The Impact of Team Processes on Team Creativity in Software Development Setting: A Longitudinal Study

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Abstract: This research examined how team cognition emerges and develops to affect problem solving and team creativity using longitudinal analysis. As a result, the carryover effects of team cognition, problem solving, and team creativity from one period to another are significant. Furthermore, our findings show that transactive memory system (TMS) of team cognition is indeed a very important factor that influences team creativity through problem solving during software development process. The results also suggest that TMS can indeed improve team creativity. For project managers, understanding the above constructs is crucial to achieve high team creativity in ISD context.

Key words: Longitudinal study, information systems development, team processes, team cognition, problem solving.

1. Introduction

On account of information systems development (ISD) is a challenging process, it needs various knowledge and skill to complete the project. Among them, team cognition is one of the constructs for understanding team knowledge coordination [1]. In order to finish the project task, team members must cooperate and sharing knowledge each other. Team cognition is an emerging perspective in information systems development could help team members effectively use their knowledge and skills to solve problems [2]. The process of problem solving can help team members to interact and ensure an effective outcome. In this study, we adopt team cognition and problem solving views to address team creativity.

The significance of this study is threefold. First, most research on team cognition is theoretical framework or proceed the study in laboratory experiment. This study contributes on SMM and TMS of team cognition theory through investigating team members in ISD context. Exploring the roles of SMM and TMS could be valuable by helping recognize team knowledge coordination in ISD project. Second, the current study investigates team cognition from a team knowledge-based approach has not been adequately explored for software development contexts to close this gap in the ISD literature. This study is the first to integrate the socio-cognitive view into team coordination to enhance software development management. Due to individual team members tend to influence each other, these approaches can provide more complete results. Third, despite the importance of team knowledge in ISD projects, little is known about relevant constructs of influencing team creativity evolve over time regarding the software development projects. It is important for both theoretical and practical reasons. This study substantially enhances our understanding on team cognition and problem solving to help managers to understand how to increase the project teams' knowledge and problem solving skills, and apply them to foster team creativity.

2. Literature Review

2.1. Team Process

[3] noted that teams must develop team cognition to successfully integrate their skills and expertise. Team cognition plays a critical role in understanding team processes. For example, shared mental model (SMM) and transactive memory system (TMS) have been stressed in team cognition literature [3]. [4] noted that SMM serves as a hidden factor and facilities an effective team in performing tasks. In addition, Software development requires different knowledge from various team members to solve problems. TMS could help team members utilize diverse knowledge to solve related problems [5]. On the other hand, due to software development is a high-complex and ill-structured task, the process of problem solving is important. Thus, we add the construct of problem solving to analyze its effect on team creativity in ISD projects.

2.2. Carryover Effects: Time Effects on Team Process and Team Creativity

Team cognition is not static, but dynamic in nature and changes as team members involve relevant tasks in the team process., That is, team cognition and problem solving may change over time. Prior studies have suggested that, in some contexts, team cognition may become similar or may diverge over time [6], [7]. [6] stated that the development of team cognition will take longer time. That is, when teams forming, they build the initial team cognition based on past knowledge, gradually teams may receive new knowledge emerging from member interactions [7]. Team members may test and refine their initial perceptions of others' knowledge through interactions. Thus, it is likely that the initial team cognition developed through early interactions will suffer changes over time as team members understand more. Through developing effective team cognition, team members may lead to increased problem solving capability. We think that team members not only require conditions of shared model, but also need to utilize diverse knowledge to solve effectively problems.

H1: SMM at T_0 will have a positive effect on SMM at T_1

H2: TMS at T_0 will have a positive effect on TMS at T_1

H3: Problem solving at T_0 will have a positive effect on problem solving at T_1

H4: Team creativity at T_0 will have a positive effect on team creativity at T_1

2.3. Longitudinal Shift of SMM/TMS on Problem Solving and Team Creativity

According the IMO model, team processes as mediating mechanisms linking emergent state with criteria such as team creativity. Empirical studies indicated that teamwork mental model improve team process. [8] found that the relationship between task SMMs and performance was mediated by team processes. Furthermore, teams who share mental models are expected to have common understandings and could predict the behavior of team more accurately. Previous literature also shows that team mental models helps team members to predict the needs of the task and team to create a better solution. The process of problem solving can help team members to interact and ensure an effective outcome.

In addition, team members often have different ideas about the goals and the ways in which they work together during the project. Team members will likely have spent a significant amount of time together and gained experience with the task and the environment. As problem solving abilities become better, team cognition is likely to become less important. Finally, team members must effectively coordinate their knowledge to achieve a common goal. As time evolving, the impact of problem solving on team performance is more significant. That is, it is likely that team processes will impact team creativity over time. Team cognition can effectively enhance team creativity through problem solving indirectly. Based on the above, we hypothesize:

H5: From T_0 to T_1, the effect of SMM on problem solving and team creativity will significantly increase.

H6: From T_0 to T_1, the effect of TMS on problem solving and team creativity will significantly increase.

SMM is found to be of particular importance in the beginning stage of ISD, when the software development project is a high level of complexity. This is because the initial stage represents certain situations in which team members face some degree of uncertainty or ambiguity. In such a complex and dynamic work environment, team members will take time to build SMM in order to corporate with others. As such, the effect of SMM must be stronger in the initial stage of SMM development. Thus, this study assumes that in the initial stage, the key determinant of problem solving is successful SMM development rather than the building of TMS. In other words, SMM increases the ability of problem solving in the initial stage of relationship development in which team members feel highly uncertain. SMM could reduce the uncertainty involved with the work context.

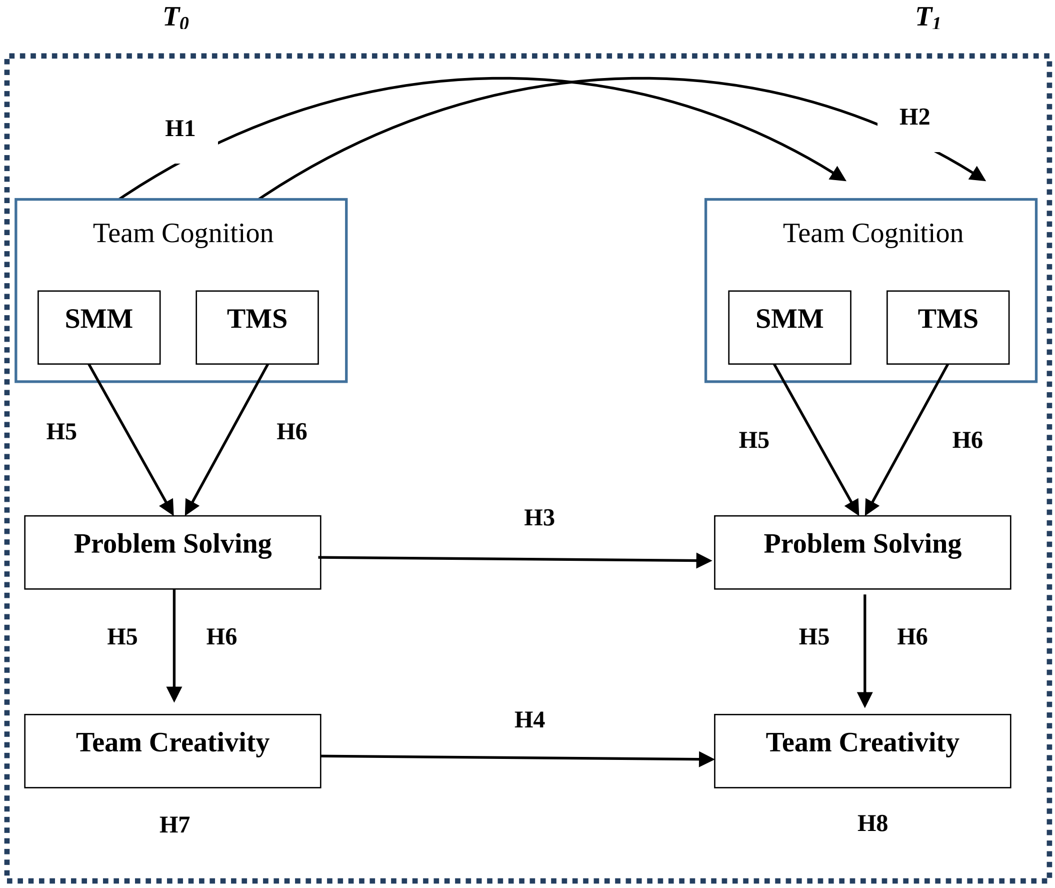


Fig. 1. Research framework.

On the other hands, the development of TMS is critical to the effectiveness of ISD to enhance those knowledge-oriented teamwork activities at the later phase. Recent studies found TMS plays a particularly important role in a team's ability to coordinate knowledge and improve team performance under various conditions. In other word, a well-developed TMS are likely to be able to effectively coordinate knowledge and solve problems and leads to team creativity. Thus, it is hypothesized that:

H7: At T0, the impact of SMM on problem solving and team creativity will be stronger than the impact of TMS on problem solving and team creativity.

H8: At T1, the impact of TMS on problem solving and team creativity will be stronger than the impact of SMM on problem solving and team creativity.

3. Research Method

3.1. Research Framework

This study develops a framework linking team cognition and problem solving to team creativity. As shown of Fig.1, team cognition and problem solving evolve over time. Exploring the dynamics could help us understand the evolution of team knowledge coordination in ISD contexts and how they influence team creativity. This framework has two main features. First, it examines four carryover effects of TMS (H1), SMM (H2), PS (H3), and TC (H4) from T_0 to T_1 time periods. That is, TMS, SMM, PS, and TC in T_0 time period should affect the same construct in T_1 time period. Second, it examines the effects of SMM/TMS on PS and TC.

3.2. Sampling

A field survey of undergraduate student teams in an information systems project implementation course and they are responsible for developing a web-based application system. The sample for the study was taken from Information Management and Computer Simulation Design students at four Taiwanese universities.

3.3. Measures

Team creativity is defined as the generation of ideas and then support creative production or the creative outcome [9]. Team cognition enables team members to effectively accomplish tasks by acting as a coordination unit [10]. Problem solving means the solving approaches and techniques for problem construction and identification of relevant information to generate solutions [11].

4. Data Analysis and Results

Table 1. Correlations of Latent Variables

			T_0				T_1			
Var.	Mean	SD	1	2	3	4	5	6	7	8
T_0										
1. SMM_0	4.54	0.80	0.78							
2. TMS_0	4.79	0.81	0.62	0.87						
3. PS_0	4.83	0.67	0.51	0.71	0.67					
4. TC_0	4.88	0.69	0.56	0.72	0.65	0.74				
T_1										
5. SMM_1	4.78	0.57	0.84	0.55	0.51	0.52	0.70			
6. TMS_1	4.95	0.67	0.47	0.87	0.85	0.60	0.58	0.85		
7. PS_1	4.96	0.58	0.48	0.84	0.95	0.62	0.51	0.64	0.62	
8. TC_1	4.96	0.60	0.52	0.64	0.62	0.93	0.53	0.62	0.61	0.71

Note: Square root of AVE is on the diagonal

To verify validity, average variance extracted (AVE), composite reliability (CR), and factor loading were performed. The Cronbach's alpha of each construct was above 0.7, which indicated high internal consistency. Convergent validity was checked by factor loadings, CR, and AVE. In addition, we assessed convergent validity by examining CR and AVE. The AVE for constructs were greater than 0.5 except problem solving at T_0, TMS and problem solving at T_1. The CR of SMM, TMS, problem solving, and team creativity at T_0 and T_1 were all greater than the recommended value of 0.7. Thus, the convergent validity was acceptable. In order to determine discriminant validity, we evaluated the measures when the square root of each factor's AVE was larger than its correlation with the other factors. Table 1 shows the results of the analysis and all square roots of AVE were larger than their corresponding correlation coefficients with other factors. In summary, these analyses demonstrate that the study scales possess convergent and discriminant validity.

Partial least squares (PLS) method was used to analyze the data in the study. Table 2 and Fig. 2 illustrate the coefficient and t-value. H1, 2, 3, 4 stated that SMM, TMS, problem solving (PS), and team creativity (TC) in the previous time period would affect the same construct in a subsequent time period. All four carryover effects from T_0 to T_1 were significant, as follows: SMM (γ=0.842, t=23.276), TMS (γ=0.876, t=17.912), PS (β=0.830, t=13.952) and TC (β=0.905, t=25.939). Of the four carryover effects, those of SMM, TMS, PS, and TC were positive. This indicates that team members who have high levels of cumulative SMM, TMS, PS, and TC in the previous time period will have higher levels of SMM, TMS, PS, and TC respectively in a subsequent time period. Thus, H1, H2, H3, and H4 were supported.

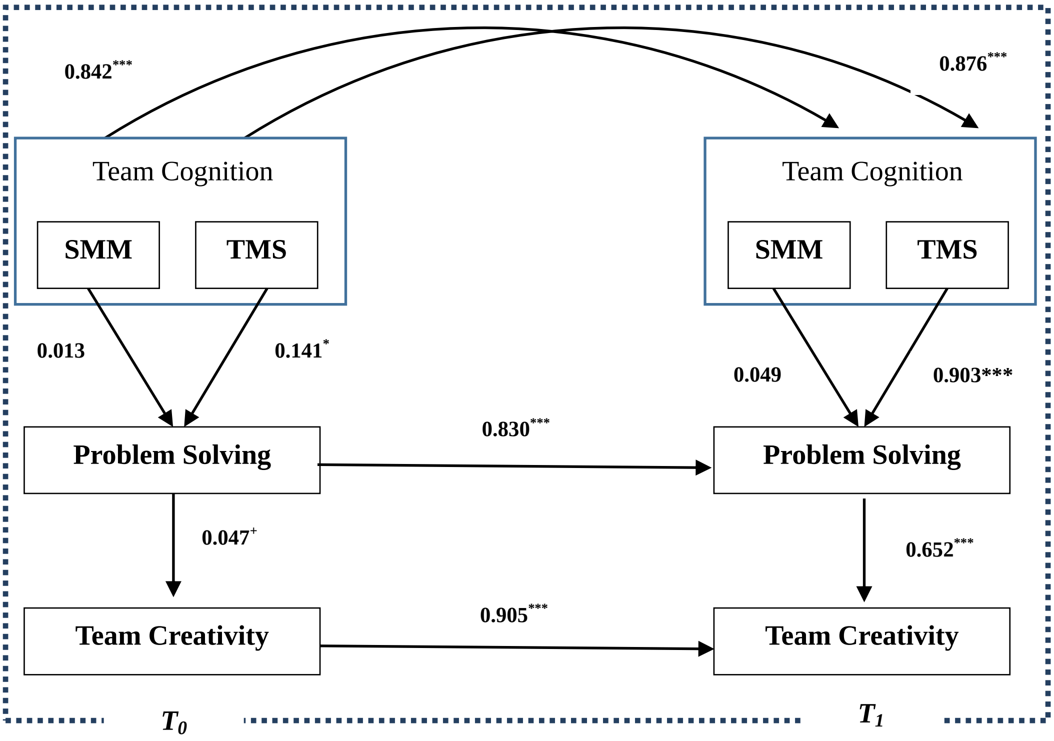
H 5 and 6 stated that from T_0 to T_1, the effects of SMM/TMS on PS and TC would be stronger. As shown in Table 2, SMM had a magnifying effect on PS and TC from T_0 (β=0.013*0.047=0.001) to T_1 (β=0.049*0.652=0.032). Likewise, TMS also had an increasing effect on PS and TC from T_0 (β=0.141*0.047=0.007) to T_1 (β=0.903*0.652=0.589). In other words, we predicted that the influence of SMM/TMS on PS and TC would increase over time. The results of PLS analysis clearly support our hypotheses, the influences of SMM/TMS on PS and TC have significantly increased from T_0 to T_1. There H5 and H6 were supported.

H7 asserted that at T_0, the effect of SMM on PS and TC would be stronger than TMS. Conversely, H8 stated that at T_1, the effect of SMM on PS and TC would be weaker than TMS. Based on Table 2, at T_0, the effect of SMM (β=0.001) on PS and TC was weaker than the effect of TMS (β=0.007). Therefore, H7 was not supported. At T_1, in contrast, the effect of SMM (β=0.032) on PS and TC was weaker than the effect of TMS (β=0.589). Therefore, H8 was supported.

Table 2. Path Coefficient of PLS

	T_0		T_1	
Direct Effects	Coefficient	t value	Coefficient	t value
SMM → PS	0.013	0.617	0.049	1.075
TMS → PS	0.141*	2.129	0.903***	18.136
PS → TC	0.047⁺	1.382	0.652***	10.487
Indirect Effects				
SMM → PS → TC	0.001		0.032	
TMS → PS → TC	0.007		0.589	
Carryover Effects	Coefficient		t value	
SMM	0.842***		23.276	
TMS	0.876***		17.912	
PS	0.830***		13.952	
TC	0.905***		25.939	

***p<0.001, *p<0.05, ⁺p<0.1



***p<0.001, *p<0.05, +p<0.1

Fig. 2. Analysis results.

5. Conclusion

5.1. Discussion

Through the perspective of team cognition has not been adequately explored in the ISD contexts. In this study, we integrated research on team cognition and problem solving to develop and test a set of hypotheses that explore the development of SMM/TMS and their impacts on problem solving, which in turn are hypothesized to influence team creativity in ISD projects. First, teams with high team cognition, problem solving skill and creativity in the previous time period have high levels of those in a subsequent time period.

Second, as the project proceed, the influences of both SMM and TMS on problem solving and team creativity also rise from the early to latter stages. To achieve high team creativity, team cognition and problem solving obviously provide a knowledge network among team members. Consistent with this perspective, the development of team cognition affects team performance over time [6].

Finally, we found that TMS and problem solving have significant influences on team creativity in particular later in the project process. Furthermore, our results also point out the importance of TMS compared to SMM in software development process. With well-developed TMS, team members could efficiently share knowledge and propose alternative solutions. This is consistent with the prediction made by [12]. They argued that TMS would allow team members to coordinate their actions and knowledge to best perform the given task. Even though group behavior literature has noted the importance of SMM, our study did not find statistical support of the importance in ISD setting. The reason may be members already are familiar with prior interaction, experience, and interpersonal knowledge, hence, team members spend little or no time to build SMM in order to corporate with others, SMM compared to TMS was less important.

5.2. Conclusion

In the study, we consider the variables pertaining to various types of team cognition and teamwork processes to impact team creativity. This study demonstrates that team cognition is associated with team creativity through problem solving. The research has some implications for ISD practice. The validated team cognition construct and its effects on both problem solving and team creativity suggest that software development process should stress the effective team knowledge provision. The development of TMS has more influence to ISD task. As thus, TMS should be viewed as a means by which team members are able to provide their expertise and knowledge to ISD project teams. As a whole, the current study contributes to fill this gap, we explore how two key mental models of team cognition impacting problem solving and team creativity. Highlighting the role of time on how team cognition and problem solving among team members influence team creativity over time. Finally, to help managers who want team members to be more creative to understand how to develop and sustain suitable team cognition and to increase teamwork processes among team members.

5.3. Limitations and Future Research

This study has its limitations that provide the impetus for further studies. First, since the sample collected ISD teams from a single, general and science technology universities, it may not represent all types of teams; therefore, the generalizability of this study is limited. Future research may wish to address this issue within other industries. Second, team cognition is a broad concept, other elements or dimensions also deserve future investigation. Finally, this study does not control for other teams' characteristics, which could affect the implementation of knowledge management; as a result, future research should control for these variables.

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