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Abstract: As social media is widely adopted in collaborative learning that make team virtual, it is critical for teams to identify and leverage knowledge of team members. Yet little is known how social media influence teams to coordinate their knowledge and collaborate effectively. In this study, we investigate the roles of two kinds of social media activity—information processing and social connection in teamwork by applying communication and transactive memory systems (TMS) as the mechanisms of explicit and implicit coordination respectively. Drawing on the data from a study that involves 40 teams of graduate students performing a complex research report over 8 weeks, we find that both TMS and communication can significantly improve teamwork outcomes. As to social media activities, the results reveal that both information processing and social connection can enhance the level of TMS, however, only social connection is positively related to communication, unfortunately, information processing can't significantly strengthen communication quality. Possible reasons are discussed and some theoretical and practical implications are also put forward.

Keywords: social media, implicit coordination, transactive memory systems, communication, teamwork outcomes

1. INTRODUCTION

Contemporary education theory suggests that learning, whether formal or informal, occurs most effectively when learners are actively coproducing content, socially involved in the process, or seeking information to solve problems[1]. In order to motivate students to discover and create new knowledge, teamwork has been the method that is mostly adopted in higher education class [2], where three or more students form a team to complete a common task. Meanwhile, as social media are easily accessible to people, learning in the context of social media has become an integral part of college experience[3].Although social media use can facilitate students' collaborative activities and connections to peers across time and space, it also makes teams more distributed and sort of virtual, meaning that teams use traditional face-to-face communication, as well as a host of social media in teamwork, and this social media enabled team poses particular challenges for knowledge coordination.

In teams, usually the success of teamwork requires to integrate intensive knowledge in problem solving, leadership, writing and presentation and so on [4], which is inherently rooted in individual members' experience and expertise. Therefore, coordination is inevitable in this process to rationally unleash each team member's ability to achieve task attainment and fulfill team members' personal learning goals at the same time. Recent studies on social media in learning revealed that social media have advantages in improving students' collaborative learning abilities as well as learning performance [5]. However, how social media facilitate this teamwork process is still vague. Specifically, yet little is known about how knowledge is coordinated and what's the impact of different coordination mechanisms on teamwork outcomes in this social media enabled teams.

To address this gap in the literature, we apply Espinosa's [6] framework of team explicit and implicit coordination, and draw on the notion of communication and transactive memory systems (TMS) as the mechanisms of explicit and implicit coordination respectively to investigate how different social media activities influence teamwork performance.

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2. LITERATURE REVIEW

2.1 Social media use in teamwork

Social media is defined as "a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of user-generated content"[9]. Prior studies suggested that users' most common motives for engaging in social media are information, entertainment and social aspects [10]. Considering that students mainly adopt social media for plans, question discussions and other task-related interactions as well as for better knowing about team members, building ties and other relationship-oriented activities for further collaboration. Thus we mainly focus on two kinds of social media activity—information processing and social connection in this research.

Much of the existing literature examined the potential effect of social media on team performance, knowledge management, and problem solving [11, 12]. For example, research find that social media is helpful for increasing introvert students' collaborative learning performance and self-confidence [14]. Al-rahmi [5] claimed that social media use could enhance students' academic performance through facilitating collaborative learning. While social media has attracted the attention of many researchers, understanding about the roles of its different activities in collaborative learning processes is still ambiguous. Therefore, our research aims at exploring the mechanism of social media's effect on teamwork outcomes.

2.2 Teamwork quality and collaborative learning outcomes

As a popular method of collaborative learning, the outcomes of teamwork not only depend on the extent of how the task is completed, but also depend on the extent of how team members' motivation and ability to engage in future teamwork is increased. Prior literatures have acknowledged the conceptualization of teamwork performance as multi-variable construct [14], and many scholars distinguished between task-related performance (e.g. quality) and people-related performance (e.g. team viability, team learning) [15]. This distinction is adopted in this research. We measure teamwork outcomes from two aspects—task performance and personal success [15].

Generally, the success of work conducted in teams depends on how team members collaborate. Based on this widespread proposition, Hogel [15] developed the construct teamwork quality as a comprehensive concept of the quality of interaction in teams, and specify six facets of the collaborative team process that integrate to this concept, that is, coordination, communication, balance of members' contributions, mutual support, effort, and cohesion. Among these six facets of teamwork quality, coordination is the most adopted construct to investigate the relationship between team behaviors and teamwork performance [16]. Considering that teamwork in collaborative learning is a knowledge intensive process, diversified knowledge as well as skills are required to complete those interdependent tasks. Thus, coordination is dominant in teamwork process. As a result, we mainly focus on coordination rather than all six aspects of teamwork quality in this research.

2.3 Explicit coordination and implicit coordination in teamwork

Coordination is usually defined as "the process of managing dependencies between activities" [17]. According to the visibility of coordination activities, Rico et al. [18] divided coordination into explicit coordination and implicit coordination. Explicit coordination refers to team members' intentional use of explicit manners, such as communication, to articulate plans, define responsibilities, negotiate deadlines, and seek information to accomplish the shared goals [6, 17]. In contrast, implicit coordination captures the capability of a team to act in concert by predicting the needs of the task and team members, and adjusting behavior accordingly, without overt communication [6, 18]. But this does not mean that these two coordination mechanisms are opposite [18]. Instead, prior research indicated that "good coordination is a subtle mixture of explicit and implicit coordination" [19], so we think that these two kinds of coordination process can exist at the same time, and well-developed explicit coordination can leverage the development of implicit coordination.

Prior research about explicit coordination mechanism suggested that team coordinate explicitly by using task organization mechanism or by communicating [17]. However, task organization mechanisms such as

planning and scheduling are less effective when the task has no or little routines, because dependencies can no longer be managed in a programmed way [6]. Therefore, we focus on communication as the main explicit coordination mechanism in our research, and it is also the dominant manner adopted by students.

Existed studies about the implicit coordination mechanism confirmed the importance of team members "being on the same page" [20], namely, similar cognitive structure being held by individuals. Compare to other team cognitions (e.g. team mental modes) that overemphasize the overlapping perspective of contents conceptualized by team members, TMS also put emphasis on complementary perspective [21]. That is, TMS involves a cooperative division of labor that requires different members specialize in learning and sharing different knowledge [22]. Given that the collaborative learning is a process full of creativity, which needs heterogeneous knowledge, we think TMS is more appropriate to be treated as implicit coordination mechanism in our study.

Then, taken together, we propose that two common usages of social media activities can influence the development of communication and TMS, and, further, influence the outcomes of both task performance and personal success. Figure 1 depicts our research model.

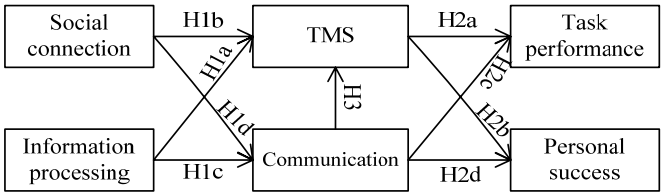

Figure 1. Research Model and Hypotheses

3. THEORETICAL DEVELOPMENT

3.1 The impact of social media use on TMS and communication

According to the theory of communication visibility [12], social media provides a forum for public communication among team members, and makes the information processing visible and network ties translucent to team members, thus, fostering team members' accurate meta-knowledge of "who knows whom" and "who knows what".

Because of the visibility of information processing, students can learn vicariously from communication occurring amongst their team members [23]. Therefore, students can identify the location of knowledge and skills, consequently, enhancing the development of TMS. Additionally, social media provides personal profiles that are visible to others, enabling team members to know "who knows what" [12], and identifying those who share the same specialty and then, by establishing social connection with these people, improving the level of familiarity among team members. Furthermore, social ties with others can facilitate accurate and common understanding, thus, leading to the formation of beliefs about members' ability and reliability to carry out the task [24]. As a result, social connection activities can contribute to the formation of TMS.

Good team communication should be moderately extensive, spontaneous, informal and open [15]. As social media make information processing visible to team members, individuals can easily track and figure out what others say, even though he (she) is not online at that time [25]. Thus, information processing activities make the team communication more open. Besides, because of the convenience of social media, one can easily share information and ask question without the limitation of space and time, team members' communication via social media tends to be more frequent than via other manners. In addition, owing to the translucent network made by social media, individual can easily connect with other team members and access to others' ideas and suggestions even they are not friends before [12]. That is, social connections with others make the communication among members become more spontaneous and informal. Therefore, taken together, we hypothesize that:

H1a: information processing is positively related to the level TMS

H1b: social connection is positively related to the level TMS

H1c: information processing is positively related to the quality of team communication

H1d: social connection is positively related to the quality of team communication

3.2 The impact of coordination mechanisms on teamwork outcomes

Prior studies have confirmed the positive impact of TMS on teamwork performance [7, 16]. Firstly, because of common knowledge map within the team, members can anticipate others' behavior [8]. Thus, the alignments of actions among team members can leverage the team to function smoothly. As a result, task performance and team members' work satisfaction can be improved at the same time. Secondly, heterogeneous knowledge owned by different members contributes to the efficiency of knowledge sharing and transferring. As a result, facilitating to solve problem and complete team task, and extending team members' knowledge scope.

It is widely agreed upon in the existed studies that communication quality positively influence teamwork outcomes [8, 16]. Effective communication can help reduce task misunderstanding, mitigate the complexity and uncertainty of teamwork and resolve interpersonal tasks and team conflicts. Besides, by communicating with others, team members can share ideas and knowledge. And these can help team members to stimulate creativity to complete the task more efficiently and effectively and enhance their growth. Therefore, we hypothesize that:

H2a: TMS is positively related to task performance.

H2b: TMS is positively related to personal success.

H2c: communication is positively related to task performance.

H2d: communication is positively related to personal success.

3.3 The relationship between communication and TMS

Past studies found that successful teams communicate more intensely at the beginning, while communicate moderately towards the end, because through communication they get to know each other's well, and can anticipate others' actions and behaviors [6]. That is, common team cognition is formed within the team. Although there are other studies proposing effective TMS can facilitate communication effectiveness [16], in our study, we think that TMS is formed after team members have collaborated for some time. So we hypothesize that:

H3: effective communication can facilitate the development of TMS.

4. METHOD

4.1 Participants

A total of 135 students (89 females and 46 males) participated in this study. All participants are graduate students who take a business analytics course during 8 weeks, and were randomly assigned to 40, four-member teams. They were required to complete a research report which includes data extraction and analysis, case study, report writing and presentations in the form of team collaboration. Additionally, the collaboration process was encouraged to be progressed on specific social media platform—Slack. During the 8 weeks, we conducted 2 rounds of survey. Because some students missed to answer one of the two surveys or failed to answer the questionnaires completely, finally, 25 students' records were removed from the research, this left 135 participants and 40 teams for the data analysis. The size of the teams ranged from 3-4 members, with an average of 3.34 individuals per team. The age average of team members is 22.74 years (S.D=1.63).

4.2 Measures

To avoid common method bias, two surveys were administrated at the classes in the 4^{th} and 8^{th} week respectively. Data of all variables except for dependent variables were collected at the first survey and data of dependent variables were collected at the second survey.

Task performance was assessed with five items that were developed and used by Zellmer-Bruhn et al. [26] to measure how well the teams completed the teamwork of research report. We adopted the scale developed and validated by Hogel et al. [15] to measure people-related success of the teamwork, including work satisfaction and personal learning effectiveness. Four items measured communication were adapted from Hogel et al. [15] to

assess the quality of team communication. Questions about TMS variable were based on the work of Borgatti and Cross [27]. Two kinds of social media activity—information processing and social connection were measured with the scales developed by Ko et al.[28]. All constructs were measured through 7-point Likert scales anchored from "strongly disagree" through "strongly agree" or "never" through "very frequently". Backward translation was used to ensure consistency between the Chinese and original English version of the instrument.

5. RESULTS

Partial least squares (PLS) analysis is used for data analysis in this research，because it works well with small-to-medium-sized samples and is suitable for predictive models and theory building[29]. Smart PLS version 3.0 is the tool we used in analyzing our model.

5.1 Measurement analysis

Individual level reliability and validity: In this research, we tested reliabilities of all variables through Cronbach's alpha (Cα) values, and assessed convergent validity by calculating Composite Reliability (CR) and Average Variance Extracted (AVE) at each individual level. All Cα values of variables exceed 0.7, suggesting a good reliability [30]. All CR exceeds 0.7, and AVE exceeds 0.5, so the scales have good convergent validity. Discriminant validity was assessed by Fornell-Larcker Criterion (FLC) and Cross Loadings (CL). All items have acceptable loadings on their intended construct. Besides, the square root of AVE is larger than its correlation coefficients with other constructs, this suggests a good discriminant validity [31].

Aggregation analysis: Data on the variables were collected at the individual level. Before aggregating individual responses to team level, it is necessary to test the conformity of the level of measurement to the level of the theoretical analysis. We tested within-group agreement by considering the R_{wg} and the ICC indices [32]. As the results demonstrated in Table 1, each F value that test ICC's significance is significant, indicating that team level analysis is more appropriate than individual level. As to the value of R_{wg}, the average values are all higher than the cut-off value 0.7, concluding a high degree of within-group agreement.

Table 1. Results of ICC and R_{wg}

	ICC1	ICC2	F value	P value	R_{wg}
IP	0.27	0.57	2.322	<0.01	0.90
SC	0.20	0.48	1.908	<0.01	0.86
CO	0.26	0.55	2.149	<0.01	0.93
TMS	0.15	0.39	1.636	<0.05	0.92
PS	0.15	0.38	1.621	<0.05	0.96
TP	0.19	0.45	1.817	<0.01	0.95

Team level of reliability and validity: Table 2 displays the results of reliability and validity test. The Cα values of each construct are above 0.7, indicating good reliability. In terms of convergent validity, composite reliability values range from 0.89 to 0.96 indicates adequate composite reliability. In addition, the AVE value of each construct is higher than acceptable level (0.5), explaining that all constructs have adequate convergent validity. According to the results of CL, two questions for personal success tapped into other constructs and were removed. After removed these two items, all other items have loadings higher than the acceptable level (see the smallest loadings (SL) in Table 2). And the square root of AVE in Table 2 (figures in bold) is larger than its correlation coefficients with other constructs, this suggests an adequate discriminant validity [31].

Table 2. Results of team level reliability and validity test

Construct	Abb.	SL	Cα	CR	AVE	IP	SC	CO	TMS	PS	TP
Information processing	IP	0.820	0.83	0.89	0.75	**0.917**					
Social connection	SC	0.838	0.86	0.91	0.79	0.727	**0.89**				
Communication	CO	0.863	0.91	0.94	0.8	0.58	0.665	**0.896**			
Transactive memory systems	TMS	0.862	0.84	0.9	0.76	0.73	0.778	0.692	**0.875**		
Personal success	PS	0.806	0.88	0.91	0.69	0.353	0.509	0.578	0.582	**0.832**	
Task performance	TP	0.908	0.95	0.96	0.85	0.392	0.463	0.69	0.663	0.663	**0.922**

5.2 Structure model assessment

Analysis of the Structural Model is the second stage in the SEM. The significance of each path coefficient was calculated by bootstrapping with 5000 samples using the replacement method. The results of analysis are represented in Figure 2.

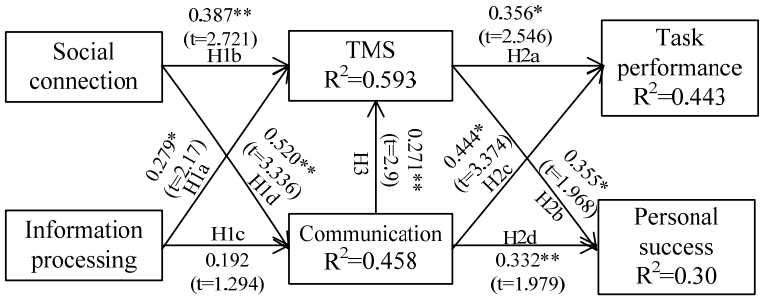

Figure 2. Results of PLS Analysis

As shown in Figure 2, R^2 of personal success is 0.30, and R^2 of task performance is 0.443. As hypothesized, TMS is significantly related to personal success (path coefficient=0.355, t-value=1.968, $p<0.05$) and task performance (path coefficient=0.356, t-value=2.546, $p<0.05$). Thus, H2a and H2b are supported. Communication is also significantly associated with personal success (path coefficient=0.332, t-value=1.979, $p<0.05$) and task performance (path coefficient=0.444, t-value=3.374, $p<0.01$), supporting H2c and H2d. As to two kinds of social media use, information processing is positively related to TMS (path coefficient=0.279, t-value=2.17, $p<0.05$), while its effect on communication is not significant. That is, H1a is supported, but H1c is not supported. The effects of social connection has on communication (path coefficient=0.520, t-value=3.336, $p<0.001$) and TMS (path coefficient=0.387, t-value=2.721, $p<0.01$) are all significant. Therefore, H1b and H1d are supported. At last, the relationship between communication and TMS is significantly positive (path coefficient=0.271, t-value=2.90, $p<0.01$), so H3 is also supported.

5.3 Mediation analysis

We test mediation effects of communication and TMS based on the three steps described by Baron & Kenny[33]. Firstly, we tested whether the relationship between independent variable (IV) and dependent variable (DV) is significant. Secondly, we estimated whether independent variable can significantly affect mediator (M). Lastly, we tested whether dependent variable is significantly affected by independent variable while held mediator consistent. The results of mediation analysis are displayed in Table 3.

Table 3. Result of mediation analysis

Mediation path			Path coefficient				Mediation effect
IV	M	DV	IV→DV	IV→M	IV+M→DV		
					IV→DV	M→DV	
IP	TMS	PS	0.391**	0.731***	-0.18	0.724***	Complete
IP	TMS	TP	0.411***	0.731***	-0.161	0.788**	Complete
SC	TMS	PS	0.538***	0.779***	0.159	0.473*	Complete
SC	TMS	TP	0.466***	0.779***	-0.146	0.787***	Complete
SC	CO	PS	0.538***	0.667***	0.253	0.416**	Complete
SC	CO	TP	0.466***	0.667***	0.011	0.684***	Complete
SC	CO	TMS	0.779***	0.667***	0.563***	0.352***	Partial
CO	TMS	PS	0.583***	0.703***	0.329*	0.372*	Partial
CO	TMS	TP	0.691***	0.703***	0.436**	0.37**	Partial

*p<0.05, **p<0.01, ***p<0.001

As the Table 4 showed, we can find that TMS completely mediates the relationship between two kinds of social media activity (information processing and social connection) and two dimensions of teamwork outcomes (personal success and task performance), but partially mediates the relationship between communication and

two dependent variables—personal success and task performance. In addition, communication completely mediates the relationship between social connection and teamwork outcomes (personal success and task performance), and partially mediates the relationship between social connection and TMS.

6. DISCUSSION AND CONCLUSIONS

This study aims at investigating the effects of social media activities on teamwork outcomes through the process of coordination. The empirical results show that two kinds of coordination, known as explicit coordination and implicit coordination, play important roles in the relationship between social media and teamwork outcomes. However, we find that information processing activities use does not significantly affect communication quality. This result is somewhat contrary to our common sense. Such a finding may be caused by the environment of the team collaboration. Although students were encouraged to use social media to collaborate with their team members, they indicated that when team members were convened for discussions on social media, they often missed some important information and felt confused because too much information could be generated soon [25]. What's more, compared with face to face, communication context on social media is much simpler. That is, team members can only judge the meaning of information by words without tone, facial expression or other body languages. As a result, misunderstandings could occur among them. In addition, team leaders' control over the discussion via social media is lower than face to face, so they indicated that they were inclined to use social media for announcement, tasks allocation and other routine activities, while mainly adopted offline meetings for team discussion to solve difficult problem.

On one hand, this study broaden our understanding of the impact of social media use on teamwork from two aspects, known as information processing and social connection, different from most past research that investigated social media use in work context as a whole (e.g. use frequency). And the results are expected to provide practitioners suggestions on how to make better use of social media through focusing on different kinds of social media use. On the other hand, we explore the relationship between social media and teamwork outcomes from both explicit and implicit coordination perspectives, and try to examine their relationships. Thus, this study also has the potential to contribute to the literature of coordination research.

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