THE EFFECTS OF PERCEIVED TEAM CLIMATE AND TEAMWORK IN A STUDENT TEAM COMPUTER SIMULATION

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Abstract

Teamwork and team learning are increasingly essential to modern management, but academic group projects generally fail to prepare students for either. The authors assigned 23 student teams to a computer simulation, predicting that team climate and technical complexity and interdependence would generate greater teamwork and learning. Structural equation analyses suggested that the technical complexity and interdependence created by the simulation enhanced learning, while team climate enhanced teamwork, satisfaction and performance. Discussed are the implications for teaching and organizational learning.

Introduction

Twenty-first Century management, so far, has been distinctive by its emphasis on two recent trends. First, complex technologies have increased the importance of teams in the workplace. Second, global competition has increased the importance of organizational learning. Consequently, recruiters and employers increasingly demand that college-educated candidates show potential for high-level functioning in both teamworking and interactive learning (Chen, Donahue, & Klimoski, 2004; Driver, 2003). Unfortunately, student group projects often fail to effectively prepare students for work teams (Ettington & Camp, 2002). The fundamental assumption that group projects improve student learning is also under-researched (Bacon, 2005).

Based on principles of sociotechnical systems theory, we develop propositions regarding the effects of perceived team climate and grounded assignments on learning and transfer in student groups. Specifically, we argue, first, that a computer simulation effectively grounds the technical aspects of a team project to facilitate teamwork and learning. Second, we argue that the existence of a team climate likewise facilitates teamwork and enhances the probabilities for transfer of learning. Next, we describe the implementation of a computer simulation used in introductory classes in Management Principles and in capstone classes in Strategic Management. Then, we present structural equation analyses of the data and provide our interpretations of the results. Finally, we identify some implications of our findings for pedagogy and practice.

Sociotechnical Systems Theory and Team Member Learning

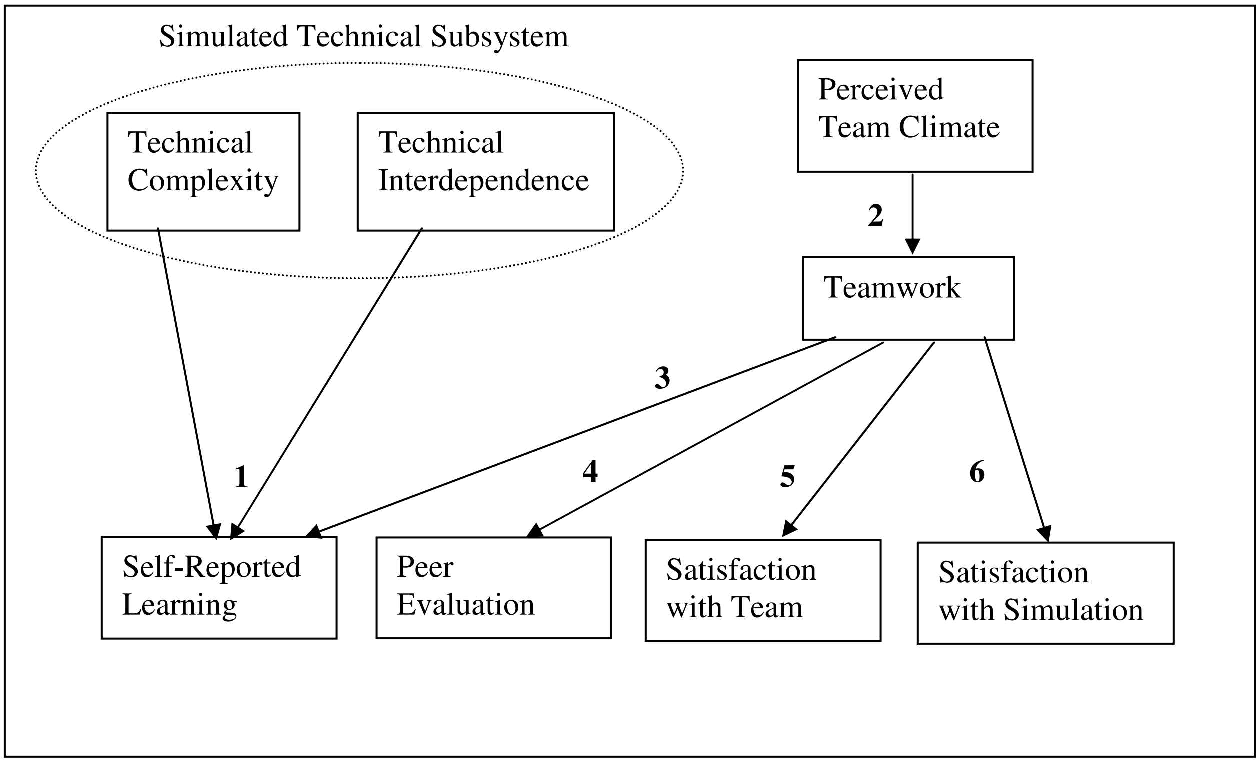
The concept of a sociotechnical system arises from the notion that any production system requires both a technical subsystem and a social subsystem (Cummings, 1978). The technical subsystem includes the tools, equipment, work processes, and the information necessary to complete tasks (Emery & Trist, 1969; Molleman & Broekhuis, 2001; Pasmore, Francis, Haldeman, & Shani, 1982). The social subsystem refers primarily to the relationships among the people who work in the organization (Molleman & Broekhuis, 2001), and includes members' attitudes, motivations, and expectations (Pasmore et al., 1982). Sociotechnical systems theory seeks to increase productivity through the joint optimization of its social and technical subsystems (Cummings, 1978). Implications of sociotechnical systems theory for teams and teamwork have been supported in recent research (E.g., Foster, Howard, & Shannon, 2002; Howard & Foster, 1999; Howard, Foster, & Shannon, 2005). Like sociotechnical systems theory, we argue that optimal learning in groups requires attention to both the task structure and the social system of the group. In particular, we develop our arguments based on the concepts of grounded learning theory and team climate. Figure 1 illustrates these arguments.

Ground learning principles are derived from the better-known concept of grounded theory (Glaser & Strauss, 1967; Strauss & Corbin, 1990). Grounded learning is a process of learning inductively from interactive involvement with the phenomenon being studied (Mosca & Howard, 1997). A grounded learning approach includes four learning elements: (1) it creates a real-world experience; (2) it establishes stimulus and response sets that are similar across learning and practice contexts (Baldwin & Ford, 1988); (3) it integrates theoretically general and empirically specific knowledge; and (4) it incorporates both positive interdependence and individual accountability (Slavin, 1990). Mosca and Howard (1997) demonstrated the difference between a typical case study project and a grounded learning case project, and concluded that the grounded learning approach was a superior pedagogy in terms of learning and student satisfaction. Grounded learning opportunities are also more likely to facilitate transfer of skills between student teams and work teams (Ettington & Camp, 2002).

Computer simulations often offer grounded learning opportunities (Amini, 1995; Leigh & Spindler, 2004; Romme, 2003; Tompson & Tompson, 1995). A computer simulation seeks to duplicate the conditions likely to be encountered in a real-world operation, thus meeting the first grounded learning element. Simulations that run over several periods, with periodic feedback, reflect real-world sequences of decision making and performance outcomes, satisfying the second grounded learning element. Simulations may be designed to represent broader applications of strategy, for example, while also requiring technical operations at the individual level, meeting the grounded learning requirement of the third element. Finally, the fourth element of grounded learning theory can be met in computer simulations that require multiple and distinct inputs in order to generate an aggregated response to a stimulus. Thus, an appropriately designed computer simulation fully meets the demands of grounded learning theory. Also importantly, such a simulation presents the two structural components of a task that imply the necessity of teamwork, technological interdependence and technical uncertainty (Cummings, 1982). Consequently, the computer simulation provides the technical subsystem that must be jointly optimized with the social subsystem in order to maximize learning (Figure 1 below, both paths marked #1).

Figure 1

Proposed Model of the Relationships Among Team Climate, the Simulated Technical Subsystem, Teamwork, and Outcomes



Team Climate, Teamwork, and Team Member Outcomes

A climate for teamwork arguably constitutes the social subsystem that must also be optimized for maximum learning and transfer in teams. A psychological climate refers to an individual's image, or psychological construction of the organizational unit, created by perceptions of behavioral prescriptions, proscriptions, and permissions (Victor & Cullen, 1988). Workers in organizations and work units might perceive norms and expectations targeting several domains, including safety, quality, service, and ethics. Each of these domain-specific clusters of conditions represents a perceived climate (Pettigrew, 1990; Schneider, 1983). Perceived team climate, therefore, constitutes an individual's understanding of how people in the unit are expected to work together. Perceived team climate includes perceptions of a shared commitment to teamwork, participative safety, high standards of performance, and systemic support for cooperation (Klivimaki & Elovainio, 1999). An individual who perceives a relatively stronger team climate would perceive norms supportive of these components.

Teamwork is the collaborative work process of team members on a common task. Through encouraging greater participation and mutual support, hallmarks of teamwork, a team climate often contributes to improved work group effectiveness and process improvement (Burpitt & Bigoness, 1997; Campion, Papper, & Medsker, 1996; Coates & Miller, 1995; Eby & Dobbins, 1997; Gupta et al., 1994; Howard et al., 2005; Klivimaki & Elovainio, 1999; O'Reilly, Williams, & Barsade, 1997). Team climate also encourages members to exercise extra-role, citizenship behaviors, some of which extend beyond the boundaries of the team itself, and may directly impact satisfaction for a team's internal and external customers (Bowen, Gilliland, & Folger, 1999; Harber, Ashkanasy, & Callan, 1997; Kirkman & Rosen, 1999; Rajnandini, Schreisheim, & Williams, 1999). A team climate encourages members to view working in a team as a desirable arrangement (Lembke & Wilson, 1998). A team climate helps members develop a sense of potency, or belief that the team can be effective (Guzzo, Yost, Campbell, & Shea, 1993). A team climate is fundamentally empowering and self-esteem enhancing (Spreitzer, Cohen, & Ledford, 1999; Tyler & Lind, 1992). We propose that perceived team climate contributes directly to teamwork (Figure 1 above, path #2).

Technical complexity drives workers from performing manual work to knowledge work or work that involves the development and transmission of knowledge and information**.** Knowledge work implies a greater amount of ambiguity, searching, researching, and learning in the job environment. Interdependence requires collaboration. Consequently, teamwork on complex and interdependent learning tasks will contribute to both learning and member performance (Kleinman, Siegel, & Eckstein, 2002; Miglietti, 2002; Figure 1, paths #3 and #4, respectively).

Employees working in teams have reported higher levels of job satisfaction than other employees in the same organizations do, but not working in teams (Kirkman & Rosen, 1999). Working in teams helps workers appreciate the meaningfulness to the organization of what they do, and helps them fulfill their needs for social interaction (Manz & Sims, 1987). The very fact of being a member of a team, however, has less influence on member satisfaction than does the level of teamwork enjoyed by the members (Foster, et al., 2002). Consequently, we also predict that teamwork will be related to team member satisfaction See (Figure 1, paths #5 and #6 above), which is likely to predict transfer of learning from the classroom to the work room (Chen, et al., 2004).

Below we first describe a computer simulation used in four classes over two semesters. Then we describe a set of additional measures we collected from these students, and present the results of structural equation analyses. Finally, we present our interpretations of the results and discuss some of the implications of our findings for pedagogy and practice.

Methods

The Computer Simulation

To meet the needs of the study, the chosen computer simulation had to offer a sufficiently complex task that would require team effort. We chose the Capstone® and Foundation® simulations by Management Simulations Inc., given the multi-product and multi-functional nature of the simulations. Also, prior use by the authors provided support that teams were essential to learning the simulations and properly operating the simulated companies. Teams competed for grades against other teams from the same class to add realism to the task.

Both simulations are created on the same platform with minor differences. In Capstone®, the industry has five distinct market segments (traditional, low end, high end, size, and performance) and teams manage firms that have one product in each segment, for a total of five products. Throughout the simulation, teams may add products to a maximum of eight total products. In Foundation®, the industry has two segments (traditional and low end) but teams start with only one product and have the opportunity to add products to a maximum of five.

The market segments are based on consumer requirements for product performance and product size. Each year the consumers desire better performance and smaller size, creating a constantly changing product market for the teams. Demand in each segment increases every year as well, from 9.2 percent to 19.8 percent. The simulations require teams to meet the needs of the market segments by making decisions in five main areas; Research and Development (R&D), Marketing, Production, Total Quality Management (TQM), and Finance.

Teams put their products through R&D to keep pace with the changing product requirements of the consumers. R&D projects change the positioning of the products, specifically the performance and size dimensions. Each time a product is altered the simulation provides a revision date, stating when the new version of the product will be ready to be produced. These revision dates change as teams order multiple R&D projects and overload their R&D departments, so teams often must make trade-offs concerning the projects that get completed and the scope of those projects. The perceived age of the product also is affected by R&D projects, adding additional complexity to the positioning decision.

Teams set the price of their products in the marketing decision, as well as the promotional budget and sales/distribution budget. The budgets affect customer awareness of the products and customer access to the products, factors that influence potential sales. Teams then need to set a sales forecast for each product, taking into account all prior decisions (positioning, price, promotion, etc.) as well as competitor activity.

The sales forecast is used to order production, taking into account inventory on hand from the prior year. Each product has its own dedicated assembly line and a designated amount of capacity. Teams must determine when to add production capacity to keep up with the segment demand growth or when to reduce capacity of lesser selling products. Teams also have the opportunity to add automation to production lines, thus lowering their labor costs, but increasing the amount of time it takes to revise a product in R&D. Adding capacity and automation is very expensive, creating more strategic trade-offs for the teams to consider.

Teams spend money in TQM to reduce material, labor, and administrative costs, to reduce R&D cycle time, and to increase demand. Eight different initiatives are available, and teams allocate funds according to what impacts they desire. There is overlap between the initiatives and the impacts, so teams must consider carefully how they allocate funds for maximum efficiency.

The final decision is to pay for all the spending outlined above. The finance function requires teams to watch cash flow and be sure they can pay for all the steps they wish to take strategically. Capital can be raised through issue of common stock or long-term bonds, as well as current debt. Stock also can be bought back and bonds retired early, if the team so chooses. To aid in these finance decisions, the simulation provides a full array of financial statements (income, balance sheet, cash flow) as well as numerous other reports (analysts, stockholder) that give teams a plethora of information to decipher.

Success in these simulations is a factor of how teams manage the complexity of these decisions, think strategically and long-term, and understand and outmaneuver their competitors.

Sample Characteristis

Sixty students participated in the simulations for course credit in two sections of a “Principles of Management” course (used Foundation®) and 56 students from two sections of capstone “Policy and Strategy” course (used Capstone®) participated, also for course credit. There were a total of 23 teams. Seventy-seven (62.4percent) were males and 87.9 percent were Caucasian. The median age was 22 (mean = 23.2). Immediately upon the conclusion of the simulation, surveys were administered to all students, yielding all data used in this study.

Survey Measures

Unless otherwise noted, all items were reported on Likert-type scales of agreement, scores from 1 to 5, and anchored by 1 = strongly disagree and 5 = strongly agree. Variables were treated as directly observed and measurement error was corrected by multiplying the variances of the variables by $1 - \alpha$.

Perceived Learning

We used four items (α = .81) to measure the degree of learning that respondents perceived: “By working on the simulation, I have gained confidence in my ability to work as part of a team;” “The simulation gave me a feeling of solving a real problem;” “The simulation motivated me to engage in outside research;” and “By working on the simulation, I have gained confidence in my ability to think critically and creatively.”

Team Climate

Eleven items (α = .89) from the Team Climate Inventory (Klivimaki & Elovainio, 1999) measured perceptions of four factors: participative safety, vision, task orientation, and support. Example items include: “There is a high degree of agreement with the team’s objectives among the team members;” “Our team has a ‘we are together’ attitude;” and “People on our team accept critical appraisal of their weaknesses.”

Teamwork

We used seven items (α = .92) adapted from the measure of cooperation of Lester, Meglino, and Korsgaard (2002) to measure teamwork. Example items include: “Members of my team cooperated to get the work done;” “Members of my team worked together to solve problems and make decisions;” and “People on our team cooperate in developing and applying ideas.”

Task Interdependence

We measured perceived interdependence with items from the measure of the same name by Bishop and Scott (2000). The four items (α = .61) were: “I frequently must coordinate my effort with others on this team;” “Jobs performed by team members are related to one another;” “For the team to perform well, members must communicate well;” and “To achieve high performance, it is important to rely on each other.”

Satisfaction with the Team

We measured satisfaction with teammates with four items (α = .73) also from Bishop and Scott (2000). Items included: “I get along well with others on my team;” “I am very satisfied with how my teammates and I worked together;” “I enjoyed the opportunity to make friends with my teammates;” and “I am satisfied with the decisions made by my teammates and me.”

Satisfaction with the Simulation

We adapted three items (α = .80) from the facet-free measure of satisfaction by Cammann, Fishman, Jenkins, and Klesh (1979): “In general, I did not like the simulation” (reverse-scored); “All in all, I am satisfied with my experience in the simulation;” and “In general, I liked working on the simulation.”

Task Complexity

We measured perceived task complexity with three items (α = .70), all reverse-scored: “My work on this project is repetitive;” “Anybody could learn how to do what I do on this project simply by following instructions in the manual;” and “Most of the work I do on this project is routine.”

Peer Evaluation

Students responded to a teammate evaluation survey on three occasions during the course of the simulation. Ten items (α = .90) included: “Carries fair share of the work required;” “Contributes positively to the team;” and “Is always well prepared and contributes to the team’s deliberation.” Each student rated every other student on his or her team each of three times, and the grand average was used to represent an individual’s peer evaluation.

Results

Descriptive statistics and intercorrelations for all study variables are presented in Table 1 below. Contrary to our expectations, teamwork was not significantly related to self-reported learning.

Table 1
Descriptive Statistics and Intercorrelations (N=116)

Variable	Mean	*s.d.*	1	2	3	4	5	6	7
1. Task Complexity	3.07	.50	(.70)						
2. Interdependence	4.41	.50	.29*	(.61)					
3. Team Climate	4.04	.58	.17	.46*	(.89)				
4. Teamwork	4.03	.65	.07	.33*	.79*	(.92)			
5. Learning	3.67	.73	.32*	.33*	.26*	.18	(.81)		
6. Sat. w/Simulation	3.86	.92	.24*	.34*	.38*	.34*	.47*	(.80)	
7. Sat. w/Teammates	4.24	.69	-.04	.25*	.25*	.80*	.22*	.39*	(.73)
8. Peer evaluation	4.53	.72	.07	.11	.14	.25*	.04	.22*	.22*

* $p < .05$.

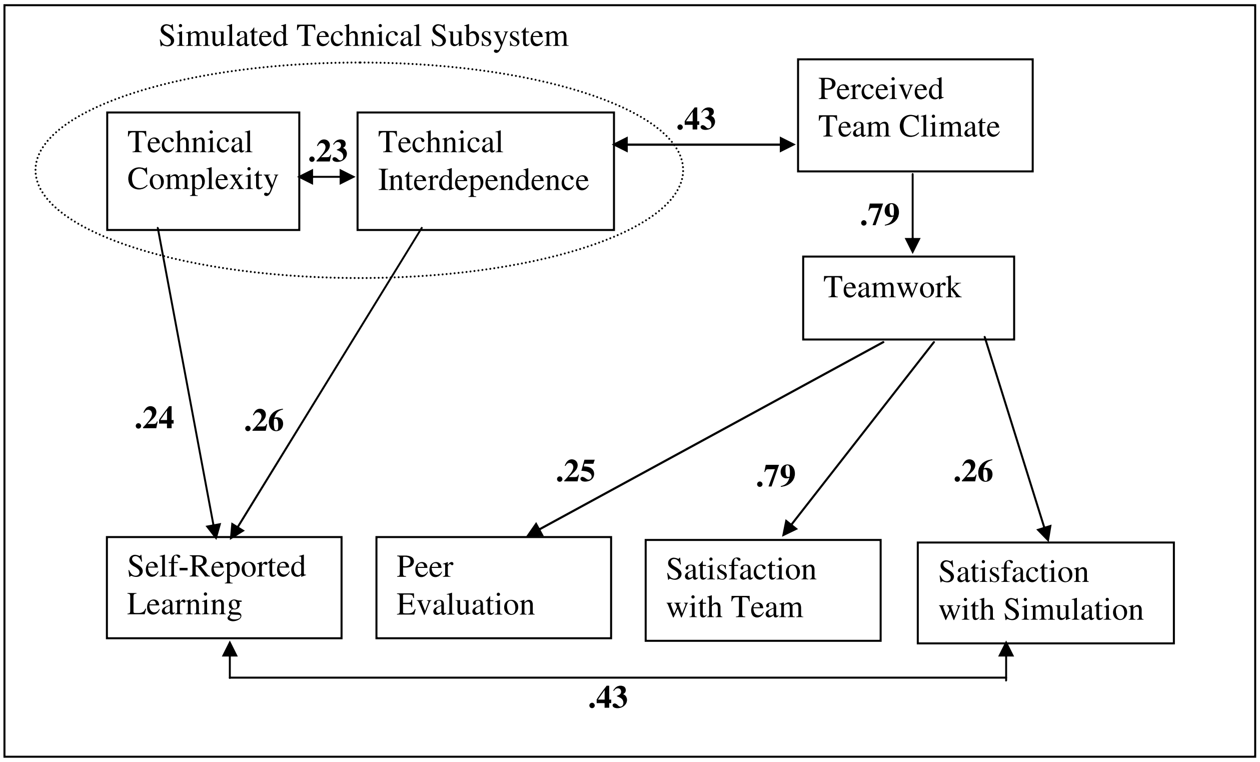
Note: Coefficient alpha estimates of reliability are on the diagonal in parentheses.

The data did not fit the structural equation very well, based on the model illustrated in Figure 1. The Chi-Square statistic of 90.25 ($df = 21$; $\chi^2 / df = 4.3$) was significant, $p < .05$. The comparative fit index (CFI) was only .79 and the incremental fit index (IFI) was .80, both substandard. The root-mean-square residual (RMR) was .08, while the root-mean-square-error of approximation (RMSEA) was .17, both higher than desired.

Given the lack of correlation between teamwork and learning, we were not surprised that this path was also not significant in the structural equation analysis. All of the other paths that we had proposed, however, were significant, providing support for most of the model. Modification indices suggested that we should add three relationships to the model. Task interdependence covaried with both team climate and task complexity, and learning covaried with student satisfaction with the simulation. After making the suggested modifications to our model, illustrated in Figure 2, the data fit the model quite well. The Chi-Square statistic ($\chi^2 = 30.30$, $df = 19$, $\chi^2 / df = 1.59$) was still statistically significant, $p < .05$, but the CFI (.97) and IFI (.97) were acceptably high, and the RMR (.04) and RMSEA (.07) were both acceptably small. The modified model in Figure 2 below is largely supportive of our rationale, but the exceptions are worth noting and discussing. Next, we also discuss the implications of the results.

Figure 2

Final Model with Standardized Path Coefficients



Discussion

Based on principles of grounded learning theory and sociotechnical systems theory, we predicted that students working in teams would report higher levels of learning when the technical subsystem and social subsystem were jointly optimized. We operationalized optimization of the technical subsystem in terms of high technical complexity and high task interdependence. We operationalized optimization of the social system as high levels of team climate. One hundred and sixteen students organized into 23 teams participated in semester-long projects in which teams represented computer-simulated companies competing against each other in a simulated industry. Subsequent to the conclusion of the simulation, we administered surveys to all students and submitted the data to structural equation analyses. In general, results supported our basic propositions.

Perceived task complexity and interdependence contributed directly to student perceptions of learning in the simulation exercise. Apparently, the simulation effectively created the technical circumstances whereby students could best learn collaboratively. Team climate contributed directly to the levels of teamwork experienced by the students. Teamwork, in turn, affected satisfaction both with the simulation and with respective teammates, while also influencing peer evaluations. Consequently, team climate apparently creates the social circumstances whereby student teams could cooperate on the project most effectively. Thus, while the technical subsystem seems to have had greater impact on learning, the social subsystem seems to have had greater impact on the likelihood of transferring that learning to future work groups. Both subsystems are critical to making student team projects successful.

The role of task interdependence is noteworthy in three aspects. First, interdependence contributed directly to student learning. This is consistent with empirical evidence generated regarding collaborative learning theory (E.g., Slavin, 1990). Second, the relationship between interdependence and team climate suggests the possibility that perceiving the need for cooperation, as influenced by perceived interdependence, represents a vital inspiration to the development of a team climate. Further research should examine the extent to which interdependence represents a necessary condition for the development of a team climate. Third, the indirect effect of interdependence on teamwork, operating through team climate, suggests that the structure of the task may be critical to the efficacy of assigning the task to a team rather than to individuals. This is one of the premises of a systems approach to job design (Cummings, 1982). These results suggest that interdependence is a critical element of the technical subsystem in order to maximize learning in a team environment, and that the computer simulation effectively created this contingency.

Although grounded learning theory, collaborative learning theory, and group effectiveness theory all note the importance of task interdependence to making teams work successfully, student groups – and perhaps work groups -- often are formed without adequate attention being paid to the level of interdependence of their work (Bacon, 2005; Driver, 2003). If left to their own devices, students will invariably find it easier to design group work so as to reflect a low level of interdependence, a level that Thompson (1967) referred to as pooled, rather than sequential or reciprocal. With pooled interdependence, each student can complete a portion of the group project alone, and then the group merely aggregates individual contributions and calls it a group output. The computer simulation in this study, however, required a complex level of reciprocal interdependence, such that each student's decisions were repeatedly counter-balanced with the decisions of other students in the team. Our results suggest that in order for team projects to provide optimal learning opportunities, team tasks need to be structured in ways that require complex interdependence.

The role of teamwork is also noteworthy, primarily in terms of its relationships with peer evaluation and satisfaction with both the simulation and the team. Social interaction not only fosters organizational learning (Kleinman, Siegel, & Eckstein, 2002), but it also reinforces values for social interaction. The relationship between teamwork and peer evaluations suggests that the students appreciated and respected the contributions of their colleagues to the group effort, and that they recognized the value in being a team player. Since learning projects at work proceed through similar phases as student projects in the classroom (Poell & Van der Krogt, 2003), this positive attitude toward valuing team members should transfer to the workplace. Satisfaction with the exercise is also likely to predict transfer of learning (Chen et al., 2004).

Teamwork was not directly related to student's self-reported learning, contrary to the hypothesis. Lacking a direct relationship between teamwork and self-reported learning, however, does not mean that teamwork did not add anything to student learning. Since our measure of learning was self-report, students may have focused their thinking about learning on the technical aspects of the course content, and not on the group process. Teamwork dynamics were not emphasized during the simulation, and teams were not exposed to team development exercises that might have sensitized them to team dynamics or provided the necessity to focus on teamworking skills.

We are not necessarily advocating team development for every group project. It is not reasonable to presume that an instructor should engage in team building every time he or she assigns a group project. Nor, according to recent evidence, is such an investment guaranteed to improve team processes (Chen, et al., 2004). However, the very strong relationship between team climate and teamwork suggests an alternate route to enhancing teamwork in student groups. That is, an instructor – or supervisor -- can establish policies and identify practices to enact those policies that make the evolution of a team climate more likely. Recall that the four factors of the Team Climate Inventory (Klivimaki & Elovainio, 1999) include participative safety, vision, task orientation, and support. Instructors can improve the likelihood of teamwork among students by establishing norms for positive participation, helping students understand the objectives and goals of the project, offering external guidance, resources, and rewards for teamwork itself, and monitoring group processes.

The primary limitations to our study involve the modest sample size and the self-report nature of our measures. Nonetheless, our sample size was adequate to provide an acceptable level of power for statistical analyses, given that our analyses all obtained at the individual level. We did not measure team climate at the team level. Likewise, we did not measure team learning, but rather individual learning. It seems plausible that if we had measured climate, teamwork, and learning at the level of the team, our results may have been different. Of course, our sample would then also have had to have been much larger. Additional research investigating level-of-analysis issues would seem beneficial. All of the measures reported here were self-report, summated scales. Nonetheless, most have a publication history and evidence of validity, and all demonstrated acceptable psychometric properties. Perhaps further research with a primary objective of relating technical and social systems to other group outputs would be useful.

Conclusions

Both the technical and social subsystems were important to teamwork and learning. The simulation created both a complex task environment and high levels of technological interdependence. It also provided a rich learning environment, with many functional areas and strategic options to master. It was primarily this combination of task complexity and interdependence that lead to self-reported individual learning in this study. While task interdependence may have contributed to the perceived need for teamwork, it was team climate that directly influenced the degree of teamwork among group members. Furthermore, the greater the level of teamwork among these students, the more satisfied they were with the process and outcomes, therefore improving the likelihood of knowledge transfer to other groups. Hopefully these lessons will contribute to making teams more effective in all learning environments, academic and professional.

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