Impact of Intra-group Coopetitive Incentives on the Performance Outcomes of Knowledge Sharing: Evidence from a Randomized Experiment

Abstract

Knowledge sharing, as a kind of social behavior that incorporates collective intelligence to achieve a certain goal, has become a remarkable developing trend in recent years. Under the context of traditional teaching, the manner in which students become effective in sharing knowledge is explored to help optimize course design and improve our existing education. Among 195 university students taking an elective, the effects of different incentives on group performance in completing tasks is explored on the basis of a randomized experiment. Results show that intra-group cooperation can be helpful to student performance, whereas intra-group competition neither improves nor worsens student performance. The former is mainly driven by reciprocity, especially for that stimulated by inter-group competition, whereas the latter is stimulated by egoism. Thus, proper reciprocity can promote student behavior to increase voluntary contribution. In addition, intra-group differences do not interfere with group performance, especially task-oriented groups. Certain suggestions are proposed to improve the curriculum design in large classrooms. Forming groups is the best way to strengthen student knowledge sharing. Within task-oriented groups, the incentives of inter-group competition can encourage students to deepen intra-group cooperation and thus effectively improve group performance under the conditions of external competition.

Keywords: Knowledge sharing; Randomized experiment; Intra-group cooperation; Intra-group competition; Student performance

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1 Introduction

In the era of Web 2.0, curriculum design emphasizes on students' learning atmosphere, including collective participation, collaboration, creativity, interactive dialogue, and knowledge creation (Lim, So et al. 2010). Wiki, as a typical interactive channel with intensive and collective knowledge collaboration, encourages participants to actively become knowledge creators and promotes collaboration among teams (Pifarré and Li 2012). As an online education platform, the massive open online course has gradually become the most popular way for online classes; this course provides students with opportunities to exchange knowledge in discussion areas (Bing 2017). However, traditional classes take precedence over online learning due to the direct interaction with teachers and intensive communication among students. Compared with online classes, students learn more efficiently and communicate more effectively face to face in traditional classes (Saleh, Asi et al. 2013). A widely accepted teaching approach called "top-down" is universal in colleges, commonly under the control of teachers and greatly curbs students' independent creativity. This approach inevitably exposes students to certain difficulties, such as low learning efficiency and insufficient critical thinking ability, making the exploration of improving students' comprehensive talents worthwhile (Yu and Tang 2010). Many teachers have begun optimizing course designs by setting group presentation assignments to improve student initiative and to strengthen their sense of cooperation in the classroom while also paying special attention to the learning needs of students (Huang 2017).

Group, as a decentralized knowledge pool, plays a critical mediator role between individuals and organizations for knowledge creation and transfer (Kunz 2011). Group requires individuals collaborative interactions to complete shared assignments, which can make a huge difference in organizational performance. Likewise, the use of small groups in classrooms has a significant impact on knowledge recombinant capabilities (Yan and Dong 2018) and can also be productive and effective under circumstances such as tasks, solutions, structures, and division of labor (Cohen 1994). In addition, the forming of groups has become a common way to mobilize student enthusiasm, especially as a means of managing large classes, where the lack of active communication is a huge weakness (Rong, Zhang et al. 2018). Due to complex groups filled with simultaneous cooperation and competition (referred to as "coopetition") in organizational learning, two types of coopetitive reward structures motivate individuals to share knowledge: dominant cooperative and dominant competitive (Gordon, Welch et al. 2000). On the one hand, with the group-based organizational structure, two types of driving forces encourage group members to share knowledge and cooperate with one another (Alexander and Knippenberg 2014). On the other hand, every group is required to accomplish shared goals (Kunz 2011). Instructors use competitive strategies, such as intra- and inter-group competitions, to impart knowledge and then make group members work dependently for achieving the best benefit (Charlebois and von Massow 2015, Kwon and Woo 2018). This incentivized intra-group competition may discourage them from sharing knowledge among group members. Individuals attach more importance to the possibility of achieving

individual acknowledgment than to improve group performance (Ghobadi and D'Ambra 2013). In this study, we define a group as a research unit. This group consists of several members who are assigned to complete common tasks. This element is also the component in learning organizations in large classrooms.

Cooperative learning, as a kind of cost-effective instructional procedure, can result in greater achievements for learning effectiveness and better interpersonal relationship than individual learning (Johnson, Johnson et al. 2007). In terms of individual learning, examination is commonly conducted to evaluate individual performance. Examination can help students consolidate and strengthen their own learning (Kulasegaram and Rangachari 2018). However, examination may not motivate students to mutually share their knowledge. For example, teachers can conduct ongoing assessments with timely feedback, including homework and small weekly tests, to aid student learning (Chen, Breslow et al. 2018). Using only "scores" as measures of ability curbs students' all-round development. To address this phenomenon, educators gradually gain a comprehensive understanding of teaching issues and effectively change the current "top-down" status quo toward an innovative "bottom-up" approach, thereby creating a student-centered atmosphere to fully motivate students to share knowledge and cooperate with others to their best endeavors. Evidence shows that during the cooperation process, students can have good performance (Shadiev, Hwang et al. 2018). Inter-group comparisons do not only reinforce intra-group cooperation but can also increase learning efficiency (Böhm and Rockenbach 2013). Thus, collective cooperation promotes the integration of different

strands of knowledge and highlights the potential of members, with a positive influence on the ultimate overall performance.

This study aims to explore the kinds of incentives, internal competition, and cooperation within teams that can effectively promote student knowledge sharing and their ultimate performance on the basis of a randomized experiment. As a practical contribution, the results of this research can help optimize course assessments, improve student enthusiasm for knowledge sharing, and enhance student comprehensive abilities, which represent a compelling reference for educators. From the theoretical perspective, the study confirms that reciprocity and egoism are factors that promote knowledge sharing. Cooperation and competition performances are also highlighted under different incentives. Factors with a heuristic role enable future researchers to explore a curricular education design.

The rest of this paper is organized as follows: Section 2 provides a detailed relevant review. Section 3 briefly introduces the data and methodology. Section 4 describes an empirical study and illustrates the results. Section 5 applies additional analyses to the research model for testing robustness. Section 6 discusses the implications and limitations of the study.

2 Literature review

2.1 Knowledge sharing

Knowledge sharing is not only a process of transmitting information but also a process of providing and receiving feedback about task information (Cummings 2004).

Knowledge sharing has gained wide attention from scholars (Eisenhardt and Santos 2002) mainly to explore why users take part in knowledge collaboration. In virtual communities, individuals' motivation to share knowledge is mainly divided into four categories: hedonism (Liao, To et al. 2013), altruism (Lin and Huang 2013), reciprocity, and egoism (Chen, Wei et al. 2017). The three aspects of personal characteristics, network characteristics, and psychological motivation (Wang and Noe 2010) are also relevant. For example, commentary is a kind of knowledge and information sharing that helps others make informed judgments; commentary is motivated by hedonism, self-enhancement, and product involvement (Dichter 1966). Comprehensively, previous studies on knowledge sharing pay attention to the virtual communities, such as online question-and-answer communities (Guan, Wang et al. 2018), social media platforms (Vuori and Okkonen 2012), and traditional enterprise teams (Morawski 2012), to explore motivations in knowledge sharing (Lin and Huang 2013), its preconditions (Wang, Yang et al. 2016), and influencing factors.

In addition, motivation toward knowledge sharing is closely related to its performance. Evidence shows that knowledge sharing has a positive and significant impact on team performance, the satisfaction felt among team members (Cao and Long 2009), and teams' innovative culture. Such altruism, in turn, promotes knowledge-sharing behavior (Ullah, Akhtar et al. 2016). Trust (Lin, Hung et al. 2009), reciprocity (Vuori and Okkonen 2012), and hedonism (Liao, To et al. 2013) are the main factors that give team members a positive attitude toward sharing knowledge in a virtual environment. Other external facilitators, such as social feedback (Guan,

Wang et al. 2018) and social networking (Chow and Lai 2008) can also affect the behavior of individual knowledge sharing. From the perspective of the impact of knowledge sharing on team performance, open-source software development and virtual society have two common basic phenomena: communication and free riding (Isaac and Walker 1988). Active communication is conducive to improving economic benefits in a voluntary contribution environment, which significantly optimizes group performance. However, the contribution value in free riding can be close to zero in the absence of communication. Members can practice knowledge collaboration under the premise of competition, and team performance depends on the degree of internal adjustment within organizations (Vanyushyn, Bengtsson et al. 2018). Thus, different knowledge-sharing motivations produce different performances.

In summary, considerable research on the antecedents to and consequences of knowledge sharing at group levels exist. However, internal mechanisms and external outcomes have been ignored. To overcome this limitation, a randomized experiment is designed in the present study for exploring the causal relationships between motivation and performance under different types of incentive. Moreover, the research is conducted under real-life teaching situations, which are innovative in the educational research field.

2.2 Intra-group competition and cooperation

Social interdependence theory explains that the realization of an individual's goals is influenced by others' behavior (Deutsch 1949). This theory can be used to

shed light on the mechanism of knowledge sharing, which emphasizes on its importance to figure out the relationship between group interdependence and group-related outcomes (Deutsch 1962). Social interdependence has two kinds, namely, negative (competition) and positive (cooperation). From Johnson and Johnson's (1989) perspectives on the extension of social interdependence theory, cooperation happens when students collaborate to accomplish a shared task with positive interdependence, which contributes to active interaction (Johnson 1992, Johnson and Johnson 2008). By contrast, competition within groups refers to students working in teams and does not completely consider group accountability; such competition only focuses on achieving personal goals with negative interdependence (Smith, Sheppard et al. 2005), which may lead to oppositional interaction or non-interactive atmosphere. Positive interdependence (cooperation) creates psychological transformation in which self-interest is expanded to become joint interest, whereas negative interdependence encourages psychological processes that self-interest is strengthened and the desire to win becomes strong (Deutsch 1962). Ibanez and Schaffland (2018) revealed that two team phenomena, cooperation and competition, affect group performance.

Intra-group competition causes hindrance to knowledge sharing. For instance, when scoring is a strong participating motivation, the vast majority of students have no voice because they are dominated by active debaters. The latter may feel guilty about this domination, but any moral restraint is weaker than the competitive motives they feel (Jhang 2006). Competition within a team can polarize members. The

self-interest of some does not lead to a true collective outcome (Avolio and Locke 2002). Internal competition, as an undesirable form of behavior, also hinders company adaptation and development (Taylor 2010). Similarly, certain team members speak eloquently in an internal competition environment, ignoring the thoughts of others and reducing opportunities for brainstorming. Thus, the harmonious atmosphere of mutual learning is lost, negatively affecting the overall team performance. Competitive learning, unlike cooperation that plays a pivotal role in improving team performance, hinders individuals from contributing to team success and creates disturbances in the harmonious collaborative atmosphere. Similar to competitive incentives, competitive learning is usually designed for winners, leading to limited peer communication (Ghobadi, Campbell et al. 2017). In addition, peer judgment and allocation on individual credits (or blames) for team performance can lead to a competitive atmosphere, thus impeding the possibility of sharing knowledge in team activities (Wray 2009). In this study, intra-group competition is motivated by individual rankings within groups, obstructing individuals from sharing knowledge for group development. Hence, related assumptions are as follows.

Hypothesis 1: Intra-group competition has a negative impact on team performance.

Intra-group cooperation may benefit individuals in groups (Majer, Holm et al. 2018). Cooperative interaction is positively and significantly associated with organizational learning (Bendig, Enke et al. 2018), which states that blending cooperation and competition facilitates good learning. Under conditions of inter-group

competition, group members feel a strong sense of internal cooperation and external competition at the same time. Intra-group cooperation and inter-group competition significantly affect member participation in a task (Stephan, Burnam et al. 1979). Cooperation constitutes a solid foundation for learning (Song and Thieme 2006) and improves firm performance (Luo, Slotegraaf et al. 2006). Therefore, intra-group cooperation strengthens members' knowledge-sharing behavior due to external competition and effectively improves team expressiveness. Cooperative learning, when compared with competitive and individual learning, motivates members to interact and collaborate efficiently, which is beneficial for task accomplishment and knowledge exploitation (Gordon, Welch et al. 2000). In teamwork, cooperative rewards promote individuals to be immersed in handling problems and have a positive and significant relationship with the quality of knowledge sharing (Ghobadi, Campbell et al. 2017). As for cooperative rewards, individuals receive similar rewards in their group that are beneficial for enhancing knowledge sharing at the group level. On the basis of the above theory, the following assumption is proposed in this study.

Hypothesis 2: Intra-group cooperation has a positive impact on team performance.

2.3 Intra-group diversity

Intra-group diversity is a group composition formed with the heterogeneity of members' demographical characteristics and identity features, such as members' gender, social economic status, and race (Webb and Palincsar 1996). Intra-group

diversity is a crucial factor that must be considered in collaborative learning (Hooper and Hannafin 1988). Scholars hold different viewpoints over whether members' diversity in a team has a significant impact on team performance. On the one hand, intra-group diversity does not only enhance elaborative innovation and division of labor but also facilitates members' knowledge exploitation and exploration (Johnson and Johnson 1987). Pieces of evidence show that common leadership can have a positive impact on the effectiveness of teams when they are infused with individual diversity (Zhou, Zhang et al. 2017). On the other hand, similarity in characteristics or abilities can lead to group cohesion and efficacy, causing few conflicts, and individual diversity is perceived to have no significant impact on task performance (Woehr, Arciniega et al. 2013). From a meta-analysis based on 53 empirical studies, Homberg and Bui (2013) found no significant and direct correlation between the degrees of diversity of executive teams and the performance of firms. The diversity of work-related experiences within a team can improve its performance to an extent; but when a team becomes overly diversified, performance declines as communication and coordination become difficult (Hoisl, Gruber et al. 2017). Gender diversity can improve the performance of competitive teams compared with single-sex environment teams (Ivanova-Stenzel and Kübler 2011). Nevertheless, single-sex environment teams still do well at task accomplishment. On the basis of the cited research, the present study also adopts the following assumption.

Hypothesis 3: Intra-group diversity has a significant impact on team performance.

3 Research methodology and data

3.1 Randomized experiment

A randomized experiment is conducted when subjects are randomly divided into several control and treatment groups, and observers make different interventions with different treatment groups to observe experimental effects (Angrist and Krueger 2001). The design of randomized experiments follows the three basic principles of setting up a control group, randomly grouping the research subjects, and the making of blinded trials (Feinstein 1983). This technique can be traced back to the earliest investigations on job hunting, re-employment, and mental health when dealing with unemployment (Caplan, Vinokur et al. 1989). The commonly adopted technique is the randomized controlled trials. This core approach is used in drug testing, especially for medicine, biology, and agronomy (Chalmers, Jr et al. 1981). In addition, randomized experiments are sometimes adopted when studying social networking fields. Such fields involve communication and product use, social commerce and advertising, information sharing and dissemination, herd behavior, coordination and cooperation, reciprocity, and altruism (Aral and Walker 2014). Compared with observation methodology, experiments can measure causal relationships among variables more effectively, the variables can be better controlled, and the results are reproducible. Compared with laboratory experiments, randomized experiments can better overcome limitations. They have gradually become popular in social science fields, such as economics. Randomized experiments can also well explain the causal relationship between different incentives and group performances.

3.2 Research context

In traditional classrooms, teachers are responsible during the entire teaching process for the provision and transfer of unilateral knowledge. Here, students have no tasks to complete. Task-oriented teaching indirectly strengthens individual learning as a result of cooperation (Seman, Gomes et al. 2016). The present study used a university elective course as the research object. A total of 229 students took the course, but some withdrew, leaving 195 students to help explore the impact of different assessment mechanisms on student performance. To understand the individual backgrounds, four-wave questionnaires were administered over seven weeks from February 2017 to April 2017 to identify the relationships among students during different periods, as shown in Table 1. The result indicated that the network of student relationships gradually expands. Their demographic distributions are presented in Table 2, highlighting the facts that students are from different colleges, with a range of grades and with different types and levels of social interaction. Gender balance is approximately equal at 50/50.

In addition, the dynamics and overall network structure of student relationships at different periods are shown in Figure 1, where modularity is evident. Newman and Girvan (2004) proposed the concept of modularity to describe the existence of community. The modular coefficient is non-zero for periods T0 and T3, in which T0 represents the period of student relationship before class. The modular structure is based on the college as a unit because students have close contact with those in the same college. T3 represents the period of teacher-arranged groupings of students to

complete tasks. Thus, the modular structure mainly consists of organized groups from different colleges. The circle of knowledge exchange among students is mainly based on mutual relationships and the changes in the modularity reflect migration of student knowledge sharing from college- to group-based relationships.

(Insert Table 1, Table 2, and Figure 1 about here)

3.3 Experimental design

To observe the dynamic evolution of communities in knowledge sharing and its impact on the internal mechanism affecting students' final performance that results from different interventions, students were randomly divided into groups without knowing our experimental intention. The teacher arranged the corresponding tasks. A PowerPoint (PPT) production and a research paper that were completed by the group were also used to measure students' final performance. This experiment aimed at promoting student knowledge sharing through different incentives, thereby encouraging voluntary teamwork contribution. Determining whether intra-group cooperation and competition produce different effects and exploring motives and outcomes is important. The experimental design process is illustrated in Figure 2.

Before the experiment, in-depth semi-structured interviews were conducted with students to enable understanding of their familiarity with the course and related-task abilities. The teacher explained the assessment criteria, the final score as measured through attendance, coursework, PPT production, and a research paper, all regarded respectively as attendance, assignment, PPT, and paper grades. The final scores were

calculated with the four grades weighted at 10%, 10%, 20%, and 60%. Students were told that they would be randomly selected to check on their teams' completion of PPT presentations and weekly reports.

During the experiment, the selected students were numbered and grouped with unfamiliar partners to complete a task. A teaching assistant randomly divided these groups into treatment and control groups. A total of 195 students were divided into 39 groups, which are randomly sub-divided into 10 PPT presentation groups, 10 weekly report groups, 10 PPT display and weekly report groups to examine external interference factors, and nine control groups, as shown in Table 3. The first two were set as treatment groups with a new incentive to present what they have done, in the one case, and to submit a weekly report, in the other. This weekly report included the evaluation of teammates. Although the teaching assistant told the treatment groups that this work could be closely related to their final assessment, the additional task was excluded in the final scores. PPT and paper scores were anonymously evaluated by 10 experts. To further observe the effect of significant differences, scores were divided into four levels: 65, 75, 85, and 95. The mode or median scores were used as final grades to clearly observe the impact on student performance.

After the experiment, in-depth interviews were conducted among experimental group members to understand their behaviors and motivations. The experiment was designed following the normal teaching process and previous commitment of score assessment. Such an experiment was ethically conduced as students' expression of their understanding on knowledge-sharing incentives after explaining the purpose of

this experiment.

(Insert Figure 2 and Table 3 about here)

To guarantee experimental randomness, students knew nothing of our intentions, and they were never identified as participants in experiments. The teacher explained the teaching schedule and how grades would be calculated at the first meeting. As stated above, treatment group selections were random in nature. To control for the potential interference of individuals and for differences among groups, levels of familiarity between group members and inter-group communication were made as uniform as possible. First, inter-group familiarity facilitates student cooperation, indicating a huge difference in communication efficiency during the process of task assignment. To eliminate this interference, students had to seek partners unfamiliar to them online or offline to finish the task illustrated in Figure 3. Most students took advantage of online channels, such as WeChat, by sending out red envelopes. Doing so allowed them to judge the abilities of their partner through offline communication, guaranteeing that every member had minimal communication with others and every group had the same level of communication efficacy. Second, the teaching assistant separately arranged each group task online to help prevent groups from communicating with each other, thereby reducing the risk of undesirable inter-group cooperation. Finally, the time given for the submission of papers and PPTs was consistent to ensure fair results. By contrast, scores were given by experts who had no information about the students to ensure anonymous marking as far as student grades were concerned.

(Insert Figure 3 about here)

4 Empirical analysis

4.1 Description of variables

The different incentives of PPT presentations and weekly reports were introduced to the treatment groups. The former requires intra-group cooperation to deal with the challenges of inter-group competition. The latter requires intra-group competition for differential member ranking. On the one hand, intra-group members in the weekly report groups were required to report their work, with member-differentiated performance in knowledge sharing and task achievement rigorously scored. Although the teaching assistant indicated that their scores might reflect the comprehensive evaluations given by intra-group members, students did not know that the scores were only incentives and were excluded from final grade calculations. The purpose was to motivate individuals to strengthen topic communication initiatives and facilitate individual task completion to improve group performance due to the pressure of intra-group competition. The research team observed whether voluntary contribution in knowledge sharing among intra-group members was affected by the introduction of intra-group competition and what effects intra-group competition would produce. On the other hand, intra-group members in PPT presentation groups were required to cooperate with others by showing their work. The teaching assistant indicated that other groups would score their performance and thus might affect their final grades. The PPT presentations were only incentives and had no impact on the final outcomes. The purpose was to motivate

members to cooperate with each other in accomplishing the task. The research team observed whether intra-group members increased their contribution in knowledge sharing, given the context of inter-group competition, and whether it affected team performance. Thus, self-evaluations among weekly report groups and inter-group evaluations of PPT presentation groups were only incentives, which are designed to increase the sense of intra-group competition and cooperation.

In this study, we defined the assignment of weekly report groups as the incentive for intra-group competition and that of PPT presentation groups as the incentive for intra-group cooperation. Meanwhile, the heterogeneity of members' features, such as gender, college, overall level of learning experience (grades), and extracurricular activity, were regarded as intra-group diversity. Therefore, the study adopted *weekly report group*, *PPT presentation group*, *grade level*, *college diversity*, *gender diversity,* and *active level* as independent variables and *PPT score* and *paper score* as dependent variables to measure group performance. The variable descriptions are given in Table 4. Under the premise of estimating parameters by the least squares method, this study assumed the linear model shown in Equations (1) and (2).

$$PPT\ score = \alpha + \alpha_1 Grade\ level + \alpha_2 College\ diversity + \alpha_3 Gender\ diversity + \alpha_4 Active\ level + \alpha_5 Weekly\ report\ group + \alpha_6 PPT\ presentation\ group + \delta_1 \quad (1)$$

$$Paper\ score = \beta + \beta_1 Grade\ level + \beta_2 College\ diversity + \beta_3 Gender\ diversity + \beta_4 Active\ level + \beta_5 Weekly\ report\ group + \beta_6 PPT\ presentation\ group + \delta_2, \quad (2)$$

where α and β are constant coefficients, α_i and β_i (i = 1, 2, … 6) are variable coefficients, $\delta 1$ and $\delta 2$ are error terms.

(Insert Table 4 about here)

4.2 Data overview

PPT and *Paper scores* were evaluated on a group basis. Scores were given for the four levels: 65, 75, 85, and 95. The descriptive statistics of group-based variables is shown in Table 5. The findings revealed that when an average score is greater than 80, the overall performance is excellent. The maximum *Grade level* was 9, indicating that members mainly consisted of senior students. The maximum *College diversity* was 5, showing that group members were from different colleges. The minimum *Gender diversity* was 1, indicating that one team was made up of all girls or all boys. The *Active level* scores ranged from 0 to 5, showing significant differences among groups at the extent to which students participated in a league or union. The variables *Weekly report group* and *PPT presentation group* were logical and took values of either 0 or 1. If the value of *Weekly report group* is 0, the group is not a weekly report group, and vice versa. The cases of *PPT presentation group* and *Weekly report group* were similar. The correlation statistics is also shown in Table 5, where the maximum correlation coefficient among variables was 0.6151. That is, no collinear relationship existed among variables.

(Insert Table 5 about here)

4.3 Pre- and post-experiment interviews

Before the experiment, students were asked several questions to enable an understanding of their task-oriented familiarities. The results showed that although more than 75% of students know about social networks, they almost have no knowledge of how to conduct research on the basis of social network analysis. They have no relevant technical skills, such as Ucinet and Gephi.

Q1: Are you familiar with social network analysis (technical course)? If yes, please talk about your experience.

After the experiment, 25 PPT presentation group members were randomly interviewed along with 25 weekly report group members. They were asked about their own behavior and that of other members during the process of completing a task, as shown in Table 6. More than 95% of students in the PPT presentation groups showed an intense tendency for communication and cooperation. They commented that knowledge sharing helped the entire team perform well and was also beneficial to them. They actively selected one person to be the leader who assigned different tasks to members. However, nearly 40% of students in the weekly report groups showed indifferent attitudes toward cooperation, whereas some had no contact with intra-group members. Other students complained that certain members always arrogantly expressed themselves because they wanted to gain support from their teammates to receive a high score. Thus, they felt that they could not arrive at a consensus as everyone always wanted to speak, indicating no sense of team spirit and therefore no final team performance. In summary, the two types of treatment groups were differently motivated, as presented in Table 6. Through grounded analysis of interview responses, mainly driven by a sense of reciprocity, collectivism, work culture (cooperative atmosphere), and team development, PPT presentation group members chose intra-group cooperation and created a good communication atmosphere under inter-group competition. Conversely, the weekly report group members selected intra-group competition and only considered themselves in relation

to gaining high grades, rather than the overall group performance. According to the coding of interview responses, egoism and work culture (competitive atmosphere) were the driving forces.

(Measure of group type) Q1: What tasks (e.g., PPT presentation or weekly report submission) do you have to complete in this class?

(Measure of motive) Q2: Do you and your colleagues actively share knowledge and information, ask questions, and offer support? Why or why not?

(Insert Table 6 about here)

4.4 Results

To verify the above hypotheses, the least squares method was used to perform regression analysis on the constructed model. The results are presented in Table 7. The PPT presentation groups had higher *PPT* and *Paper scores* ($p < 0.05$), thus supporting Hypothesis 2. Knowledge sharing can create win–win situations bringing about mutual benefits. Students usually made active and effective voluntary contributions under the incentive of inter-group competition. The team performance outcome closely mirrored the results of its individual members. The motivation of reciprocity, collectivism, and cooperative atmosphere further enhanced team spirit and significantly affected the extent of voluntary contribution, which is conducive to good overall performance. However, weekly report groups and those possessing high intra-group diversity did not produce outstanding grades, indicating poor team performance. Hence, Hypotheses 1 and 3 were not supported. On the one hand, although weekly report groups might be mainly driven by egoism, individualism, and

competitive atmosphere (as shown from interview responses), the weekly report was also designed to motivate active participation in communication under conditions of competition. Excellent students are desired to achieve individual acknowledgment and gain peer recognition. However, intra-group competition cannot promote student knowledge sharing as students are prone to reduce the rate of voluntary contribution to their team and merely promote themselves. Evidence also shows that intra-group competition does not seem to directly improve (or impair) individual creative behaviors or group creative outcomes (Navaresse, Yauch et al. 2014). Therefore, this incentive has no effect on team performance. Social psychologists suggest that people tend to work with intra-group members when fighting inter-group offensives known as inter-group biases (Hewstone, Rubin et al. 2002), including intra- and inter-group competitions. Inter-group competition can enhance adaptability among intra-group members (Henrich 2004), further improving the adaptive advantage of intra-group cooperation (Choi and Bowles 2007). The evolution of cooperation transforms the group process from self-interest to mutual benefit (reciprocity) in psychology (Deutsch 1962). Intra-group competition weakens intra-group cooperation (Goldman, Stockbauer et al. 1977). This statement is consistent with our findings on intra-group cooperation and competition. On the other hand, intra-group diversity plays a weak role in influencing outcomes, especially if members have the same level of task-related abilities. Group diversity does not significantly affect group performance, especially when groups have no prior knowledge of the course concerned.

(Insert Table 7 about here)

5 Additional analyses

5.1 Optimizing regression analysis

To eliminate the influence of irrelevant variables, stepwise regression was used for confirming whether PPT presentation group had high group performance (*PPT* and *Paper scores*). The F values were 10.955 and 4.417 ($p < 0.05$), which also excluded the external influence of teams' structural characteristics and team members' demographic attributes (*College diversity*, *Grade level*, *Gender diversity*, and *Active level)*. Moreover, setting up a weekly report group does not affect team performance. This finding is consistent with the above results. The final regression model involving the method of backward elimination is presented in Equations (3) and (4).

$$PPT\ score = 77.632 + 9.368\ PPT\ presentation\ group \quad (3)$$

$$Paper\ score = 82.368 + 5.632\ PPT\ presentation\ group. \quad (4)$$

5.2 Changing the experimental group

To observe the impact of experimental group motivated by intra-group cooperation or competition (*PPT presentation group* or *Weekly report group*) on group performance (*PPT* and *Paper scores*), the occurrence when a kind of group belongs to the PPT presentation and weekly report groups is explored. This group is required to present PPT and report the work. Therefore, we take variables *PPT presentation and weekly report groups* to study whether their knowledge sharing can help improve job performance when students face intensive inter- and intra-group competitions at the same time. The simultaneous incentives of inter- and intra-group competitions *(PPT presentation and weekly report groups)* had no impact on team performance (PPT

score: $\beta = 6.714$, $p > 0.05$; Paper score: $\beta = 2.047$, $p > 0.05$). That is, when team members are simultaneously motivated by inter- and intra-group competitions, students do not have great enthusiasm to contribute to the whole team through knowledge sharing. Thus, in the case of intra-group competition, team performance cannot be significantly improved, further proving that a PPT presentation group is suitable for student improvement. To fully realize a team's potential, appropriate inter-group competition should be given to promote intra-group cooperation. Therefore, inter-group competition, rather than intra-group competition, can act as a catalyst to stimulate students to be creative and thus influences their final performance.

5.3 Analyzing the effect of setting up a group

5.3.1 Impact of grouping on changes in the overall relationship

Teamwork is considered a valuable learning factor in higher education (Mishra, Ostrovska et al. 2015), and grouping is the precursor of teamwork. Its purpose is not only to improve student knowledge sharing and cooperation but also to positively reinforce student relationships. Gephi was used (Figure 1) to visually describe the observed data, but the overall network structure cannot be analyzed from a quantitative perspective. To further observe the relationships among students after grouping, the social network method was used to analyze the changes in network parameters from T0 to T3, as shown in Table 8. The network diameter and average path length gradually decreased, whereas graph density and average weighting

increased. The network of knowledge sharing and student relationships became intensive, showing that grouping, apart from affecting performance, also promotes positive relationship changes. Thus, to opt for grouping is the best decision for relationship enhancement in classrooms and is a necessary step for fostering knowledge sharing behavior.

(Insert Table 8 about here)

5.3.2 Impact of grouping on comprehensive and individual performance

Linear regression was used to figure out whether the design of experimental group has a significant impact on comprehensive and individual performances. In the assessment, the assignment and attendance scores reflected individual performance as determined by their own traits, whereas *PPT* and *Paper scores* reflected team performance. Comprehensive score was composed of the above four scores for measuring comprehensive performance, and individual score consisted of assignment and attendance scores to gauge individual performance. Weighted comprehensive score was calculated according to different weightings of the four scores (i.e., 10%, 10%, 60%, and 20%), whereas unweighted comprehensive score presented the four scores with equal proportion. Table 9 shows that in terms of comprehensive performance, the existence of a PPT presentation group positively affected members' comprehensive scores (weighted: $p < 0.05$; unweighted: $p < 0.05$). Meanwhile, weekly report groups had the same impact as PPT presentation groups on students' comprehensive performance (weighted: $p < 0.05$; unweighted: $p < 0.05$). However, students' demographic characteristics (grade, gender, and social activity) had no

correlation with their comprehensive performance ($p > 0.05$). That is, personal attributes related to the tasks are evidently insufficient in terms of ability improvement. As for individual performance, PPT presentation groups played a negative and significant role in individual performance, whereas weekly report groups had no obvious effect on individual performance. The members of PPT presentation groups stimulated by inter-group competition (intra-group cooperation) cared about group-based rewards and did not show a strong competitive advantage for individual-based rewards. Furthermore, gender affected individual scores (attendance score: $p < 0.05$; assignment score: $p < 0.05$; and individual score: $p < 0.05$), indicating that females are prominent individual performers. Many studies have shown that women are better curriculum performers than men (Mcnabb, Pal et al. 2002) because women are better at knowledge acquisition. Thus, grouping, as intervened by coopetitive structures, has a positive impact on comprehensive performance. However, grouping does not play an important role in individual performance, which is closely related to gender.

To further examine the impact of different groups on individual performance, we conducted detailed statistical analysis on the distribution of scores in different groups. According to the statistics, members in weekly report groups have the highest average individual scores, especially when compared with students in PPT presentation groups. These scores are divided into four levels, that is, A, B, C, and D, indicating that the scores are lowered in order. Weekly report groups take up the largest proportion in a high-scoring area, followed by control groups. We assumed that when an incentive is

given to weekly report groups, they spare no effort to pursue personal achievements. This incentive can make intra-group members competitive for individual-based rewards. By contrast, when PPT presentation groups are stimulated by inter-group competition that can increase intra-group cooperation, their individual performance is not outstanding compared with group outcomes. Note that presentation groups target group-based rewards and consider collective interests.

In summary, forming coopetitive groups by cooperative or competitive incentives can enhance members' comprehensive performance through improving team or individual performance. Surprisingly, intra-group cooperation is not conducive to individual development, whereas intra-group competition encourages students to stride for individual recognitions. Thus, the design of coopetitive groups should exert a profound influence on future teaching methodologies and academic research.

(Insert Table 9 about here)

5.4 Excluding the impact of PPT presentation order on PPT scores

To avoid inadvertent bias, the order of PPT presentations was determined by lottery. However, any sequence of presentations might affect performances. That is, an early group presentation might inspire later groups. Therefore, the presentation order was taken as a variable to see whether any effect occurred on the final PPT scores. The result indicates that the PPT presentation order had no significant effect on the PPT scores ($\beta = -0.144$, $p > 0.05$), proving the rationality of this experiment.

6 Conclusions and implications

The study adopted the randomized experiment approach to explore the impact of intra-group competition and cooperation on team performance, as promoted by different incentives to share knowledge. In this experimental design, we defined the assignment of PPT presentation groups as dominant cooperative reward (referred to as "intra-group cooperation") and that of weekly report groups as dominant competitive reward (referred to as "intra-group competition"). The results showed that inter-group competition can enhance intra-group cooperation and further improve its voluntary contribution of knowledge sharing to improve team performance. However, intra-group competition does not play a positive role in team performance. Furthermore, intra-group diversity is not that relevant to team performance and thus need not constitute a factor affecting the establishment of experimental groups. In addition to clarifying the consequences of two incentives for knowledge sharing, understanding its antecedents is also crucial. The interview responses can reflect the psychological process of knowledge sharing when each group is stimulated by different incentives. Therefore, inter-group competition strengthens intra-group cooperation due to reciprocity (mutual interests), cooperative culture, and collectivism, whereas intra-group competition discourages students from engaging in team development, which is mainly due to egoism, competitive culture, and a lack of collectivist spirit. This study explored behavioral performances and psychological processes in knowledge sharing under the contexts of intra-group competition and cooperation. The theoretical and practical implications are as follows.

6.1 Theoretical implications

This research leads to several theoretical implications. First, from the perspective of organizational learning, the choices of whether to share or hoard knowledge in learning can be beneficial to individual or collective development, which has attracted much attention from scholars (Yang, Fang et al. 2014). For example, the choice between cooperation- and competition-based learning (Das and Teng 2000). The study provides an empirical answer that intra-group cooperation is conducive to team performance but does not play a positive role in individual achievement. This answer stems from the observation that students in a dominantly cooperative environment pay more attention to team performance than to individual acknowledgment. Moreover, intra-group competition has no significant impact on team or individual performance, but most members can achieve excellent scores in individual performance. In a dominantly competitive environment, intra-group conflict can immediately occur, which causes students to focus on their individual accomplishments, as individual-based rewards can keep individuals in high spirits to create knowledge for their own development (Lee and Ahn 2007). Intra-group cooperative learning is the top priority in comprehensive performance. In summary, the most effective organizational learning is under the flux of cooperation and competition, rather than any idealized forms, such as pure competition or pure cooperation (Jashapara 2003), as the proper combination of cooperation and competition can enhance team performance (Böhm and Rockenbach 2013).

Second, this study confirmed several theories. On the basis of social

interdependence theory, this study examines the relationship among group interdependence, group-related outcomes, and individual-based psychological process; this analysis is consistent with the ideas of Deutsch (1949), Deutsch (1962), Johnson and Johnson (1989). Group denotes a mutual interdependence among members who are assigned to complete common tasks (Lewin 1936). Group learning includes simultaneous cooperation and competition (referred as "coopetitive"), which affects the behavior of knowledge sharing (Gordon, Welch et al. 2000). Intra-group cooperation (dominantly cooperative reward) that is reinforced by inter-group competition increases interactive collaboration and team performance. From the perspective of motivation in knowledge sharing, individuals stimulated by intra-group competition focus on self-interest, whereas those motivated by intra-group cooperation can shift from self-interest to joint interest, which is also in accordance with previous research findings on motivations for knowledge sharing (Morawski 2012, Guan, Wang et al. 2018). This behavior is affected by egoism (Wang, Yang et al. 2016) and reciprocity (Liao, To et al. 2013). Egoism causes individuals to reduce voluntary contribution, whereas reciprocity enhances individual voluntary knowledge sharing contribution. Unlike altruism, reciprocity is a stronger behavioral tendency (Carpenter, Bowles et al. 2009). Individuals in a competing environment can choose to cooperate and compete, as appropriate, for maximizing their benefits (Ibanez and Schaffland 2018) that are positively affected by their voluntary contributions to knowledge sharing. Thus, reciprocal incentives help teams work effectively and cooperatively.

Finally, through this randomized experiment, group diversity is found to have no correlation with performance (Homberg and Bui 2013). In addition, individual differences are generally not that obvious and significant when teams are task-oriented. Research evidence reveals that age is positively related to intra-group cooperation, whereas gender and familiarity of intra-group members have no impact on their knowledge sharing (Majolo and Maréchal 2017). For complex tasks, especially when groups are stimulated by coopetitive rewards, the impact of intra-group formations with different demographic characteristics on team performance is confirmed as insignificant and can be ignored. Cooperative learning is found to be an effective way to improve team performance and has nothing to do with intra-group diversity (Johnson, Johnson et al. 2007).

6.2 Practical implications

From a psychological perspective, justice-based altruism is a powerful source of human cooperation; however, cooperation is chosen by egoists when it suits their self-interest in cases such as economic remuneration, completely negating the altruistic cooperation model (Fehr and Rockenbach 2003). Reciprocity, which is under the conditions of cooperation, maximizes thinking skills in the learning context (Lee, Parsons et al. 2016). Reciprocity is a combination of altruism and egoism, and interests are mutual. Therefore, the awareness of cooperation can be strengthened when under the pressure of competition. From a behavioral perspective, different interactive modes, namely, cooperative or competitive, can result in different group

outcomes (Johnson and Johnson 1974). Traditional classroom teaching involves one-way knowledge transfer and is teacher-centered. By contrast, student-centered knowledge sharing is the way to encourage students to actively participate and interact with others (Kulasegaram and Rangachari 2018). Thus, cooperative learning is a better choice than competitive learning in organizational learning.

The experiment results offer certain suggestions to teachers on optimizing their teaching mode in classrooms for the benefit of students. Students effectively grasp basic knowledge, team spirit is fostered, and all-around development is improved. Practical implications are as follows.

First, grouping is the best way to manage large classes to deepen the integration of student relationships. Cooperative culture can also help groups enhance their knowledge sharing behavior and favorable interaction. Grouping, which has mutual interdependence, can therefore cause tasks to be completed effectively and to increase students' sense of responsibility.

Second, incentive is the driving force that affects intra-group competition and cooperation among students. Providing students with appropriate inter-group competitive activity to reduce intra-group conflict and to enhance their intra-group cooperation is necessary for promoting voluntary knowledge sharing among group members. Therefore, the design of incentives, such as evaluations, should be based on the exercise of reciprocity to maximize student voluntary knowledge sharing.

Finally, student–student interaction facilitates students to use potentially new knowledge for creating additional values and promoting good complementarity with

teacher–student interaction. For example, instructors should appropriately arrange complex tasks for students. Task-oriented curriculum design greatly promotes team knowledge sharing and communication efficiency and improves the overall performance. Arranging suitable tasks is a catalyst for knowledge exchange and interaction among students.

6.3 Limitations and future directions

The study has several limitations. We cannot guarantee that all individuals in the experiment actually communicated. Although this experiment excludes intra-group differences, individual skills, such as thinking and writing, inevitably vary from person to person. To address these points, first, we plan a psychological survey to gain further understanding of individual abilities and explore whether these abilities affect the judgments of expert assessors. Second, the QQ group that serves as a communication channel will not be established to explore whether student outcomes are consistent with observations. Third, future analysis and comparisons with additional experiments may accurately explain the behavior of group members. Fourth, we can narrow the research scope and explore the extent to which the size of communication circles has an impact on knowledge sharing.

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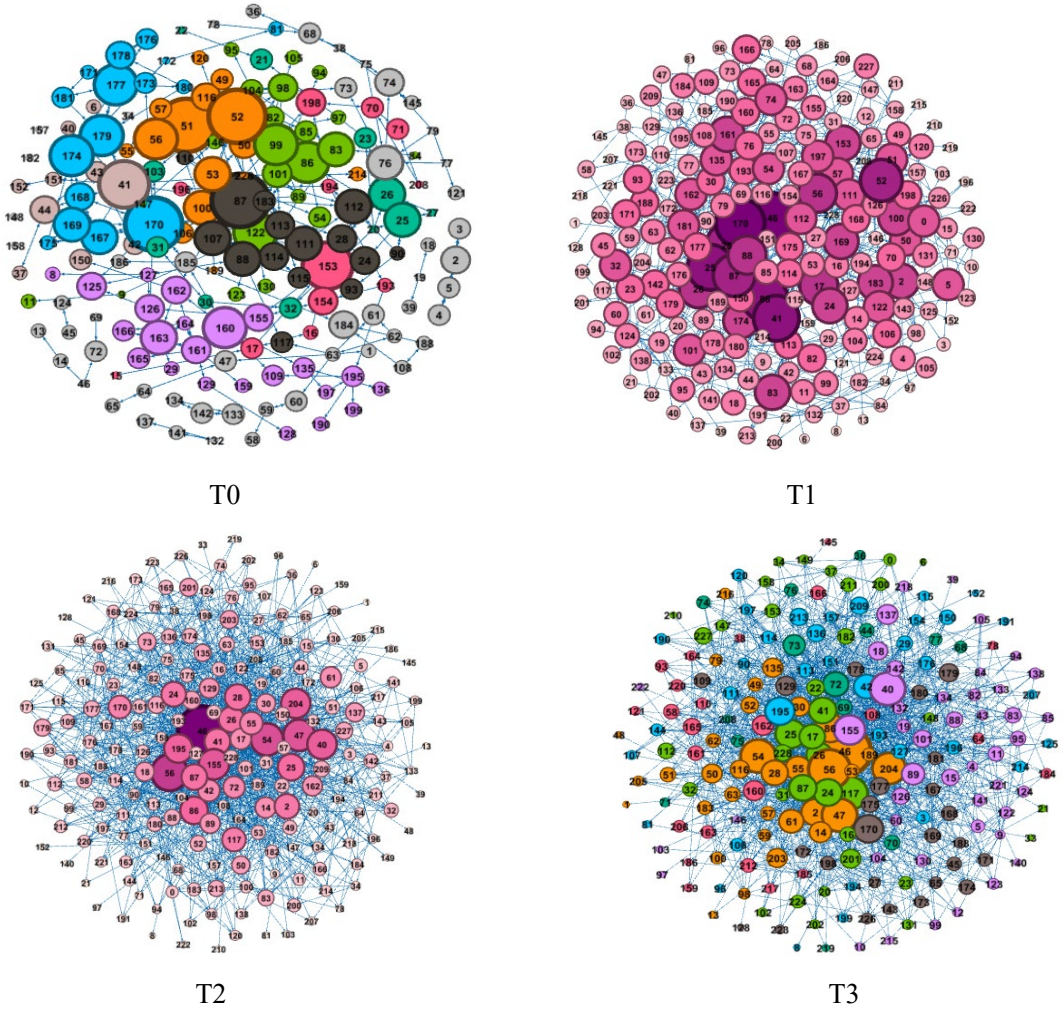
Appendix

Figure 1. Relationship between elective students in the period from T0 to T3
Note: Students are numbered and sorted by college.



T0 T1

T2 T3

Figure 2. Experimental design

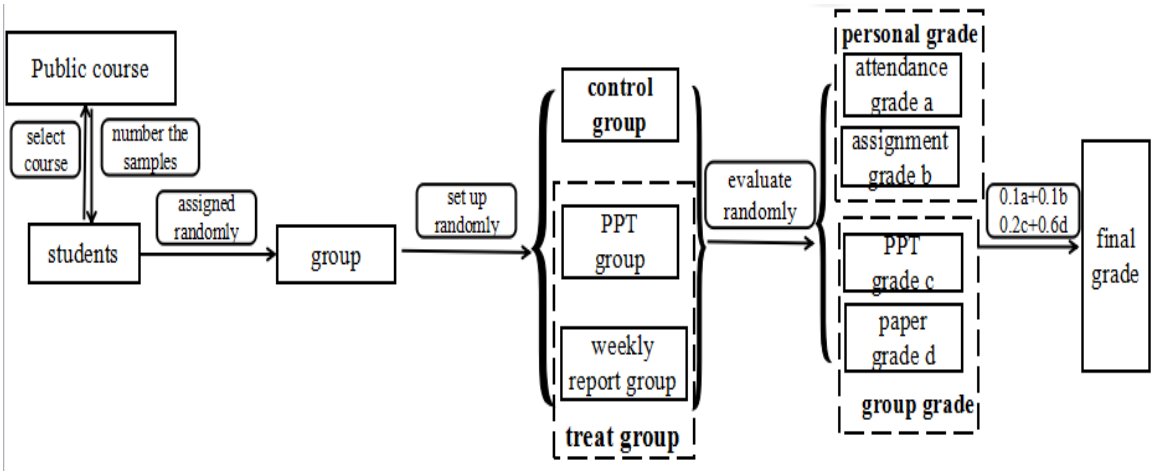


Figure 3. Mode of grouping

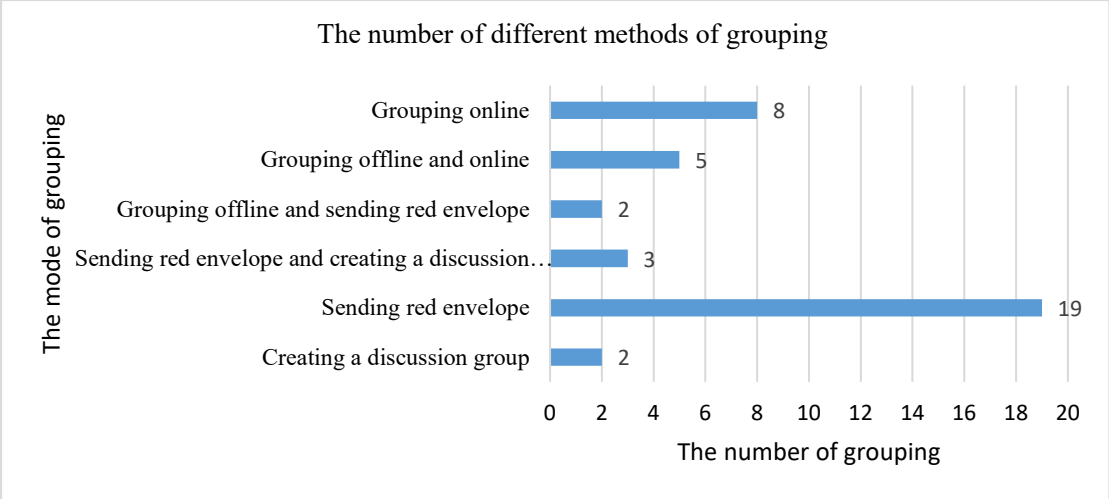


Table 1. Students' relationship in public electives

Period	Explanation	Number of subjects	Number of students' relationship
T0	Student's initial relationship before the first week of public elective class.	176	347
T1	Students' relationship in the second week of public elective course, when group was arranged in the first week, then asked to find unfamiliar members to complete the task.	207	903
T2	Students' relationship in the fourth week of public elective course, when they had finished the self-introduction task in the QQ group, and active students in the enrolment were given extra points.	215	1743
T3	Students' relationship in the sixth week of public elective course, when PPT presentation task and weekly report task were arranged in the fifth week.	215	2023

Table 2. Demographics of students in public electives

Property	Distribution of different property				
College	School of Economics and Management 20.21%	International School of Software 10.64%	School of Electronic Information 10.11%	School of Information Management 9.57%	Other Schools 49.47%
gender	female 47.34%	male 44.68%	Missing item 7.98%		
dormitory	Department of Informatics 34.57%	Department of engineering 21.28%	Other departments 44.15%		
social activity	league 35.11%	Neither league or student union 33.51%	Student union 23.40%	Missing item 7.98%	
hometown	Hubei 21.81%	Henan 9.57%	Anhui 6.38%	Guangdong 5.32%	Other provinces 56.92%
grade	Sophomore 47.65%	Freshman 28.23%	Junior 21.18%	Senior 2.35%	Others 0.59%

Table 3. Experiment design at different groups

Experimental Design	Control Group	Experimental Group1	Experimental Group2	Experimental Group3
The number of different kinds of groups	9	10	10	10
Whether is required to report the work weekly	NO	NO	YES	YES
Whether is required to present PPT	NO	YES	NO	YES
Whether is required to submit PPT production	YES	YES	YES	YES
Whether is required to submit a research paper	YES	YES	YES	YES

Note: “YES” presents the group is required to complete the corresponding assignment in the first column, while “NO” refers to the group is not required to complete the corresponding assignment in the first column.

Table 4. Description of the variables

Variable	Index	Description
Dependent variable	*PPT score*	*PPT score* represents the score of PPT production rather than PPT presentation.
	Paper score	*Paper score* represents the score of a research paper (thesis).
Independent variable	*Grade level*	*Grade level* represents the sum of members' grade, and the grade of freshman is marked as zero, sophomore is marked as one, junior is marked as two, senior is marked as three. For example, if a group consists of five freshmen, the value of Grade level is 0; if a group consists of five sophomores, the value of Grade level is 5.
	College diversity	*College diversity* represents the number of different colleges that members are from.
	Gender diversity	*Gender diversity* represents the category of members' gender, including female and male. If a group consists entirely of girl (or boy), the value of *Gender diversity* is 1, otherwise 2.
	active level	*active level* represents the number of members who participate in league or students Union.
	Weekly report group	*Weekly report group* represents that the group are randomly selected to submit report and self-evaluation in the fifth week.
	PPT presentation group	*PPT presentation group* represents that the group are randomly selected to present PPT and accept external evaluation in the sixth week.

Table 5. Descriptive and correlative statistics of the group variable

Variable	Mean	Std Dev	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
PPT score	82.436	9.925	1							
Paper score	85.256	8.732	0.615	1						
Grade level	4.333	1.951	-0.145	0.01	1					
College diversity	3.769	0.706	-0.162	-0.118	0.268	1				
Gender diversity	1.821	0.389	0.014	0.169	-0.127	0.037	1			
active level	2.821	1.189	-0.152	-0.021	0.276	0.2	0.384	1		
Weekly report group	0.513	0.506	0.216	0.089	0.115	0.045	0.213	0.157	1	
PPT presentation group	0.513	0.506	0.478	0.327	-0.391	-0.323	-0.189	-0.28	-0.026	1

Note: 1,2…8 in the first row respectively represent *PPT score*, *Paper score*, *Grade level*, *College diversity*, *Gender diversity*, *active level*, *Weekly report group*, *PPT presentation group.*

Table 6. Result of interview (part)

Group	Motivations	Answers
PPT Presentation group	(1) Reciprocity, hedonism and work culture	(1) To gain a high score for the whole team, we work together happily, where everyone shares and discusses the information they collected after class.
	(2) Team development and collectivism	(2) In the process, I feel the sense of teamwork and accomplish tasks together is very effective. Because I think the team performance is importance as we can learn more than knowledge through sharing.
	(3) Individualism and personal characteristic	(3) Someone is very active to express, and I keep silent due to the fact I want to study by myself.
Weekly Report group	(4) Egoism and work culture	(4) I don't like this assessment, which lets us care more about individual performance, someone is always dominated in speaking, who makes me disappointed.
	(5) Egoism and work culture	(5) I give me a high score because I am unfamiliar with others, everyone is passive and just occasionally discuss if we need to submit a general task.
	(6) Work culture and no sense of collectivism	(6) I almost take no active in discussing as no one organizes it as if we don't belong to a team. Everyone is almost indifferent, doing what they want to do.

Table 7. Regressive results of the least squares

	PPT score			***Paper score***		
	Path coefficient	Standard error	t	Path coefficient	Standard error	t
PPT presentation group	9.789**	3.392	2.89	7.800*	3.154	2.47
Weekly report group	4.197	3.026	1.39	0.311	2.814	0.11
Grade level	0.369	0.897	0.41	1.153	0.834	1.38
College diversity	-0.177	2.248	-0.08	-0.461	2.090	-0.22
Gender diversity	2.885	4.442	0.65	7.096	4.131	1.72
active level	-0.885	1.450	-0.61	-0.601	1.348	-0.45
_cons	71.579***	12.742	5.62	66.614***	11.849	5.62

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

Table 8. Overall network parameters of students' relationship

Period	The number of nodes	The number of edges	Average degree	average weighting	network diameter	Graph density	Modular Coefficient	Average path length
T_0	176	340	3.864	1.932	21	0.011	0.737	6.53
T_1	207	903	8.725	4.362	8	0.021	0.000	3.601
T_2	215	1743	16.214	8.107	6	0.038	0.000	2.637
T_3	215	2023	18.819	9.409	5	0.044	0.044	2.509

Table 9. Regression analysis of individual performance

	Attendance score	*Assignment score*	*Comprehensive score 1 (weighted)*	*Comprehensive score 2 （unweighted）*	*Individual score*
Weekly report group	0.991	-0.536	2.195*	1.900**	0.454
PPT presentation group	-1.561	-1.365	4.882***	3.010***	-2.926*
Grade	-0.517	-0.169	-0.165	-0.164	-0.686
Social activity	-0.213	0.685	0.123	-0.158	0.471
gender	1.885*	1.430*	-0.240	0.725	3.314*
_cons	1133.666	432.628	415.139	415.500	1566.294

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