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Creativity of student information system projects: From the perspective of network embeddedness

Heng-Li Yang [a,*], Hsiu-Hua Cheng [b]

[a] Department of MIS, National Cheng-Chi University, 64, Sec. 2, Chihnan Rd., Mucha Dist., Taipei 116, Taiwan
[b] Department of MIS, Chaoyang University of Technology, Taichung, Taiwan

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ABSTRACT

Many companies have pursued innovation to obtain a competitive edge. Thus, educational reform focuses mainly on training creative students. This study adopted the concept of an affiliated network of projects to investigate how project embeddedness influences project team creativity. This work surveys 60 projects in a Management Information Systems Department of a University. Validity of the specific study hypotheses is tested by using moderate hierarchical regression analysis to determine how project embeddedness affects project team creativity and assess how the team innovation climate moderates the relationships between project embeddedness and project team creativity. Analytical results indicate a positive association between structural embeddedness and project team creativity, a negative relationship between positional embeddedness and project team creativity, and a positive influence of team innovation climate on the relationships between network embeddedness and project team creativity. An attempt is also made to understand the role of positional embeddedness by classifying the interactions based on the content of interactions. According to those results, positional embeddedness is positively related to project team creativity during problem–identification interaction; during solution–design interaction, positional embeddedness is negatively related to project team creativity. Results of this study explain the phenomena of divergent thinking and convergent thinking during creative development.

1. Introduction

With the advent of knowledge economy, innovation has become a major impetus of economic development. Thus, educational reform heavily emphasizes training creative humans (Hu & Adey, 2002). Educational reform goals in various countries strive to enhance creative and scientific capability. They expect students to use knowledge and creativity during their lives (Victor, Jenaro, Carlos, & Amparo, 2002). Education activities can focus creativity (Isaksen & Parnes, 1985). Educational environment and method are vital for training students to develop creativity (Anderson, 2002). Educational goals should focus on assisting learners in participating in knowledge creation, and help learners develop problem solving abilities. Thus, project-based learning (PBL) is proposed in the educational field. PBL differs from traditional teaching methods. In PBL, "students pursue solutions to authentic problems by asking and refining questions, debating ideas, making predictions, designing plans and/or experiments, gathering information, collecting and analyzing data, drawing conclusions, and communicating their ideas and findings to others" (Krajcik, Blumenfeld, Marxr, & Soloway, 1994). Morgan (1983) pointed that students in PBL do not accept knowledge passively, but rather learn actively. Additionally, Morgan identified teachers in PLB as not only teaching students, but also guiding and assisting students. Nagel (1996) also expressed that learners must organize, interpret and explain knowledge by themselves, and try to solve problems actively in PBL. Through exploration and learning, students not only learn knowledge and skills, but also establish views and ideas.

Students employ team work during project learning. Team members must communicate and discuss with other members of their team (Laffey, Tupper, Musser, & Wedman, 1998). Li (2002) demonstrated that cooperative learning promotes learning performance. Dawson (2008) indicated that learner-to-learner interactions support knowledge co-construction and the sharing of information and resources.

* Corresponding author.
E-mail addresses: yanh@nccu.edu.tw (H.-L. Yang), natashac09@gmail.com (H.-H. Cheng).

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Additionally, Chiu, Huang, and Chang (2000) indicated that the more message group members exchange, or the more they interact, the more the group formulates shared knowledge and the better the group performs in knowledge map construction. During learning, learning communities can help students receive knowledge and ideas from other students. When the knowledge that students receive differs from existing knowledge, students adjust their existing knowledge and ideas to develop new ideas and knowledge. This might be helpful for students in proposing new solutions to problems in PBL.

Given the increasingly pervasiveness of the Internet, scholars have identified web technology as a key tool in PBL (Land & Greene, 2000). E-learning increases opportunities for cooperative learning. Cooperation between students is not limited to face–face interaction. Students can engage in cooperative learning via both the Internet and information technology (Johnson, Suriya, Yoon, Berrett, & Fleur, 2002). In such cooperative situation, specialists proposed the concept of computer supported collaborative learning, which learners can use to share and exchange information to achieve cooperative learning targets using computer (Tomlinson & Henderson, 1995). Learners can use information technologies (IT) to learn via various methods that differ from traditional teaching methods.

Researchers pointed that computer supported collaborative learning can assist in student learning. Selwny and Bullon (2000) also indicated that computer-assisted courses possess advantage over traditional teaching courses, because computer-assisted courses can attract students to learn and stimulate their learning motivation. Salmon (2002) illustrated that e-learning broke the limitations of learning time and space. In e-learning, when learners login to systems, read and write articles, they enjoy more time to think and organize the information that they want to post than is the case with traditional teaching, and can review previous posted messages and records that posted before. Veerman, Andressen, and Kanselaar (2000) observed that when learners do not understand the statements of other students, they can request detailed explanations through on-line discussion to foster learning and understanding of information to achieve cooperative learning. Furthermore, Wheeler, Waite, and Bromfield (2002) found that IT can assist student interaction and problem solving, and thus develop creative behavior. These interactions can help student teams to develop their creativity. This study would explore how interactions among students influence team creativity in this learning environment.

The literature contains two main perspectives on project team creativity. The first perspective is the effects of contextual determinants, such as team member social networks (Leenders, van Engelen, & Kratzer, 2003). This network perspective is based on the general concept that social context influences project team actions/operations. For example, Yang and Tang (2004) demonstrated that social structural properties are important to group performance, such as learning performance. Educators also demonstrate that social network is a fundamental to collaborative learning environments (Harasim, Hiltz, Teles, & Turoff, 1995). From the social network perspective, learning is a social and collective outcome achieved via shared information and networks of social connections (Brown & Duguid, 1991). Knowledge is co-constructed through ongoing social interactions and collaborations among multiple learners embedded in social networks (Lave & Wenger, 1991). Social network guide knowledge exchanges in learning environments.

In PBL, the relations between projects are established by project members who join different projects and interact with other project members (Grewal, Lilien, & Marllapragada, 2006). This study uses the term "network embeddedness" to capture the structures of inter-project relationships. The higher the network embeddedness of a project, the more deep-rooted it is in the network. Networks of contacts between projects can be important sources of information and knowledge for the students. The naturally evolving structure of relationships between the involved students and projects provides a critical focus for the exchange of ideas, information and knowledge. Tsai and Ghoshal (1998) pointed out that the fabric of social relations facilitates creativity generation via inter-unit information and knowledge exchange. Exchanging ideas and information can reinforce creativity (Hargadon & Sutton, 1997; Woodman, Sawyer, & Griffin, 1993).

The second perspective on project team creativity is the effects of team factors (West, 1990). A crucial factor is team innovation climate, which is the shared perception of organizational policies, practices and procedures essentially to innovation. West (1990) indicated that team innovation climate includes vision, participative safety, task orientation and support for innovation. Ekvall (1996) presented that climate may focus attention and behavior on creativity and innovation. PBL involves a cooperative learning situation. Thus, team innovation climate influences the integration of new knowledge and existing knowledge, and the process of ideas changes. These might push creative development.

Previous studies have already pointed out that team innovation climate can influence creativity. However, previous creative studies rarely focused on the impact of both contextual and team determinants on project team creativity. Moreover, previous studies neglected the interaction between contextual and team determinants on project team creativity. This study explores the influence of network embeddedness on project team creativity in different team innovation climates. This study thus addresses three research questions, as follows:

1. How does network embeddedness influence project team creativity in PBL?
2. How does team innovation climate moderate the relationship between network embeddedness and project team creativity?
3. In software companies, one person frequently participates in multiple projects. If school students are grouped similarly, is the project team creativity affected?

2. Conceptual background and hypotheses

2.1. Team performance – project team creativity

Project team performance in this study stressed creativity area. Oldham and Cummings (1996) defined the results of creativity as including new, original, suitable or useful outcomes, ideas or procedures. Gurteen (1998) similarly suggests that creativity refers to the generation of ideas while innovation involves implementing creativity. Previous works have examined creativity on three levels, including the individual (Amabile, 1997), team (Chen, 2006) and organizational levels (Woodman et al., 1993). This investigation focuses on project team creativity. According to the previous creativity literature, the study defines team creativity as the extent to which a project team produces new and useful ideas rather than end products or services.

2.2. Affiliation networks

A social network can be defined as "a set of nodes (such as, persons, organizations) linked by a set of social relationships (e.g., friendship, transfer of funds and overlapping membership) of a specified type" (Laumann, Galaskiewicz, & Marsden, 1978). Affiliation networks refer to social relationships among actors (e.g., persons, teams, organizations) formed through their common participation in events which are social activities (for example, projects). In affiliation networks, actors tie with other actors through common events in which they are involved; events link to other events via common actors (Wasserman & Faust, 1994). Faust (1997) indicated that affiliation networks include two key elements: a set of actors and a collection of subsets of actors (called events). Actors create ties between events which they belong and events create linkages between actors. Grewal et al. (2006) mentioned the phenomena of two-mode affiliation networks. In two-mode affiliation networks: the actors are project members, the events are projects, and the projects are related to each other via common members.

Researchers have pointed out that centrality is one network property that is frequently used to examine features of actors or events in affiliation networks (Bonacich, 1991). Faust (1997) explained degree centrality, betweenness centrality and eigenvector centrality within an affiliation network. This study focuses on how a project network impacts project team creativity. Thus, the centralities of events (projects) are illustrated as follows.

The degree centrality of a node represents the number of its direct ties (Wasserman & Faust, 1994). In the two-mode network, the direct ties of a project are formed through their project members. Thus, the degree centrality of a project denotes the number of its members (Faust, 1997). Fig. 1 shows an example of a two-mode network. The degree centrality of project 1 is three, because it has three members (members A–C).

According to the definition of betweenness centrality, a node with high betweenness centrality shows that there are numerous pairs of nodes linking each other through it (Faust, 1997). The situation is more complicated for a two-mode network. A given project α has high betweenness centrality owing to three phenomena: (1) many other projects connecting with each other via project α, (2) many members connecting with each other through project α, or (3) numerous other projects connecting with members through project α. In Fig. 2, project 2 has four members who are C–F. These four members link to each other because they attend project 2. Additionally, members C and E participate in multiple projects (projects 2 and 3) simultaneously. Therefore, either project 1 or project 3 can link to member D through

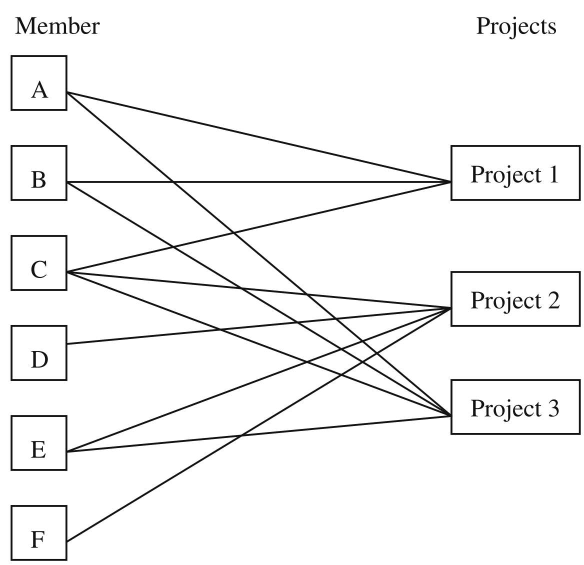

Fig. 1. An example of a two-mode network.

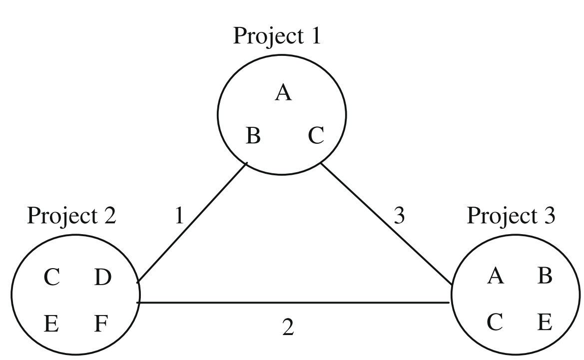

Fig. 2. An example of projects network corresponding to Fig. 1.

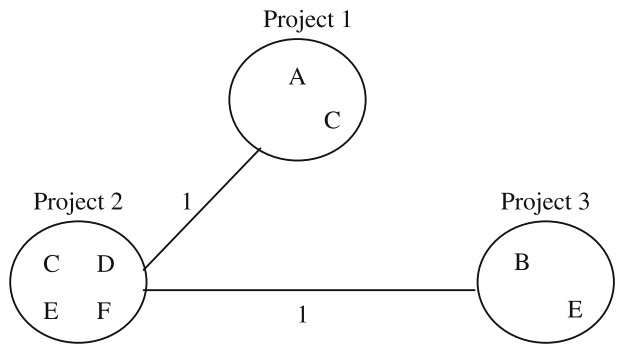

Fig. 3. Another example of projects network.

project 2. Currently, projects 1 and 3 can connect with each other not necessarily via project 2. In another example, if member participation was changed as in Fig. 3, projects 1 and 3 can be only connected via project 2.

Eigenvector centrality is an eigenvalue of the adjacency matrix. Two conditions influence the eigenvector centrality of a node: (1) the centralities of all connected nodes and (2) the strength of ties. It means that all the nodes, to which a given node connects influence its eigenvector centrality. In a two-mode network, two factors influence the eigenvector centrality of a project, namely: (1) the number of members and (2) the centrality of members (Faust, 1997). When the project has more members with high centrality, it can have more ties; that is, the project can have more opportunities to link to other projects. When many members simultaneously join the two projects, more ties exist between the two given projects. In Fig. 2, members A–C simultaneously join projects 3 and 1. Thus, the number of ties between projects 3 and 1 is three. Meanwhile, the number of ties between projects 3 and 2 is just two. Furthermore, the number of ties between projects 1 and 2 is one. Therefore, project 3 has five ties while project 2 only has three ties. All members of project 3 join two or more projects, but in project 2 only members C and E join two or more projects. The eigenvector centralities of projects 1, 2, 3 are 0.376, 0.354 and 0.483. Project 3 has the highest eigenvector centrality in the network, despite projects 2 and 3 having the same number of members. In Fig. 2, project 3 occupies the core position in the network.

2.3. Project embeddedness of two-mode affiliation networks

Embeddedness refers to the fact that exchanges and discussions within a group typically have a history, and this history stabilizes linkages among members (Marsden, 1981). In two-mode affiliation networks, Grewal et al. (2006) proposed three sub-constructs to represent network embeddedness, namely structural, junctional, and positional embeddedness, which were operated by degree centrality, betweenness centrality, and eigenvector centrality, respectively. Projects with high structural embeddedness have numerous members. Projects with high junctional embeddedness are located on bridges of many other projects. When projects have high positional embeddedness, they are closely linked with other projects. That is, project with high eigenvector centrality involve many members with high centrality.

To fully express the reality of social networks, this study further calculated the above three types of centrality by considering the frequencies of the member interactions. That is, this study operated structural, junctional, and positional embeddedness by weighted-degree centrality, weighted-betweenness centrality, and weighted-eigenvector centrality, respectively.

2.4. The correlation between project network embeddedness and project creativity

Social embeddedness differs across projects and is important in project team creativity. Project network embeddedness enables project members to access information and resources (Portes, 1998) which are crucial in expressing creativity (Hargadon & Sutton, 1997).

Projects with high structural embeddedness have many team members, typically all involved in intense discussion. In this situation, on the one hand, sufficient eyeballs can produce higher quality outcomes (ideas/information/solutions) (Raymond, 2001). On the other hand, team members can observe, share and discuss ideas and questions through interactions to establish a common perspective on knowledge building. Consequently, in projects with high structural embeddedness, it is helpful for the project team to find new ideas and solutions (project team creativity) to project questions. This study thus proposes hypothesis 1 as follows:

Hypothesis 1: The structural embeddedness of a project is positively related to project team creativity.

A project with high junctional embeddedness serves as a bridge between many other pairs of projects and members. This bridging project acts as a network broker, and can reach projects located on the network boundaries or isolated from most other projects. Researchers indicated peripheral projects are creative and have different views (Perry-Smith & Shalley, 2003). There are two reasons for this phenomenon. First, peripheral nodes were likely to explore connections to network outsiders (Cho, Gay, Davidson, & Ingraffea, 2007). These external connections may provide peripheral projects with different approaches to facilitate creativity (Sutton & Hargadon, 1996). Second, because peripheral projects are somewhat isolated from the majority of the network, they may perceive less social pressure to conform. Under slight norm pressure, peripheral projects may have high freedom and flexibility to search for solutions to project tasks. Thus, team members of the bridging project can access unique and rare information, insights or knowledge, and observe creative opportunities (Freeman, 1979; Okoli & Oh, 2007). Rare information fosters team members to develop creative solutions. This study thus proposes hypothesis 2, as follows:

Hypothesis 2: The junctional embeddedness of a project is positively related to project team creativity.

Projects with high positional embeddedness have many important members with high centrality (Bonacich, 1972, 1987; Freeman, 1979). Therefore, such projects are located in core position and can quickly access external and high quality information from other projects. When rich information and knowledge from external projects differs from existing knowledge of team members, team members adjust their knowledge and views. It would encourage team members to consider project problems from diverse perspectives and develop new solutions. Thus, this study proposes hypothesis 3 as follows:

Hypothesis 3: The positional embeddedness of a project is positively related to project team creativity.

2.5. A moderator of team innovation climate

James, James, and Ashe (1990) identified climate as a cognitive interpretation of an organizational situation that has been labeled "psychological climate". Scott and Bruce (1994) define climate as individual cognitive representations of organizational setting. West (1990) indicated that team innovation is mainly related to a climate that includes vision, participative safety, task orientation and support for innovation. This study defined team innovation climate as referring to the extent to which project members perceive project expectations regarding behavior focused on developing creative outcomes.

Numerous researchers have already indicated that climate may focus attention and behavior on creativity and innovation (Ekvall, 1996; West, 1990). This study explores the effects of social networks on project team creativity. However, since the interactions between these factors have been relatively neglected, this study further examines how team innovation climate moderates the relationships between project embeddedness and project team creativity. Thus, this study proposes the following three hypotheses:

Hypothesis 4: Team innovation climate moderates the relationships between project structural embeddedness and project team creativity.
Hypothesis 5: Team innovation climate moderates the relationships between project junctional embeddedness and project team creativity.
Hypothesis 6: Team innovation climate moderates the relationships between project positional embeddedness and project team creativity.

2.6. Research model

Previous research has identified numerous influences on team creativity, including group composition, group member creativity, and group process, influencing team creativity (Woodman et al., 1993). This study considers network embeddedness and a moderator of team innovation climate to describe the influences on project team creativity. This study explores the influences of social embeddedness and team innovation climate on team creativity, and thus controlled individual ability, motivation, and creative self-efficacy variables of project team members via a quasi-experimental design. Thus, this study proposes a research model, as shown in Fig. 4.

3. Methods

This study conducted a semester-long quasi-experiment. Data were collected from three sources: questionnaires, discussions on a e-learning platform, and team scores in creative performance.

3.1. Participants

This study used data from 127 students to examine the relationships among network embeddedness, team innovation climate, and project team creativity. The participants were students of a university Management Information Systems Department. Some 43% of participants were female and 57% were male. Over 63% had graduated from information-related departments at high school. Over 85% were first-year students. Sixty project teams comprising 4–10 members were formed from 127 participants.

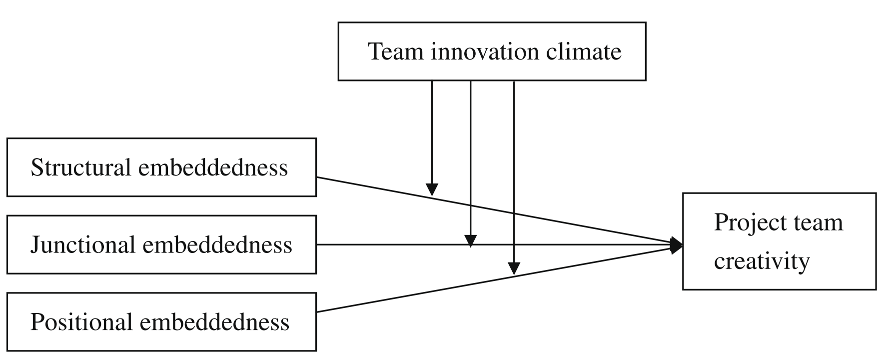

Fig. 4. A model of factors influencing project team creativity.

3.2. Tasks

According to Constructivism, students explore real problems during learning. In this study, each project team must submit an operating proposal based on web 2.0 concepts for a theme website before the end of the semester (12 weeks). The proposal should be creative and feasible. However, teams did not need to build the proposed websites. A 12-week learning and milestone agenda was suggested to teams. Students were advised to search related information, play different roles within a team, e.g., users, system analyst, marketing researcher, website owner, social organization/government, etc. They were encouraged to interview with interested groups or conduct small scale of opinion surveys. During the quasi-experimental period, every participant was required to discuss the project task with team members on the e-learning platform. The face-to-face discussions were not prohibited, but were required to produce a meeting record, including detailed discussions among members, and uploaded to the e-learning platform. The course instructor would frequently give feedback comments or opinions on group discussions through the e-learning platform. The e-learning platform, called iCAN xp iLCMS, is 3-tiers, ASP-based learning system, which includes the e-learning functions (satisfied to Instruction Model Standard, SCORM and Microsoft's LRN2.0) supporting for students, teachers, and university staffs.

Before this quasi-experiment, another survey had already been conducted in this same university to establish the top 50 familiar websites for the students. These websites covered those popular sites, such as shopping, entertainment, games, job search, travel, restaurants and dining, news and media, sports, education, social networking and blogs, etc. In this study, each project team had the freedom to choose one of these websites as the task theme context. Following choosing a theme (such as, on-line bookstore), every project team was required to develop creative proposals that have web 2.0 features for its theme website. Students were provided with two weeks of instruction regarding what could be deemed as web 2.0. Some course materials (e.g., O'Reilly, 2005) were distributed and discussed in class to illustrate the following important concepts. The web 2.0 features should include the web as platform, harnessing collective intelligence, data is the next Intel inside, end of the software release cycle, lightweight programming models, software above the level of single device, and rich user experiences. Wiki.com, an on-line encyclopedia, is an example of harnessing collective intelligence. Web users can add entries or edit the entries of others. Bugs thus are automatically corrected given sufficient eyeballs. The book review mechanism of Amazon.com provides another example of harnessing collective intelligence. However, this idea would no longer be creative if other on-line bookstores also followed it. After the two week training, a web 2.0 efficacy test was given to participants. By ANOVA analysis, this study found that there was no significant difference among the 60 teams.

3.3. Procedures

Before forming project teams, every participant was asked to complete an initial questionnaire including items such as personal data, creative self-efficacy, familiar computer software, and computer self-efficacy. Creative self-efficacy denotes the degree to which participants perceive themselves as being capable of developing novel and valuable ideas. The items were directly from Yang and Cheng (2009), which adapted from Zhou and George (2001). Zhou and George measured creativity and obtained a Cronbach's α of 0.96. Yang and Cheng (2009) changed the wording of items to measure the creative self-efficacy and reported Cronbach's α of 0.94. A sample item was: "The belief that I would suggest new ways to achieve goal or objectives." In our study, the Cronbach's α was 0.83. Computer self-efficacy indicates the judgment and confidence of IS developers in their abilities to accomplish computer-related tasks, and was measured using items proposed by Compeau and Higgins (1995). A sample item comprised: "I could complete the job using the information technique if there was no one around to tell me what to do as I go." In the study of Compeau and Higgins, the internal consistency reliability coefficient of computer self-efficacy was 0.95. In this study, the Cronbach's α was 0.88.

According to the data which were collected from the initial questionnaire, this study assigned every participant to join three project teams. Finally, 60 project teams were formed. The steps involved in team formation are detailed below:

Stage 1: The grouping of stage 1 ensures that every project team has basic IT knowledge, the appropriate confidence in their abilities to develop creativity and the abilities to consider project problems from various angles. The IT knowledge included the number of familiar computer software and computer self-efficacy. Referencing to IT knowledge and creative self-efficacy of participants, this study assigned every participant into two project teams. The purpose of the assignment procedure was to assure that every project team had approximately four members including one with a high IT capability, one with a low IT capability, one with a high creative self-efficacy, and one with a low creative self-efficacy.

Stage 2: The grouping of stage 2 is designed to create the difference in number of team member. This study randomly assigned every participant to join the third project team.

Through the grouping of two stages, every participant joined three project teams and 60 teams of 4–10 members were included in the quasi-experimental study. We have performed three ANOVA tests and found these 60 teams had no significant difference on the number of familiar computer software, computer self-efficacy, and creative self-efficacy, respectively.

At the end of the semester, every project team was required to submit the proposal for evaluation. Finally, every participant was required to complete the questionnaire on the team innovation climate of each project they joined. During the quasi-experiment period, eight students dropped out of the course and 119 questionnaires were collected.

3.4. Measures

To derive a measure of project team creativity, this study adopted the questionnaires of Burningham and West (1995). The project team was rated by the course instructor on four dimensions of creativity using web 2.0 concepts including number of new ideas, newness, significance, and effectiveness of ideas. The number of new ideas measures the amount of creative ideas in the proposal. Furthermore, the newness of ideas measures the degree to which ideas are radically novel (is technology new or business new? is new in the business field? in Taiwan? or in the world?). Moreover, the significance of ideas measures the importance of ideas for the theme website (important to customers? business partners? or website owner? would obtain competitive/strategic advantages?). Finally, the effectiveness of ideas measures the usefulness and feasibility of ideas for the theme website (operating feasible? technology feasible? economic feasible? user acceptance?). Each project team was rated on each dimension using a scale ranging from 1 to 5. The initial ratings were first made by the second author (the course instructor) and then reviewed and discussed with the first author.

This study adopts a two-mode affiliation network to measure a project network. The actors are project members while the events are projects. Projects are related to each other via common students. Restated, actors are ties among projects. However, individual actors participate in projects with different degrees. Thus, this study counted the interactions between members through data obtained from the e-learning platform and meeting records. Meaningless or unimportant discussions were not counted. Then interaction frequencies became the weights for calculating the above mentioned three types of network embeddedness, namely structural, junctional and positional embeddedness. That is, this study operated structural, junctional, and positional embeddedness by weighted-degree centrality, weighted-betweenness centrality, and weighted-eigenvector centrality, respectively. The details of formula calculating these three centralities can be referenced to (Grewal et al., 2006). This study adopted the social network software, called UCINET 6.0, to assist the computation. The weights would put the importance on interactions. A frequently-discussing team (compared with average interaction frequencies) would obtain high weight.

The instrument of West (1990) was adapted to measure team innovation climate (Kivimaki et al., 1997). However, the experiment context presented in this study differs slightly from West's study. Therefore, this study deletes one item from the 38 items of West for measuring team innovation climate. The final 37-item measure comprised a five-point Likert scale ranging from "strongly disagree" to "strongly agree". Participants were instructed to complete the questionnaires of three project teams to which they belonged.

4. Analysis and results

4.1. Aggregation tests

The team-level effect of team innovation climate was aggregated by averaging the scores of project members. Both between-group differences and within-group agreement on the two measurements were examined to assess the aggregation suitability (Goodman, Ravlin, & Schminke, 1990). An assessment of within-group inter-rater agreement (r_{wg}) was calculated as suggested by James, Demaree, and Wolf (1993). The r_{wg} coefficients of team innovation climate for 60 projects, respectively, exceeded 0.7, demonstrating within-group agreement (George, 1990). Furthermore, to verify between-group differences, this study calculated one-way ANOVA, and the results demonstrated statistical significance for team innovation climate. The within-group and between-group analysis confirmed the suitability of the proposed method for inferring group-level constructs for team innovation climate.

4.2. Validity and reliability

One hundred and nineteen students completed the entire experiment. Table 1 lists the means, standard deviations, Cronbach's α, and correlation matrix for all variables. The Cronbach's α levels of team innovation climate and project team creativity exceed 0.7, demonstrating the internal consistency of the measurement.

The construct validities of the measures for team innovation climate and project team creativity were validated via exploratory factor analysis. The percentages of variances explained of team innovation climate and project team creativity were 94.35% and 75.81%, and all the measures displayed significant loadings above the suggested threshold (0.4).

4.3. Hypotheses testing of the whole model

Before testing the study hypotheses, this study examined the possible influences of team size. Teams containing 4–6 members were classified into small teams while teams comprising 7–10 members were classified as large teams. The result of one-way ANOVA indicated that project team creativity of both types of teams was not significantly different ($F = 0.108$, $p > 0.1$).

To test the specific hypotheses proposed in this study, the work used moderate hierarchical regression analysis to isolate the main effects of project embeddedness on project team creativity and to assess how team innovation climate moderated the relationships between project embeddedness and project team creativity.

The regression results, for both main and moderated effects, are listed in Table 2. Model 1 includes the independent variables in testing the main effects. Model 2 adds the moderator, namely the team innovation climate, to test the association between team innovation climate and project team creativity. Furthermore, Model 3 adds the two-way interactions to test the moderated effects. The analytical results showed that all three models, namely model 1 ($F = 2.67$, $p < 0.05$), model 2 ($F = 3.10$, $p < 0.05$) and model 3 ($F = 3.06$, $p < 0.01$), were significant. The variance inflation factor (VIF) of each variable within models 1, 2 or 3 was below 5. This phenomenon implies that multi-collinearity was not an issue (Neter, Wasserman, & Kutner, 1990).

Table 1
Descriptive statistics of the variables.

Variable	Mean	Standard deviation	Cronbach's α	(1)	(2)	(3)	(4)	(5)
(1) Structural embeddedness	2.49	1.11	–	1.00	0.59*	0.78*	0.38*	0.09
(2) Junctional embeddedness	184.83	101.75	–		1.00	0.25	0.16	−0.03
(3) Positional embeddedness	0.08	0.10	–			1.00	0.40*	−0.09
(4) Team innovation climate	3.58	0.26	0.97				1.00	0.22
(5) Project team creativity	2.49	1.10	0.98					1.00

* $p < 0.01$.

Table 2
Results of regression analysis.

Variable	Hypothesis	Model 1	Model 2	Model 3
Structural embeddedness	1	0.74*	0.68*	0.69*
Junctional embeddedness	2	−0.32	−0.31	−0.24
Positional embeddedness	3	−0.59*	−0.65*	−0.72*
Team innovation climate			0.27*	0.27*
Structural embeddedness × team innovation climate	4			0.55*
Junctional embeddedness × team innovation climate	5			−0.36*
Positional embeddedness × team innovation climate	6			−0.25
ΔR^2			0.05	0.11
R^2		0.13	0.18	0.29
ΔF			3.96*	2.65*
F		2.67*	3.10*	3.06*

Note: Standardized coefficients are shown.
* $p < 0.05$.

4.3.1. Main effects

Model 1 shows the main effects. The analyses indicate that hypothesis 1 and hypothesis 3 are supported. The structural embeddedness is positively related to the creativity of a project team ($\beta = 0.74$, $p < 0.01$). Furthermore, the positional embeddedness is negatively related to the creativity of a project team ($\beta = -0.59$, $p < 0.01$). However, hypothesis 2 is not supported. The junctional embeddedness is not related to project team creativity.

4.3.2. Moderating effects

Beyond the direct relationships, this investigation also found that the results support the effects of interaction on project team creativity (as shown in model 3). The analytical results indicate that team innovation climate moderates the relationship between project embeddedness and project team creativity. As shown in model 3, the interaction between structural embeddedness and team innovation climate (hypothesis 4) was significant and positive ($\beta = 0.55$, $p < 0.05$), the interaction of junctional embeddedness and team innovation climate (hypothesis 5) was significant but negative ($\beta = -0.36$, $p < 0.05$), and the interaction of positional embeddedness and team innovation climate (hypothesis 6) was insignificant. Table 3 summarizes these hypotheses.

5. Discussion and conclusion

5.1. Implications drawn from main effects

Based on the findings, the following discusses three project embeddedness that are likely to influence project team creativity.

5.1.1. Implications drawn from structural embeddedness

The analytical results indicated that the structural embeddedness of a project was positively related to its creativity. Because structural embeddedness was operated by interaction frequency weighted-degree centrality, projects with high structural embeddedness indicate two things. First, the project involves numerous team members; second, the team members frequently interact. Students learn the concept of web 2.0 and develop the solutions of project task based on their own knowledge and life experiences. Thus, a project with many members can have rich ideas and suggestions for project problems because of member heterogeneity. Milliken and Martins (1996) have demonstrated that links between diversity and creativity, primarily achieved via a diversity of opinions or perspectives in a group. Furthermore, in cases involving high structural embeddedness, students interact closely. Students thus can easily share ideas and knowledge to form common views for rapidly and completely forming solutions for project problems.

The experimental task of our study, which uses web 2.0 concepts to drive website creativity, requires diverse knowledge. For example, mashup, an application based on web 2.0 concepts, means combining diverse domain information to develop ideas. For instance, Google Maps combines map search and store introduction functions. Travelers can use Google Maps to research traveling paths and obtain information on hotels and restaurants along the way. Project teams with high structural embeddedness have rich and diverse knowledge, experience, ideas and views because their members have different experiences and interests, including traveling, shopping and trying gourmet foods. Frequent interactions enable team members to explore associations between issues with which they are familiar and map searching to promote project team creativity.

Table 3
Hypothesis summaries.

Hypothesis	Support	Relational direction
Hypothesis 1: The structural embeddedness of a project is positively related to project team creativity	Supported	Positive
Hypothesis 2: The junctional embeddedness of a project is positively related to project team creativity	Not supported	
Hypothesis 3: The positional embeddedness of a project is positively related to project team creativity	Supported	Negative
Hypothesis 4: Team innovation climate moderates the relationships between project structural embeddedness and project team creativity	Supported	Positive
Hypothesis 5: Team innovation climate moderates the relationships between project junctional embeddedness and project team creativity	Supported	Negative
Hypothesis 6: Team innovation climate moderates the relationships between project positional embeddedness and project team creativity	Not supported	

5.1.2. Implications drawn from junctional embeddedness

The second main effect discusses the relationship between junctional embeddedness and project team creativity. The results indicated that junctional embeddedness did not significantly impact on project team creativity.

A project with high junctional embeddedness can act as a bridge between many projects. This study infers that projects with high junctional embeddedness can more easily observe solutions and ideas of network peripheral projects than can other projects. However, in the quasi-experiments conducted in this study, all project members come from the MIS department of a school, and have few opportunities to connect with projects outside school. According to the quasi-experimental grouping in this study, the *isolated* project does not really exist in the proposed network. Junctional embeddedness does not differ significantly among quasi-experimental projects. The bridge effect in this quasi-experiment cannot be established or moderated by other factors (team innovation climate), as illustrated below. Thus, hypothesis 2 is not supported.

5.1.3. Implications drawn from positional embeddedness

The third main effect discusses the relationship between positional embeddedness and project team creativity. The analytical results revealed that a negative relationship between positional embeddedness and project team creativity. A project has high positional embeddedness because it has many ties to other projects. Such projects can obtain detailed information and clarify uncertain information. A project occupying a core position in the network can verify and confirm acquiring information to assist in developing team creativity. However, Perry-Smith and Shalley (2003) indicated that excessive centrality may be constraining. Not all information is useful in developing project team creativity. Project teams with higher positional emeddedness can spend time filtering information to pay less attention to developing creativity or the solutions of project teams may fail to converge because too many ideas influence the direction of thinking.

It is worth exploring this negative relationship between positional embeddedness and project team creativity. This study thus conducts further analysis based on the following.

5.1.3.1. Further hypotheses testing related to positional embeddedness. According to web discussions and meeting records, this study divides interactions among students into three interacting types: *problem–identification interaction, solution–design interaction* and *other interactions*. The problem–identification interaction includes student thinking and discussion regarding the problems of the theme website. For example, in the Taiwan railway website project, students indicated that customers cannot order tickets on the eve of a holiday via website. Student identified the problems associated with ordering tickets and canceling orders, etc. The solution–design interaction includes students discussing web 2.0 suggestions for the problems of theme website. Continuing the railway website example, students suggest that the theme website can create a platform for transferring tickets. The railway website can serve as an automatic broker acting as a bridge between buyers wanting to buy tickets and sellers wanting to cancel tickets. The suggestion of these students is inspired by web 2.0 – the web as platform. That is, the service (transferring tickets platform) automatically improves with increased number of users (O'Reilly, 2005). When more people (buyers and sellers) use the platform to transfer tickets, the operations of the platform improve. Other interactions include process management discussion (e.g., the discussion of division of labor) and general information sharing (e.g., introducing functions and services in the theme website).

The frequencies of interactions of three types become the weights for calculating positional embeddedness for hypotheses testing. Owing to limitations of space, this study does not provide detailed statistics[1]. The results showed that the positional embeddedness testing for hypotheses 3–1 differs from that for the above original model. The results demonstrated that positional embeddedness is positively related to project team creativity in the situation of problem–identification interaction; moreover, the situation of solution–design interaction, positional embeddedness is negatively related to project team creativity. However, positional embeddedness-project team creativity does not hold in the model of other interactions.

In the process of creativity development, project teams must experience both divergent and convergent thinking. In problem–identification interaction, teams must discuss the problems of theme website from the perspectives of user requirements and website operations, and identify the problems because of not fully and properly applying information technology. A project team with high positional embeddedness means there are many team members who join numerous projects. The project team can view and emulate many ideas and acquire rich knowledge and information from team members participating in other projects. These ideas, knowledge and information stimulate project teams to adopt different approaches to identifying problems of project tasks. The outside information can stimulate project teams to think divergently and assist project teams have different perspectives. Diverse information provides project teams enhance opportunity of developing creativity. In this situation, positional embeddedness is positively related to project team creativity as expected.

In solution–design interaction, project teams must propose creative solutions to solve problems. During solution–design interaction, project teams make convergent thinking. Project members may waste their time filtering information and pay less attention to creativity development because of acquiring too much outside information and imitating ideas from other projects. Thus, in this situation, the positional embeddedness became negatively related to project team creativity.

According to the above discussions, diverse information from external sources and viewing and emulating other projects may promote or impede creativity. In the original model, information and emulations are negatively related to team creativity. The result indicates project teams rely on interaction among team members to converge their ideas finally. Team members interactions within the project is more important then external stimulus in achieving creative solutions.

5.2. Implications drawn from the interactions

The following discusses three interaction effects between embeddedness and project team creativity (hypotheses 4–6).

[1] Splitting three types of frequencies of interactions, this study also performed the statistical testing on structural and junctional embeddedness. But there was no other interesting finding.

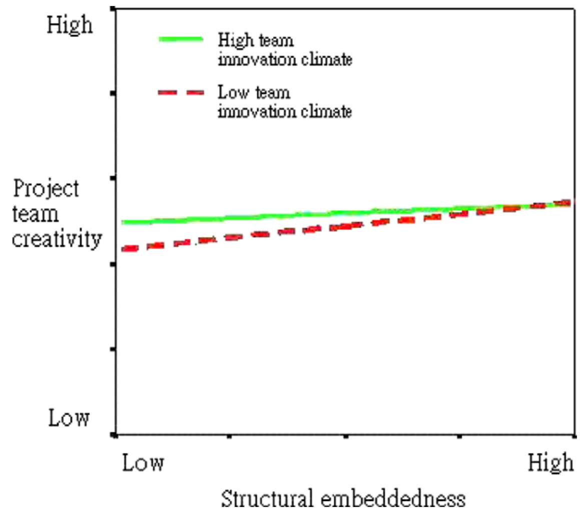

Fig. 5. Structural embeddedness and project team creativity interaction.

5.2.1. Implications from the first interaction

The first interaction involves team innovation climate moderating the relationship between structural embeddedness and project team creativity. This study plots the interaction between structural embeddedness and team innovation climate, as shown in Fig. 5. Several interesting phenomena are observed, as follows:

The first interesting phenomenon is that the slopes of the two levels of team innovation climate (low or high) were positive. Under high team innovation climate, the result is consistent with the findings of previous studies that the climate would facilitate project team creativity. For low team innovation climate, project members may perceive that there is less innovation support, and may be unable to achieve the task's object individually. However, increasing the structural embeddedness of a project means it has more (human) resources and has more opportunities to consider diversely the project task for enhancing creativity development.

The second interesting phenomenon is that at high structural embeddedness, the project team creativity for a high team innovation climate was almost identical to that for a low team innovation climate. Previous research results suggested that team innovation climate is positively related to project team innovation. The participants in this study were freshmen who used unformed knowledge and abilities to develop project team creativity within a limited time period. These may place restrictions on project team creativity. So, under high structural embeddedness, the effect of team innovation climate is limited.

The third interesting phenomenon is that the slope was steeper under low level team innovation climate than high level team innovation climate. The effects of structural embeddedness on creativity in a low team innovation climate exceed in a high team innovation climate. Under a high team innovation climate, project members perceive greater task feasibility. In contrast, under a low team innovation climate, project members consider finishing the project task as being impossible. However, when structural embeddedness increases, project members frequently communicate with each other to acquire more experience, knowledge, or ideas, and become more confident of completing the project task. This change can enhance member confidence and willingness to consider of the project task from different perspectives. Thus, the effects of structural embeddedness on creativity in a low team innovation climate exceed those in a high team innovation climate.

5.2.2. Implications from the second interaction

The second interaction is that team innovation climate moderates the relationship between junctional embeddedness and project team creativity. Fig. 6 graphs this interaction, and divides the samples into two levels of team innovation climate (low and high). This study obtained two interesting findings, as shown in Fig. 6. The first interesting phenomenon is that the slope was positive for low team innovation climate, but negative for high team innovation climate. This simultaneous existence of both positive and negative relations might be also one reason of the insignificant main effect of junctional embeddedness on project team creativity.

A climate conducive to team innovation encourages project team members to share information and increases the intrinsic motivations of developing creativity. Projects with low junctional embeddedness receive fewer external unique views. Consequently, in a high team innovation climate and with low junctional embeddedness, project team members perceiving team innovation support can actively focus on internal information for developing creativity. On the contrary, projects with high junctional embeddedness can access diverse strange or uncommon views from bridged projects. However, in the present experiment, views from bridged projects may be less useful. Furthermore, owing to the network typology, the bridging projects may have no alternative channels for verifying or understanding the views from external projects. Thus, in high team innovation climates and those with high junctional embeddedness, project team members may face disorderly and confused information and confront information overload. This phenomenon may lead team members to think divergently and make it difficult for them to converge in their ideas. Thus, the slope was negative for high team innovation climate.

Members of an organization with low team innovation climate sense weaker support for team creativity. Such project teams have lower creativity. In such cases, the team members cannot fully employ the internal resources (supports). However, on other hand, external unique perspectives can stimulate such team members to develop creativity. Thus, the slope was positive in low team innovation situations.

The second interesting phenomenon is that compared with those with low team innovation climate, the project team with high team innovation climate has higher creativity in circumstances of low junctional embeddedness, but has lower creativity on the condition of high junctional embeddedness. The explanations of this phenomenon are as follows.

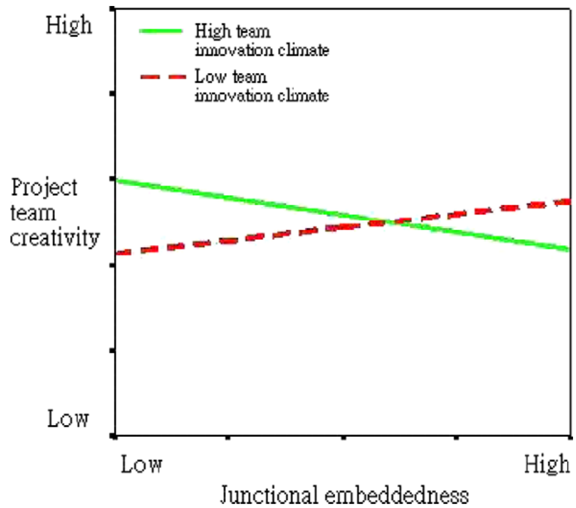

Fig. 6. Junctional embeddedness and project team creativity interaction.

A project with low junctional embeddedness can access less external unique information. This means that the project team members can only use internal views to develop creativity. If teams have encouraged an innovation climate, team members can more actively consider their internal information in developing creativity than in situations where the team has not encouraged an innovation climate. Thus, with low junctional embeddedness, project teams with high team innovation climate have higher creativity than those with low team innovation climate.

However, projects with high junctional embeddedness can access more external and unique information. It means that the project team members can use both internal views and external information to develop creativity. If a team has encouraged an innovation climate, team members may more actively pay attention to internal and external information, and may be unfortunately be pulled to think incorrect thoughts. Consequently, in situations with high junctional embeddedness, the project team with high team innovation climate has lower creativity than that with low team innovation climate.

5.2.3. Implications from the third interaction

The third interaction describes the situation in which team innovation climate moderates the relationship between positional embeddedness and project team creativity. However, the results indicated that the interaction between positional embeddedness and team innovation climate was not significant. As previously described, projects with high positional embeddedness can easily acquire and learn ideas and knowledge of other projects. In this situation, projects may develop diverse perspectives on project problems, thus causing project teams to fail in converging ideas to develop creativity. However, the quasi-experiment presented here, only limited time was available for developing creativity. Regardless of team member perceptions of the degree of team innovation climate, it is impossible to avoid the problem of numerous ideas pulling thinking in various directions. Thus, in both high and low team innovation climates, projects with high positional embeddedness have lower creativity than those with low positional embeddedness.

6. Conclusions

Based on use of student project, this study simulates a situation in which members simultaneously join several projects in a real company. Analytical results indicate that project network embeddedness significantly influences the development of creativity. To stimulate the creativity of student teams, teachers can encourage team members to interact with each other and to view and emulate ideas and suggestions related to other projects. Further illustration is presented as follows.

Analysis results indicate that project members who interact closely and discuss actively can promote learning knowledge and sharing information to help develop team creativity. Thus, teachers may provide many opportunities and appropriate spaces to help students share knowledge and information, conduct in depth discussions, and cooperate with others to encourage creative development. However, these interactions should be naturally conducted. Teachers can design tasks and activities in PBL. Students would undertake more informal interactions to complete these tasks and activities. Besides, Jankowska and Atlay (2008) proposed C-space, which is perceived as an excellent space for unconventional learning. Teachers can arrange classroom space to enable students to easily discuss to developing creativity.

This study also demonstrates that developing team creativity requires divergent and convergent thinking. In different project phases, team members require different information and interactions to finish tasks. In the initial phase, teachers can organize students from different departments into a team. Team members share various views and use these shared views to drive the development of new ideas. Besides, teachers can ask students to participate in other projects and to emulate ideas from other projects. These arrangements all could assist teams in thinking diversely. After a period of time, teachers should guide students to stress close interactions within projects and decrease the level of student participation in other projects. During this phase, team members should concentrate their attentions on project problems and exchange ideas with each other. These focusing interactions can help build knowledge and verifying ideas.

Moreover, this study confirmed the existence of a positive relationship between team innovation climate and team creativity. Team innovation climate can stimulate potential for and promote team creativity. Thus, teachers should use many channels (language, regulations activities) to convey the view that they stress the developing creativity of students, and should provide support and affirmation in relation to developing creativity.

However, there are some limitations on this study. The experiment was only conducted in one course and at one university. The testing of hypotheses was performed on only 60 teams and some explanations were based on conjecture. Those hypotheses should be tested to larger samples in the future work.

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