(注意：請以中文回答否則不予計分)

1. 說明知識如何分類？又，知識可分為哪些型態？(10 分)
2. 本文如何以溝通的理論來解釋知識的轉換？(10 分)
3. 決定知識轉換的因素有哪些？說明這些因素與知識轉換如何關聯？(15 分)
4. 說明本文之貢獻與意涵。(15 分)

Knowledge transfer within information systems development teams: Examining the role of knowledge source attributes

Abstract

Knowledge transfer is considered to be an important topic for both researchers and practitioners. However, very little research has been pursued to understand the factors affecting knowledge transfer within teams, an important social unit within organizations. This study attempts to fill this void by examining factors that affect knowledge transfer within information systems development (ISD) teams. Taking a "connectionistic" epistemological perspective and drawing on the communications-based research on knowledge transfer, the theoretical model of the study proposes that the source's capability, credibility, and extent of communication will play an important role in determining the extent of knowledge transferred to recipients. Results from an empirical study involving student teams engaged in semester-long ISD projects supported the role of credibility and extent of communication. Interestingly, capability was not found to play a significant role in knowledge transfer. Possible explanations for this lack of significant effect of capability on knowledge transfer are presented.

1. Introduction

In order to gain and sustain a competitive advantage in the global economy, today's organizations need to effectively mobilize their knowledge resources [26,35]. Knowledge transfer (KT) activity is central to the organizations' knowledge mobilization efforts [1,28,44]. Researchers argue that in today's "knowledge-driven organizations," managers are often confronted with the question of "how can I encourage people to share what they know," making knowledge transfer an important topic of interest for both academics and practitioners [46]. Knowledge transfer occurs when knowledge is diffused from one entity (e.g., an individual, group, or organization) to other entities. Knowledge may be purposefully transferred, or it may occur as an unintended outcome of other activities.

Research in the area of knowledge transfer has been conducted in many settings and for various objectives. Initial work on knowledge transfer focused on international technology transfers in light of Vernon's product life cycle [21,73]. Research on knowledge transfer has also focused on inter-firm governance modes such as transfers among strategic alliances and between merged and acquired units [16,68]. In addition, some research efforts have recently been directed toward understanding knowledge sharing within co-located and distributed

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teams [38,42,62,64]. This work on teams is particularly important, given the acknowledgement that teams are a fundamental social unit within which team members share knowledge and learn from each other in the process of completing an assigned task [12,66]. In spite of this recent interest in knowledge transfer, Levin et al. [46] assert that "there exists little systematic evidence" on what actually "promotes effectiveness of knowledge transfer." They further argue that without knowing the critical linkages between factors associated with effective knowledge transfer, managers may be "left in the dark as to what they can do to foster valuable knowledge exchanges." In response to these arguments by Levin et al. [46], the observations of other researchers [3,79] that there have been limited studies on knowledge transfer within teams, and also to make our work relevant to the IS discipline, we examine factors affecting knowledge transfer within information systems development teams.

Information systems development (ISD) teams are deployed to conceptualize, design, develop and implement information systems to support business functions. Curtis, Krasner, and Iscoe [22] describe an ISD project as a process involving both communication and learning. A typical ISD team consists of individuals in various roles — designers, system developers, engineers, and project managers, to name just a few. To successfully build a large and complex system, team members have to continuously communicate and learn from each other regarding different issues ranging from the capabilities of the new system, application-specific algorithms, and architecture of the computers to articulating the intentions of the customers as reflected in the requirements statements [22]. Further, from their study of numerous large ISD projects involving multiple organizations, Curtis et al. [22] concluded that team members who possessed knowledge and were viewed as "exceptional designers" had the ability to control the direction of projects and positively influence their outcomes by making their knowledge available to other team members. This further lends support for the importance of knowledge sharing and transfer within ISD teams. Our study focuses on this very issue, which has not received much attention in the literature in the past.

Boisot [15] argues that successful knowledge transfer needs a "degree of resonance" between two or more agents, suggesting that knowledge transfer requires both the *transfer* (i.e., sending) of knowledge from the source agent, and the *internalization/learning* of that knowledge by the recipient agent. This transfer of knowledge depends not only on the type and complexity of the knowledge but also on the attributes and behaviors of the human agent sharing that knowledge [15]. Based on

this, the specific research question examined in this study is: What are some of the key factors associated with ISD team members (i.e., the source agents) who are able to transfer significant knowledge to other team members (i.e., the recipient agents)?

Our research question approaches the issue of knowledge transfer with consideration of both the source and the recipient perceptions, which we believe is in itself a contribution to the literature on this topic.

The rest of the paper proceeds as follows. First, the theoretical background for this research is discussed. Next, a theoretical model for this study is posited, and the primary hypotheses of the study are presented. This is followed by a discussion of our research methodology, data collection procedures, instrument validation, analysis techniques, and the results. Finally, we discuss the study's findings, its implications for research and practice, its limitations, and future research directions.

2. Theoretical background

2.1. Prior research on knowledge transfer

Venzin, von Krogh, and Roos [72] argue that before researching any issue related to knowledge, it is important to discover the epistemological roots, since "concepts take different forms depending on the epistemology they are based on." Other researchers [20] have also argued for the significance of viewing knowledge management-related issues through an epistemological perspective. Along with the epistemological underpinnings, Venzin et al. [72] emphasize the importance of specifying the "appearance" or forms of the knowledge (e.g., tacit, explicit, and embedded) being examined.

Research in the area of knowledge transfer has been conducted from three different epistemological stances [72]: cognitivistic, connectionistic, and autopoietic. The *cognitivistic* perspective views knowledge as a "fixed and representable entity (data) universally stored in computers, databases, archives, and manuals" [72]. This perspective holds that knowledge is like data, and that it can be "unproblematically shared from one entity to another" [72]. Notably, since within this perspective, knowledge (used virtually synonymously with data) is "universal," specific characteristics of the sender, receiver, or the knowledge itself play no role in the transfer or sharing. Other factors such as prior knowledge or knowledge process rules are also not viewed as critical to knowledge transfer under this perspective.

The *connectionistic* perspective [41] on the other hand does not view knowledge as having universal characteristics. Knowledge is seen to be contextual, and

"local differences between the rules and stocks of knowledge exist" [72]. Unlike the cognitivistic perspective, the connectionistic theorists believe that knowledge transfer between knowledge sources and recipients is inherently difficult especially due to the contextualized nature of knowledge, and due to different factors such as the need for shared understanding, and the nature of "connections" through social interactions, ties, or networks.

The *autopoietic* perspective to knowledge transfer owes its origin to the concept of autopoiesis (i.e., self-production) [50]. At the core of this perspective are the concepts of autonomy, unity, and co-evolution. Knowledge is viewed as history-dependent. Further, knowledge is believed to develop in an autonomous manner [72], and is not characterized as abstract; therefore it is not seen as shareable [75]. Researchers adhering to this perspective refer to knowledge "conversion" and not knowledge "transfer." They further argue that since knowledge cannot be ever shared, it is always created [54]. Different strategies such as socialization, externalization, internalization, and combination have been suggested as methods for the conversion (or re-creation) of one type of knowledge to another.

Venzin et al. [72] suggest that none of the three epistemologies mentioned above is inherently superior to another, though one epistemological perspective may be better suited to study a particular phenomenon. They argue that researchers will need to "position themselves within the epistemological continuum" and make their epistemological assumptions explicit. We believe that in the context of our study (i.e. information systems development), the connectionistic perspective would be most suitable. This is because the contemporary view of information systems development (ISD) is that it is a process of sense-making that involves social interaction, cooperation, and learning [22,33], all based on human connection. Systems are co-constructed through a process of communication and negotiation among different stakeholders involved, who hold different "local" views. Overall, we believe that today's conception of systems development matches the essence of the connectionistic arguments, and thus provides the basis for our choice of epistemology in examining knowledge transfer in an ISD setting.

2.2. The "appearance" of knowledge

The connectionistic perspective views knowledge as "context-bound," and holds that the specification of the "appearance" (or nature) of knowledge is critical. A variety of knowledge taxonomies, based on knowledge levels (e.g., data, information, knowledge, wisdom), knowledge types and knowledge modes have been suggested in the literature [36,57]. Knowledge has been categorized as tacit [57], embodied [54,80], encoded [80], embrained [5], procedural [78], and embedded [7]. Tacit knowledge refers to the type of knowledge that is difficult to explicate or articulate. Embodied knowledge on the other hand can be "partially articulated and results from physical presence" [72]. Encoded knowledge refers to the knowledge residing in notebooks and data banks long after the knowledge contributor has left the organization. Embrained knowledge refers to the cognitive ability of understanding underlying patterns of a given phenomenon (e.g., double-loop learning), while procedural knowledge refers to the knowledge about the processes. Finally, embedded knowledge refers to knowledge that is contained within a "variety of contextual factors and is not pre-given" [72].

Prominent KM researchers in the Information Systems discipline [34,53] have suggested that it is not only important to specify the form of knowledge but also to acknowledge the fact that knowledge is fundamentally multifaceted. The inability to conceptualize and apply various dimensionalities of knowledge in KM research and practice could potentially inhibit the growth of KM as a discipline. Nissen and Jennex [53] convey this point aptly by stating, "This call [for treating knowledge as a multidimensional concept] also underpins our ever-clearer realization that KM research and practice face a very real and dangerous risk of stagnation if the many different kinds and behaviors of knowledge cannot be separated out and accounted for." They also posit an analytical framework to conceptualize and inter-relate the key dimensions of knowledge. While we do not use their framework directly in this particular study, we are in full agreement regarding the need to avoid studying knowledge as a unidimensional concept.

Not surprisingly, such a position is consistent with research on ISD, where knowledge has been viewed as a multidimensional construct [9]. Acknowledging the multidimensional nature of IS knowledge, Basselier, Reich, and Benbasat [10] suggest that information technology knowledge consists of both "hard" (explicit) component and "soft" (tacit) component. Explicit ISD knowledge refers to the technical knowledge such as knowledge about applications and technologies required for gathering information from the users or for developing the information system application. On the other hand, the tacit ISD knowledge refers to managerial knowledge related to ISD. Basselier et al. [10] further argue that these tacit and explicit components of IT knowledge are closely linked together and should be

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investigated in conjunction with one another. Sensitized by this body of work, in this study, we view ISD knowledge to be composed of technical knowledge as well as managerial knowledge. We believe that this conceptualization not only helps us in clarifying the types of knowledge relevant to ISD, but also in emphasizing the multidimensionality of knowledge, as recommended by Nissen and Jennex [53].

3. Theoretical model

The connectionistic perspective adopted for the study of knowledge transfer derives many of its basic ideas from communication theories [43,70]. Communication theory-based knowledge transfer research emphasizes the critical role of the context and the interaction between the various stakeholders involved in the knowledge transfer process (i.e., the sources and the recipients) on the knowledge transfer (Szulanski 1996) [70]. The principles underlying these studies are derived primarily from the "mathematical theory of communication" [67], Schramm's [65] theory of mass communication, and Berlo's [13] communication model. While these theories differ somewhat in their terminology, or "in the addition or subtraction of one or two elements" [13], they have "great similarities," and unanimously agree that the basic elements of a communication include a *message*, a *sender*, a *receiver*, a *channel*, *transmission*, and *communication effect* [6,13,43]. A *message* refers to the content a communicator seeks to convey. A *sender* is the entity which sends the message. A *receiver* is a message's destination, that is, an entity which receives and deciphers a message. We note that a sender may simultaneously act as a receiver and a receiver may also serve as a message source. A *channel* is the vehicle or medium through which a message travels. The *transmission* element refers to the actual sending and receiving of messages through designated channels. Finally, the communication effect typically refers to the outcome or general results of the communication process. Shannon and Weaver's theory of communication [67], given that it was developed to understand electronic communication (and not human-to-human communication), emphasized on the transmission and reception of a message. The message was equated with information and was assumed to be unproblematically communicated. In this regard, Shannon and Weaver's theory of communication could be seen as adhering to the cognitivistic epistemology. Though they did introduce the concept of "noise," or "factors that distort the equality of a signal" or communication [13], it was only later that theories of

human–human communication [65], that emphasized the role of noise in communicative exchanges. Consistent with the essence of the connectionistic epistemology, these new perspectives argued that communication is inherently problematic and "complicated." They proposed a range of "noise-related" factors such as the nature of the relationship between the source and the receiver, the context, the characteristics of the source and the recipient that can potentially affect the effectiveness of the communication [13,65].

Researchers drawing upon the communication theories, view transfer of knowledge as "the transmission of a message from a source to the recipient in a given context" [70]. Transfer is "seen to be effective" when it is "absorbed" by the recipient, and "absorption" often influences the "behavior of the recipient" in a certain way [71]. Within this perspective, the message corresponds to the knowledge content that is being transferred. A sender corresponds to the knowledge source involved in transferring knowledge or the generalized knowledge resource. A receiver, commonly referred to as knowledge recipient, is the knowledge transfer destination or the entity which receives and internalizes the knowledge content. A channel corresponds to the medium, such as face-to-face, phone, computers, through which the knowledge is transferred. Further, within the knowledge transfer context, the transmission element corresponds to the activities and processes, such as communication activities, through which knowledge is transferred from one entity to the other. Finally, the effect element corresponds to the impact of knowledge transfer. The knowledge transfer effects, although conceptualized and operationalized in numerous ways within the knowledge transfer literature, focuses on the results of the knowledge transfer outcome such as entity's performance, learning, and satisfaction. While researchers holding the communications perspective to knowledge transfer may have initially drawn on Shannon and Weaver's [67] model (associated with the cognitivistic epistemology), their emphasis on the factors impeding/enabling knowledge transfer make their perspective consistent with Schramm [65] and Berlo's [13] view of communication (and therefore, to the connectionistic epistemology).

Given our connectionistic epistemological assumptions, we focus our attention on the characteristics of the source, whose critical role is emphasized within the communications perspective [6,23,64,70–72]. We view knowledge transfer as the transfer of the multidimensional ISD knowledge from a source to the recipient. The source and the recipients are individual members within an ISD team. It is worth noting that in our study,

like in most communication studies, each individual acts simultaneously as a source and a recipient. Within an ISD team, this implies that individuals with varying experiences and backgrounds may have the potential to share knowledge with and absorb knowledge from each other. The "transmission" of the knowledge in the co-located teams occurs primarily through face-to-face communications.

While there are a large number of source character-istics that can be studied, in selecting our characteristics of interest, we drew upon prior studies in communica-tion and knowledge transfer. Berlo [13] refers to two important factors associated with the source that "can increase the fidelity" of a communication, thereby reducing the level of noise within a communication exchange. They are: the level of communication from the source, and his/her knowledge of the subject matter. Based on the views of Berlo [13] as well as those of the connectionistic researchers who emphasize the role of both the source's communication and its capability in knowledge transfer, this study investigates the effect of the source's extent of communication and ISD capabil-ity on knowledge transfer. In addition, our study also examines the role of the source's credibility on knowledge transfer, as highlighted in the literature. For example, Arrow [6] views the source's credibility as being critical to ensuring the success of the knowledge transfer process. More recently, Szulanski et al. [71] have emphasized the importance of credibility and trustworthiness of the source in ensuring successful knowledge transfer. We would like to acknowledge that there exist other factors that are potentially relevant to explaining knowledge transfer. As a starting point, we have chosen to focus on a parsimonious set emphasized within the communications-based perspective.

4. Hypotheses development

4.1. Source capability and knowledge transfer

The outflow of knowledge from a source to a recipient depends upon the wealth of a source's knowledge-base [31]. Zander and Kogut [31,78] developed and empir-ically tested the argument that the accumulation of experience in an activity facilitates communication and understanding of relevant knowledge. This facility, in turn, equips knowledge sources to transfer knowledge in a more effective manner. Szulanski [70], drawing on the work of Perloff [56], argued that an expert source will easily initiate a transfer of knowledge from itself to a recipient and is thus, more likely to influence the recipient. Researchers such as Davenport and Prusak

[23], von Krogh, Ichijo, and Nonaka [74] have also argued that a positive relationship exists between the degree of the source's capability and knowledge transfer. This view is consistent with the connectionistic belief that knowledge transfer is facilitated by "key experts" who have "mastered" a particular concept [72].

In the IS context, Bock and Kim [14] tested the argument that employees who perceive themselves as capable have higher propensity to share knowledge, and found some support for this hypothesis. Similarly, Wasko and Faraj [76] found support for a proposition that individuals are less likely to share when they perceive their own expertise to be inadequate with respect to others. In yet another study, Wasko and Faraj [77] found some support for a positive effect of source capability on knowledge transfer.

An ISD team consists of multiple members from different backgrounds, with different levels of skills, and in different roles (e.g., analysts, designers, developers). A successful ISD project thus requires significant amount of knowledge transfer amongst team members in an effort to develop a shared frame of reference [22]. The knowledge that needs to be transferred may be classified as following [40]: a) technical knowledge (e.g., programming), and b) IS project management knowledge (e.g., relationship management, application of systems development methodologies).

In summary, we argue that sources that have a greater ISD related knowledge than their team members (i.e., potential recipients) will transfer more knowledge.

Hypothesis 1. ISD knowledge of an individual source will be positively related to the extent of knowledge transferred by that source.

4.2. Source credibility and knowledge transfer

Source credibility refers to the extent to which a recipient perceives a source to be trustworthy and reputable. Thus the credibility concept has two dimen-sions: trust and reputation. Knowledge transfer researchers have indicated that the presence of trust is crucial in order for individuals to transfer knowledge [28,31,70]. For example, Rolland and Chauvel [60] state that, "trust is after all, the single most important precondition for knowledge exchange." Yet others have referred to trust as the "magic" ingredient for knowledge transfer [46]. Likewise, the knowledge source's reputation is seen as critical, since it is often used by the potential recipient to screen and evaluate the value of the source's knowledge [23]. In the absence of reputation of a source, recipients perceive a source's knowledge to be less persuasive and valuable. Further,

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Davenport and Prusak [23] suggest that reputation is best gauged by the performance of the individual.

A credible (i.e., a trustworthy and reputable knowledge) source is more likely to influence the behavior of a recipient [70]. When the knowledge source is perceived as credible, the recipients are "more open and receptive to the message" [71]. The importance of a source's credibility is amplified in the context of a knowledge transfer process because this process is not amenable to enforcement by contract [59]. Within the IS context, Ko, Kirsch, and King [40], who examined the transfer of knowledge between the clients and the consultants in an ERP implementation project found source credibility to be critical to knowledge transfer. Based on the literature discussed, in this study we argue that an individual who is perceived as credible will be able to transfer more knowledge to his/her team members.

Hypothesis 2. Credibility of, an individual source will be positively related to the extent of knowledge transferred by that source.

4.3. Communication and knowledge transfer

In the past, some scholars have argued against the positive effects of intra-team communication [8,45,48]. A variety of reasons such as decreased productivity level, member distraction, and creativity blocking have been presented to support the argument of a negative relationship between communication and knowledge transfer. However, in recent knowledge transfer studies, the importance of face-to-face communication in the process of knowledge transfer between intra-firm units such as new product development teams as well as inter-firm alliance partners has been theoretically argued and empirically established [14,24,31,45,70].

Leenders et al. [45], who studied knowledge transfer and creativity among new product development team members, found that the frequency of intra-team communication is critical. Burkink [18] examined the determinants of inter-firm knowledge transfers among wholesalers and retailers. The study revealed that both the frequency of communication and interpersonal relationship significantly accounted for the transfer of knowledge between wholesalers and retailers. Bresman et al. [16] studied knowledge transfer among alliances and found that communication and frequency of meetings were significant predictors of knowledge transfer. Szulanski [70] examined the impediments of the transfer of best practices in a firm and concluded that frequent communication between the source and the recipient facilitates the creation of a shared meaning and context, which is crucial for effective knowledge transfer. Cumming and Teng [21] studied the transfer of R and D knowledge and found that transfer success increases with frequent communication among the stakeholders. This finding supports the Brown and Eisenhardt [17] claim that learning in complex new product development projects is enhanced by high level of communications among team members.

In summary, communication plays a crucial role in the process of knowledge transfer because:

1) Communication leads to socialization which nurtures relationships important for team-oriented values, collaboration, cooperation, harmony, consensus, participative decision making, and team accountability [31,37,55]. All these components collectively aid in cultivating an ardent relationship between the recipient and the source. An ardent relationship among the source and the recipient has shown to facilitate knowledge transfer [70].
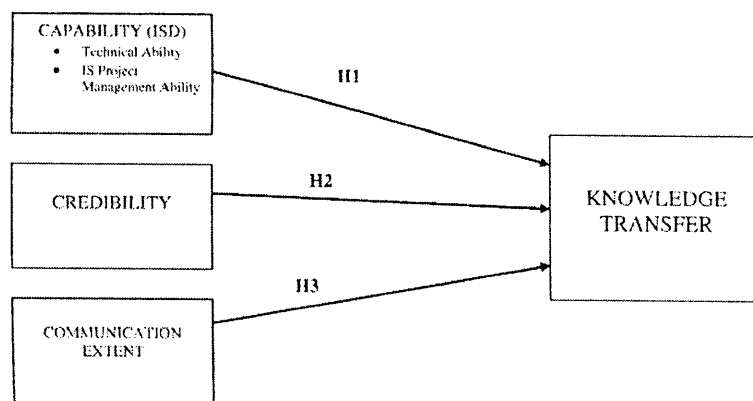

Fig. 1. The research model.

2) Frequent communication helps in building and maintaining a team's social capital embedded in team members' relationships.

3) By building on the knowledge of the various team members, teams facilitate the exchange and internalization of knowledge and insights [21]. Allen [2] indicated that in order to transfer knowledge, engineers and technologists have to converse with each other in each other's presence. While the engineers and technologists can access and read about new technologies, specific market conditions, or competitive developments, in order to internalize and apply this knowledge, they need the context of the information. This context is learned through communication with others [2,25,45].

Given that ISD is a process involving frequent communication and negotiation, often amongst collocated stakeholders, higher degree of communication from a source will lead to a more ardent relationship with the recipient, thereby facilitating knowledge transfer. In fact, contemporary agile software development practices are based on this premise [52]. Thus, we argue:

Hypothesis 3. The extent of communication between an individual source and his/her other team members will be positively related to the extent of knowledge transferred by that source.

We summarize our hypotheses in Fig. 1.

5. Research method

5.1. Sample

The sample consisted of teams comprising of 4–5 students enrolled in an information systems project management course and a database management course in a large US public university. The useable sample size was 114 (an individual level of analysis was used in this study). While student subjects have often been criticized for lack of generalizability (this issue has been discussed in the limitations section in greater detail), researchers have consistently suggested that they are similar to working professionals, and hence are appropriate for investigating psychological/social processes [30], such as knowledge transfer. The majority of the respondents were within the age range of 18–25. Among the 114 respondents, 96 were males and 18 were females. 86 of the 114 respondents were MIS majors (some of them had double or triple majors with one of them being MIS). We provide more details regarding our sample in Table 1.

5.2. Design

Each of the teams investigated was associated with a "client." The teams in the IS project management course were responsible for developing a web-based application system for their client, and were required to incorporate technologies such as ASP and Macromedia Flash. Similarly, teams in the database management course were assigned different clients for whom they had to develop a database application system using technologies such as a DBMS. The communication among the team members occurred primarily through face-to-face interaction, though some amount of email communication was also used.

A detailed description of the ISD task and project deliverables are summarized in Appendix A.

5.3. Data collection

Data for this study was collected using questionnaires. The data was collected in two phases. The individual members' capability and demographic data were captured at the beginning of the project development phase. All other constructs were measured toward the end of the project, when the teams were focused on finishing the actual development of the systems. A research assistant kept track of all the students who completed the questionnaires, and course credit was given to students to encourage participation.

Table 1
Descriptive statistics of the sample

Age of the respondents	Respondents' year of study	Gender of the respondents	Major of the respondents
Majority of the respondents (104) were within the age range of 18–25 years, 7 respondents were in the range of 26–30 years, and the remaining were above 30 years.	97 of the 114 respondents were senior-level undergraduate students, 15 respondents were junior-level students, and one of them was a graduate student (1 respondent did not to answer the question)	Among the 114 respondents, 96 were males and 18 were females.	86 of the 114 respondents were MIS majors (some of them had double or triple majors with one of them being MIS).

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Table 2
Questionnaire items

Knowledge transfer (Cronbach's alpha = .96)

KT1. To what extent have you learnt about technical IS project issues from the following individuals?

KT2. To what extent have you learnt about managerial/behavioral IS project issues from the following individuals?

Capability

Technical Ability: On a scale of 1 (low) to 7 (high) (Cronbach's alpha = .89)

T1. My general computer skills

T2. My knowledge of procedural programming

T3. My knowledge of object-oriented programming.

T4. My knowledge of database systems (Oracle, MS Access, etc.).

T5. My knowledge of web-based systems development technologies (MS FrontPage, ASP, Java, etc.)

IS Project Management Ability: On a scale of 1 (non-existent) to 7 (expert) (Cronbach's Alpha = .89)

I1. My overall understanding of how to communicate with Information Systems users/clients.

I2. My overall understanding of how to manage the relationship between the systems development team and the users/clients.

I3. My overall understanding of how to manage large projects

I4. My overall understanding of the social/psychological aspects of the systems development process.

I5. The extent to which I feel ready to work on a serious IS development project for a company.

Credibility (Cronbach's alpha = .92)

C1. To what extent do you trust the following individuals/entities?

C2. How would you rate the performance of the following individuals/entities up to this point?

Communication

COM1. Indicate to what extent you have communicated with the following individuals?

5.4. Measures

In selecting our measure for the dependent variable, we drew on the work of prior researchers (e.g., Boisot 2002) who have argued that successful knowledge transfer requires "resonance" between the source and the recipient (i.e., it needs both the diffusion of knowledge from the source and the internalization/learning of that knowledge by the recipient). Similarly, Davenport and Prusak [23] have argued that "Knowledge Transfer = Transmission + Absorption." We thus measured our dependent variable,

the extent of knowledge transferred by a source, by *asking each recipient* (i.e. other team member) about his/her extent of learning from that source. Two items, reflecting the multidimensionality of knowledge transferred, were used to measure the extent of knowledge transfer. The first item asked each team member to specify on a scale of 1 (Not at all) to 7 (to a great extent), the extent to which they had learnt *technical-ISD* related skills from each of their team members. The second item asked each member to specify on a scale of 1 (Not at all) to 7 (to a great extent), the extent to which they had learnt *managerial/behavioral ISD* related skills from each of their team members. From this we computed the extent of knowledge transferred (including technical and managerial/behavioral ISD issues) by each individual (i.e., a source) to his/her other team members. In other words, knowledge transferred by an individual was the "mean" of the extent of learning of the other team members from this individual.

The ISD capability construct, also reflecting the multidimensionality of a priori knowledge of team members, comprised of the technical ability and the IS project management ability, which was measured using items in a self-reported questionnaire (See Table 2). This questionnaire had been validated in previous knowledge transfer studies [62,64], and was modified to fit the current context.

We measured credibility by using the constructs of trust and performance. Each individual rated each of his/her other team members on their trustworthiness and their performance in the project at that point of time. Thus, in most cases, for each individual we received 3 to 4 measures of trust and performance from the other members. The mean of these measures was taken as the credibility of the individual.

Finally, we measured extent of communication by asking team members to specify the extent of communication they had with each other. The mean of the extent of communication reported by each team member for a certain individual (source) was taken as the measure of the extent of communication of that individual.

5.5. Analysis and results

The analysis was conducted in two stages: instrument validation and hypothesis testing. In the instrument

Table 3
First-order confirmatory factor analysis results

Measurement model	Range of standardized factor loadings	GFI	NFI	CFI	IFI	RMSEA	$\chi^2_{(df,\ p\text{-val})}$
Capability (technical ability and IS project management ability, credibility, and knowledge transfer)	.69–.98	.84	.89	.94	.94	.095	$\chi^2_{(71,\ p < 0.01)} = 144.15$

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Table 4
Second-order confirmatory factor analysis for capability

Coefficient	Capability
Technical ability	.68**
IS project management ability	.88**

Overall model fit: χ^2 (34)=93.37, $p<0.01$; GFI=.85; NFI=.89; CFI=.92; IFI=.92, RMSEA=.125.
**$p<0.001$.

validation stage, we computed the reliabilities of each of our construct measures (See Table 2). Even though we used pre-validated instruments, given that the context of our empirical examination was different from prior studies, a first-order confirmatory factor analysis (CFA) using structural equation modeling was conducted to re-establish the validity of the items for technical ability, IS project management ability, credibility, and knowledge transfer. Results indicated a good fit of the model with the data (See Table 3). For example, the goodness-of-fit index (GFI), a measure of the relative amount of variance in the data that is jointly explained by the hypothesized model was found to be in the range of the .8s [19]. Similarly, the Comparative Fit Index (CFI) which accounts for the sample size was found to be close to the recommended range of .95 [11]. Further, all of the items had high factor loadings (from .69) and loaded on the relevant factors at $p<0.01$. Next, a second-order factor analysis was conducted to ensure that both technical ability and IS project management ability indeed loaded on the construct of ISD capability. As the results show, both technical ability and IS project management ability loaded on ISD capability at $p<.001$. In addition, similar to the first-order CFA, the fit statistics were within the recommended ranges (See Table 4).

Next, we used linear regression to test our hypothesis. Table 5 lists the descriptive statistics and Table 6 summarizes the results of the hypotheses testing. Hypothesis 1 posited that individuals with higher capabilities would transfer more knowledge. Our results

Table 5
Descriptive statistics

Construct	X1	X2	X3	X4
Knowledge transfer (X1)	1			
Capability (technical + IS project management) (X2)	.112	1		
Communication extent (X3)	.739	.103	1	
Credibility (X4)	.733	.092	.795	1
Mean	4.98	5.12	6.02	6.17
Standard deviation	1.42	.89	1.07	1.10

Table 6
Hypothesis testing

Variable	Coefficient (standard error)	Hypothesis support
Capability (technical + IS project management)	.052 (.096)	No
Communication extent	.557*** (.120)	Yes
Credibility	.507*** (.127)	Yes

Overall Model Fit: $R^2=.605$; Adjusted $R^2=.594$
***−$<.01$.

do not support the hypothesis (H1: $b=0.052$, ns). Hypothesis 2 proposed that individuals who have high credibility will transfer more knowledge to their other team members. This hypothesis is strongly supported (H2: $b=.557$, $p<0.01$). We also found a strong support for Hypothesis 3, which suggests that individuals who are perceived to have a high extent of communication with their team members transfer more knowledge (H3: $b=.507$, $p<.01$). The R^2 of the model was .605 suggesting that over 60% of the variance in the dependent variable (extent of knowledge transferred by the source) was being accounted for by the parsimonious set of independent variables (i.e., source capability, source credibility, and extent of communication) tested in the model.

6. Discussion

The findings of this study indicate that in ISD teams, an individual is perceived to transfer a significant amount of knowledge to his/her team members if this focal individual extensively interacts with other team members (i.e., the potential recipients of knowledge from this individual) and is perceived to be credible by them. Although the extent of communication being positively associated with knowledge transfer is consistent with recent studies that posit communication to be a primary mechanism for transferring knowledge, this association has not been empirically established in the context of face-to-face ISD teams. Our study confirms that the transmission of ISD knowledge content, accomplished through frequent communications, is important for transfer (i.e., transmission + absorption) to occur.

Our assertion that an individual with high credibility (i.e., one who displays trustworthy behaviors and is a high performer) will be perceived as a significant knowledge transferor, also received empirical support. This finding suggests that ISD project team members who need to effectively transfer knowledge to other team members, would benefit from enhanced visibility of performance and by gaining the trust of other

members. This is an interesting finding because some recent knowledge management studies show that trust may not have a strong impact on knowledge management processes [14,39]. Knowledge transfer literature suggests that in situations, where the utility and validity of the transferred knowledge cannot be clearly verified, the credibility of the source may be used as a proxy for knowledge valuation [23]. This appears to be the case in this study where recipient team members may indeed be valuing the knowledge through credibility attributions, and absorbing knowledge from credible sources.

Interestingly, our proposition that more knowledgeable team members will be able to transfer more knowledge was not supported. The *knowledge engineering* paradox seems to prevail in ISD knowledge transfer. This paradox states, "that the more expert an individual, the more compiled is his/her knowledge, and harder it is to extract this knowledge" [47]. So, it is conceivable that a more capable individual is unable to successfully explicate his/her knowledge in forms that can be internalized by other less capable team members. In other words, the source is unable to convey the message in forms that a knowledge receiver can easily absorb. Hinds, Patterson, and Pfeffer [32] in their study examined the effect of expertise on knowledge transfer. The finding of their study revealed that novices instructed by beginners would perform the target task better than novices instructed by experts, thus supporting the knowledge engineering paradox.

The source capability result, which is not consistent with the proposed theory, needs to be investigated further. It is conceivable that there are moderating and mediating factors associated with this relationship which are leading to this anomalous finding. For instance, one possibility is that the knowledge engineering paradox is likely to exist when the knowledge gap or knowledge distance between the source and the recipients is high. Moreover, in order to transfer knowledge, the source has to expend significant effort in encoding the message in absorbable forms. The source's proclivity to expend such an effort may be amplified in the presence of certain factors (such as high motivation, reciprocity pressures, ardent relationships) and likewise, attenuated in the absence of such factors. Future research needs to examine the moderating and/or mediating role of the aforementioned factors while examining the effect of capability on knowledge transfer. Further, research shows that groups often fail to maximize the capabilities and contributions of all members due to information exchange failures [69]. In order for teams to learn from their most capable members, it is imperative that we understand the conditions that enable capable members to transfer their knowledge to their colleagues.

7. Implications and limitations

In this section, we highlight the implications of this study for both research and practice, and provide some future directions to researchers interested in this area. In addition, we discuss some of the limitations of this study to provide a context for interpreting the results presented.

7.1. Implications for research

Although some amount of knowledge transfer work has been conducted on new product development teams, R and D teams, and the transferring of best practices among units, very little is known about the factors that determine knowledge transfer within teams, especially ISD teams. In order to investigate how knowledge transfer may be fostered and to provide prescription for creating structures that foster knowledge transfer, we first have to identify the factors that facilitate and impede knowledge transfer in ISD projects. This study took a small step in that direction. Future research can use this model as a starting point and extend it: by characterizing the message differently (such as, using a different knowledge taxonomy to capture ISD knowledge), by including additional psycho-social factors that shape the transfer of knowledge content (such as, capturing recipient's absorptive capacity, sender's motivation), by using different channels as means of transmitting knowledge (such as, asynchronous or synchronous technologies), and by measuring the effect of knowledge transfer on team outcomes (such as team's performance, recipient satisfaction).

Considering that communication is a strong predictor of effective knowledge transfer, future research needs to examine this construct in a more comprehensive and in-depth manner and not treat it as monolithic. One possible way to approach this would be to devise knowledge transfer-related communication dimensions that would include: the extent of communication, the quality of communication, the mode of interaction (e.g., person-to-person, chat rooms, emails), communication and inter-personal skills, and the nature of symbolisms (referential or evocative) used in communication [63]. This approach will allow researchers to determine the aspects and dimensions of communication that has the greatest impact on a successful transfer of knowledge.

In the inaugural issue of Knowledge Management Research and Practice, Edwards et al. [27] found that relatively few instances of KM research have theoretical underpinnings and very few use empirical means to examine KM phenomena. Moreover, Edwards et al. [27] highlighted that one of the top challenges for the KM

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research community in coming years is to produce theoretically-grounded work which is supported by empirical evidence. On similar lines, the Special Issue on knowledge transfer in Management Science, Argote et al., [4] voiced a concern that conceptual studies in knowledge transfer have outpaced empirical studies. In light of this observation, we believe that this paper provides a much needed empirical evidence to strengthen our understanding of knowledge transfer within the ISD context.

The study provides a validated survey instrument that future knowledge transfer researchers interested in the ISD context may be able to use. This, we believe, can be viewed as an important contribution to the knowledge management field where much of the work is conceptual, and where there is a dearth of instruments for measuring KM-related constructs, while recognizing their multidimensionality [53].

7.2. Implications for practice

In order to attenuate knowledge asymmetries within IS units, it is crucial that IS managers have a better understanding of how to facilitate knowledge transfer among their employees [40]. One mechanism for initiating such an effort is to encourage knowledge transfer among group members who are involved in systems development. This study assists such an effort by providing guidance on selecting group members who are likely to facilitate a group's knowledge transfer goals. Moreover, the study's characterization of a team member who is able to transfer significant amount of knowledge to others also provide human resource personnel with a list of knowledge source attributes they need to emphasize on while providing group/team development training.

The finding that the frequency of communication among group members is crucial to knowledge transfer not only informs organizations of the salience of communication, but also underscores the need for developing structural mechanisms (such as collaborative tools, group events) and encouraging behaviors (e.g., by means of rewards and incentives) which are instrumental in facilitating frequent communications among group members.

The finding that knowledge source credibility is an important antecedent to knowledge transfer emphasizes the need for encouraging employees to build and maintain trustworthy relationships with their colleagues. Moreover, it also highlights the criticality of cultivating and nurturing a trusting organizational climate.

Although our study could not support the proposition that source capability facilitates knowledge transfer, the result is noteworthy in that it suggests that highly capable individuals placed in a team for achieving high performance may not contribute to the team's learning objectives. As explained in the discussion section, a positive relationship between source credibility and knowledge transfer may be nuanced. Future research needs to characterize and test relevant contingencies.

7.3. Limitations

The use of student ISD groups is a potential threat to external validity, and thus, the study may be criticized for having limited generalizability. However, student data provides a more homogenous and comparable data in light of ISD scope, complexity and focus, and in terms of participants' demographics and backgrounds, which could be hard to control in the field settings. Ruchala [61] has argued that student subjects should be preferred over managers in research studies, since managers are "influenced by their work environment and are likely to carry organizational or job-specific perceptions." This makes it difficult to identify and control "organizational influences," and thereby, tends to taint the results. Other researchers, after systematically comparing student subjects with managers in real organizations, have concluded that there is no significant differences in the costs, erraticism, or patterns of biases in decisions made by these two groups [51,58], and have argued that use of student subjects does not necessarily reduce the external validity. Still, we believe that future studies should attempt to mitigate the external validity threats by replicating this study using different samples and settings [49]. It must be noted, however, that research studies using non-student data can also experience threats to external validity. Such studies use a single organizational/ unit setting in the interest of homogeneity, and run into the same external validity threats as the student sample, since the results in a particular organization or unit may not be generalizable to other organizations [30].

In essence, the utility and appropriateness of student versus organizational participants have been argued extensively in the literature. Some scholars have concluded that, "... student and non-student samples may be equally useful sources of information about the processes underlying organizational phenomena" [30], while others have recommended that the studies with student data should be considered a suspect [29]. We take a more moderate view regarding this matter. We believe that this study provides one snap-shot of the knowledge transfer phenomena under investigation. Further, the relevance of the task (ISD) and the realism associated with the project and clients enabled the students to enact the role of professional ISD team members. Still, we acknowledge

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that in order to gain a more comprehensive and generalizable understanding of this phenomenon, the study needs to be conducted in other settings.

8. Conclusion

Despite potential limitations associated with the use of student subjects and other variables associated with the context of our study (e.g., the length and nature of the project), we believe that this paper makes some important contributions. Knowledge transfer is critical to success of organizational initiatives, such as information systems development where multiple stakeholders with varying backgrounds and knowledge need to develop a shared frame of reference. The creation of this shared frame of reference depends largely on the extent to which the individuals involved share knowledge and learn from each other. While we acknowledge that this one study does not provide a complete view of the knowledge transfer process, the empirically validated model with variables posited in this study provides a good starting point. Further, the model captures the multidimensionality of knowledge and therefore responds to the call to view knowledge as a multifaceted concept [53]. Future research should extend this model by including other factors that may affect the extent of knowledge transfer within ISD teams. In any case, much remains to be learned regarding knowledge transfer within ISD teams, and we hope this study provides an impetus to future researchers in this area.

Appendix A. Details of the ISD task

The sample consisted of students enrolled in a database development course or in an information systems project management course. Both the courses involved a semester-long team project, which served as the context for this study. The projects in both the courses were designed to provide the participants with valuable practical experience in systems design and development, working in teams, and project management. While the project design in both the courses were fairly similar, the database management course laid more emphasis on the database aspects of a system, while that of the IS project management course laid more emphasis on the web-based interface aspects.

Teams were responsible for gathering a client's system requirements, analyzing the requirements, designing the system, and developing the system using a variety of technologies such as MS Access, Oracle, Macromedia Flash, and Active Server Pages (ASP). In addition, each team had to prepare a number of documents through the life of the project. Some of the specific activities and deliverables that teams were required to create are listed below:

- initial description of the project
- plans for project management (including charts such as GANTT and PERT)
- justification of the new system to be developed for the client
- system and database designs (e.g. E-R diagrams, relational models, or appropriate process models).
- an operational information system or a working prototype.

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