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ABSTRACT: This paper addresses the understudied issue of *how* individually held expertise in information systems development (ISD) teams results in creativity at the team level during the development process. We develop the idea that team creativity results primarily from integration of individually held expertise of team members at the team level. We further propose the quality of intrateam relationships and knowledge complementarities that align the work of individual team members at the project level influence creativity primarily through the process of expertise integration. We use data from a field study of 142 participants in 42 ISD projects to test the proposed model.

The paper makes three new contributions to the IS literature. Its key contribution lies in developing an expertise integration view of team creativity. We demonstrate the centrality of integrating individually held tacit and explicit knowledge about the problem domain and the technology at the team level in achieving team creativity. The use of a process-focused conceptualization of team creativity is especially noteworthy here.

The second contribution of the paper lies in conceptually developing and operationalizing the concept of expertise integration, a mechanism by which individually held knowledge is integratively applied at the project level. Although the importance of knowledge in the ISD process is widely recognized in prior research, this is the first study to develop the concept in a operationally meaningful way. The third key contribution lies in showing that the compositional and relational attributes of ISD project teams—diverse specialized knowledge in a team, the quality of intrateam working relationships, and members' cross-domain absorptive capacity—do not engender creativity by themselves; they do so primarily because they enhance integration of individual knowledge at the project level. We offer empirical evidence for such full mediation. These findings have important theoretical and practical implications, which are discussed in the paper.

KEY WORDS AND PHRASES: absorptive capacity, creativity, expertise integration, information systems development, information systems innovation, integration, knowledge integration, knowledge management, knowledge transfer, software development.

DEVELOPMENT OF INFORMATION SYSTEMS (IS) is a creative effort that involves the expertise, insights, and skills of many individuals. As organizations encounter the need to develop systems for novel business applications (e.g., knowledge management, peer-to-peer collaboration) and new problem domains (e.g., reverse logistics in supply chains), the need for creativity in the information systems development (ISD) process is increasingly recognized in practice. However, the creativity construct itself remains narrowly studied in the IS literature. A review of over two decades of literature (1981–2003) reveals three themes in IS studies on creativity. First, studies have focused primarily on creativity as a causal outcome of IS use. Examples include studies of how decision support systems enhance individual creativity (e.g., [42]), how creativity support systems (CSS) influence the quality and quantity of individual creative output (e.g., [43, 73]), and how the use of software tools stimulates individual creativity [23, 41, 49, 58, 59]. No prior study has examined creativity *during* the ISD process. Second, the unit of analysis used to examine creativity has primarily been individuals, whereas most ISD in contemporary organizations is carried out in project *teams.* Third, IS researchers have operationalized creativity as a novel and useful outcome, as judged by experts. However, creativity researchers in other disciplines have cautioned that this reductionist approach is biased toward successful outcomes and prone to retrospection bias [22, 66]. Thus, while creativity is recognized as an important element of ISD, gaps in the existing literature prevent us from answering the basic question of *how* expertise in an ISD team translates into creative processes. In the present study, we address two research questions that follow from this overarching research problem.

   1. How does the expertise of individual team members influence an ISD project team's creativity?

   2. How do the compositional attributes of an ISD team influence its creativity?

We theoretically develop the idea that an ISD team's creativity is predicted by the extent to which its members integrate their specialized expertise to jointly develop project concepts, designs, and solutions. We refer to such recombination of individual expertise at the project level as expertise integration. We then focus on some antecedents of expertise integration that are rooted in the compositional attributes of the team: heterogeneity of expertise, the quality of the relationships among team members, and their ability to interrelate with the expertise of their peers outside their own domain. Their influence on creativity is fully mediated by expertise integration. The model is empirically tested through a field study of 142 participants in 42 ISD project teams and their senior management project stakeholders.

The study makes three novel contributions to the ISD literature. First, it conceptualizes the perspective that individually held expertise influences creativity in the ISD process *primarily* through the process of expertise integration at the team level. This is an important contribution, because it highlights the central role of expertise integration in facilitating team creativity—a relationship that has not previously been conceptually developed or tested. This has pervasive implications for ISD, because it shifts attention away from knowledge transfer (as implicitly assumed in ISD activities such as requirements specification and models such as the waterfall approach) toward its integration at the project level. The second noteworthy contribution of this paper is in showing how integration of individually held expertise at the team level enhances team creativity in the ISD process. With the sole exception of Cooper's [15] descriptive study, no prior study has examined the role of expertise integration in enhancing creativity in ISD. It is noteworthy that although the importance of diverse knowledge in the ISD process is well recognized in prior IS research, this is the first study to actually measure the concept of expertise integration and empirically test its relationship with team creativity. The third important contribution is demonstrating that the compositional attributes of the project *team*—heterogeneity in team members' expertise, the quality of the working relationships within the team, and their collective absorptive capacity—influence the extent to which its members can integrate their diverse expertise bases in formulating a coherent set of ideas for the project solution. This lends new insights into managing ISD projects, which continues to be a dominant challenge in contemporary organizations [50, 71], especially aligning ISD projects with their business objectives [39, 68]. Although it was not the focus of this study, we also demonstrate that higher levels of creativity at the team level are associated with higher levels of project success. This finding complements prior work on improving ISD project outcomes by using tools for enhancing ISD productivity [18, 62], project control mechanisms [47], and utilization of a variety of methodological variations [34]. In summary, the study contributes new insights into a key mechanism—the process of integrating individual

knowledge at the project level—through which individually held expertise leads to creativity during the ISD process.

Theoretical Development

IN THIS SECTION, WE FIRST EXAMINE the theoretical domain of creativity in ISD. We then develop the idea that creativity at the team level emerges from integrating individually held expertise at the project level. Such integration, in turn, is facilitated by the compositional antecedent characteristics of the project team's knowledge and relational attributes.

Team Creativity

Team creativity is defined as the degree to which a project team's processes are novel in the context of the project's objectives [22]. Creative processes can exist both at the individual level and at the group level. Since researchers have only recently paid attention to the differences between individual and team creativity, it is worthwhile considering how the two differ. The noteworthy difference is that creativity at the team level is an inherently social process [53]. Individual contributions are a part of, but not the entirety of, team creativity.[1] Team creativity emerges from an improvisational process where individual team members collaboratively build on and interrelate their ideas with the perspectives and unique skills of other individuals in the project team, so that the joint activities of individual team members create a collective system of creative actions. In addition, there are occasions where one individual's actions spark collective actions that are creative in nature. Thus team creativity is inherently a social process that builds on and incorporates individual creative processes at the project level.

ISD is an inherently creative process because it involves generation and evaluation of new ideas, designs, solutions, and artifacts (for a review, see [51]). The systems development life cycle involves translating an abstract business idea into project requirements, which are then used to create project concepts and system specifications, and eventually the functionality and features in the software code. Successful ISD thus depends on a team's developing a preliminary idea beyond its embryonic state by drawing on several interdependent bases of expertise. There is rarely "one right design" for an ISD problem, because there is often more than one possible solution to the same end [55]. Depending on how creative the process is, a team might come up with one of many possible solutions to the same problem. Thus a creative development process is likely to explore multiple possible solutions.

The importance of creativity in the ISD process has only recently been explicitly recognized [15], and the construct itself has received little direct attention in IS research. The collective nature of creativity has been largely unexplored [53].[2] The prevalent conceptualization of creativity as a novel and useful outcome further blurs the distinction between creative processes and outcomes.[3] An approach that assesses

the degree to which a team's processes are creative recognizes that creative processes are a necessary but insufficient condition for creative outcomes [22], and is thus more appropriate for assessing creativity in ISD teams [61]. It also ensures that creative processes are conceptually separable from their outcomes. Team creativity, in turn, influences project outcomes—an assumption that is later empirically confirmed in this study.

Expertise Integration

At the core of the knowledge-based view of organizing is the conception of organizational entities such as project teams as vehicles for integrating tacit and explicit knowledge that is distributed among many individuals [27]. While expertise is "owned" at the individual level, it is necessary to integrate specialized, individually held expertise into collective (project) knowledge for a project to benefit from it [52, 61]. Building on Grant's [27] initial conceptualization and recent team-level extensions of Grant's definition [2, 52], we define expertise integration as the coordinated application of individually held specialist expertise in the accomplishment of tasks at the *project* level.[4] Expertise is integrated when at least one piece of knowledge from one individual is used together with expertise from another team member to accomplish a project task. Thus, integration of the understanding and expertise of different individuals at the project level renders it usable for creating the system.

Central to the process of integrating expertise is the conversion of knowledge consisting of socially derived scripts, interpretations, and goals of individual team members into a coherent software system. Much of the prior research on knowledge management has focused on knowledge transfer and knowledge sharing. Little attention, however, has been paid to expertise integration, which refers to the process by which existing individually held expertise is *brought to bear* at the project level [2]. Although expertise integration is one mechanism for applying the knowledge of many individuals in a team to the ISD process, in theory this end can also be achieved through knowledge transfer or knowledge sharing. It is therefore useful to distinguish expertise integration from knowledge transfer and sharing.

For simplicity of illustration, consider a two-person setting where person A and person B each possess one piece of unique knowledge $K(a)$ and $K(b)$ before the transfer/sharing/integration process. *Knowledge transfer* refers to transmission of knowledge from one individual to another [2]. Ideally, at the end of such a knowledge transfer process, the transferee should possess the transferred knowledge $K(a)$ of the transferor in its entirety [17]. Therefore, the widely used waterfall model of ISD implicitly assumes that such knowledge transfer is possible during the initial requirements determination phase of systems development. However, the presence of tacit components of knowledge makes knowledge transfer—while theoretically feasible—a less viable mechanism for applying members' knowledge to the ISD process. The primary reason is that knowledge transfer is an inherently slower and inefficient process [64]. As our results later illustrate, the typical project in this study lasted only about six months, leaving little time for knowledge transfer to be viable. *Knowledge*

sharing is a more limited instance of knowledge transfer: It involves revealing the presence of pertinent knowledge without necessarily transmitting it in its entirety (i.e., B's gaining only a subset of knowledge $K(a)$ from A via knowledge sharing). The viability of knowledge sharing as an approach for knowledge application in software projects is problematic for two reasons. First, the tacit elements of knowledge, such as a customer's understanding of his or her needs, are difficult to fully articulate up front in the form of formal project requirements or system specifications. Second, knowledge sharing does not ensure that the knowledge shared by individual project participants will be *utilized* during the ISD process. Moreover, technical change or requirements volatility might render some knowledge irrelevant by the time it is transferred or after it is shared.

Effective teamwork emerges from new knowledge that results from interactions among specialists in a team, not simply from individual gains in knowledge by individual team members [52]. In other words, individuals in the team must integrate the knowledge that is shared at the project level to realize its value. When considerable tacit knowledge is involved, coordinated application of the knowledge held by many individuals to the project is more feasible through expertise integration, because it does not incur the time and costs needed for team members to teach each other their jobs (i.e., full-fledged knowledge transfer). Expertise integration involves development of new *project-level* knowledge based on the insights contributed by many individuals. Unlike knowledge sharing or knowledge transfer, expertise integration builds on, *but goes beyond,* specialized domain expertise. It requires both sharing of individually held knowledge with the rest of the team and utilization of the shared knowledge in the context of the project. Expertise integration therefore cannot be reduced to knowledge sharing, although it involves some degree of iterative knowledge sharing. The outcome of expertise integration is new project-level knowledge that synthesizes insights from the multiple thought worlds of the team members [21]. Project-level knowledge that results from the process of integration is idiosyncratic to the project and is held collectively at the team level [52]. Expertise integration thus creates a *negotiated* set of beliefs among the project team members. Such integration creates a "mutual equivalence structure" [72] wherein each team member recognizes that the ISD process consists of his own and other team members' interdependent expertise, and constructs individual actions to be relevant to project activities.

Expertise Integration in ISD Project Teams

Fully understanding the problem that the intended system must solve is often one of the most challenging aspects of ISD [32]. Developing a system that addresses the problem domain requires two types of knowledge: Technical knowledge and knowledge about the application problem domain [57], much of which is dispersed among different project stakeholders such as analysts, domain experts, programmers, and potential users [16, 32]. Such technical and application domain knowledge must be integrated at the project level in formulating project concepts and solutions. Some of it—even when available within the team—is not readily available in an explicit form

(such as requirements documents) or captured in formal specifications [9, 69].[5] Moreover, ISD largely consists of heuristic tasks—that is, tasks that do not have clear and readily identifiable paths to the solution [15]. This makes it difficult to fully transfer knowledge through requirements documents and formal specifications.[6] Unless this knowledge is integrated during the ISD process, it is unlikely that artifacts of the ISD process (e.g., requirements documents, specifications, features, use cases, code, and documentation) will accurately capture the capabilities that users need from the system. For example, information that software architects and programmers need in the ISD process is often not available to them through documents, although analysts and end users may have this knowledge [38]. When integration of team members' expertise at the project level is poor, the team might build its *ignorance*—unstated requirements, evolving user needs, unrecognized constraints, and incomplete understanding of the problem domain—into the design of the system. Thus some of the considerable risk involved in the ISD process stems from the risk that the delivered solution simply fails to meet changing business needs [6, 7].

Expertise Integration and Creativity

Next, consider how expertise integration influences creativity at the team level. Highest levels of team creativity are a result of different cognitive structures coming together [46]. Team creativity results from finding novel associations and linkages among the diverse ideas, perspectives, and domain expertise that individual team members hold [4, 15, 30, 63]. Individuals in a team often bring different ideas, perspectives, and expertise to the project. Access to a variety of alternatives, example solutions, and ideas can *potentially* lead to higher team creativity [4]. But realizing this potential for creativity requires that such ideas be relevant to the project. This requires that individually held expertise be applied to project activities with an appreciation of the project context, its business needs, and constraints.

  ISD projects must draw on and integrate the contributions of various members into a coherent solution [14]. Integration of individually held expertise at the team level provides a mechanism for enhancing team creativity, because it leads team members to access, explore, and use diverse information from related knowledge domains associated with the project. Individual team members, however, often start out with their own partial mental models about the design problem and possible solutions, which are biased by their prior experience in other ISD projects [55]. Before connections among diverse ideas and viewpoints can be explored, individual team members must first overcome their preexisting biases and stereotypes that are deeply rooted in their functional identities and backgrounds [74]. Team members' exposure to different alternatives, approaches, and ideas can trigger a generation of divergent solutions [53]. As they engage in integrating their understanding of the project with other team members, the team can arrive at an agreeable shared vision of the system's structure, function, interdependencies, and needed capabilities. This common understanding brings various team members closer to a common understanding of the requirements that the system must address [32]. Expertise integration thus creates a shared under-

standing about the project within which novel associations among individually held diverse expertise bases can be created [22, 44]. This shared understanding allows the ISD team to remain cognizant of various technical, operational, and economic constraints, which might not be known in their entirety to any single individual in the team. This facilitates consideration of design and implementation problems from less obvious perspectives, because the ISD process then draws on the expertise of many individuals in generating and evaluating potential design solutions. Expertise integration thus facilitates experimentation with novel associations among the expertise, viewpoints, potential solutions, and perspectives held by individual team members, thereby enhancing the ISD team's creativity. Integration of individually held expertise at the team level is therefore necessary for creative processes to emerge in the ISD process. This leads to our first hypothesis.

> *H1: Expertise integration is positively and directly related to creativity in ISD teams.*

Compositional Antecedents of Team Creativity. Clearly, one of the challenges facing managers is that of organizing a team at the outset of a project that is more likely to be creative during the ISD process. This is a question concerning team design, which is defined as the clustering of individuals and their relationships into a project team, and the knowledge complementarities that align their work at the project level. The most diverse collection of expertise bases in a given team is likely to result in *potentially* the most creative teams, but *realizing* creativity in a diverse, interdependent group of individuals in a team is another issue. This dilemma poses a problem of organizing a team that will likely be creative, rather than merely have the potential to be creative.

Given the central position of the perspective that team creativity in ISD projects emerges through the process of integrating individually held expertise at the team level, we chose to focus on a subset of antecedent variables that collectively specify some team-level compositional attributes that influence expertise integration at the team level. Although several factors have been linked to creativity, three important factors are directly relevant to this view—the diversity of knowledge available in a team, the working relationships among team members, and the extent to which the team members can interrelate with each others' expertise. Normally, such expertise integration is difficult to achieve in cross-functional project teams, because people from different functional areas hold biases and stereotypes toward one another, which need to be adapted. The most profound challenges to integrating knowledge come from the ability of individuals to utilize the expertise of their peer team members in their collective project activities and from the quality of relationships among them [64]. We therefore focus on three key antecedents of ISD team creativity—expertise heterogeneity, relational capital, and absorptive capacity.[7] These variables capture the key intrateam properties of the content of individually held expertise and the relationships through which that expertise is applied to *project* activities. The conceptual logic that we develop is that these variables influence team creativity by facilitating expertise integration. Clearly, this set of factors is a subset of all possible factors that can influence expertise integration, as acknowledged later in the paper.

Expertise Heterogeneity

ISD projects must draw on knowledge from multiple technical and functional domains [16, 70]. One mechanism for gaining direct access to such diverse expertise is to have team members with heterogeneous expertise, who will bring to the project different sets of skills, perspectives, and knowledge that are less likely to be available to a homogenous team [5, 10]. We define expertise heterogeneity as the diversity in the expertise possessed by the members of a project team. As the number of functional domains represented by individual members increases, so does the variety of ideas and the range of possible linkages and associations among those ideas. Individual team members can then borrow ideas and concepts from outside their own domains, often drawing different implications from the same ideas. Recombination of ideas that are old in a specific knowledge domain but new to the team can lead to creative new ways of formulating and conceptualizing project ideas. In contrast, individuals with similar backgrounds and experiences tend to view things similarly, thereby missing opportunities for exploring novel design ideas. Members of a heterogeneous team also provide access to a broader set of external networks [5]. This allows the team to draw on a broader set of external sources of information and knowledge during the ISD process.[8] Therefore, a team with a heterogeneous expertise base is likely be better at exploring design decisions at depth, pose more diverse alternatives, and challenge assumptions that might be readily accepted in more homogenous teams. However, too much expertise heterogeneity can be a mixed blessing: while heterogeneity brings a more varied pool of expertise for potential recombination, the difficulties in reconciling diverse interpretations of project goals and divergent perspectives can impede the team's ability to reach consensus on project goals and priorities. In such instances, it is imperative that the variety of expertise in a team also be pertinent to the project. This might be especially the case in ISD projects, where team processes involve more complex forms of interdependence among team members relative to, say, industrial work teams. In summary, expertise heterogeneity is likely to provide a team more opportunities for creatively combining a variety of knowledge and perspectives, while simultaneously posing a challenge in the team's ability to reconcile excessively divergent ideas when heterogeneity is high. This leads to our second hypothesis.

> *H2: Expertise heterogeneity is positively related to expertise integration in ISD teams.*

Relational Capital

Relational capital is defined as the level of trust, reciprocity, and closeness of working relationships among the members of a team [35]. Integrating a given team member's expertise into the team's development activities requires that others in the team both trust his or her expertise and be able to incorporate it with relative ease. Relational capital facilitates this. Higher levels of relational capital increase the likelihood that individuals in the team trust each other [64], which in turn, increases their willingness

to build on each other's perspectives, ideas, and expertise during the ISD process. The close working relationship facet of relational capital reduces the costs of doing so, given that stronger ties are associated with lower costs of sharing and eventually integrating complex tacit knowledge [29]. Recall also that the precise expertise contributions of each individual can be difficult to predict ex ante, although the general nature of each individual's contributions is predictable based on her assigned role in the project. The reciprocity facet of relational capital facilitates contributions of expertise beyond levels that can be negotiated in advance [45]. Higher levels of relational capital will thus enhance team creativity by facilitating project-level integration of diverse ideas, perspectives, and expertise that individual team members bring to the project. This leads to our third hypothesis.

> *H3: Relational capital is positively and directly related to expertise integration in ISD teams.*

Absorptive Capacity

Absorptive capacity is defined as the ability of the members of a team to interrelate with the expertise of their peer team members [13, 67]. Although the construct of absorptive capacity has been studied mostly at the firm level, Cohen and Levinthal's [13] original description also explicitly identifies the construct at the group level. Although a team's absorptive capacity stems from the individuals belonging to it, they caution that it is not resident in any single individual but depends on a mosaic of individual capabilities. A team's absorptive capacity in a given knowledge domain is therefore a function of the expertise of the individuals in that domain *and* the expertise of other team members with whom such individuals are collaborating.[9] Absorptive capacity at the team level raises individuals' awareness of the pool of available expertise in their team, lowers interpretive ambiguities, and breaks individual team members from confinement in their own thought worlds, as discussed next.

First, integration of complex technical knowledge requires that team members be competent in their individual areas of expertise but also familiar with the expertise and skills of others in their team [13, 52]. Members of a team with higher absorptive capacity are more likely to hold shared conceptualizations of each other's expertise. This allows team members to recognize how their peers' expertise complements their own, especially when it falls outside their own speciality.

Second, the same information is subject to multiple plausible interpretations. For example, project requirements are derived from expressed or inferred customer needs and business goals [3]. Interpretations of such information are socially constructed by the members of a project team. But, using any such information requires that the receivers possess sufficient background knowledge to understand it. The cognitive limits of individual knowledge, however, force them to rely on their peer team members to help interpret and integrate such information [27]. Individual team members therefore serve as knowledge brokers or interpreters of information that relates to their area of expertise, thereby making it more intelligible to the entire team. In a

qualitative field study, Curtis et al. [16] found that individuals with specialized expertise often act as hubs for bringing outside expertise into the project team. In contrast, critical information held by one team member might never be utilized by a team that lacks the capacity to interpret it. Therefore, higher levels of absorptive capacity will assist the team in the interpretation of project-related information, raising its prospects for integration during the ISD process. This leads to our fourth hypothesis.

H4: Absorptive capacity is positively related to expertise integration in ISD teams.

The Mediating Role of Expertise Integration

Finally, we posit that the effects of expertise heterogeneity, relational capital, and absorptive capacity on creativity are mediated by expertise integration. Consider each in turn. Diverse individually held expertise enhances the creativity of software project teams primarily because such expertise can potentially lead to its project-specific recombinations in less obvious ways. Although the positive association between the diversity of viewpoints in a team and creativity has been known since the early 1960s, such heterogeneity by itself does not lead to higher levels of creativity. For example, Dougherty's [21] study of cross-functional product development teams found that teams perform better when their members combine their perspectives in an interactive, iterative fashion. Similarly, relational capital enhances creativity because it allows team members to experiment with new recombinations of tacit knowledge embodied in individual expertise, viewpoints, and ideas. Likewise, absorptive capacity enhances creativity because it helps find novel linkages between disparate ideas, perspectives, and knowledge held by individual team members. For the foregoing reasons, we hypothesize that these variables influence creativity primarily because they facilitate expertise integration. This leads to our final hypotheses.

H5a: The influence of expertise heterogeneity on an ISD project team's creativity is fully mediated by expertise integration.

H5b: The influence of relational capital on an ISD project team's creativity is fully mediated by expertise integration.

H5c: The influence of absorptive capacity on an ISD project team's creativity is fully mediated by expertise integration.

Methodology

A FIELD SURVEY WAS CONDUCTED to test the hypothesized relationships. Figure 1 provides an overview of the methodology. Project-level data on each project were collected from multiple stakeholders in each project team. The respondents included multiple members from each project team as well as the primary user-side manager from the organization that eventually used the system that was developed by each project team. This approach was appropriate for the study, because the objective was
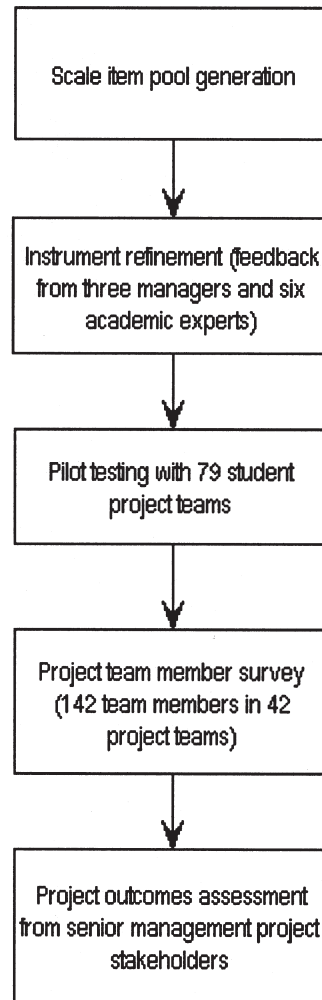
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┌─────────────────────────────┐
│  Scale item pool generation │
└─────────────────────────────┘
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│ Instrument refinement (feedback │
│  from three managers and six │
│      academic experts)      │
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│   Pilot testing with 79 student │
│        project teams        │
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│   Project team member survey │
│    (142 team members in 42  │
│        project teams)       │
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│  Project outcomes assessment │
│ from senior management project │
│        stakeholders         │
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Figure 1. An Overview of the Study Methodology

to empirically test the proposed model, which itself was built on a synthesis of prior work that had adopted an observational, qualitative approach for examining knowledge management issues in ISD projects.

Description of the Research Setting and Data Collection

We gained access to a sample of interorganizational software projects through management sponsorship in a large U.S. services conglomerate. All teams in our study were created temporarily for the project and were collocated for its entire duration. The typical project lasted about six months, and some were as short as eight weeks. The short duration of these projects afforded little time for knowledge transfer among team members, as discussed earlier in the theory section. Therefore, the sample was

Table 1. Summary of Key Constructs and Their Measures

Construct	Definition	Number of items	Source of scale
Creativity	The degree to which a project team's processes are novel in the context of the project's objectives.	3	[19]
Expertise integration	Synthesis of individually held specialist expertise at the project level.	4	New scale
Expertise heterogeneity	The diversity in the expertise possessed by the members of a project team.	3	[10]
Relational capital	The level of level trust, reciprocity, and proximity of ties among the members of a project team.	5	[35]
Absorptive capacity	The ability of the members of a team to interrelate in a project's context to the expertise of their peers outside of their own specialized domain.	3	New scale

appropriate to examine the issue of expertise integration, since it was more likely to be salient in such relatively shorter projects. We approached 173 individuals working in 46 different project teams with the survey questionnaire.[10] Data were collected from multiple team members in each project team. We received 142 responses from individuals in 42 project teams after two reminders. This represents an 82 percent (142 responses/173 requests) response rate at the individual level and 91 percent (42 projects for which responses were obtained/46 projects whose members were contacted) at the project level. Following this round of data collection, project success evaluations for each project were obtained from a senior manager who spearheaded the project.

Construct Operationalization and Scale Development

All research variables were measured using multi-item five-point Likert scales, as summarized in Table 1. Since this study involves constructs that exist at multiple levels of analysis, we paid close attention to ensuring that all of our scales were operationalized at the team level (see [37]).

Expertise heterogeneity was measured using Campion et al.'s [10] three-item scale that assesses the extent to which team members represent diverse backgrounds, experiences, and nonoverlapping domains of expertise. Relational capital was measured using a team-level adaptation of Kale et al.'s [35] five-item scale. This scale assesses member's perceptions of team-level trust, reciprocity, and strength of ties. Creativity was assessed by tapping into the extent to which the team's *processes* were creative. An outcomes-oriented approach in a variance model would instead have measured the extent to which the team's *outcomes* were judged as being creative. We used

Denison et al.'s [19] three-item measure that assessed the team's experimentation with alternative ways of solving the problem at hand, the extent to which a team was imaginative in thinking about new and better ways, and invention of new ways to address nonroutine project matters.[11]

Scales to measure expertise integration and absorptive capacity were developed through a multistep, iterative procedure.[12] We measured expertise integration by assessing the extent to which a team's members synthesized their individual expertise at the project level, synthesized various members' tacit knowledge and expertise in developing project concepts, understood the project from a systemic perspective, and synthesized their own expertise with such project-level knowledge [27, 52, 70].[13] We measured absorptive capacity as a team-level construct that assessed the extent to which individual members in each project team could interrelate with the knowledge, expertise, and skills of their peer team members (e.g., [8, 13, 75]).

We controlled for two variables that might influence team creativity: (1) technological uncertainty and (2) stage of the project at which data were collected from team members. Technological uncertainty is defined as the rapidity with which the hardware and software central to the project and the skill sets associated with them were changing. A project context characterized by high technological uncertainty is more likely to evoke creative responses to project problems. The scale was adapted from Poppo and Zenger's [54] technological uncertainty scale that was developed in an IS context. As for project stage, as a project approaches its very last stages, a team is less likely to engage in creative processes and will instead focus on tying loose ends before looming deadlines approach. The measure asked the *project* manager (not the project sponsor who evaluated the project's success) to assess the current stage of the project on a five-point scale with 20 percent increments.[14]

Limitations

Before discussing the results, five limitations of this study should be noted. First, the model did not cover all antecedents of team creativity. Instead, it focused only on a subset of factors that influence expertise integration. Second, the correlations between relational capital and expertise integration were high. Although measurement model analyses showed that there is sufficient discriminant validity between these constructs, caution must be exercised in interpreting the associated results. Third, project success assessments from senior managers were used as a secondary check for common methods bias. Since this variable is downstream from creativity, it only partially addresses this concern. Nevertheless, since the main dependent variable—team creativity—was based on assessments of multiple team members in each project, common methods bias is not likely to be a persuasive threat. Fourth, lack of support for the hypothesized positive relationship between expertise heterogeneity and expertise integration warrants further attention. It is difficult to rule out the possibility that the absence of the significant relationship might be an artifact of the way in which the construct was measured. Finally, creativity was measured as the degree to which a team's processes were creative, consistent with the variance modeling ap-

proach used in this study. This, however, is not the same as truly process observations, which require longitudinal data.

Results

WE USED PARTIAL LEAST SQUARES (PLS)—a second-generation structural equation modeling technique—to revalidate the measurement model and then to test the hypothesized relationships in two steps using PLS-Graph 2.91.[15]

Measurement Model Assessment

Convergent and discriminant validity for all scales was assessed both before and after aggregating data to the team level (only postaggregation values are reported for brevity). The correlations among various constructs shown in Table 2 are the team-level, postaggregation values. As Table 2 shows, each item loaded highly on its respective construct. Cronbach's alpha for all constructs exceeds the 0.7 threshold recommended by Nunally [48], and the internal consistency reliability (ICR) for each construct exceeds 0.8, confirming convergent validity [25]. The loadings of all indicators on the corresponding theoretical constructs exceed the recommended 0.7 threshold in the PLS measurement model (see Table 2) [12, 33]. Cronbach's alpha is not computed for technological uncertainty because it has two measurement items. Discriminant validity was indicated by three assessments in the PLS measurement model: (1) items had low (< 0.5) and nonsignificant cross-loadings, (2) the diagonal elements representing $\sqrt{\rho_{vc}}$ exceeded the off-diagonal elements in the construct correlation matrix, and (3) the ratio of the variance in the indicators for each construct relative to the total amount of variance ρ_{vc} exceeded 0.5 [25]. For example, the bold diagonal element for expertise integration is 0.92, which exceeds all off-diagonal elements in Table 2. Similarly, relational capital has a diagonal element of 0.86, which again exceeds all off-diagonal elements in the correlation matrix. This assessment along with ρ_{vc} values of 0.85 and 0.74, respectively (both of which exceed 0.5), suggests that in spite of the correlations observed in the exploratory factor analysis (shown in the Appendix), the constructs exhibit sufficient discriminant validity. Similar patterns of results for expertise heterogeneity and absorptive capacity suggest that the constructs exhibit sufficient discriminant validity.

Data Aggregation

Data were collected from multiple respondents for each project team and were aggregated for each project after assessing within-team agreement. To assess such within-team agreement, the interclass correlation coefficient (ICC) was used to test whether membership in a team also led to similar patterns of responses. The ICC values reported in Table 1 range from 0.58 to 0.87, which indicates sufficient within-team agreement to justify aggregation [36]. Note that all constructs are operationalized at

Table 2. Psychometric Properties and Aggregation Statistics of Key Constructs

	Mean	S.D.	Number of items (PLS loadings)[a]	α_i	α_t	ICR	ICC	ρ_{vc}	1	2	3	4	5	6	7	8
1. Expertise integration	3.77	0.54	4 (0.87, 0.94, 0.95, 0.93)	0.92	0.94	0.96	0.74	0.85	**0.92**							
2. Creativity	3.63	0.69	3 (0.92, 0.80, 0.93)	0.80	0.86	0.91	0.58	0.71	0.71	**0.84**						
3. Expertise heterogeneity	3.75	0.43	3 (0.98, 0.89, 0.93)	0.95	0.92	0.95	0.87	0.91	−0.19	−0.18	**0.95**					
4. Absorptive capacity	3.91	0.67	3 (0.94, 0.97, 0.88)	0.93	0.93	0.95	0.82	0.55	0.76	0.6	−0.18	**0.74**				
5. Relational capital	3.74	0.81	5 (0.86, 0.91, 0.94, 0.92, 0.92)	0.91	0.93	0.96	0.73	0.74	0.70	0.53	−0.04	0.55	**0.86**			
6. Project success[b]	3.71	0.37	3 (0.62*, 0.91, 0.82)	—	0.8	0.83	—	0.63	0.18	0.21	0.18	0.19	0.24	**0.79**		
7. Technological uncertainty	2.94	0.61	2 (0.98, 0.90)	—	—	0.94	0.86	0.81	0.11	0.13	−0.27	0.18	0.1	−0.23	**0.9**	
8. Project stage	80–100 percent[c]	1.42	Single item measure	—	—	—	—	—	0.17	−0.01	0.27	0.25	0.15	0.35	−0.07	—

Notes: Shaded diagonal elements are the square root of the shared variance between the constructs and their measures. Off-diagonal elements are the correlations between the different constructs (aggregated team-level data). ICR = Fornell and Larcker's (1981) internal consistency reliability. [a] $p < 0.001$; * $p < 0.01$. [b] Senior manager's evaluation. [c] Median value on a five-point scale with 20 percent increments. α_i and α_t represent pre- and postaggregation construct reliability coefficients.

the team level; aggregated values are therefore the average of individual members' perceptions of their *team*. Since only one response was available for each project's success, no such aggregation was possible for this construct.

Descriptive Statistics and Demographics

The respondents in our sample had about 7.8 years of information technology (IT) experience and had been with their organization for about 16 months on average. The average team consisted of about nine members. The average duration of the projects was 6.2 months. At the time data were collected from project team members, most projects were in their final stages (the median value of the project stage variable was "80–100 percent complete").

Structural Model Assessment

A PLS structural model represents the relationships among various latent constructs. Paths in this model are interpreted as standardized regression weights and the loadings on each construct as loadings in principal component analyses. A bootstrapping procedure with replacement using 500 subsamples was used to estimate the statistical significance of the parameter estimates. A summary of these results is presented in Figure 2.

Expertise integration had a significant positive effect on creativity ($\beta = 0.719$, t-value = 7.616, $p < 0.001$), supporting H1. H2, which posited a positive relationship between expertise heterogeneity and expertise integration, was not supported ($\beta = -0.059$, t-value = -1.08, $p > 0.1$). Relational capital had a significant positive effect on expertise integration ($\beta = 0.349$, t-value = 3.76, $p < 0.001$), supporting H3. Finally, absorptive capacity had a significant positive effect on expertise integration ($\beta = 0.645$, t-value = 7.39, $p < 0.001$), supporting H4. To test the mediation role of expertise integration, we assessed the direct effects of expertise heterogeneity, relational capital, and absorptive capacity on creativity. The effects of expertise heterogeneity ($\beta = -0.023$, t-value = -0.228, $p > 0.1$), relational capital ($\beta = 0.100$, t-value = 0.728, $p > 0.1$), and absorptive capacity ($\beta = 0.355$, t-value = 1.365, $p > 0.1$) on creativity all lacked statistical significance. Thus, the full mediation hypotheses, H5b and H5c, were supported. Absence of any significant direct relationships between these variables and creativity confirms full mediation by expertise integration and lends support to our argument that they influence creativity primarily because they facilitate expertise integration. As expected, technological uncertainty had a significant positive relationship with creativity ($\beta = 0.246$, t-value = 2.154, $p < 0.05$). The other control variable, project stage, was not significant ($\beta = -0.14$, t-value = -1.492, $p > 0.10$). Although it is difficult to establish causality using cross-sectional data, the absence of any significant direct effects of expertise heterogeneity, relational capital, and absorptive capacity on creativity provide some support for a causal association. We also assessed the threat of common methods bias and confirmed that creative
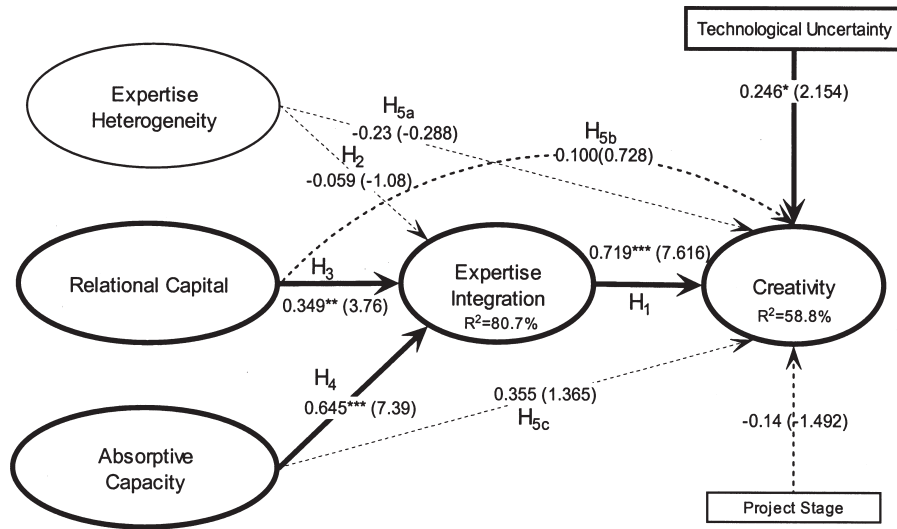
Figure 2. Research Model and Results
Notes: ----- Nonsignificant path; significant paths are in boldface; *** $p < 0.001$,
** $p < 0.01$, * $p < 0.05$.

processes at the team level do lead to superior project outcomes.[16] Table 3 summarizes these results.

Model Quality Assessment

The predictive quality of a model can be assessed in two ways: (1) percentage of the total variance it explains (R^2) and (2) its predictive relevance score (Q^2). Our model explained 58.8 percent of the variance in creativity ($R^2 = 0.588$). Of this, 7.1 percent of the variance was explained by the two control variables and the remaining 51.7 percent was explained by expertise integration. In addition, the model explained 80.7 percent of the variance in expertise integration, suggesting that relational capital and absorptive capacity are powerful predictors of expertise integration. Furthermore, the average Q^2 value across all five runs was 0.3553, which suggests that our model has high predictive relevance [11].[17] Together, the R^2 and Q^2 values suggest that the model predicts creativity reasonably well.

Discussion and Implications

THIS STUDY WAS MOTIVATED BY the scantness of prior research on team-level creativity in the ISD process, which is becoming ever more critical as organizations seek to develop software applications in new and novel problem domains. A noteworthy feature of our approach is that we conceptualized creativity in the ISD process instead of simply judging whether the outcomes of the project were creative. This refined

Table 3. Summary of Hypothesis Tests

Hypothesis	Hypothesized effect	Supported	β (*t*-value)
H1: Expertise integration → Creativity	+	Yes	0.72*** (7.62)
H2: Expertise heterogeneity → Expertise integration	+	No	−0.06 (−1.1)
H3: Relational capital → Expertise integration	+	Yes	0.35** (3.76)
H4: Absorptive capacity → Expertise integration	+	Yes	0.64*** (7.39)
Full mediation hypothesis			
H5a: Expertise heterogeneity → Creativity	Full mediation by expertise integration	No	−0.23 (−0.29)
H5b: Relational capital → Creativity		Yes	0.10 (0.73)
H5c: Absorptive capacity → Creativity		Yes	0.35 (1.36)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

conceptualization is consistent with the emerging contemporary view of creativity in management and psychology.

This is one of the first studies to develop a conceptual explanation of the mechanism of knowledge integration through which individually held expertise in a team translates into creativity at the team level. We further developed an explanation for the antecedents of creativity, which we argued influence creativity by facilitating integration of individually held expertise at the project level. Our conceptualization of ISD project teams as systems of relationships and expertise, use of teams as the unit of analysis, a field setting, and use of multiple informants for each project are noteworthy. The results (see Table 3) provide considerable support for the proposed idea that expertise integration is the key explanatory mechanism through which individually held expertise leads to creativity at the team level.

The Relationship Between Expertise Integration and Team Creativity

The first important finding in our analysis is the positive and significant relationship between expertise integration and creativity (H1). The results suggest that team creativity results from developing novel associations and linkages among the diverse ideas, perspectives, and domain expertise that individual team members bring to the project. A large path coefficient of about 0.72 between expertise integration and creativity implies that teams that can draw on their members' expertise in ways that

allow individuals to build on each other's knowledge, skills, and perspectives are more likely to be creative. Expertise integration alone explained over 50 percent of the variance in creativity, suggesting that integration of individually held expertise in a team is an important predictor of an ISD team's creativity. Such integration allows the diverse perspectives and skills within a team to be brought together in a fashion that directly contributes to the creativity of the team in the ISD process. This finding is the first to test the idea that higher levels of creativity are the result of different cognitive structures and skill sets coming together. This result has profound implications for how organizations must approach the organizing of teams for creativity-seeking ISD projects. Clearly, bringing together the right set of skills is insufficient for enhancing creativity in the ISD process; it also requires that those skill sets be appropriately integrated and brought to bear on the development process. We also demonstrated empirically that team creativity is positively associated with superior project outcomes.[18]

The Mediating Role of Expertise Integration

The second important finding is that the expertise integration plays an important mediating role between the presence of expertise in a project team and its creativity in the ISD process. Our perspective details a team process whereby synergy across disparate knowledge bases can lead to more creative ISD processes.

We had predicted that the presence of diverse expertise in a team, members' ability to interrelate with each other's expertise, and good working relationships within the team are important for creativity because they facilitate integration of their expertise at the project level. The absence of any direct effects of these compositional characteristics of team expertise and relational characteristics (H5a, Hb, and Hc) supports this logic. This finding shows that the compositional characteristics of an ISD team's expertise influence its creativity primarily through the process of expertise integration. Prior research on knowledge management in ISD projects has never before established this linkage, although the concept of integration has been alluded to as being important [24, 70]. This is a novel insight, because it identifies a key mechanism through which expertise in a team translates into creativity during the ISD process. This finding cautions managers that merely collecting a variety of relevant expertise in a project team is not sufficient for creativity to emerge; managers can collect all the relevant skills, expertise, and experience bases in a team yet fail to stimulate creativity unless they conduce project-specific integration of team members' expertise.

The concept of expertise integration and the empirical support that it received in our analyses brings into question an implicit assumption that problem domain knowledge can be transferred to the ISD team during the up-front requirements gathering phase of the project. This has often resulted in requirements that either end up being unstable or incomplete, exposing the project to the risk of misfit between the users' needs and the delivered system. Our results highlight the need to consider expertise integration as a viable mechanism instead of relying too heavily on the assumption

that knowledge about customer needs can easily and accurately be transferred. Notably, no prior study that has explored the idea of integration in ISD projects has developed such a measure for the concept. Our study developed and validated a new team-level measure for expertise integration, which might be readily usable in exploring the concept in future research.

Compositional Antecedents of Expertise Integration and Creativity

The third important set of findings in this study relate to how the compositional attributes of an ISD project team's design influence its creativity through the process of expertise integration. Since this influence was fully mediated by expertise integration, we restrict the scope of this discussion only to their influence on expertise integration. Including the antecedents of expertise integration has theoretical importance because it provides some new insights into how teams that seek creativity ought to be constituted. We focused on a subset of three such attributes—expertise heterogeneity, relational capital, and absorptive capacity—that most directly influence the ability of individuals to utilize their peer team members' expertise for project tasks and the relationships through which expertise integration is facilitated. (These correspond with H2, H3, and H4.) Our findings not only lend support to, but also extend, Szulanski's [64] guiding logic for the choice of these variables.

Relational Capital

The observed positive and significant relationship between relational capital and expertise integration suggests that accessibility of other individuals' expertise within a team is an important predictor of its application to the project, especially when a detailed breakdown of each member's contributions cannot be fully anticipated in advance. Since relational capital might accrue from interactions over time, it is possible that teams with history will have higher levels of relational capital. From a theoretical perspective, future research should also examine whether there are any downsides to having too much relational capital. A potential theoretical lens could be the strength of ties literature, which suggests that the same strong ties that ease knowledge sharing might also reduce the prospect for novel recombinations. From a pragmatic perspective, this finding suggests that managerial interventions that build relational capital in newly formed teams can enhance creativity.

Absorptive Capacity

The positive influence of absorptive capacity on expertise integration points to the value of individual team members' having a basic understanding of the knowledge domains of other individuals with when they interact over the course of a project. Such understanding enhances their awareness of where complementary expertise resides within their team, reduces the likelihood of misinterpretation of project-related

information outside of their immediate domain, and allows the team to experiment with new combinations of ideas, perspectives, and concepts.[19] This finding cautions managers against perfect partitioning of project tasks among individual team members under the presumption that it improves development efficiency, because it unintendedly might stifle creativity. A larger path coefficient between absorptive capacity and expertise integration compared to that between relational capital and expertise integration indicates that absorptive capacity has a more pronounced effect on a team's capacity for integrating its members' expertise. However, the absolute magnitude of the path from relational capital is fairly large at about 0.35, indicating that relational capital is critical to the creativity of ISD project teams.

Expertise Heterogeneity

The lack of support for the predicted positive relationship between expertise heterogeneity and expertise integration is a surprising result. The negative direction of this path coefficient warrants further discussion. Although much of the contributing literature led us to predict a heterogeneous collection of expertise in a team as being unconditionally helpful, these results indicate that that might not always be the case. There are two possible interpretations for this result: (1) high levels of dissimilarity among individually held expertise might raise the arduousness of resolving conflicting ideas held by individual members to a point where the benefits of access to diverse expertise outweigh the costs of using it, or (2) previous theory is not completely applicable in this context. Both these interpretations are discussed next.

First, individuals in highly heterogeneous teams have fewer overlaps in their knowledge.[20] In the absence of sufficient overlaps, they might have difficulty in discussing the knowledge that they uniquely hold [56]. Although heterogeneity brings a more varied pool of expertise for potential recombination, the difficulties in reconciling diverse interpretations of project goals and different perspectives on possible solutions might impede the team's ability to reach consensus on project goals and priorities. This interpretation is consistent with Cooper's [15] suggestion that increased diversity in ISD groups can decrease goal congruence.

Second, the existing body of research that suggests a positive relationship between heterogeneity and team processes was developed largely in industrial teams such as those found in assembly lines and manufacturing plants (see, e.g., [19, 20, 40]). The tasks of such teams are less knowledge intensive, involve lower levels of expertise interdependence (i.e., they rely on simple pooling or sequential application of individual expertise), and their outputs are less contingent on integrating the knowledge of various members. Creativity theories remain largely untested in uncertain and rapidly changing environments [60]. Therefore, the theory behind the hypothesized positive relationship might not be generalizable to ISD teams that typically are engaged in knowledge-intensive tasks that involve more complex forms of interdependence.

Overall, the pattern of results suggests that the composition of a team is a critical factor in determining whether that team is likely to be creative in the ISD process. Managers must clearly consider both the relationships among team members and the

knowledge complementarities that align their work at the project level. Although a variety of organizational constraints might limit the discretion that managers can exercise in manipulating team design from these perspectives, some sensitivity to these issues can inform team constitution at the outset of an ISD project.

Key Contributions

The study makes three novel contributions to the IS literature. We first developed and tested the idea that individually held expertise influences creativity in the ISD process *primarily* through the process of expertise integration at the team level—a relationship that has not previously been examined. Our finding of full mediation of the limited set of antecedents of creativity by expertise integration supports this idea. This contribution integrates two disparate bodies of literature on knowledge in the ISD process and the understudied issue of creativity. The second contribution of this paper is in showing that expertise integration enhances creativity in the ISD process. With the exception of one qualitative study [15], no prior study has even raised the role of team-level expertise integration in enhancing ISD team creativity. A large proportion of variance in creativity explained by expertise integration points to its centrality in explaining team creativity. We also built on prior descriptive studies on the integration of knowledge in ISD projects [16, 70] to develop and validate a new team-level measure for the construct of expertise integration. The third contribution of the study is showing that the compositional and relational attributes of a *team's* expertise influence the extent to which its members can integrate their diverse expertise bases in formulating a coherent project solution, which in turn influences creativity at the project level. Such compositional attributes have seldom been considered in prior studies of project teams [56]. These attributes were the level of heterogeneity of team members' expertise, the quality of the working relationships within the team, and the team's absorptive capacity. The logic developed and validated was that these variables predict the degree to which the disparate expertise held by the individuals in a team can be integrated at the project level. In summary, relational capital and absorptive capacity do not influence creativity in software project teams in and of themselves; they do so because they facilitate expertise integration. This understanding of the factors that shape creative processes in teams and our findings related to the mediating role of expertise integration provides managers some basic tools to enhance creativity both by better structuring teams and by deploying collaborative development tools that support expertise integration during systems development.

Conclusions

THE OVERARCHING GOAL IN THIS PAPER was to examine how the expertise of individual team members translates into creativity in the ISD process. We theoretically developed the idea that the key process through which this happens during the ISD process is via the integration of individually held expertise at the project level. We also identified three attributes of the team's composition that were likely to influence

expertise integration at the team level, and in turn, the team's creativity during the ISD process. We tested the proposed model using data collected from a field study of 142 individuals in 42 software projects. ISD project teams as the unit of analysis and the use of multiple respondents for each project are noteworthy strengths of the study. Our team-level conceptualization especially complements prior research that has focused largely on personal factors that influence individual creativity.

The paper contributes three new insights into creativity in ISD project teams. First, it theoretically links expertise integration with team creativity. Second, it shows that the ability of a team's members to interrelate with the expertise of others in the team and good working relationships are critical for creativity. The surprising lack of relationship between heterogeneity of expertise and team creativity raises issues for future inquiry. While creativity is often portrayed as something that cannot be defined, implemented, or created, our findings suggest that IS managers can indeed *design* ISD teams to be more creative, albeit within organizational constraints. Third, it shows that expertise integration is the key mechanism through which individual expertise results in team creativity during the ISD process. Although this study provides a starting point for research into the domain of team-level creativity in the ISD process, more exhaustive team-level models must be developed before we can fully grasp creativity in ISD.

NOTES

1. We are grateful to an anonymous reviewer for suggesting this point.

2. The prevalent tradition of creativity research in the reference disciplines such as management and psychology has largely been at the individual level, focusing primarily on individual differences and antecedent conditions for individual creativity [74]. But teams rather than individuals usually develop software systems. Since ISD involves the collective creative processes of many team members, it is necessary to adopt a group-level perspective on creativity [15].

3. In this study, we measure some process-related attributes of creativity, since the model itself is a variance model; studying the process itself requires a process model. Therefore, we assess the degree to which the team's processes were creative in our measurement of the construct.

4. Although Grant's [27] conceptualization of expertise integration is anchored at the firm level, Grant explicitly recognizes that organizations merely provide the context for integrating expertise and that the actual integration is carried out in teams composed of individuals. We use the term *expertise* to acknowledge the presence of tacit as well as explicit knowledge. Notably, it is individually held tacit knowledge that is most closely associated with ISD tasks [55]. Such knowledge involves an understanding of the application problem domain as well as technical knowledge.

5. Explicit knowledge is also referred to as declarative knowledge in the software development literature. Declarative knowledge is defined as knowledge that is static and based on facts concerned with objects, persons, and events and their relationships [1, 55]. Tacit knowledge involved in the software development process is similarly referred to as contextual, application domain, and procedural knowledge [55, 57]. Robillard's description of such knowledge—it is

difficult to describe, but once learned, is rarely forgotten—mirrors Nonaka's definition of tacit knowledge.

6. Such need for integrating knowledge about the problem domain is reflected in the participatory design philosophy for ISD, which emphasizes the active involvement of potential users of the system in the design and development process of the system.

7. Although Szulanski [64] did not explicitly identify these variables, he suggested that poor integration is caused by the inability to build on other individuals' knowledge and by the poor quality of relationships among them that make integration difficult. By corollary, teams with compositional attributes that are conducive to integrating individually held expertise at the project level are more likely to be effective in achieving higher levels of expertise integration.

8. For example, a team might be able to validate its interpretation of customer requirements through its access to other external groups that might have previously worked with that customer. Or, a team might get feedback on the choice of a particular programming language or design approach that is new to the team but has been used elsewhere in one team member's extended network.

9. Expertise heterogeneity and absorptive capacity are conceptually distinct constructs: although a team might have heterogeneity in its members' expertise, it does not necessarily follow that the members of the team can relate with each other's expertise. A simple example is a two-person team composed of an accountant and a programmer. Although they have high-expertise heterogeneity, it does not automatically imply that the accountant can relate with programming or that the programmer can understand accounting (i.e., each other's domains). Therefore, a team can have high expertise heterogeneity yet be low on absorptive capacity. Similarly, it is also possible that the same team above has a programmer who has a basic understanding of what the accountant does and vice versa (i.e., absorptive capacity is high).

10. Data were collected using a Web-based questionnaire. A list of 46 active projects was coded into the questionnaire. Each project had a unique identification number known to all respondents; this was also included in the project list. We electronically distributed the questionnaire by sending 173 individuals e-mail messages with a personalized URL for the survey.

11. In their original study, this measure assessed creative strategy that was a team-level process-focused measure. Although it bears some similarities to earlier individual-level measures of creativity, there is considerable theoretical support for the similarities in the conceptual structure of creativity at individual and group levels [22, 74].

12. We identified potential items for both scales beginning with a comprehensive review of the literature. We refined this initial item pool through multiple rounds of feedback from three managers and six academic domain experts. We conducted a review session with these experts before the first pretest, and then again after the first and second pretest phases. We administered the instrument to a convenience sample of 79 semester-long software project teams in three sequential sessions involving 25, 21, and 33 teams. Only a small subset of the potential scale items from the initial pool were retained. Various items were refined and simplified based on their feedback and the results of exploratory factor analyses. The final scales for absorptive capacity and expertise integration consisted of three and four items, respectively, and were revalidated with the main data set.

13. Our use of Grant's [27] conceptualization of knowledge integration is somewhat limited in the sense that our measure does not tap into the various mechanisms by which knowledge can be integrated. Instead, the items in our scale measure it largely as an outcome, consistent with its operationalization as a reflective construct (i.e., the scale items are caused by the latent construct). A mechanisms-oriented scale would require a formative scale wherein the scale items lead to knowledge integration. See Chin [11] for an exposition on the differences between reflective and formative measures.

14. It is, however, possible that the effect of project stage is not simply linear. Since our objective was simply to control for the effects the stage of each project in the study, we used a coarse, single-item measure to control for project stage. To prevent confounding effects from a history of having worked together [65], we sampled only teams that were formed anew and whose members did not have prior history of working together.

15. Our choice of PLS was guided by three considerations. First, two constructs in this study use newly developed scales. PLS allows triangulation of the convergent and discriminant validity of these constructs with the traditional scale validation procedures used in the pretests.

PLS's ability to assess the measurement model within the context of its theoretical-mediated model therefore makes it superior to multiple regression and path-analytic techniques. Second, PLS is well suited for analyzing the smaller data set that resulted from aggregating individual responses to the team level. Third, unlike LISREL, PLS makes no *a priori* normality assumptions regarding the data.

16. Since team creativity was assessed by multiple respondents for each project and sufficient interrater agreement was observed among all respondents within each team, common-methods bias is not a persuasive threat to the study. As a *secondary* check, correlations between team creativity and project success assessments obtained for each project from the key external project sponsor (who was a manager external to each project team) provided further assurance that common-methods bias was not a persuasive problem. We used evaluations collected from the upper-management sponsor for each project, each identified with the help of the three sponsoring top managers and their choice corroborated with the key senior manager stakeholder listed in the internal project roster. Following project success measures used in prior studies of ISD [28, 31], these managers were asked to evaluate the extent to which the project provided the desirable features and functionality, met its business objectives, and its overall success *at the time the completed project was delivered.* Creativity had a significant positive effect on project success (β = 0.338, *t*-value = 1.844, *p* < 0.05). While this relationship is not central to this study, it provides empirical support that creative processes do contribute to superior project outcomes. Although this does not entirely eliminate the threat of common-methods bias, this result suggests that it is not a persuasive threat to our findings. Since project success was assessed by a respondent different from the team's members, and the data related to the independent variables were collected from individual team members, this multisource approach somewhat further mitigates the threat of common methods bias. Notably, this test also empirically confirmed that creative team processes do contribute to superior project outcomes.

17. We used a blindfolding procedure that omits part of the data for a given block of indicators and then attempts to estimate the omitted part based on existing estimates [26]. Only prime numbers less than the sample size can be used for such omission distances. We blindfolded creativity using omission distances of 11, 13, 19, 31, and 41, and reestimated the model in five separate runs. The Q^2 estimates obtained were 0.3534, 0.3639, 0.3600, 0.3562, and 0.3430.

18. Recall that the projects in this study were novel Internet software applications. The relationship between creativity and project success might be weaker in software maintenance (as opposed to applications development) projects.

19. High levels of expertise heterogeneity might lower the absorptive capacity of a team because heterogeneity reduces the expertise overlaps among individual team members. This relationship is not formally hypothesized in this study. Nevertheless, in testing this relationship, we found that the path coefficient was negative but the relationship lacked statistical significance (β = –0.181, *t*-value = –1.56, *p* > 0.1).

20. The mean construct score of 3.75 on a five-point scale for expertise heterogeneity supports this assertion.

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Appendix. Scale Items and Results of Factor Analysis

Item	Scale item[a]	Factor[b]					
		C	A	R	H	K	S
Creativity							
C_1	Our team frequently experiments with alternative ways to carry out our work.	**0.757**	0.155	0.328	−0.005	0.153	−0.001
C_2	Our team is highly imaginative in thinking about new or better ways to perform our tasks.	**0.623**	0.207	0.226	−0.003	0.009	−0.001
C_3	When a nonroutine matter comes up in our work, we often invent new ways to handle the situation.	**0.519**	0.392	0.468	−0.102	0.274	−0.002
Absorptive capacity							
A_1	Overall, members of this team can interrelate to each other's unique skills and abilities.	0.284	**0.731**	0.461	−0.008	0.189	0.000
A_2	Overall, members of this team can interrelate to each other's unique expertise.	0.225	**0.837**	0.477	−0.007	0.122	−0.001
A_3	Members of this team recognize the potential value of their peers' expertise.	0.321	**0.533**	0.453	−0.009	0.235	0.000
Relational capital							
R_1	There is close, personal interaction among team members at multiple levels.	0.276	0.174	**0.689**	0.226	0.003	0.001
R_2	At multiple levels, this project team is characterized by mutual respect among members.	0.114	0.270	**0.839**	0.136	0.153	0.152
R_3	At multiple levels, this project team is characterized by mutual trust among members.	0.119	0.243	**0.841**	0.151	0.153	0.121
R_4	At multiple levels, this project team is characterized by personal friendship between members.	0.197	0.120	**0.565**	0.150	0.104	−0.001
R_5	At multiple levels, this project team is characterized by high reciprocity among members.	0.198	0.180	**0.754**	0.195	0.154	0.005

Expertise heterogeneity

H$_1$	Members of this team vary vary widely in their areas of expertise.	0.003	0.001	0.009	**0.892**	0.008	0.173
H$_2$	Members of this team have a variety of different backgrounds and experiences.	−0.005	−0.003	0.194	**0.918**	0.130	0.004
H$_3$	Members of this team have skills and abilities that complement each other's.	−0.004	−0.005	0.218	**0.917**	0.116	0.004
	Expertise integration						
K$_1$	Members of this team synthesize and integrate their individual expertise at the project level.	0.329	0.299	0.419	0.191	**0.454**	0.002
K$_2$	Members of this team span several areas of expertise to develop shared project concepts.	0.328	0.381	0.414	0.269	**0.457**	0.122
K$_3$	Members of this team can clearly see how different pieces of this project fit together.	0.277	0.255	0.414	0.294	**0.693**	0.005
K$_4$	Members of this team competently blend new project-related knowledge with what they already know.	0.269	0.301	0.486	0.273	**0.567**	0.102
	Project success (manager's evaluation)						
S$_1$	In light of marketplace-mandated changes and new business requirements that arose *during* project execution, at the present time, this project delivers *all* desirable features and functionality.	−0.001	−0.003	0.008	0.004	0.000	**0.884**
S$_2$	In light of marketplace-mandated changes and new business requirements that arose *during* project execution, at the present time, this project meets key project objectives and business needs.	0.000	0.003	0.004	0.170	0.001	**0.716**
S$_3$	In light of marketplace-mandated changes and new business requirements that arose *during* project execution, at the present time, this project overall is very successful.	0.000	0.002	0.002	0.133	0.006	**0.874**
	Eigenvalue	6.11	3.32	2.85	2.34	1.10	0.94
	Percent variance explained	26.6	14.4	12.4	10.2	4.7	4.1

Notes: [a] Scale range: 1 = Strongly disagree; 5 = Strongly agree; [b] Exploratory factor analysis used the maximum likelihood procedure. Loadings in boldface indicate factor structures.