracco, 1991; Prahalad and Hamel, 2003). Studies of new product development contexts reveal the importance of having complementary resources at the same time. The product innovation process includes a complex interaction of complementary physical, human, and intangible resources, such as resources and capabilities developed with stakeholders (Grant, 1991). Moorman and Slotegraaf (1999) concluded that product development outcomes can be enhanced when firms possess both marketing and technical capability. Taylor and Lowe (1997) also reached the same conclusion, i.e., that assets may not have value when standing alone. A firm can advance their knowledge based on the complementary assets they possess.

In this study, we adopt this concept and propose that the knowledge complement can enhance problem-solving competency in the ISD context. To complete an ISD project requires knowledge in multiple technical and functional domains (Curtis et al., 1988; Walz et al., 1993). The final system cannot be accomplished or the developed system fit business requirements if either type is, or both are, absent. Again let's take the distributed database problem as an example. Database and network administrators possess the complementary knowledge needed for the target problem. Database knowledge is required to understand the structure of each database in each of the different locations and how to optimize the storage design. Meanwhile network knowledge cannot be absent in understanding the network structure and avoiding potential dram traffic problems. A lack of either one of the above not only reduces the capability of understanding the causes of a problem but also increases the difficulty of generating a high quality solution.

Moreover, when the team's members have similar backgrounds and experiences, they may be unable to generate a comprehensive understanding of the problems at hand because only one perspective is adopted. In contrast, the construction of teams with varied and complementary backgrounds and experiences not only guarantees diverse viewpoints but also bring different sets of skills, perspectives, and knowledge to the project (Singh and Gupta, 2014). In sum, with heterogeneous and complementary knowledge within the team, the team can develop a more comprehensive view of the problem, generate a wealth of potential solutions, and implement selected solutions.

H2. Problem solving competency is positively associated with knowledge complement within the team

2.2.2. Knowledge deployment

Knowledge deployment is defined as the assignment of tasks according to members' specialized ability to deploy them in an appropriate position. Such a construct of knowledge deployment is also based on the RBV. Many scholars applied the RBV to understand how the deploying of valuable resource, such as coordinated tasks, can effectively enhance the end result (Henderson and Cockburn, 1994; Miller and Shamsie, 1996; Schroeder et al., 2002). For example, a superior deployment of capabilities helps an organization achieve a competitive advantage (Christensen and Overdorf, 2000; Day, 1994).

An IS project team includes individuals from various areas of knowledge, such as project leaders, analysts, programmers, database administrators, etc. Each possesses knowledge in different technologies, a different skill set, and different knowledge. For instance, team leaders need capabilities in management, planning, and coordination; programmers need the skill of coding programs. In addition, the technology demands of IS development are changing fast. In practice, the task properties of no ISD project can be homogeneous; hence appropriate experts being strategically matched to positions where their skill sets can be most effectively used is a critical factor for improving related process effectiveness. That is, effective teamwork is a function of identifying the roles most appropriate for completing a task, assigning the right people to those roles, and enabling people who can develop their capabilities to solve problems and share their knowledge with everyone.

Team level studies also indicate that task outcomes tend to be more successful when tasks are assigned to members on the basis of their relative knowledge (Brandon and Hollingshead, 2004; Christensen and Overdorf, 2000; Day, 1994; Hollingshead, 1998; Littlepage et al., 1997; Stasser et al., 1995). Effective teamwork is based on correctly identifying the right roles and responsibilities and assigning the most knowledgeable person to each role (Liang et al., 1995; Reagans et al., 2005). Each team member serves as a gate keeper between external knowledge and internal practices. A team has to count on members' ability to apply external knowledge to internal use. When responsibility and knowledge don't match, it is difficult for the gate keeper to search for useful information in a timely manner. When knowledge and roles match closely, the filtering of external knowledge can be done more effectively and efficiently. Moreover, psychologically, people are more willing to share their knowledge and knowledge with everyone when tasks are assigned to them on the basis of their relative knowledge (Brandon and Hollingshead, 2004). Therefore, we proposed the following hypotheses.

H3. Problem solving competency is positively associated with knowledge deployment within the team

2.2.3. Knowledge location

In addition to securing complementary knowledge and assigning tasks based on individual skills, we also suggest a knowledge map be created by and for the ISD teams. Knowledge resources are a critical driver for performance and a lack of knowledge resources lead to project failure (Gemino et al., 2007; Melville et al., 2004). Their importance was first articulated by Attewell (1992), who argued that overcoming knowledge barriers is the key point to successfully implementing complex systems. Knowledge resources in an organization can be classified as explicit or tacit. Explicit knowledge is embedded in organizational processes, routines, rules, and product and process technologies. Tacit knowledge resides in the minds of human resources (Becerra-Fernandez et al., 2004; Bharadwaj, 2000; Ross et al., 1998). Since both types of knowledge are possessed by individuals or stored in an organization, certain processes are required before they can be applied to specific problems. Whether those existing knowledge resources can be transformed into usable ones is contingent on how well team members are aware of the location of their knowledge (Griffith et al., 2003).

Knowledge location refers to the extent to which members of one team are able to identify what expert possesses which knowledge and know where to find their required sources of knowledge (Faraj and Sproull, 2000). This concept originates from the transactive memory system (TMS) stream. TMSs were conceptualized by Wegner (1987) to explain how members in close relationships organize and remember information important for cooperative tasks. A TMS emerges as a collective understanding of member-knowledge associations and has been developed as a cooperative organization functioning as a collective knowledge resource providing information required for its members to complete a joint task (Hollingshead, 1998; Wegner, 1987, 1995). Wegner (1995) proposed that a TMS include two parts: the stores of individual member knowledge and an indexing system that tells members who has what knowledge. Such a construct has been applied in some team studies to predict team performance in a laboratory experiment context (Hinsz et al., 1997; Liang et al., 1995; Stasser et al., 1995). Faraj and Sproull (2000) also found that knowledge location can enhance knowledge coordination in software development teams.

Regulations for describing tasks, assignments, roles, knowledge location, and areas of knowledge must be established so that ISD team members can maximize these resources and their project success. The resources for knowledge location include specialized documents, corporate Q & A files, and just knowing who has what knowledge/skill (Faraj and Sproull, 2000).

In an organization, the understanding of knowledge location serves as a knowledge resource, fulfilling the important functions of identification. Knowledge location facilitates efficient sourcing of required knowledge (Driessen et al., 2007; Faraj and Sproull, 2000). Thus, teams with a mechanism for knowledge location have a direct line to sourcing specializations, resources, and any information they may require (Stasser et al., 1995). So we deem that if an ISD team creates a good mechanism for knowing who has what knowledge/skill and where, it will enhance the effectiveness of problem-solving competency. Based on the above statements, we propose the following hypothesis.

H4. Problem solving competency is positively associated with knowledge location.

The research model of this study is listed in Fig. 1. As shown in the model, characteristics of knowledge within ISD team structure are expected to affect problem solving competency, which are important antecedents of project success. In addition, we include two control variables. *Project duration* refers to the time a project has existed and is critical for project performance. Boer and Berends (2003) and Fiske (1991) suggested that knowledge sharing are affected by time. As group members have more time to relate to one another, they will engage in more communication, interaction or mutual understanding, and form friendships and shared visions. Some studies have also indicated that group longevity may diminish any tendency for diversity to trigger task conflict (Katz, 1982; Pelled et al., 1999). *Team size* is defined as the number of fulltime members of the team participating in the team efforts (Smith et al., 1994). Team size represents in essence a team's structural and compositional context and should be critical for performance. For example, Stasser (1992) proposes that as a team increases in size, it becomes easier for individuals to hide in the crowd, thus it may cause individual members to escape making contributions. Kidwell and Bennett (1993) also suggest

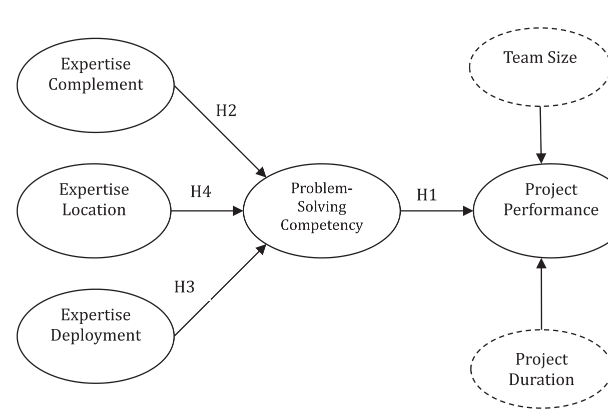


Fig. 1. Research model of this study.

that individuals may feel their contributions are more crucial to the success of the process for small size groups. Based on the above-indicated literature, we employ project duration and team size as control variables to analyze how they impact project performance.

3. Research method

3.1. Sampling

A survey was conducted to examine the proposed hypotheses. We adopted a two-step approach to collect the required data. First, we sent a letter to all 359 institute members of the Information Management Association (IMA) in Taiwan. IMA is an organization that aims at improving IT usage and enhancing communication among IS professionals. Almost every member of this organization is an IS department manager. Members who were willing to participate in our study were then contacted by telephone. On the phone, we introduced the major purpose of this study and detailed data collection procedures. In the second stage, we delivered the survey package to 750 project managers or team leaders. We followed the total design method approach proposed by Dillman (1978) to increase the response rate. Two weeks after the initial survey package delivered, a reminding letter with full survey questionnaire was sent to those who did not return the survey package. A total of 215 people returned the survey package after the second mail, yielding a valid response rate of 28.67%. Table 1 gives the profile of the respondents.

Most of the participants worked in manufacturing (28.95%), followed by the information technology industry (25.00%), and the financial industry (18.42%). Ninety-eight percent of respondents participated in their project for less than 2 years. Fifty percent of the teams had fewer than 6 people. Most respondents were 30–39 years old (41.83%) and 40–49 years old (29.97%). Most of the respondents had completed college (59.64%), with 23.14% of them holding a master's degree or higher. More than three-fourths of the team respondents were male.

3.2. Construct and measurements

The questionnaire was administered in Chinese and thus it had to be translated; reverse translation was therefore used to ensure consistency between the Chinese and the original English versions of the instrument. Three research assistants majoring in English linguistics were employed in this effort; versions were then compared and discrepancies resolved by a committee including an English professor and two MIS professors.

We pre-tested our Chinese questionnaire by asking 10 MIS professionals in the knowledge management as well as in the ISD project area to assess its logical consistency, ease of understanding, sequence of items, and contextual relevance. Those 10 professionals are considered qualified because all of them have college or above degree, have been leading at least one project, and have more than 6 years experience in ISD. Based on the collected comments, we made several minor modifications in the wording and readjusted the item sequence.

Knowledge complement refers to the capability, experience, knowledge and skill of various heterogeneous experts fitting well within a team. A total of 5 items, 3 of which were obtained from the study of Tiwana and McLean (2005), were used to measure expert heterogeneity in ISD teams. Another 2 items, which were used to measure the resource complement within a team, were obtained from the study of Lin and Chen (2006) and amended. *Knowledge deployment* refers to the assignment of tasks according to members' areas of specialized knowledge, skills, and knowledge. Three items were founded on the resource

Table 1
Profile of respondents.

Industry	# of response	Percent	Team Size	# of response	Percent
Manufacturing	63	29.3%	<3	30	14.0%
Financial	35	16.3%	4–6	55	25.6%
IT	64	29.8%	7–9	82	38.1%
Service	50	23.3%	10–12	35	16.3%
Government	3	1.4%	12 <	13	6.0%
Team duration	**# of response**	**Percent**	**Education**	**# of response**	**Percent**
Under half year	71	32.89%	High school	1	0.5%
Half year–1 year	76	35.52%	College (2 years)	34	15.8%
1 year–2 years	65	30.26	College (4 years)	131	60.9%
Over 2 years	3	1.32%	Graduate school	49	22.8%
Related work experience (years)	**# of response**	**Percent**	**Age**	**# of response**	**Percent**
<5	29	13.49%	~29	28	13.0%
6–10	59	27.44%	30–39	84	39.1%
11–15	64	29.77%	40–49	73	34.0%
16–20	53	24.65%	50–59	20	9.3%
>20	10	4.65%	60~	10	4.7%
Gender	**# of response**	**Percent**			
Male	163	75.8%			
Female	52	24.2%			

Table 2
Validity and reliability.

Constructs and Items	Loading	ITC
Knowledge complement (AVE = 0.63; CR = 0.84; Alpha = 0.72)		
1. The capabilities of various experts fit well with my team.	0.86	0.64
2. Members are dependent on other members' expertise and knowledge.	0.79	0.66
3. Members of this team have skills and abilities that complement one another.	0.76	0.56
Knowledge deployment (AVE = 0.65; CR = 0.85; Alpha = 0.75)		
1. Different team members are responsible for knowledge in different areas.	0.71	0.43
2. The specialized knowledge of several different team members was needed to complete the project deliverables.	0.83	0.64
3. Team members are assigned to tasks commensurate with their task-relevant knowledge and skill.	0.88	0.69
Knowledge location (AVE = 0.67; CR = 0.86; Alpha = 0.75)		
1. The team has a good "map" of one another's talents and skills.	0.71	0.56
2. Team members know who on the team has specialized skills and knowledge that is relevant to their work	0.86	0.68
3. Team members know which team members have knowledge in which specific areas.	0.88	0.51
Problem-solving competency (AVE = 0.54; CR = 0.78; Alpha = 0.74)		
1. Identifying problems	0.79	0.55
2. Generating alternative solutions	0.72	0.60
3. Evaluating alternatives	0.70	0.57
Project performance (AVE = 0.55; CR = 0.88; Alpha = 0.84)		
1. Ability to meet project goals	0.73	0.60
2. Expected amount of work completed	0.80	0.72
3. High quality of work completed	0.82	0.69
4. Adherence to schedule	0.72	0.61
5. Adherence to budget	0.71	0.60
6. Speed of operation	0.66	0.46

Note: ITC: Item-total correlation.

deployment perspective of the RBV and subsequently developed by us. *Knowledge location* refers to an ideal situation in which a team's members know where to find their required sources of knowledge and how to identify what expert possesses which knowledge (Faraj and Sproull, 2000). Three items obtained from Faraj and Sproull (2000) were used to measure the levels of creation and implementation of knowledge location within the team. *Problem-solving competency* refers to the degree of members' ability to reduce the gap between the existing state and the desired state through the work processes (Aladwani, 2002; Cerveny et al., 1990). Three items adapted from Aladwani (2002) were used to measure how well team members can effectively identify causes, generate alternatives, and evaluate alternatives for problems in hand. *Project performance* refers to the extent to which a project team accomplishes system development tasks efficiently and effectively (Henderson and Lee, 1992). This was measured using seven items adopted from existing scales that tapped into subjects' perceptions of project performance in terms of ability to meet goals, work quantity, work quality, schedule, budget, efficient task operations, and speed of operation (Guinan et al., 1998; Henderson and Lee, 1992; Jones and Harrison, 1996).

Table 3
Cross-loading table.

	Knowledge complement	Knowledge deployment	Knowledge location	Problem solving competence	Project performance
KC1	0.86	0.29	0.42	0.44	0.58
KC2	0.79	0.08	0.42	0.18	0.57
KC3	0.76	0.24	0.34	0.25	0.48
KD1	0.06	0.71	0.20	0.19	0.19
KD2	0.15	0.83	0.16	0.27	0.19
KD3	0.32	0.88	0.24	0.41	0.38
KL1	0.30	0.18	0.71	0.21	0.42
KL2	0.48	0.21	0.86	0.26	0.46
KL3	0.42	0.23	0.88	0.32	0.47
PSC1	0.33	0.31	0.27	0.79	0.43
PSC2	0.19	0.27	0.14	0.72	0.35
PSC3	0.28	0.28	0.29	0.70	0.32
PP1	0.49	0.29	0.39	0.50	0.73
PP2	0.43	0.20	0.30	0.34	0.80
PP3	0.56	0.24	0.45	0.35	0.82
PP4	0.41	0.22	0.33	0.34	0.71
PP5	0.44	0.23	0.26	0.42	0.71
PP6	0.43	0.07	0.36	0.09	0.66

3.3. Non-response bias

To examine potential non-response bias, we compared different waves of responses at the statistical significance level of 0.05 and found no significant difference between earlier respondents and later respondents on the scores of all question items. The absence of differences is consistent with the claim that response bias does not seem to be a major problem (Armstrong and Overton, 1977).

3.4. Common method variance

Since both independent and dependent variables were collected simultaneously from the same respondent, there is a potential for common method bias (CMV) in this study, so we performed statistical analyses to assess the possibility. First, we conducted a Harman's single factor test. The results showed that seven factors were extracted, and the first factor explained 27% of the variance. Second, we followed the approach suggested by Malhotra et al. (2006) to estimate the potential impact of CMV. We chose the second-smallest positive correlation between two manifest variables (0.02 between project duration and problem solving competence) as a conservative estimate. No significant difference was found between the original and adjusted correlation matrix. The results from the statistical analyses indicate that common method bias is not an issue in this study.

3.5. Reliability and validity

Item reliability, convergent validity, and discriminant validity tests are often used to evaluate the measurement model in partial least square (PLS). Reliability can be assured through composite reliability, Cronbach's alpha, and factor loading. Factor loadings higher than 0.7 can be viewed as having high reliability whereas factors with loadings lower than 0.5 should be dropped.

Convergent validity should be assured when multiple indicators are used to measure one construct. It can be examined by item-total correlation (ITC), composite reliability, and variance extracted by constructs (AVE) (Fornell and Larcker, 1981; Kerlinger, 1970). To have the required convergent validity, ITC should not be lower than 0.3 whereas composite reliability should be higher than 0.7. Moreover, when the AVE is less than 0.5, it means that the variance captured by the construct is less than the measurement effort, while the validity of a single indicator and construct is questionable (Fornell and Larcker, 1981). To have the required discriminant validity, the correlation between pairs of constructs should be lower than 0.90 while the square root of the AVE should be higher than the inter-construct correlation coefficients (Bagozzi et al., 1991; Chin, 1998; Fornell and Larcker, 1981). For each construct in this study, all assurances were met, as shown in Table 2 to Table 4.

3.6. Model fit

Wetzels et al. (2009) suggested a method to calculate global fit for PLS. Goodness of Fit (GoF) is defined as the geometric mean of average AVE index and the average R2. The equation for calculating GoF is √(average AVE * average R^2). Moreover, Wetzels et al. (2009) suggested GoFsmall = 0.1, GoFmedium = 0.25, and GoFlarge = 0.36 as baseline values for validating the PLS model globally, based on the AVE cut-off value of 0.5 (Fornell and Larcker, 1981) and the effect size of R2 (Cohen et al., 2013). The result for our research model was a GoF value of 0.492, which exceeds the cut-off value of 0.36 for the large effect size of R2.

Table 4
Variable information and correlation matrix.

Constructs	Mean	SD	Correlation matrix				
			1	2	3	4	5
1. Knowledge complement	5.39	0.72	**0.80**				
2. Knowledge deployment	6.06	0.62	0.26	**0.81**			
3. Knowledge location	5.72	0.59	0.49	0.25	**0.82**		
4. Project performance	5.75	0.48	0.67	0.34	0.55	**0.70**	
5. Problem-solving competency	5.68	0.55	0.37	0.39	0.32	0.50	**0.74**

Notes: (1) Diagonal elements are the square root of AVE; (2) SD: standard deviation.

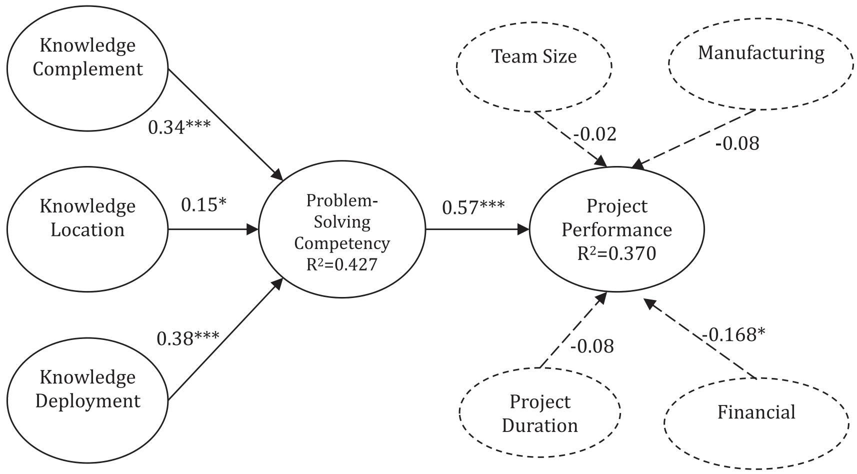
4. Hypotheses testing

Hypothesis testing was conducted through PLS analyses by using PLSgraph 3.0 (Chin and Frye, 2003). The explanatory power of the structural model was evaluated by the R^2 value. In addition to each R2 value, we also calculate the averaged R^2 and Q^2. Both indexes show that the proposed model is accepted. Furthermore, in order to examine if each hypothesis was established, we assessed the t-statistic for the standardized path coefficient, calculated with bootstrapping approach with 500 samples, and 215 cases each.

The results indicated that almost all hypotheses were supported. All the path coefficients and explained variances for the model are shown in Fig. 2. Among three control variables, industry is found to have impact. Projects in financial sector are found to have lower performance than projects in other industries.

In addition to the direct effect, we also tested the mediating effect of problem solving competency. We followed Barron and Kenny's (1986) approach to evaluate the type of mediating effect. Three direct links from antecedents to project performance were added, without the link from problem solving competency to project performance. All three antecedents were all found to have significant impact on project performance ($\beta = 0.49$ for knowledge complementary, $\beta = 0.25$ for knowledge location, and$\beta = 0.12$ for knowledge deployment; all with $p < 0.01$). After adding the link from problem solving competency to project performance, the direct links from three antecedents to project performance are weaker ($\beta = 0.4$, $p < 0.01$ for knowledge complementary; $\beta = 0.21$, $p < 0.01$ for knowledge complementary; and$\beta = 0.03$, $p > 0.05$ for knowledge deployment). In addition, three Sobel tests were conducted to understand the mediating effect of problem solving competence. Since the Z-value is 3.86 for knowledge complementary, 3.42 for knowledge deployment, and 3.3 for knowledge location, we therefore claim that the effects of knowledge complementary and knowledge location are partially mediated by problem solving competency, the effect of knowledge deployment is fully mediated. Since problem solving competence only partially mediates the effect of knowledge complement and knowledge deployment, an alternative model contains the direct effect of three independent variables on project performance is thus provided (See Fig. 3).

First, results reveal that the knowledge complement had a positive effect on problem-solving competency. This is consistent with prior related research on resource complements (e. g., Lin and Chen, 2006); these studies proposed and confirmed that, when resources are complementary, a desirable outcome is expected because of the synergistic effect. *Second*, knowledge deployment had a positive effect on problem-solving competency. Such results confirm the RBV perspective which asserts that an organization



Notes: * p<0.05; ** p<0.01; *** p < 0.001

Fig. 2. Results of the research model.

deploying valuable resources can effectively enhance the end result (Christensen and Overdorf, 2000; Day, 1994). *Third*, the positive and significant coefficient from knowledge location to problem solving competence indicates that an ISD team creates a good mechanism for knowing who has what knowledge/skill and where will enhance the effectiveness of problem-solving competency. However, even though knowledge location was found to have a positive effect on problem-solving competency, the obtained coefficient is much smaller than other two factors. This also implies that having needed resources and put resources in the right places are more critical, compared with knowing the location of resources.

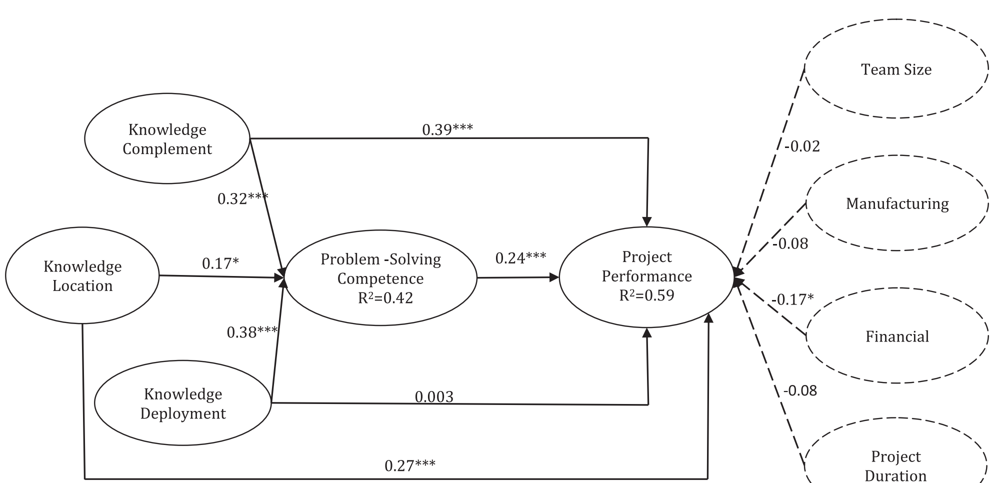
Finally, a positive and significant relationship between problem-solving competency and project performance confirms the related research findings. For instance, problem-solving strategies impact the success of systems development while having problem-solving competency is necessary to secure the ultimate desired task, and psychological and organizational outcomes (Aladwani, 2002).

5. Conclusion

The focus of this study was to integrate the three research streams: RBV in team, knowledge management process, and ISD project management. Information systems development is knowledge intensive work as well as a continuation of the problem solving process. To accomplish a predefined goal within time and on schedule, members need to integrate knowledge possessed by individuals and use the integrated results to solve problems. We examined the effects of team knowledge complement, knowing knowledge location, and effective knowledge assignment on problem-solving competency. Data collected from 215 IS project managers or team leaders confirmed our hypotheses.

5.1. Academic contribution

This paper makes several novel contributions to knowledge composition structure, KM, and ISD literature. *First*, this study



Notes: * p<0.05; ** p<0.01; *** p < 0.001

Fig. 3. Alternative model.

seeks to shift attention from resource diversity to complement and deployment. We argue that the assemblage of expert resources for an ISD team should not only focus on knowledge heterogeneity. More attention should be paid to the knowledge complement and knowledge deployment since they contribute to problem-solving competency. Team composition research asserts that the availability of diversified resources is the basic purpose for adopting teamwork structure by organizations. Work outcome is improved when people with various knowledge are gathered together to increase available resources and comprehend diverse viewpoints. Therefore, researchers aimed at exploring the consequences brought about by demographic diversity, informational diversity, and value diversity. In this study, based on RBV perspective, we advanced this research stream by showing that having a scant variety of knowledge resources isn't enough. Those resources must operate in a complementary manner to support ISD team to solve problem. In addition, we again highlight the importance of matching knowledge with position. That is, putting the right people in the right position according to their knowledge.

Second, since ISD can be viewed as a series of problem solving activities, understanding the antecedents of problem solving competence is worth paying attention to. Although Aladwani (2002) has illustrated the mediating role of problem solving competence between traditional attributes (such as use of support technology, project team size, clear goals, knowledge of staff, and management advocacy) and final performance, we extended his purview by employing knowledge-related factors in the model. Specifically, we argued and confirmed that, although the existence of required knowledge can benefit project performance, this effect goes through problem solving competence. That is, in addition to having sufficient knowledge resources, the team needs to utilize those resources and transform them into team level resources to counter challenges. When required knowledge is available, put in the right positions, and known by members, team can better identify and define problems, generate solutions, implement selected solutions, and evaluate the implemented results.

In sum, as indicated above, this study provides several new insights into ISD and team research. We reveal the relationships among knowledge composition, the problem-solving process, and project performance. Such a relationship framework has been the worthy focus of IS theorists and scholars from other disciplines. Future research can extend the current study by exploring other factors so as to obtain a more comprehensive view of team knowledge composition, studying potential antecedents and other consequences of enhancing team knowledge composition, and/or applying the current research model in other contexts.

5.2. Practical implications

This study also contributes to the project manager's role in the following ways. *First*, our study shows that the knowledge complement has a positive effect on problem-solving competency. Such a result indicates that members with specialized and complementary knowledge provide a resource that reflects their effectiveness in executing development activities. This demonstrates that the value of specific human resources may be inextricably linked to the presence of other complementary resources, and that the combination of these resources within a team can increase that team's effectiveness and productivity.

Member selection has long been studied by researchers (Barczak and Wilemon, 2003; Jiang and Klein, 2000). These studies aim at understanding criteria for selecting appropriate members to form an effective team. Our results suggest that, while selecting members, ISD project managers should consider not only employing a variety of experts but also focus on composing a team of experts who individually complement one another. Although diversity or heterogeneity increases the range and availability of various knowledge resources, it cannot guarantee those resources are actually required, can fit in with each other, and can be combined to solve problems. The benefit of heterogeneity reaches its peak when deep individual wells of knowledge are complementary to each other. That is, problem solving competence cannot be necessarily enhanced by merely having various resources, since focusing on individuals' complementary values is too important.

Second, knowledge deployment has a positive effect on problem-solving competency. This implies that project managers have the responsibility to strategically assign knowledgeable workers to suitable tasks. The ISD tasks, each requiring a very specific skill (or skills), need experts from various specialized fields to complete them. In order to maximize efficiency and ensure competent completion of tasks, managers should assign members to tasks which fit their area of knowledge, and skill level. With the appropriate matching of knowledge to the requirements of a particular task, members can better contribute to their team through more focused concentration on their individual work, becoming more cohesive, and enhancing learning and knowledge mining in their specific area. Moreover, the inappropriate matching of job with knowledge often leads to low morale and increases members' motivation to leave their current job. Therefore, project managers or team leaders need to develop a complete understanding of each member's knowledge and then assign tasks according to individuals' knowledge in order to build a team into an effective, cohesive, efficient working unit.

Third, knowledge location also affects problem-solving competency. It is clear that an ISD team creates a knowledge resource in knowing that the location of knowledge can benefit problem solving. First, transactive memory systems help reduce the cost for searching for required knowledge for problem solving within the team. Second, knowing who knows what allows the team to allocate people to appropriate positions. Thus, the team manager should create a complete knowledge map to indicate knowledge sources by identifying who is an expert, in which field, and how to reach that expert. Several identified approaches, such as training, joint decision making, and team building can be adopted to enhance TMS within the team.

Fourth, project performance is considered as the extent to which project can be accomplished efficiently and effectively. Assuring project goal can be met is critical given that company may lose competitive advantage or waste investment if project is failed. Problem solving competence is this study aligns with the concept of quality management, such as six sigma, that project team should be able to identify problem, analyze, and solve problem. By focusing on continuous ISD performance improvement, organizations can then really be benefited by the introducing of information technologies.

5.3. Limitations and future studies

The proposed model has certain limitations, and additional theorizing is needed. *First*, the survey method employed in this study was cross-sectional; thus the longitudinal circumstances caused by time were not well explored. *Second*, the present model was derived from the existing literature on knowledge characteristics and ISD project outcome. For the sake of parsimonious and adequate statistic power, other configurations, including important and solid antecedents affecting project performance, were excluded. We suggest that future research incorporate other related variables such as manager control, political conflict, staff involvement, task uncertainty, independence, clear goals, rewards, etc., to construct a more elaborate framework for related studies in the fields of problem-solving competency, and project outcome. Third, facilitation is another critical competence for project performance as well as problem solving competence. However, to control the research model in a manageable manner, this variable is not included. Future studies are encouraged to include this variable in their model to demonstrate the importance of project team leader's role in building an effective team which can solve various problems and achieve high performance.

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