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The promise of using study-together groups to promote engagement and performance in online courses: Experimental evidence on academic and non-cognitive outcomes

Xuehan Zhou [a,*], Qiujie Li [b], Di Xu [b], Amanda Holton [c], Brian K. Sato [d]

[a] Institute of Economics of Education, Graduate School of Education, Peking University, Beijing 100871, China
[b] School of Education, University of California, Irvine, Irvine, CA 92697, United States of America
[c] Department of Chemistry, University of California, Irvine, Irvine, CA 92697, United States of America
[d] Department of Molecular Biology & Biochemistry, University of California, Irvine, Irvine, CA 92697, United States of America

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ABSTRACT

Researchers and practitioners of online education have consistently emphasized the importance of facilitating peer interaction and mutual support to create a sense of community, which in turn may enhance motivation, promote extrinsic accountability, and improve learning outcomes. Despite these assertions, experimental evidence on the effects of peer support in college online courses is limited. To address this gap, we conducted a randomized controlled trial to examine the impact of a study-together group intervention on students' academic and non-cognitive outcomes in a for-credit online course at a public four-year college. Our findings indicate that students who were offered a study-together group reported a higher sense of belonging than those who were not. Additionally, students with lower academic preparation and lower baseline motivation demonstrated improved academic performance as a result of this intervention, while students who preferred passive interaction reported increased motivation. However, for students with higher baseline motivation and those who preferred active interaction, the intervention appeared to negatively influence their time management.

1. Introduction

Notable theories on academic interest and success converge to emphasize the crucial role of effective peer-to-peer interaction in promoting a sense of belonging (Delahunty, Verenikina, & Jones, 2014; Gilken & Johnson, 2019; Shackelford & Maxwell, 2012), motivation (Jung, Choi, Lim, & Leem, 2002; So & Brush, 2008), and academic performance (Jaggars & Xu, 2016; Kurucay & Inan, 2017) in college online courses. Yet, prior literature on online teaching and learning suggests that a significant challenge in the virtual learning environment is the greater difficulty in achieving meaningful peer-to-peer interactions due to the physical separation between learners (Bambara, Harbour, Davies, & Athey, 2009; Huguet, Dumas, Monteil, & Genestoux, 2001; Jaggars & Xu, 2016). This physical separation poses a barrier to student's ability to seek timely academic and social support from their peers, which can negatively impact their sense of belonging, motivation, and academic performance, particularly for those with lower levels of academic preparation and motivation (Figlio, Rush, & Yin, 2013; Xu & Jaggars, 2014). Additionally, the lack of joint presence with classmates creates fewer opportunities for extrinsic accountability, which can impede students' ability to manage their time effectively, especially for those with lower levels of time management skills (Baker, Evans, Li, & Cung, 2019; Mullen & Tallent-Runnels, 2006; Zhan & Mei, 2013).

To address these challenges, researchers and practitioners have sought low-cost and scalable interventions that have the potential to promote peer interaction and build a robust peer support system in fully online coursework (e.g., Chang & Kang, 2016; Osborne, Byrne, Massey, & Johnston, 2018; Sheeran & Cummings, 2018). One promising approach is the study-together group, where a small group of students meets regularly to study together and discuss course materials, ask questions, share insights, and mutually assist one another in comprehending subject matter either related to a particular course or broader academic concern (e.g., Arendale & Hane, 2014; Chen & Chen, 2015). Unlike formal group projects, where individuals are often bound together by grades and have to compromise their personal interests for the benefit of the group (Chang & Kang, 2016), study-together groups

* Corresponding author.
E-mail addresses: xuehanz@pku.edu.cn (X. Zhou), qiujiel@uci.edu (Q. Li), dix3@uci.edu (D. Xu), abrindle@uci.edu (A. Holton), bsato@uci.edu (B.K. Sato).

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are not associated with graded assignments and allow individuals to choose their preferred learning content and work style, where free-riding or lack of agency is less of a concern (Chen & Chen, 2015; Tang, 1993; Zevenbergen, 2004). By asking students to check in with each other regularly and setting aside time to study together, study-together groups can not only enhance learning through collaboration and sharing, but may help build extrinsic accountability, address problems such as cramming and procrastination, and develop a sense of community (e.g., Bourgault, Galura, Kinchen, & Peach, 2022).

A growing number of studies have examined the effects of facilitating study-together groups in in-person classes through either in-person group meetings (e.g., Arendale & Hane, 2014; Holliday & Said, 2008; Tang, 1993; Zevenbergen, 2004) or virtual meetings using social network applications such as Facebook, WhatsApp, and Zoom (e.g., Sheeran & Cummings, 2018; Thai, Sheeran, & Cummings, 2019). These studies consistently indicate that study-together groups positively influence student academic engagement, interpersonal skills, sense of belonging, and motivation. Given the promising findings from in-person classes, many practitioners have advocated creating and facilitating study-together groups in online settings to support peer interactions and build learning communities (e.g., OLT Faculty Development, 2020). Yet, rigorous evidence on the impacts of such groups in online courses is limited.

To address the gap in the current literature, this study used a randomized controlled trial to test the efficacy of a study-together group intervention in an online course at a four-year public college. The intervention involved assigning treatment students into small study groups with three randomly selected class peers and providing clear guidance on scheduling and carrying out regular study sessions with their peers. Specifically, we aimed to answer two research questions (RQs):

RQ1. What is the impact of a study-together group intervention on students' course grades, sense of belonging, motivation, and time management in an online course?

RQ2. Are there variations in the impact of a study-together group intervention for students with different baseline levels of academic preparation, motivation, time management, and interaction preferences?

This study contributes to the existing literature in three keyways. First, while several studies have identified noticeable benefits of study-together groups in in-person courses (e.g., Thai et al., 2019), it is unclear to what extent these findings apply to the online setting, considering that online courses have greater difficulties in providing effective interpersonal interactions than in-person courses. To our knowledge, this study is the first to examine the efficacy of study-together groups in college online courses. Second, unlike previous studies that primarily focused on motivation, sense of belonging, and peer relationships as key outcome measures (e.g., Hurt et al., 2012; Thai et al., 2019), the current study further includes course performance as a key outcome along with the other non-cognitive measures, thus advancing the literature by illuminating the impacts of study-together groups on student academic performance. Finally, our study assesses the differential effects of the study-together group intervention on students with varying levels of academic preparation, motivation, time management, and interaction preferences, providing insights into possible ways to mitigate equity gaps.

2. Literature review

2.1. The importance of peer-to-peer interaction in online learning

Multiple theoretical frameworks have highlighted peer-to-peer interaction as an essential component of online learning. For instance, Moore's interaction framework, one of the foundational theories in distance education, suggests that peer-to-peer interaction, the communication between two or more students in the course, promotes critical thinking and in-depth understanding and thus is critical for distance learning (Moore, 1989). Community of inquiry (CoI), another predominant framework in online learning, emphasizes three effective online learning elements: cognitive presence, social presence, and teaching presence. It argues that peer-to-peer interaction is vital in promoting social presence and teaching presence within a learning community and that the two elements work in tandem to enhance cognitive presence and improve learning outcomes (Garrison, Anderson, & Archer, 1999; Miao, Chang, & Ma, 2022; Swan, 2003).

The critical role of peer-to-peer interaction in online learning environments has also received extensive support from the empirical literature. First, research has demonstrated that peer-to-peer interaction can foster a sense of belonging in online learning (e.g., Delahunty et al., 2014; Motz, Quick, & Morrone, 2022; Shackelford & Maxwell, 2012), which is essential for persistence and course performance (SchWeber, 2013). For example, based on survey data and online learning management system data from multiple campuses, Motz et al. (2022) found that peer-to-peer interactions can enhance students' perceived support from others and effectively improve a sense of acceptance of and belonging toward the learning context. Second, prior literature has consistently shown that high levels of peer-to-peer interaction, such as students sharing personal experiences with each other, are also predictive of greater course motivation, engagement, and satisfaction (e.g., Jung et al., 2002; Sher, 2009; So & Brush, 2008). For instance, Jung et al. (2002) found that when online students worked collaboratively on a specific topic or shared ideas and materials to solve a given problem, they were more likely to be actively engaged in and satisfied with the learning process. Finally, a number of studies have identified peer-to-peer interaction as a crucial factor in enhancing students' academic performance (e.g., Bernard et al., 2009; Kurucay & Inan, 2017; Sher, 2009; Sunar, White, Abdullah, & Davis, 2017). Specifically, interactions among students can expose them to diverse perspectives and facilitate an in-depth and comprehensive understanding of course content (York & Richardson, 2012). For example, Kurucay and Inan (2017) conducted quasi-experimental research among 77 students in an online course, where treatment students completed assignments in small groups and control students completed course assignments individually. The study revealed that peer-to-peer interactions positively affected students' perceived learning and academic achievement.

2.2. Practices to promote peer-to-peer interaction in online settings

Extensive empirical evidence confirms that insufficient peer-to-peer interaction is a common phenomenon in online learning environments, resulting in students feeling unsupported and unaccountable (Cox, 2006; Jaggars & Xu, 2016; Moore, 2012). To encourage opportunities for extrinsic accountability and construct a strong social support system, there is a growing interest in identifying effective practices that promote online peer interaction. Three practices are commonly used to enhance peer interaction in online and face-to-face courses, including asynchronous discussion boards, group assignments, and study-together groups. Below we first summarize the literature regarding each practice. We then describe how our intervention is situated in the extant literature.

2.2.1. Asynchronous discussion boards

Where students can discuss course-specific content on discussion forums on the course websites, have been one of the most commonly used tools in online learning to foster peer interactions (Osborne et al., 2018). Nevertheless, researchers have yet to reach a consensus on the effectiveness of discussion boards. Some studies have argued that discussion boards are essential for a better online learning experience and should be integrated to improve student learning in online courses (e.g., Ho & Swan, 2007; Osborne et al., 2018; Pacansky-Brock, Smedshammer,

& Vincent-Layton, 2020; Schellens & Valcke, 2006). In contrast, other studies have reported that students were disinterested in interacting with their peers on discussion boards and viewed the experience as an artificial communication (Jaggars & Xu, 2016; Li, Jung, & Friend Wise, 2021). In addition, asynchronous discussion boards may not provide students with timely feedback and support, nor do they offer the immediacy required for social interactions (McInnerney & Roberts, 2004), which can further diminish their effectiveness as a means of fostering interaction.

2.2.2. Group assignments

Where students work collaboratively on an assignment or project assigned by the instructor, have been widely used in online courses (e.g., Brindley, Blaschke, & Walti, 2009; Chang & Kang, 2016). Compared with asynchronous interaction through a discussion board, group assignments offer more opportunities for timely and regular interactions, allowing students to engage with each other in a reciprocal manner. Some research suggested that completing assignments in a small group can lead to higher academic achievement compared to completing them individually (e.g., Kurucay & Inan, 2017; Madland & Richards, 2016; Motz et al., 2022; Roulston, Pope, Paulus, & deMarrais, 2018). However, other studies collecting feedback from students have identified a number of challenges associated with group assignments in online courses, as individuals may need to compromise their personal interests and autonomy for mandated collaborative tasks and may lack a sense of control over the process and quality of group work, and subsequently assigned grade (Brindley et al., 2009; Chiong, Jovanovic, & Gill, 2012; DeVoe et al., 2007; Piezon & Ferree, 2008).

2.2.3. Study-together groups using social networking sites

Study-together groups using social networking sites are increasingly applied in in-person courses to develop accompanying online learning communities (Hurt et al., 2012; Sheeran & Cummings, 2018; Thai et al., 2019). Study-together groups in these studies typically acted as supplementary and non-project-based platforms where groups of students could hold each other accountable and discuss academic questions or matters that happened outside classrooms informally via social network sites. Therefore, unlike group assignments aimed at collaborative knowledge construction (Smith & Dirkx, 2007), study-together groups focus on constructing social and academic support. It offers students more flexibility and personal control over the learning process and consequences, which may promote students' engagement and socialization within groups (Brindley et al., 2009). Prior studies have tested the efficacy of such groups and consistently pointed out that they can leverage students' motivation, sense of belonging, and self-perceived academic performance. For instance, Sheeran and Cummings (2018) surveyed 471 students and found that students with a Facebook study group had better peer relationships and a higher sense of belonging than students without such groups. The promising results of study-together groups from survey studies are further confirmed by quasi-experimental evidence (Hurt et al., 2012; Thai et al., 2019). For instance, Thai et al. (2019) examined the impact of a Facebook group in a college course. They found that students with Facebook groups reported a greater sense of social connectedness and lower course-related stress than students without a Facebook group.

2.2.4. Intervention in the current study

Building on the previous literature, the present study designs a study-together group intervention and examines its impact on a variety of student outcomes in a fully online course offered at a four-year college. We selected study-together groups as a means to enhance online peer interaction due to three advantages they offer over alternative methods such as discussion boards and group assignments: First, study-together groups facilitate direct and reciprocal communication among students, thereby emulating spontaneous personal connections typically experienced in in-person settings; this fosters a heightened sense of social presence, promoting a more engaging learning environment. Second, study-together groups allow individuals to select their preferred learning content and levels of commitment, necessitating fewer group logistics management than other activities that offer similar levels of social interaction, such as collaborative projects. Third, the design and implementation of study-together groups are independent of the course content, making them applicable to all subjects and relatively straightforward to scale up to other online courses.

Although several studies have examined the effectiveness of study-together groups in face-to-face courses (Hurt et al., 2012; Sheeran & Cummings, 2018; Thai et al., 2019), this strategy was less utilized and examined in college online coursework, where peer interaction is often lacking.

To provide information on the potential benefits of study-together groups in college online courses, we conducted a randomized controlled trial to examine its impacts on both academic and non-cognitive outcomes in a for-credit online course at a public four-year college. We further examined the heterogeneity of the intervention according to students' academic preparation, baseline motivation level, interpersonal interaction preferences, and baseline time management. The heterogeneous results can shed light on who may benefit more from study-together groups, informing important implications for educational equality.

3. Methodology

3.1. Course and participants

The study was conducted in a fully online 10-week undergraduate chemistry course in the fall quarter of 2021 at a selective, public 4-year college. The course provided voluntary synchronous lectures held by the professor twice a week and one weekly virtual discussion session held by teaching assistants. Students were given the option to attend the synchronous lectures or watch recorded videos. The course required weekly assignments, including one video assignment and three homework assignments. In addition, three midterm exams were held in week 4, week 7, and week 10, respectively, and a final exam was held in week 11. Final grades were determined by video assignments (10%), homework assignments (20%), scores on the three midterm exams (40%), and final exam scores (30%).

A total of 528 students enrolled in this course. Before the course officially started and prior to the random assignment, all the students were invited to participate in the study with an information sheet explaining the purpose of the study and the implementation details. All of the students, despite their study-groups assignment and participation, were provided with the opportunity to earn two extra credits by participating in the research study and completing the pre- and post-surveys. Among the 528 students who were initially invited, 296 students opted into the research study, representing a 56% participation rate. Compared to non-participants, participants were more likely to be Asian, had higher weighted high school GPAs, enrolled in more units during the quarter, and were more likely to be freshmen (see Appendix A for more details).

3.2. Experimental design

After the recruitment, participants were randomly assigned to either a treatment group ($N = 144$) or a control group ($N = 152$) in week 1. Below we describe each condition in detail.

3.2.1. Treatment condition

Students in the treatment group were randomly assigned into small study-together groups of three individuals, and were provided with detailed instruction and guidance on how to connect with their group members through (1) the email addresses of the group members; (2) a preset link to a Discord group chat where students could chat with each

other asynchronously; and (3) a link to the weekly Zoom conference meeting at a preset time based on availability indicated by the three group members. Students had the flexibility to contact their group members via email or Discord, and they could choose to study with their group members either in person or via Zoom.

The intervention consists of two phases. In the first half of the course (weeks 2 to 5, Phase I shown in Fig. 1), we designed a weekly check-in homework assignment, "Learning & Study Habits Homework" (refer to "LSH homework" hereafter) and offered course credits to provide stronger incentives for students to initiate connections with their peers and cultivate group study habits. LSH homework was unrelated to course content and required students to complete three tasks: (1) studying with at least one group member for one uninterrupted hour during the week; (2) self-reflecting on last week's learning progress with group members; and (3) making a study plan for the following week with group members. Each student in the treatment group was required to complete the three tasks with their group members and then upload screenshots/photos and answer related questions in the LSH individually. If one group member was not able to attend a meeting, the other two members could still earn full credits if they completed the three tasks together. Students were graded based on LSH completion and uploaded screenshots and can earn up to 3% toward the final course grade if they completed all LSH homework in weeks 2 to 5.

From weeks 6 to 10 (Phase II in Fig. 1), we removed the LSH homework to examine whether the study group established during Phase I was sustainable without intentionally designed incentives. Students still had access to their initially assigned group members through the same Zoom link and Discord link but were provided with the flexibility of working with the groups at their own discretion.

3.2.2. Control condition

Students in the control group were not assigned into small study-together groups. These students were also given LSH homework each week during Phase I and were encouraged to continue doing so during Phase II. Similar to the treatment group, the LSH homework for control students also includes three tasks: (1) studying for one uninterrupted hour during the week; (2) self-reflecting on last week's learning progress; and (3) making a study plan for the following week. Similar to the treatment group, control students were also graded based on LSH completion and uploaded screenshots and could earn up to 3% toward the final course grade if they completed all LSH homework in weeks 2 to 5. The main difference between the LSH homework for treatment and control students is that treatment students were required to complete the three tasks as a group, while control students completed them individually.

3.3. Data collection and key measures

We obtained data from two sources, institutional data that include students' demographic characteristics and course grades, and four waves of survey data: (1) a pre-course survey that collected student demographic characteristics, baseline time management, motivation, and interpersonal interaction preferences. This information was used to perform the balance check to assess the success of the randomization, create student control variables for regression analyses, and assist heterogeneity analysis of the treatment effects by student baseline characteristics; (2) two short surveys administered in weeks 4 and 5, respectively, that collected information about students' group study behaviors during Phase I when the LSH homework was required; (3) a post-course survey administered at the end of the quarter that collected

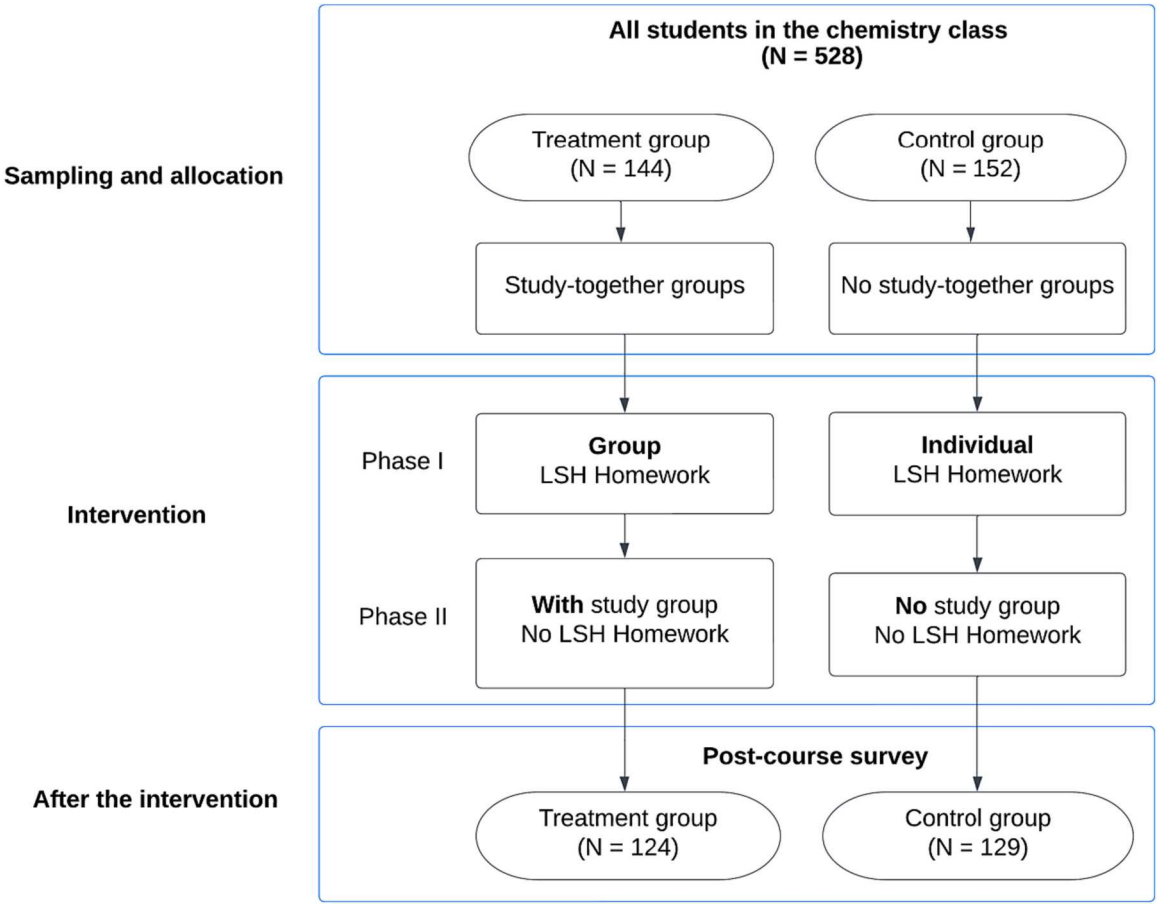

Fig. 1. Intervention process.

information about students' group study behaviors during Phase II when the LSH homework was removed, as well as end-of-course non-cognitive outcomes such as sense of belonging, self-assessments of time management, and motivation. All questions included in the pre-course and post-course surveys are presented in Appendix B. Below we describe in detail the specific measures used in the analysis.

3.3.1. Course performance

We used two measures to capture a student's course performance: the final exam score and the course grade (i.e., the weighted average of several course components, including assignments, midterm exams, and the final exam). Both final exam scores and course grades were measured on a 100-point scale.

3.3.2. Sense of belonging

Sense of belonging refers to the extent to which students feel that they are comfortable in the classroom and are supported by their peers in the class. We adapted the Sense of Belonging Scale from Xu, Solanki, McPartlan, and Sato (2018), which was initially developed by Hoffman, Richmond, Morrow, and Salomone (2002) and validated in multiple college-aged samples in the work of Tovar and Simon (2010). Students' sense of belonging was measured by six survey items, where students were asked to indicate how true each statement was, such as "*If I miss a chemistry class, I know students from whom I could get the notes*" and "*I feel comfortable asking my chemistry classmates for help if I do not understand course-related materials,*" on a 1 (not at all true) to 5 (very true) Likert scale.

3.3.3. Time management

Time management captures the extent to which students can effectively plan and allocate time for and keep up with their coursework. This measure was adapted from a combination of time management subscales in Pintrich and De Groot (1990) Motivated Strategies for Learning Questionnaire and Penn State's Online Learning Readiness Survey (Penn State University, 2023). The original items have been validated in multiple studies conducted at various colleges (e.g., Cho & Cho, 2017; Cholifah, Rini, Nuraini, Satriani, & Saidah, 2020; Jansen, van Leeuwen, Janssen, & Kester, 2018; Zgheib, AlDaia, Serhan, & Melki, 2019). Students' time management was measured by four survey items, such as "*I make sure I keep up with the weekly readings and assignments for this online course.*" All the questions about time management were measured on a five-point scale ranging from 1 (not at all true) to 5 (very true), with higher scores indicating higher levels of time management. We collected this information in both the pre-course and post-course surveys.

3.3.4. Motivation

Motivation consists of students' interests, attainment, and utility values regarding the chemistry course. Items of course motivation were adapted from Eccles and Wigfield (2002). This measure was constructed by nine survey questions, such as "*how interested are you in Chemistry*" and "*how important is being good at the material taught in this course to you*." All the questions about course motivation were measured on a five-point scale ranging from 1 to 5, with higher scores indicating higher levels of motivation. We collected this information in both the pre-course and post-course surveys.

3.3.5. Group study behaviors

Group study behavior items measure whether students have studied with their peers and for how long. Specifically, group study behaviors were captured by two items in week 4 and 5 surveys and the post-course survey: "*did you study with the peers in this class last week*" on a dichotomous scale and "*how many hours did you spend studying with the peers per week*" on a 5-point Likert scale (1 = 0–1 h; 5 = more than 10 h). We took an average of the responses to week 4 and 5 surveys to get students' group study behaviors for Phase I. We used the responses to the post-course survey to get their group study behaviors for Phase II.

3.3.6. Interpersonal interaction preferences

Interpersonal interaction preferences refer to the extent to which students prefer to interact with their peers. This was measured by four survey questions, such as "*I prefer to study with peers in the same course rather than studying individually*." Students were asked to indicate how true statements are on a 5-point Likert scale (1 = not at all true; 5 = very true). We collected the information in the pre-course survey.

3.3.7. Student demographics and academic history

Student demographics and academic history variables, including gender, race, low-income status, first-generation status, transfer status, weighted high school GPA, quarter units enrolled, and cohort information, were collected from the administrative data and the pre-course survey.

3.4. Data analysis

3.4.1. Analytical sample

The analytical sample in our study comprised 253 out of the 296 students who participated in the intervention (i.e., intervention sample) and completed all four surveys (Treatment group = 124; Control group = 129). To ensure consistency in our analysis, we used the analytical sample for all subsequent analyses.[1] However, one potential concern related to using the analytical sample is that the survey completion rates might differ between the treatment and control groups, thus leaving the two groups of students with different baseline characteristics and biased results. To address this concern, we conducted two analyses. First, we compared the survey completion rates for treatment and control groups for the intervention sample and found no significant difference between the two groups. Second, we assessed the balance in baseline characteristics between the treatment and control groups for the analytical sample, which we elaborate on in the following section.

Table 1 presents summary statistics on student characteristics for the analytical sample, as well as for the treatment group and the control group respectively. The analytical sample consisted primarily of female students (67.6%) and a high proportion of Asian students (49%), followed by Latinx (26%), White (8%), African American (6%), and other races (12%). Around half of the students were low-income and first-generation students (defined as neither parent having a college degree), and about 2% of the students transferred from other institutions. The average weighted high school GPA was around 4.0 (on a 0–5 GPA scale), and students enrolled in an average of around 12.5 units during the intervention period. The majority of the students were freshmen (87.4%), followed by sophomores (9.1%), juniors (3.2%), and seniors (0.4%). The average scores of students' baseline motivation, time management, and interpersonal interaction preferences were 3.71, 3.89, and 3.37, respectively. As most of the students in this class were first-year college students, we used students' weighted high-school GPA as the indicator of prior academic performance.

Table 2 presents summary statistics on student course performance and non-cognitive outcomes for the analytical sample, the treatment group, and the control group. On a descriptive basis, treatment students had better course performance than their counterparts in the control group. The average final exam score among the treatment students was 70.5 on a 100-point scale versus 66.9 among control students. The average course grade among the treatment students was 88.12 on a 100-point scale versus 86.15 among control students. In terms of non-cognitive outcomes, treatment students reported a stronger sense of belonging and higher motivation than their counterparts in the control group. Yet, students' self-reported time management was fairly comparable between the two groups.

[1] Compared to the intervention sample, participants in the analytical sample were more likely to be female and freshmen, had higher weighted high school GPAs, and had higher levels of baseline motivation.

Table 1
Demographic statistics by experimental condition.

	(1) Treatment group ($N = 124$)		(2) Control group ($N = 129$)		(3) *p*-value
	M (SD)	N	M (SD)	N	
Panel A: Institutional administrative data					
Female	0.734 (0.444)	124	0.620 (0.487)	129	0.054
Race					
Asian	0.532 (0.501)	124	0.450 (0.499)	129	0.190
Latinx	0.250 (0.435)	124	0.264 (0.442)	129	0.806
White	0.065 (0.247)	124	0.093 (0.292)	129	0.403
African American	0.040 (0.198)	124	0.070 (0.256)	129	0.308
Other races	0.113 (0.318)	124	0.124 (0.331)	129	0.785
Low income	0.476 (0.501)	124	0.419 (0.495)	129	0.362
First generation	0.492 (0.502)	124	0.524 (0.501)	126	0.616
Transfer student	0.016 (0.126)	124	0.016 (0.124)	129	0.968
Weighted high school GPA	4.073 (0.252)	124	4.065 (0.245)	129	0.799
Quarter units enrolled	12.55 (2.624)	124	12.37 (2.853)	129	0.601
Cohort					
Cohort 2018	0.008 (0.090)	124	0 (0)	129	0.309
Cohort 2019	0.040 (0.198)	124	0.023 (0.151)	129	0.440
Cohort 2020	0.065 (0.247)	124	0.116 (0.322)	129	0.154
Cohort 2021	0.887 (0.318)	124	0.860 (0.348)	129	0.526
Panel B: Pre-course survey data					
Motivation	3.704 (0.570)	124	3.717 (0.576)	129	0.864
Time management	3.855 (0.705)	124	3.919 (0.676)	128	0.460
Interpersonal interaction preferences	3.365 (0.751)	124	3.377 (0.664)	128	0.893

Note. All variables under institutional administrative data are binary except for weighted high school GPA and quarter units enrolled. Motivation, time management, and interpersonal interaction preferences from the pre-course survey were measured on a scale from 1 (strongly disagree) to 5 (strongly agree). Columns 1–2 present the means of variables with standard deviations in parentheses. The *p*-value in the last column tests the difference between the treatment and control group means of each variable. Sample sizes vary based on which data are available for which students.

3.4.2. Balance in baseline characteristics between the treatment and control groups

To assess the validity of the random assignment, we examined the differences between the treatment and the control groups in pre-determined student characteristics (see Table 1). The last column of Table 1 shows the individual *t*-tests on the treatment and control group mean difference for each variable. We observed no significant differences between the two groups in any of the variables, except for gender. Given the large number of tests performed, we consider this as evidence of the balance between the treatment and the control groups.

3.4.3. Main effect of the treatment

We employed a linear regression approach to estimate the treatment effects on students' standardized outcomes. Eq. (1) was used to estimate the intent-to-treat (ITT) effect for a student *i,* which estimates the effect of the treatment assignment on student outcomes. Since the average compliance rate for the intervention was extremely high (95%), we only reported the ITT estimates in the result section. We also used the instrumental variable (IV) approach, where we used treatment assignment as an instrument for actual intervention take-up to examine the treatment-on-the-treated (TOT) effects. The IV results were quite consistent with the OLS results.

Table 2
Descriptive statistics for course performance and non-cognitive outcomes by experimental condition.

	(1) Treatment group	(2) Control group
Panel A: Course performance		
Final exam score	70.45 (20.14)	66.88 (19.86)
Course grade	88.12 (12.13)	86.15 (12.98)
Panel B: Non-cognitive outcomes		
Sense of belonging	3.285 (0.984)	3.047 (0.972)
Motivation	3.581 (0.609)	3.494 (0.692)
Time management	4.052 (0.763)	4.041 (0.824)
Observations	124	129

Note. Course performance outcomes were measured on a scale from 0 to 100. Non-cognitive outcomes were collected from the post-course survey; these three variables were measured on a scale from 1 (strongly disagree) to 5 (strongly agree). Standard deviations are in parentheses.

$$Yi = \alpha + \beta^{*} \text{ Treati} + \gamma^{*} \text{ Xi} + \varepsilon i \quad (1)$$

where *Yi* is the outcome of a student *i*, which includes course performance, sense of belonging, time management, and motivation measured at the end of the class. *Treati* is an indicator for (random) treatment assignment. *Xi* is a vector of student-level covariates, including 11 covariates from the institutional administrative data and the pre-course survey (listed in Table 1). In Eq. (1), the key coefficient of interest is β, which estimates the differences in outcomes between treatment and control groups and thus measures the main effect of the intervention on student outcomes.

3.4.4. Heterogeneity check

Considering that students with different baseline levels of academic preparation and non-cognitive capacities may benefit differentially from the treatment, we conducted heterogeneity tests using four variables: prior academic performance (measured by weighted high-school GPA), baseline motivation, time management, and interpersonal interaction preferences. To conduct these analyses, we first stratified students into high and low categories for each of the four measures using a median split. Next, we examined and reported the treatment effects on each subgroup separately. Finally, we tested whether the treatment effects on two subgroups were significantly different by interacting each heterogeneous measure with the treatment indicator.

4. Results

4.1. Effects on group study behaviors

We first examined whether the intervention achieved its intended goal of increasing the likelihood of students studying with peers after class, as well as the number of hours spent studying with peers in a given week. We reported the results of this analysis in Table 3, where Panel A presents the outcomes from Phase I, during which treatment students were incentivized to study with their peers with extra credits. Panel B reports the outcomes from Phase II after the incentive was removed.

Table 3
Impact of intervention on group study behaviors (intervention implementation efficacy).

	(1)	(2)	(3)
	Treatment sample mean	Control sample mean	Gap
Panel A: Phase I			
Studying with peers in this class	0.992	0.566	0.382***
	(0.090)	(0.498)	(0.045)
Hours studying with peers per week	0.377	−0.353	0.668***
	(0.840)	(0.980)	(0.113)
Panel B: Phase II			
Studying with peers in this class	0.911	0.752	0.140**
	(0.285)	(0.434)	(0.048)
Hours studying with peers per week	0.110	−0.096	0.188
	(0.856)	(1.102)	(0.126)
Covariates	–	–	Yes
Observations	124	129	253

Note. During Phase I, we offered the "Learning & Study Habits" homework. We removed the homework in Phase II. Studying with peers is a binary variable; hours studying with peers were standardized and measured in hours. Columns 1 and 2 present the means with standard deviations in parentheses. In column 3, we regressed each variable on treatment status to examine the gap between treatment and control students while controlling for covariates listed in Table 1. Standard errors are in parentheses. + $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

During Phase I, as shown in Panel A, 99.2% of the treatment students reported that they studied with their class peers at least once in a given week, compared to only 56.6% of the control students. After controlling for covariates presented in Table 1, regression-adjusted estimates indicate that treatment students were significantly more likely to engage in group study behaviors than control students by 38.2 percentage points ($p < 0.001$). Additionally, the intensity of group study behaviors increased, with treatment students studying with peers for an average of 0.67 standard deviations (SDs) longer than control students ($p < 0.001$).

During Phase II of the study, treatment students were no longer provided with extra incentives to engage in group studying with their classmates. Despite this change, treatment students continued to display significantly higher levels of participation in group studying compared to the control students, although the gaps between the two groups narrowed during this phase. Specifically, the results presented in Panel B of Table 3 indicate that the proportion of students who studied with peers decreased from 99.2% to 91.1% for the treatment group, possibly due to the removal of the LSH homework. In the meantime, the proportion of students in the control group who studied with peers increased from 56.6% to 75%, indicating a gradual development of social networks over time. Nevertheless, regression-adjusted estimates shown in column 3 indicate that treatment students remained significantly more likely to study with peers than control students by 14.0 percentage points ($p < 0.01$). In terms of intensity, although treatment students still spent more hours studying with peers than control students during Phase II, the gap was no longer significant ($\beta = 0.188$, $p > 0.1$).

4.2. Main treatment effects

Having confirmed the impacts of the intervention on group study behaviors, we then examined its impact on a variety of academic and non-cognitive outcomes, including final exam scores, course grades, sense of belonging, motivation, and time management (Table 4). In terms of academic performance, treatment students scored higher than control students by 0.16 SDs ($p > 0.1$) and 0.09 SDs ($p > 0.1$) for the final exam and course grade, which correspond to 3.2 and 1.1 points in the final exam and course grade on a 100-point scale, respectively.

Table 4
Impact of intervention on course performance and non-cognitive outcomes.

	Treatment
Panel A: Course performance	
Final exam score	0.155
	(0.094)
Course grade	0.086
	(0.077)
Panel B: Non-cognitive outcomes	
Sense of belonging	0.205+
	(0.116)
Motivation	0.128
	(0.105)
Time management	−0.022
	(0.118)
Covariates	Yes
Observations	253

Note. All outcome variables were standardized. Each coefficient represents a separate regression using the treatment status to predict each outcome variable controlling for covariates listed in Table 1. Standard errors are in parentheses. + $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

However, these differences were not statistically significant. With respect to the three non-cognitive outcomes, the intervention did not significantly affect students' motivation ($\beta = 0.128$, $p > 0.1$) or time management ($\beta = -0.022$, $p > 0.1$). Nevertheless, treatment students reported a significantly higher sense of belonging than control students by 0.205 SDs ($p < 0.1$).

4.3. Heterogeneous effects by student baseline characteristics

We then conducted heterogeneity analyses to explore whether the effects of the intervention differed among students with different baseline levels of high school GPA, motivation, interpersonal interaction preferences, and time management (Tables 5 and 6).

Columns 1–3 in Table 5 report the heterogeneous effects of the intervention by students' high-school GPAs. We found that the treatment had positive impacts on group study behaviors for both high and low-high-school GPA students, and the effect sizes were not significantly different between the two groups. However, the intervention had a significant positive impact on course performance outcomes, including final exam scores ($\beta = 0.439$, $p < 0.01$) and course grades ($\beta = 0.314$, $p < 0.05$), for students with low high school GPAs, while it had no significant effect on students with high-high-school GPAs. Additional analyses on the significance of the interactional effects indicate that the differences in treatment effects between the two groups reached statistical significance for both final exam scores ($\beta = 0.564$, $p < 0.01$) and course grades ($\beta = 0.445$, $p < 0.01$) (column 3). In contrast, we did not identify any significant interactional effects on the sense of belonging, motivation, or time management. Overall, students with weaker academic preparation gained greater benefits from the intervention than their better-prepared counterparts in terms of course performance, while both groups showed similar responses to the intervention in terms of group study behaviors and non-cognitive outcomes.

We next examined the differential treatment effects for students with low and high baseline motivation (columns 4–6 in Table 5). First, we found that during Phase I, the intervention had a greater impact on the likelihood of studying with peers for students with low baseline motivation ($\beta = 0.431$, $p < 0.001$) as compared to high-motivation students ($\beta = 0.254$, $p < 0.001$), with a significant interaction effect ($\beta = 0.177$, $p < 0.1$). Additionally, the intervention had positive impacts on the final exam scores ($\beta = 0.257$, $p < 0.05$) and course grades ($\beta = 0.189$, $p < 0.05$) for students with low baseline motivation, while the corresponding estimates for the high-motivation students were small and not significant. Results from the pooled analysis revealed significant

Table 5
Heterogeneous effects of intervention by high-school GPA and baseline motivation.

	(1)	(2)	(3)	(4)	(5)	(6)
	Weighted high school GPA			Baseline motivation		
	Low	High	Diff.	Low	High	Diff.
Panel A: Group study behaviors - Phase I						
Studying with peers in this class	0.390***	0.333***	0.057	0.431***	0.254***	0.177+
	(0.064)	(0.070)	(0.095)	(0.064)	(0.065)	(0.092)
Hours studying with peers per week	0.531**	0.657***	−0.126	0.651***	0.582***	0.068
	(0.159)	(0.171)	(0.234)	(0.161)	(0.171)	(0.237)
Panel B: Group study behaviors - Phase II						
Studying with peers in this class	0.118+	0.128+	−0.010	0.178**	0.106	0.072
	(0.071)	(0.073)	(0.102)	(0.065)	(0.078)	(0.101)
Hours studying with peers per week	0.088	0.195	−0.106	0.349*	0.043	0.307
	(0.190)	(0.189)	(0.269)	(0.171)	(0.206)	(0.266)
Panel C: Course performance						
Final exam score	0.439**	−0.125	0.564**	0.257*	−0.111	0.368+
	(0.152)	(0.125)	(0.197)	(0.123)	(0.149)	(0.192)
Course grade	0.314*	−0.131	0.445**	0.189+	−0.142	0.331*
	(0.129)	(0.099)	(0.163)	(0.109)	(0.120)	(0.162)
Panel D: Non-cognitive outcomes						
Sense of belonging	0.086	0.244	−0.158	0.302+	0.118	0.183
	(0.187)	(0.154)	(0.242)	(0.169)	(0.176)	(0.245)
Motivation	0.328+	0.042	0.286	0.254	0.054	0.200
	(0.171)	(0.132)	(0.216)	(0.166)	(0.151)	(0.229)
Time management	0.102	−0.165	0.267	0.109	−0.387*	0.496*
	(0.192)	(0.159)	(0.249)	(0.174)	(0.164)	(0.244)
Covariates	Yes	Yes	Yes	Yes	Yes	Yes
Observations	127	126	253	136	117	253

Note. All outcome variables were standardized. The columns with "Diff." are the results of joint F-tests examining whether the two groups of coefficients are significantly different from each other. All models controlled for all the covariates listed in Table 1. Standard errors are in parentheses. + $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 6
Heterogeneous effects of intervention by baseline interaction preferences and time management.

	(1)	(2)	(3)	(4)	(5)	(6)
	Baseline interaction preferences			Baseline time management		
	Passive	Active	Diff.	Low	High	Diff.
Panel A: Group study behaviors - Phase I						
Studying with peers in this class	0.419***	0.385***	0.034	0.374***	0.360***	0.014
	(0.067)	(0.065)	(0.094)	(0.067)	(0.067)	(0.096)
Hours studying with peers per week	0.656***	0.794***	−0.138	0.515**	0.756***	−0.241
	(0.161)	(0.175)	(0.238)	(0.182)	(0.158)	(0.241)
Panel B: Group study behaviors - Phase II						
Studying with peers in this class	0.199*	0.142*	0.057	0.169*	0.074	0.095
	(0.083)	(0.056)	(0.100)	(0.076)	(0.067)	(0.101)
Hours studying with peers per week	0.346	0.208	0.138	0.193	0.074	0.118
	(0.212)	(0.157)	(0.264)	(0.199)	(0.179)	(0.268)
Panel C: Course performance						
Final exam score	0.176	0.040	0.136	0.208	0.136	0.072
	(0.148)	(0.124)	(0.194)	(0.171)	(0.115)	(0.201)
Course grade	0.157	−0.040	0.196	0.090	0.125	−0.035
	(0.118)	(0.111)	(0.162)	(0.141)	(0.095)	(0.166)
Panel D: Non-cognitive outcomes						
Sense of belonging	0.405*	0.051	0.353	0.257	0.123	0.134
	(0.175)	(0.171)	(0.245)	(0.194)	(0.162)	(0.251)
Motivation	0.399*	−0.172	0.571*	0.207	−0.077	0.284
	(0.168)	(0.149)	(0.225)	(0.159)	(0.143)	(0.214)
Time management	0.220	−0.352*	0.573*	−0.086	−0.068	−0.018
	(0.188)	(0.146)	(0.239)	(0.224)	(0.148)	(0.261)
Covariates	Yes	Yes	Yes	Yes	Yes	Yes
Observations	130	123	253	119	134	253

Notes. All outcome variables were standardized. The columns with "Diff." are results of joint F-tests examining whether the two groups of coefficients are significantly different from each other. All models controlled for all the covariates listed in Table 1. Standard errors are in parentheses. + $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

interaction effects for both performance measures ($\beta = 0.368$, $p < 0.1$ for the final exam and $\beta = 0.331$, $p < 0.05$ for the course grade). To explore whether the differential impact on course performance was driven by the differential impact on group study behaviors, we further controlled for between-group differences in study behaviors by adding an interaction term between the likelihood of studying with peers in Phase I and student baseline motivation. The difference in treatment effects on course performance was reduced significantly, indicating that the greater treatment impact on course performance for students with lower baseline motivation was primarily driven by the greater treatment

impact on group study behaviors for this subgroup. As for non-cognitive outcomes, the intervention had a significantly negative impact on time management for high-motivation students ($\beta = -0.387$, $p < 0.05$) but a small and insignificant effect on low-motivation students, resulting in a significant interaction effect ($\beta = 0.496$, $p < 0.05$). After controlling for between-group differences in study behaviors, the interaction effect of the treatment on time management was only reduced slightly, and the change was not significant, suggesting that the greater negative impact on time management for high-motivation students was driven by other mechanisms beyond its impact on group study behaviors. Overall, students with low baseline motivation benefited more from this intervention in terms of their course performance than their high-motivation counterparts, and the greater benefits were primarily driven by the differential impact of the intervention on group study behaviors. However, the intervention may harm high-motivation students' time management.

Columns 1–3 in Table 6 report the heterogeneity of the treatment effects by students' baseline interpersonal interaction preferences. The results showed that the intervention had equally increased group study behaviors for both passive and active interpersonal interaction preference groups. Similarly, we did not identify any significant heterogeneous effects on course performance outcomes. However, students who preferred passive interpersonal interaction benefited significantly from the intervention in motivation ($\beta = 0.399$, $p < 0.05$), while the corresponding coefficient for the students who preferred active interpersonal interaction was not significant, resulting in a significant interaction ($\beta = 0.571$, $p < 0.05$). Moreover, the intervention had a significantly negative impact on time management for students who preferred active interpersonal interaction ($\beta = -0.352$, $p < 0.05$) but a small and nonsignificant effect on students who preferred passive interaction, resulting in a significant interaction effect ($\beta = 0.573$, $p < 0.05$). Overall, students who preferred passive interpersonal interaction benefited more from this intervention in terms of their motivation, while the intervention negatively affected time management for those who preferred active interaction.

Finally, we did not find any heterogeneous effects by students' baseline time management (columns 4–6 in Table 6), indicating that the intervention had similar effects on students with high and low baseline time management.

5. Discussion

Prior literature suggests that inadequate peer interaction is a critical challenge to successful online learning, as it hinders students from seeking timely academic support and developing a sense of community (e.g., Bambara et al., 2009; Jaggars & Xu, 2016). Thus, it is essential to identify effective and scalable practices to promote peer interactions in online settings. Our study contributes to this area by providing the first rigorous experimental evidence of the effectiveness of offering study-together groups in college online courses. We found that offering study-together groups positively affects both academic performance and critical non-cognitive outcomes in online courses, where the benefits vary by students' baseline characteristics. These findings have significant implications for educators, policymakers, and researchers seeking to improve the quality and outcomes of online learning experiences. First, our findings provide experimental evidence for the importance of peer interactions in online learning. Second, this study extends the previous literature by examining the differential effects of the intervention across student baseline characteristics. The results shed light on the various roles that students may assume in peer interaction and the ways in which different subgroups of students may benefit from such interactions. Finally, this study provides empirical support and practical guidance for using study-together groups as a low-cost, easy-to-implement, and highly scalable strategy to enhance peer interactions and student academic and non-cognitive outcomes in college online courses.

5.1. Key findings and relevance with the existing literature

5.1.1. Positive effects on group study behaviors

Our results suggest that the intervention effectively improved students' group study behaviors. More importantly, the treatment students were more likely to study with their peers even after removing the homework assignment requirement. This finding indicates that the peer network established through the intervention was sustainable, and induced a persistent preference or inclination toward collaborative learning even in the absence of external incentives. Interestingly, we also found that control students engaged in peer study activities substantially more as the quarter progressed, in line with prior research on the gradual development of social networks among students as class proceeds (Gunawardena, Lowe, & Anderson, 1997; Tang, 1993; Tawfik et al., 2017). However, this finding does not diminish the importance of instructors proactively fostering the creation and growth of social networks. Indeed, studies on social networks suggest that intentional class activities early on in a course can facilitate the formation of social networks (Dawson, 2008; Fajer, 2020), and therefore, instructors should make efforts to promote and support peer interactions from the beginning of the course.

5.1.2. Positive effects on students' sense of belonging

Our results show that, on average, students who were offered a study group reported a higher sense of belonging than those who were not. Sense of belonging has been identified as a promising target for psychological intervention as it is positively correlated with motivation (Freeman, Anderman, & Jensen, 2007), engagement (Wilson et al., 2015), persistence (Walton & Brady, 2017), and achievement (Zumbrunn, McKim, Buhs, & Hawley, 2014). The effect size was fairly comparable to that in Solanki, McPartlan, Xu, and Sato (2019) study, where offering learning communities during students' first year in college improved their sense of belonging by 0.21 of one standard deviation. Yet, the scalability of the study-together intervention examined in the present study is substantially lower compared with year-long learning communities. Our results also support previous research conducted in in-person courses that identified a positive association between study groups and students' sense of belonging (Hurt et al., 2012; Sheeran & Cummings, 2018; Thai et al., 2019). However, our study adds to this literature by providing empirical evidence for the potential of using study groups to promote students' sense of belonging and course engagement in an online setting.

5.1.3. Greater academic benefits for students with lower levels of motivation and academically underprepared students

This intervention positively affected students' course performance for those with lower levels of baseline motivation. Notably, the greater treatment effect on course performance of low-motivation students was largely attributed to the increased influence on their group study behaviors. This finding suggests that study groups may provide a safe place for students who are academically less motivated and tend to encounter more challenges in an online environment, as documented in prior research (Hart, Friedmann, & Hill, 2018; Xu & Jaggars, 2014). By participating in study groups, these students could receive academic support and emotional encouragement from their peers, leading to improvements in their course performance.

Additionally, our study found a strong and positive impact on course performance for students with lower high-school GPAs. This aligns with previous studies conducted in in-person classes, where efforts to promote social network formation, such as learning communities, were found to be particularly beneficial for students with lower academic preparation (e.g., Solanki et al., 2019; Xu et al., 2018). Interestingly, we did not observe any differential impacts of the intervention on group study behaviors between students with low and high high-school GPAs. One possible explanation is that low- and high-achieving students may assume different roles within the study group, which could lead to

varying academic benefits, despite comparable levels of participation. For instance, high-achieving students may act as tutors within the study group, providing their low-achieving peers with additional course resources and answering their questions. Conversely, high-achieving students may receive limited academic support from their low-achieving peers. Therefore, even if the intervention had a similar effect on peer engagement, low-achieving students could benefit more from study groups in terms of their academic performance. This possibility suggests that study groups may act as an effective tool to support academically underprepared students and help bridge the academic achievement gap.

5.1.4. Positive effects on motivation for students who preferred passive interaction

The intervention in our study had a positive effect on the motivation of students who were initially hesitant about interacting with their peers. Interestingly, although the intervention also increased group study behaviors for students who preferred to actively engage with others, it did not have an impact on their motivation. This suggests that active and passive students may have different roles in peer interactions. Active students may serve as leaders, promoting group discussions and participating more in group activities. As a result, study groups can provide scaffolding and support for passive students who lack the initiative to engage with their peers, leading to greater benefits for these students.

5.1.5. Negative effects on time management for highly motivated students and those who preferred active peer interaction

Despite the previously mentioned positive impacts of the intervention, it is important to acknowledge the potential negative effects on time management for students who reported high baseline motivation and a preference for active peer interactions. One possible explanation for this is that highly motivated and outgoing students may spend a significant amount of time managing and organizing group interactions, leaving them with limited time to focus on their individual progress and complete course assignments. Consequently, highly motivated and outgoing students may perceive a decrease in their time management. This is consistent with prior research showing that highly motivated individuals tend to over-commit and have difficulty managing their time effectively (Rybczynski & Schussler, 2011). It is important for instructors to be aware of these potential negative impacts and provide guidance on time management and task prioritization to help students balance their group work and individual responsibilities.

5.2. Implications

These findings have several implications for both research and practice. Firstly, this study confirms the crucial role of peer-to-peer interactions in online courses and nominates study-together groups as a highly scalable and low-cost strategy to promote direct and reciprocal communication among students and enable greater group autonomy. Future research can further refine the study group design, including different considerations of group composition and size, to identify the most effective ways of organizing study groups to facilitate peer-to-peer interactions in online courses.

Furthermore, the heterogeneous results suggest that students may have distinct roles in peer interactions, and the ways they benefit from such interactions may differ depending on the specific ways an individual participates in group activities. This highlights the need for future research to understand group dynamics through discourse analysis or thematic analysis on group dialogues or student interviews to gain a better understanding of the specific ways students interact with each other in group activities.

In terms of practice, this study provides guidance on how to implement the intervention and suggests specific ways to tailor the intervention based on student background characteristics. For instance, in view of the sustainability of the peer network created in the early stage of the course, instructors may consider incorporating the intervention as part of the course orientation or incorporate it in the welcome email before classes start to optimize the benefits of study groups. Moreover, the fact that students with lower levels of academic preparation and motivation benefitted especially strongly from the intervention highlights the importance of identifying students with greater needs for peer support and actively reaching out to them to encourage participation. Lastly, the results highlight the need to alleviate the negative impacts of study groups on student time management. For instance, instructors may consider providing group study tips and offering regular opportunities for students to reflect on their own progress and adjust their group study approaches accordingly.

5.3. Limitations and future research

The present findings should be interpreted in light of several limitations. First, this study only included students enrolled in one course. Future studies on this topic may wish to extend the intervention to different fields of study and institutional settings to examine whether the findings are generalizable to courses in other fields of study and different institutional contexts. Relatedly, another limitation of this study is sample recruitment bias. Our descriptive statistics suggest that students who volunteered for this intervention were more likely to be Asian, had higher weighted high school GPAs, enrolled in more units during the quarter, and were more likely to be freshmen. Considering that the intervention had stronger impacts on academically underprepared and less motivated students, the effects identified in the present study may underestimate the true benefits of study groups on all students. To address the potential sample recruitment bias, future studies may consider collaborating more closely with instructors to increase participation rates. Second, some of the measures employed in the study consist of items adapted from multiple scales. While the original scales have been validated previously, it is important to acknowledge that the synthesized scale created for this specific study may benefit from further validation. Future studies would be prudent to undertake the task of validating these scales, particularly with their own research population, to enhance the validity and reliability of the measures. Thirdly, more research is needed to determine the optimal way of dividing students into small study groups. In the present study, we randomly assigned treatment students to small study groups of three based on suggestions from the course instructor. However, future studies should explore different group assignment methods and investigate how the benefits of the intervention may vary based on different assignment rules and group sizes. Such information will help provide more comprehensive guidance on how to effectively design and implement study groups in online courses. Lastly, it is worth noting that in the current study, students had the choice to engage in group studying with their peers either in person or through online platforms like Zoom. In light of this flexibility in study settings, future studies could explore how the effects of the intervention may vary depending on the chosen mode of interaction. Investigating the potential differences in outcomes between in-person group studying and virtual group studying could provide valuable insights into the effectiveness and suitability of different modes of collaborative learning. By examining these variations, researchers can gain a deeper understanding of the nuances and implications associated with different study settings and make well-informed recommendations for optimizing group studying interventions in educational contexts.

6. Conclusion

This study conducted a randomized control trial to examine the effects of offering a study-together group on academic performance and non-cognitive outcomes in a for-credit online course at a public four-year college. Overall, our findings provide evidence that study-together groups can build a robust peer support system, leading to improvement in both academic and social-emotional outcomes. These

findings also offer valuable insights for practitioners seeking to enhance peer interactions in online learning programs and implement a scalable peer intervention strategy. By incorporating study-together groups into online learning platforms that are able to generate study groups automatically, educators can facilitate an effective and easily scalable intervention that benefits a large number of students.

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Appendices

A. *Descriptive statistics for student demographic characteristics*

	(1)	(2)	(3)
	Participants	Non-participants	Raw gap
Panel A: Institutional administrative data			
Female	65.5%	63.4%	2.2%
Race			
Asian	48.6%	36.2%	12.4%**
Latinx	25.3%	38.4%	−13.0%**
White	8.5%	7.8%	0.7%
Black or African American	5.7%	7.8%	−2.0%
Other races	11.8%	9.9%	1.9%
Low income	44.3%	41.6%	2.7%
First generation	50.3%	54.5%	−4.2%
Transfer student	1.7%	2.6%	−0.9%
Weighted high school GPA	4.036	3.989	0.048*
Quarter units enrolled	12.32	11.77	0.550*
Cohort			
Cohort 2018	1.4%	0.9%	0.5%
Cohort 2019	4.1%	3.5%	0.6%
Cohort 2020	9.1%	15.9%	−6.8%*
Cohort 2021	85.5%	79.7%	5.7%+
Observations	296	232	528

Notes. All variables are binary except for weighted high school GPA and quarter units enrolled. In column 3, we regressed the indicator of participant against student characteristics to examine whether the differences between the participants (column 1) and non-participants (column 2) reached statistical significance. Standard errors are in parentheses. + $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

B. *Surveys questions*

(a) Pre-course Survey

Below, we would like to know your background information.

1. What is your gender?

Male	Female	Non-binary	Prefer not to say

2. What is your race and ethnicity?

White	African American	Latinx	Asian	Other

3. How many people do you know in this class prior to this quarter? Please fill in a number__.

Here are some questions about your feelings. Please select the response that best describes how you feel.

4. How much fun is learning Chemistry to you?

None at all	A little	A moderate amount	A lot	A great deal

5. How interested are you in Chemistry?

Not at all interested	Slightly interested	Moderately interested	Very interested	Extremely interested

6. How much do you enjoy dealing with Chemistry topics?

None at all	A little	A moderate amount	A lot	A great deal

7. How important are good grades in this course to you?

Not at all important	Slightly important	Moderately important	Very important	Extremely important

8. How important is being good at the material taught in this course to you?

Not at all important	Slightly important	Moderately important	Very important	Extremely important

9. How important is performing well in this course to you?

Not at all important	Slightly important	Moderately important	Very important	Extremely important

10. How much does being good at the material taught in this course mean to you in your everyday life?

None at all	A little	A moderate amount	A lot	A great deal

11. How valuable are good grades in this course to your future job?

Not at all valuable	Slightly valuable	Moderately valuable	Very valuable	Extremely valuable

12. How valuable are good grades in this course to your future academic career?

Not at all valuable	Slightly valuable	Moderately valuable	Very valuable	Extremely valuable

Here are some questions about your learning approaches. Please select the response that best describes how you feel.

	Not at all true	Somewhat untrue	Neutral	Somewhat true	Very true
13. I make good use of my study time for this online course.	○	○	○	○	○
14. I keep a record of what my assignments are and when they are due.	○	○	○	○	○
15. I make sure I keep up with the weekly readings and assignments for this online course.	○	○	○	○	○
16. I usually plan my work in advance so that I can turn in my assignments on time.	○	○	○	○	○

Here are some questions about your interaction preferences. Please select the response that best describes how you feel.

	Not at all true	Somewhat untrue	Neutral	Somewhat true	Very true
17. I often anxious when talk to other people in a course.	○	○	○	○	○
18. I prefer to study with the peers in the same course rather than studying individually.	○	○	○	○	○
19. I think it is frustrating to ask my classmates questions.	○	○	○	○	○
20. I think frequently interacting with my classmates would help me get a higher score in the course.	○	○	○	○	○

(b) Post-course Survey

Below, we would like to know about your learning experience after you stopped doing the Learning & Study Habits Homework.

1. Did you get a chance to study with anyone from this class after the Learning & Study Habits Homework ended?

Yes	No

2. After the Learning & Study Habits Homework ended, on average, how many hours in each week did you spend studying with your chemistry classmates per week?

0	1	2	3	4	5	6	7	8	9	≥ 10 h

Below, we would like to know your feelings and experience throughout the quarter. Please indicate how true each statement is for you.

	Not at all true	Somewhat untrue	Neutral	Somewhat true	Very true
3. If I miss a chemistry class, I know students from whom I could get the notes.	○	○	○	○	○
4. I discuss events that happen outside of class with my chemistry classmates.	○	○	○	○	○
5. I have developed personal relationships with other students in my chemistry class.	○	○	○	○	○
6. I feel comfortable volunteering ideas or opinions in my chemistry class.	○	○	○	○	○
7. I feel comfortable asking my chemistry classmates for help if I do not understand course-related material.	○	○	○	○	○
8. I feel comfortable asking my chemistry classmates for help with a personal problem.	○	○	○	○	○
9. I made good use of my study time for this online course.	○	○	○	○	○
10. I kept a record of what my assignments were and when they were due.	○	○	○	○	○
11. I made sure I kept up with the weekly readings and assignments for this online course.	○	○	○	○	○
12. I usually planned my work in advance so that I can turn in my assignments on time.	○	○	○	○	○

Here are some questions about your feelings. Please select the response that best describes how you feel.

13. How much fun is learning Chemistry to you?

None at all	A little	A moderate amount	A lot	A great deal

14. How interested are you in Chemistry?

Not at all interested	Slightly interested	Moderately interested	Very interested	Extremely interested

15. How much do you enjoy dealing with Chemistry topics?

None at all	A little	A moderate amount	A lot	A great deal

16. How important are good grades in this course to you?

Not at all important	Slightly important	Moderately important	Very important	Extremely important

17. How important is being good at the material taught in this course to you?

Not at all important	Slightly important	Moderately important	Very important	Extremely important

18. How important is performing well in this course to you?

Not at all important	Slightly important	Moderately important	Very important	Extremely important

19. How much does being good at the material taught in this course mean to you in your everyday life?

None at all	A little	A moderate amount	A lot	A great deal

20. How valuable are good grades in this course to your future job?

Not at all valuable	Slightly valuable	Moderately valuable	Very valuable	Extremely valuable

21. How valuable are good grades in this course to your future academic career?

Not at all valuable	Slightly valuable	Moderately valuable	Very valuable	Extremely valuable

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