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ORIGINAL PAPER

Beyond grades: improving college students' social-cognitive outcomes in STEM through a collaborative learning environment

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Abstract
We investigated social-cognitive outcomes for U.S. university students engaged in a supplemental small-group peer-learning program which provided a more intimate learning environment than the associated course. We surveyed 604 students taking part in such a program at the beginning and end of an academic term on social-cognitive factors related to their experience in an introductory-level STEM (science, technology, engineering, and mathematics) course, to which the supplemental peer-learning program was attached. A comparison group consisted of 676 non-participants enrolled in the same courses, but not taking part in the supplemental program. Those who had participated in the peer-learning program experienced greater gains, relative to the comparison group, in self-efficacy for course tasks and self-regulation for learning, and they were less likely to use surface-level memorisation in studying for the course. The findings suggest that small-group learning in the university setting can be used as a means to improve students' study habits and confidence about the course, contributing social-cognitive outcomes to an existing body of literature which emphasises academic performance outcomes.

Keywords Collaborative learning environment · Higher education · Small-group learning · Social-cognitive factors · STEM education

Introduction

Collaborative learning, broadly speaking, has become an increasingly common feature of the university experience in many parts of the world, following the trend previously established in primary and secondary educational environments. Collaborative learning environments are thought to promote desirable outcomes by virtue of the small size, active engagement, and peer-to-peer communication that they typically offer. Indeed, calls for

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adoption of collaborative learning in higher education were prevalent in the late 1990s and into the 2000s (e.g. Lammers and Murphy 2002; Panitz and Panitz 1998) and they continue today. In higher education, outcome variables in studies of collaborative learning tend to be related to course grades, examination performance or student retention in courses or majors (e.g. Bonsangue and Drew 1995; Drane et al. 2014; Lewis and Lewis 2005; Tien et al. 2002).

Research on collaborative learning in elementary and secondary education has identified extra-academic outcomes such as improved motivation, attitudes towards school and interpersonal dynamics (Slavin et al. 2003). For instance, in a meta-analysis of 36 studies of peer-assisted learning among elementary school-aged students, Ginsburg-Block, Rohrbeck and Fantuzzo (2006) found small-to-moderate effect sizes for outcomes related to social interaction, self-concept and learning-related behaviours, with unweighted mean effect sizes (Hedges *g*) ranging from 0.40 to 0.65. Also in the elementary arena, Smith et al. (2014) found an association between group work in mathematics and both performance and attitude towards mathematics among a large sample of school-aged students in the US. Some research has identified extra-academic effects of collaborative learning within the postsecondary arena, including Dolmans and Schmidt's (2006) review identifying motivational benefits for medical students in problem-based small-group learning, provided that the groups were high-functioning, and Ning and Downing's (2010) work revealing improvement in motivation and information-processing behaviours among business undergraduates in a small-group supplemental instruction program. Still, research demonstrating benefits beyond academic performance for collaborative learning is limited, especially in the higher-education arena.

Our study attempted to fill that gap. Given the demonstrated social-cognitive benefits of collaborative learning found in the primary school arena, as well as the broader findings that collaborative learning generally seems to benefit college students, we wanted to explore specific social-cognitive outcomes of a common type of collaborative learning in STEM: small, peer-led study groups. In this study, we focused on three social-cognitive outcome measures which are key to student success in college or university: academic self-efficacy, self-regulation for learning, and avoidance of unrelated memorization. We chose these outcomes both because theory and prior research suggests that they might arise from engagement with a supportive and structured study-group experience, and because they previously have been established as predictors of learning and academic performance. Below, we explore each of these three constructs, as well as collaborative learning itself.

Academic self-efficacy

Self-efficacy (Bandura 1997) refers to an individual's belief that they are capable of performing effectively in some domain, and *academic self-efficacy* (Schunk and Pajares 2002) refers to the beliefs that students hold about their own ability to succeed in a given academic area. Academic self-efficacy has been widely studied over several decades and found to be closely associated with students' academic success at both K–12 and postsecondary levels (e.g. Chemers et al. 2001; Multon et al. 1991; Zajacova et al. 2005). When self-efficacy is high, students are more likely to feel motivated and to achieve in their academic pursuits (Pajares 1996; Schunk 1995), as well as to persist when working to solve problems (Bouffard-Bouchard et al. 1991; Multon et al. 1991), to use learning strategies that enable them to learn material deeply (Liem et al. 2008), and to persist in college (Gore 2006; Robbins et al. 2004).

In prior research, educational practices that can promote academic self-efficacy have been investigated. These include instruction on learning strategies, highlighting successful role models among similar peers, and feedback about what is working well in one's learning efforts (Schunk 1995). In regard to self-efficacy as an outcome of collaborative learning, previous work has shown that cooperative learning (a type of collaboration in which there is a reward to individuals for success of the group) promotes self-efficacy among high-school and college students (Nichols 1996; Nichols and Miller 1994; Supanc et al. 2017) and that peer tutoring promotes academic self-efficacy in primary-school students (Supanc et al. 2017; Van Keer and Verhaeghe 2005). Supanc et al. (2017) reported a Hedges' *g* effect size of 0.73 for highly-structured cooperative learning groups, as compared with a control, for self-perceived competence; Van Keer and Verhaeghe (2005) reported an effect size of 0.31 for improvement in self-efficacy in peer-tutoring matches relative to a control. Self-efficacy is also known to be influenced by the social environment (especially observing the success of other similar students, including those who demonstrate working through challenge) and by positive feedback or persuasion from others (Usher and Pajares 2008; Van Dinther et al. 2011). A collaborative learning environment in which role models are available and which is supportive and growth-oriented, then, has the potential to strengthen students' self-efficacy. We thus predicted that the small peer-led study group experience would be associated with higher levels of academic self-efficacy in the domain on which the group focused.

Self-regulated learning

Self-regulation for learning refers to students' ability to understand and manage their own learning process: to engage in activities such as establishing learning goals, organising learning tasks, evaluating one's own progress, and correcting one's course after an error. Self-regulated learning is not a personality trait, but rather the situational use of strategies that allow someone to study and learn effectively (Zimmerman 2000). Self-regulation involves the student's internally derived thoughts and actions, and therefore assumes agency on the part of the learner (Schunk and Zimmerman 2003). Zimmerman (2000, p. 200) describes self-regulation as comprising three stages: *forethought*, or the motivations students experience and the goals and plans they set out for themselves; *performance*, or the actual process of engaging with the material to be learned, which requires effort to maintain focus and to notice where one is progressing or failing to progress; and *self-reflection*, or making judgements about how well one did and why. Self-regulation is also understood to comprise a number of individual behaviours, including long-term goal-setting, selection of strategies for meeting goals, time management, progress monitoring, attention to the environment to reduce elements that detract from learning, self-assessment, reflection on causes for particular outcomes, and revision of strategies as needed (Zimmerman 2002).

Self-regulation in learning has been linked consistently to academic achievement (Caprara et al. 2008; Mega et al. 2014; Pintrich and De Groot 1990) and academic self-efficacy (Pajares 2002), as well as to persistence in education (Nota et al. 2004). Academic self-regulation is understood to be, in large part, a socially learned behaviour (Schunk and Zimmerman 1998; Zimmerman 2000) and a process that requires practice (Paris and Paris 2001). Social transmission of information related to self-regulation can happen both indirectly, involving students watching peers managing their own learning, and directly, involving students receiving instruction from teachers and peers. Thus, environments that provide opportunities for students to interact with others around study and learning strategies would be expected to promote self-regulation skill. Additionally, environments that highlight individual development, as opposed to relative performance across students, are likely to promote good self-regulatory practices in students (Pajares 2002).

While collaborative learning has been assumed to promote self-regulation in learners (Schraw et al. 2006), and while collaborative regulation of learning within learning-group discussions is often a desired outcome of group learning programs (e.g. Volet et al. 2009), research into the link between collaborative learning and individual self-regulation [e.g. Sungur and Tekkaya 2006), with reported η^2 of 0.13] has been minimal. It is plausible, however, that a collaborative learning environment that provides role modeling and feedback, and which de-emphasises competition among individuals, would promote self-regulation behaviours. We predicted that a small-group, peer-led STEM learning experience with these characteristics would increase students' academic self-regulation.

Approach to learning and memorisation

Another body of work which addresses the ways in which students engage in learning tasks is the approach-to-learning literature, which highlights the distinction between 'deep' and 'surface' ways of approaching academic learning. The foundational research showed that, while some students attempted to understand a text holistically, others focused their attention on discrete pieces of information which they might recall later (Marton and Säljö 1976). The deep/surface contrast has been explored and expanded upon by other researchers (e.g. Biggs 1993; Ramsden 2003). Surface approaches involve simple memorisation to recall material later, absence of reflection on the material, and lack of attention to larger patterns among pieces of information; these approaches are also associated with higher levels of anxiety about learning. Surface approaches have also been associated with less-effective learning and lower levels of academic performance (Booth et al. 1999; Chin and Brown 2000; Liu et al. 2015). Deeper approaches involve effort to understand underlying concepts, active engagement and interaction with material, and seeking relationships among pieces of information (Biggs 1993; Entwistle 1997; Prosser and Trigwell 1999).

There is substantial evidence that classroom environment and teaching style can affect students' approaches to learning: a classroom in which the primary goal is to transfer information to students is associated with students taking a more surface approach, while a classroom in which the primary goal is to engage students actively and conceptually with the material is associated with students taking a deeper approach (Gibbs and Coffey 2004; Kember and Gow 1994; Trigwell et al. 1999). A classroom environment that emphasises individual students' development as learners and de-emphasises competition among students has also been shown to promote deeper approaches (Dart et al. 2000; Greene et al. 2004; Mazlum et al. 2015).

Based on this previous work, we might expect that a regular and sustained collaborative learning environment, in which students have the opportunity to delve more deeply into course concepts than they would when working individually and when the comfort of the group setting might ease anxiety, would encourage deeper approaches to learning (i.e. less focus on simply memorising discrete bits of material). We therefore predicted that a small-group, peer-led sustained learning environment which emphasises conceptual learning and de-emphasises competition among students would be associated with a decrease in use of surface, memorisation-based approaches to learning.

Collaborative learning

Grounded in constructivist learning theory, collaborative learning allows students to interact, which is anticipated to promote cognitive development (Vygotsky 1980). Collaborative learning can take a number of forms, from paired exercises to jigsaw learning groups, in which students rely on one another to complete a task (Aronson 1997), to the problem-based learning used commonly in medical education (Wood 2008), to team-based learning that incorporates testing and feedback within the group (Michaelsen and Sweet 2011). Collaborative learning is increasingly used at the college level, in tandem with broader efforts to bring more active-learning approaches into educational environments. In science, technology, engineering and mathematics (STEM) courses, in particular, small-group learning using peers as facilitators has become popular in many universities, with generally positive results around course performance (see reviews by Felder and Brent 2007; Wilson and Varma-Nelson 2016). This model involves small groups of students meeting together with a more-experienced peer facilitator, and it can complement the traditional large-classroom environment. In these groups, students share questions and ideas, practice offering explanations, and are exposed to others' ideas and problem-solving processes (Cohen 1994).

These qualities of collaborative learning set the stage for potentially rich learning of the course material. Students who learn together, however, are also providing information and feedback to one another about the way in which they are learning and the sorts of approaches and attitudes that they take to learning; they are acting as role models in multiple ways; and, ideally, they are providing social support and encouragement. Moreover, when a peer leader is present—a common attribute of the small-group model—students are regularly interacting with somebody who can act as a role model in a variety of ways. As role models, peer leaders can provide a vicarious experience of academic success, potentially boosting self-efficacy (Bandura 1997); previous research has revealed that peer mentors are effective in changing students' attitudes towards and motivation for learning (e.g., Hall et al. 2013; Murphey and Arao 2001). Another related line of research has involved cooperative learning, which is a type of collaborative learning in which students must work together to achieve goals and rewards which apply to the group as a whole, rather than to single individuals. This kind of environment can create what Johnson and Johnson (2009) have termed *promotive interaction,* or interaction characterised by individuals working to promote the success of other members of the group (e.g., by sharing resources, offering advice and so forth). While not technically cooperative learning, small study groups in which a peer facilitator is present to help to create a supportive environment is likely to produce some degree of promotive interaction. Cooperative learning has been associated with a number of positive psychosocial outcomes, including confidence, self-esteem and ability to cope with adversity (Johnson and Johnson 1989, 2009), with Cohen's *d* effect sizes ranging from 0.44 to 1.17 standard deviations for cooperative versus competitive tasks. Because the small-group, peer-led learning model features elements of positive interdependence as well as role modeling, we anticipate that it would offer benefits beyond academic performance, including students' attitudes, feelings and behaviours surrounding their course experience.

Hypotheses

Relative to students not taking part, students engaging in a supplemental peer-based study group:

H1 will make greater gains over the term in *course self-efficacy*.

H2 will make greater gains over the term in *academic self-regulation*.

H3 will use less *unrelated memorising* (or memorising discrete bits of information).

Methods

Study context

This study took place at a selective research university in the US Midwest among undergraduate students enrolled in STEM (science, technology, engineering and mathematics) and social science courses, most of which are large, lecture-based and introductory. Students had the opportunity to join an optional weekly peer-led study group consisting of approximately 5–7 students who meet weekly for 9 weeks during an academic term to collaboratively review key concepts, discuss questions from the group, work through practice problems and prepare for assessments. Group peer facilitators were trained to promote active learning for which students are guided to figure out solutions for themselves and to emphasise conceptual understanding over simply the ability to arrive at the correct answer; the intention is to discourage rote- or memorisation-based approaches to learning the material. The peer facilitators were also encouraged to share suggestions on learning and study strategies and to offer feedback on students' problem-solving approaches. Peer leaders were also trained to create open, welcoming environments, with the goal of encouraging students to proffer ideas and answers even when unsure of whether they were correct.

The program was open to all students; it was not targeted to any particular student group. However, the program drew somewhat higher percentages of students from lower socioeconomic backgrounds, students underrepresented at the university by race, first-generation college students and women relative to the course populations at large. Group leaders were other undergraduates who had taken and performed well in the course and who had been screened for strong interpersonal skills and empathy. These peer leaders were trained through a credit-bearing course focusing on small-group facilitation, learning research and theory, group problem-solving techniques and psychosocial aspects of group learning. Students who participated in the program were required to attend weekly and received a pass/fail notation on their transcripts for their participation.

Measures

We used the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al. 1991) and the Approaches and Study Skills Inventory for Students (ASSIST) (Entwistle 1997; Entwistle et al. 2000). The MSLQ assesses student motivation and cognition, including self-efficacy and self-regulation. *Self-Efficacy* was measured through an 8-item scale from MSLQ; an example of an item is "I'm confident I can do an excellent job on the assignments and tests in this course." *Self-Regulation* was measured using the 10-item scale from MSLQ (Pintrich et al. 1991); an example of an item is "When reading for this course, I make up questions to help focus my reading." *Unrelated Memorising* was measured using a 4-item scale from ASSIST; an example of an item is "I'm not really sure what's important in lectures, so I try to get down all I can."

Sample

Students in our sample were enrolled in the program in courses in introductory macroeconomics, microeconomics, statistics, chemistry, physics and biology from fall 2011 through spring 2017. The sample comprised 36.8% males ($n=471$) and 63.2% females ($n=809$). With regards to ethnicity, 22% ($n=279$) were from an underrepresented group (African American, Hispanic/Latinx or Native American). Demographic information was collected from the institution's admissions records. We conducted an a priori power analysis using G*Power version 3.1 to identify the minimum sample size required to detect a small effect ($d=0.1$) for the difference between participants and non-participants through MANOVA analysis. Using $\alpha=0.05$ as the criterion of statistical significance and 80% for power, the analysis revealed a minimum sample size required of $n=114$.

Procedure

Students were recruited for the group-study program via class announcements and emails early in the academic term; they were told that the program was likely to be useful for them if they were feeling the need for extra support in the course. Students self-selected into the program. Students in the courses associated with the study groups—including those who participated in the study groups as well as those who did not—received a request to complete an online survey at the start and end of the 10-week academic quarter. Human-subjects approval was obtained by the university's Institutional Review Board. In total, 1280 students had complete data for both surveys, with 604 study-group participants and 676 non-participants.

Fidelity to the group-study program's structure was checked in several ways. First, a program coordinator checked in with group peer leaders weekly to find out what the group's activity for the week had been, as well as to suggest modifications if expected procedures were not being adhered to. The program coordinator also made periodic visits to the groups for the same purpose. In addition, feedback was solicited from students participating in the program at mid-term and, in the few cases for which it seemed that peer leaders were not operationalising the program as expected, the program coordinator worked with the peer leader to correct this.

Results

An initial descriptive analysis for the full sample for each of the three dependent variables, at start of term and end of term, yielded the means shown in Table 1. Because prior literature has suggested demographic differences in the three variables, we examined differences between underrepresented minority (URM) students and non-underrepresented students, as well as differences between women and men. ANOVA results indicated that underrepresented students and women had significantly lower scores for self-efficacy and significantly

Table 1 Pretest and posttest means for various subgroups

Variable	Pretest					Posttest				
	Full sample	Female	Male	URM	Non-URM	Full sample	Female	Male	URM	Non-URM
Self-efficacy	4.93	4.69*	5.33	4.74*	4.98	4.82	4.60*	5.20	4.63*	4.87
Self-regulation	4.65	4.66	4.64	4.65	4.65	4.67	4.65	4.69	4.68	4.66
Unrelated memorising	3.68	3.78*	3.50	3.90*	3.62	3.83	3.91*	3.68	4.00*	3.78

*Significant difference between comparison groups (female–male, URM–non-URM), $p < 0.01$

Table 2 Descriptive statistics for change in response variables

Variable	Group	Mean change	SD	*N*
Self-efficacy	Nonparticipant	− 0.1840	1.14583	676
	Participant	0.0054	1.11366	604
Self-regulation	Nonparticipant	− 0.0324	0.67850	676
	Participant	0.0974	0.70029	604
Unrelated memorising	Nonparticipant	0.1942	1.09592	676
	Participant	0.0799	1.10692	604
Total sample				1280

higher scores for unrelated memorising, at both time 1 and time 2, relative to non-under-represented students and men, respectively (see Table 1).

Table 2 provides descriptive statistics for the sample of participants and non-participants for changes in self-efficacy, self-regulation and unrelated memorising. A positive value for the mean change indicates that the value at the end of the quarter was larger than at the beginning.

To test the hypotheses, we compared changes (using a change score calculated as time 2 score − time 1 score) over the 10-week term for all three variables between participants and non-participants. We used MANOVA to determine whether participating students showed more improvement in the variables of interest over the term than non-participating counterparts. Later, we used a univariate ANOVA to compare groups for each individual variable to identify the ones that showed significant gains for the participants compared with non-participants. The overall MANOVA was statistically significant based on Wilks' lambda test ($F = 5.034$, $p = 0.002$), indicating that participating students showed greater improvement over the academic period for at least one of the dependent variables. The observed power of the multivariate test was 0.918.

ANOVAs uncovered significant differences in pre-to-post gains in self-efficacy ($F = 8.946$, $p = 0.003$) and self-regulation ($F = 11.316$, $p = 0.001$). Non-participants decreased in self-efficacy over the quarter, while participants' self-efficacy remained relatively stable. With regard to self-regulation, non-participants decreased over the quarter whereas participants showed a slight increase. The analysis also revealed a marginally significant difference in unrelated memorising ($F = 3.435$, $p = 0.064$). Both participants and non-participants showed an average increase in unrelated memorising over a quarter, with participants having a marginally significant lower increase (Table 3).

Table 3 Univariate ANOVA results

Variable	*F*	*p*	Observed power	Cohen's *d* effect size
Change in self-efficacy	8.946	0.003	0.848	0.17
Change in self-regulation	11.316	0.001	0.919	0.19
Change in unrelated memorising	3.435	0.064	0.457	0.10
Change in unrelated memorising—full data set	4.555	0.033	0.569	0.11

As Table 3 indicates, the observed power based on the ANOVA for changes in unrelated memorising scores was only 0.457, suggesting that the sample size might not have been sufficient to detect a statistical significant difference between the two samples for this dependent variable. Therefore, we conducted a follow-up ANOVA analysis with all of the available data for unrelated memorising. The new expanded sample included students who had complete data for unrelated memorising but had missing data for either of the other two dependent variables (self-efficacy and self-regulation), and thus were not included in the original MANOVA (which included just those students who had completed items for all three scales.) The resulting sample had 1390 students, with 640 participants and 750 non-participants. As illustrated in Table 3, this follow-up ANOVA with the expanded sample showed a statistically-significant difference for unrelated memorising in favour of participating students ($F=4.555$, $p=0.033$), indicating that, although both groups showed an increase in unrelated memorising, non-participants had a larger increase than participants.

Table 3 also shows effect sizes for the intervention in terms of average changes in the response variables over the course of the quarter. Although these effects sizes are considered small, they are noteworthy considering that the intervention took place over a limited period of 2 h weekly for 9 weeks during a single quarter.

Based on these results, we found support for hypotheses H1, H2 and H3. That is, participation in the program was associated with gains in self-efficacy and self-regulation, and to suppression of unrelated memorising.

Because of the demographic differences noted in the self-efficacy and unrelated memorisation scores, we additionally explored whether there was a differential effect of study group participation based on gender or URM status. Two separate two-way ANOVAs were run to test for interaction effects between gender and study-group participation, as well as between URM status and study-group participation, with change score in self-efficacy and unrelated memorising used as dependent variables. All interaction effects were nonsignificant, indicating that the differences observed in self-efficacy and unrelated memorising for study-group participants applied equally regardless of gender or URM status.

Discussion

The small-group, peer-to-peer learning environment offers features that are often lacking in the traditional classroom, particularly in university environments in which the large lecture hall—with its sense of anonymity and primarily one-way communication—figures as a key facet of students' academic experience. As noted earlier, prior research has identified academic performance benefits associated with participating in small peer-learning groups at the university level. The present study suggests that small peer-learning group experiences which complement a university course also can have a beneficial impact on factors apart from course or examination performance, namely, students' belief about their ability to succeed in, monitor and regulate their learning, as well as their tendency to study in a superficial, disconnected way.

Why might the small-group experience produce such outcomes? Students meeting regularly with classmates to discuss course material are paying regular, sustained attention to the material, which could mean that students are simply practising more, which alone might help to increase both knowledge and a confidence in one's ability to solve problems effectively. Students working together in groups could also experience higher levels of affiliation, which in turn could increase students' involvement in course-related activities

(Anderson et al. 2004) and thus increased learning and confidence. Moreover, peer facilitators and fellow students could be sharing their own learning and study strategies, and offering one another feedback, as well as serving as role models for one another. These features, based on previous research and theory, also are likely to promote self-efficacy (Schunk 1995). Additionally, constructivist learning environments—particularly those promoting reflection and engagement with concepts—have been shown to promote self-efficacy (Alt 2015). The small-group environments in this study were designed to encourage both reflection and conceptual learning: peer leaders were trained to prompt students to think about the approaches that they are taking to the material and why, and to explore concepts fully rather than simply seeking to arrive at the right answer. Program participants were also engaged in a community of fellow learners, who probably talked about their approaches to studying (as well as a peer leader, who would be doing the same but with more expertise). This might prompt experimentation with new study approaches and increased attention to study practices. Finally, a reduction in surface-oriented memorisation could result from the small groups' focus on conceptual understanding, or seeking to understand isolated bits of material in the context of broader concepts. It is also possible that the small-group environment, influenced by a facilitator trained to create a low-stakes atmosphere, might reduce students' worry about making mistakes publicly and therefore their overall stress levels. In turn, this could reduce the surface, memorisation-oriented approach to learning (Chen et al. 2015; Spada et al. 2006). Surface-level approaches can also be minimised by learning environments that are more participatory and in which students receive personal attention (Dart et al. 2000); the small-group environment is likely to achieve this more readily than a large lecture environment would.

A number of questions remain. First, it is unclear whether these benefits apply equally to all students participating in the groups, or whether some students might be more or less likely to benefit. For instance, are students who are outliers in the groups in terms of their levels of understanding less likely to gain in self-efficacy? How might general student anxiety level interact with the group experience in using an unrelated-memorisation approach? What are the particular qualities of a group that promote the gains seen in this study—including behaviours of the peer facilitator, group activities, group composition and so forth? Future research might investigate these questions.

This study had several limitations. First, because the research site was a highly selective institution, the impact and outcomes of the peer learning experience at a different type of institution might be different. Second, students were not randomly assigned to participate in the program, but rather opted into the program. It is therefore possible that the students who chose to join the program were for some reason already more likely to change in particular ways over the academic term. To address this issue, future research could attempt to control for pre-existing differences in motivation to improve one's learning strategies and approaches, as well as for other activities in which students might be engaged (e.g., outside academic coaching) and which might have an influence on their learning strategies and approaches.

References

Alt, D. (2015). Assessing the contribution of a constructivist learning environment to academic self-efficacy in higher education. *Learning Environments Research, 18*(1), 47–67.

Anderson, A., Hamilton, R. J., & Hattie, J. (2004). Classroom climate and motivated behaviour in secondary schools. *Learning Environments Research, 7*(3), 211–225.

Aronson, E. (1997). *The Jigsaw classroom: Building cooperation in the classroom*. London: Longman.
Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: Macmillan.
Biggs, J. (1993). What do inventories of students' learning processes really measure? A theoretical review and clarification. *British Journal of Educational Psychology, 63*(1), 3–19.
Bonsangue, M. V., & Drew, D. E. (1995). Increasing minority students' success in calculus. *New Directions for Teaching and Learning, 1995*(61), 23–33.
Booth, P., Luckett, P., & Mladenovic, R. (1999). The quality of learning in accounting education: The impact of approaches to learning on academic performance. *Accounting Education, 8*(4), 277–300.
Bouffard-Bouchard, T., Parent, S., & Larivee, S. (1991). Influence of self-efficacy on self-regulation and performance among junior and senior high-school age students. *International Journal of Behavioral Development, 14*(2), 153–164.
Caprara, G. V., Fida, R., Vecchione, M., Del Bove, G., Vecchio, G. M., Barbaranelli, C., et al. (2008). Longitudinal analysis of the role of perceived self-efficacy for self-regulated learning in academic continuance and achievement. *Journal of Educational Psychology, 100*(3), 525–534.
Chemers, M. M., Hu, L., & Garcia, B. F. (2001). Academic self-efficacy and first year college student performance and adjustment. *Journal of Educational Psychology, 93*(1), 55–64.
Chen, Y., Henning, M., Yielder, J., Jones, R., Wearn, A., & Weller, J. (2015). Progress testing in the medical curriculum: Students' approaches to learning and perceived stress. *BMC Medical Education*, *15*(1), Article 147.
Chin, C., & Brown, D. E. (2000). Learning in science: A comparison of deep and surface approaches. *Journal of Research in Science Teaching, 37*(2), 109–138.
Cohen, E. G. (1994). Restructuring the classroom: Conditions for productive small groups. *Review of Educational Research, 64*(1), 1–35.
Dart, B. C., Burnett, P. C., Purdie, N., Boulton-Lewis, G., Campbell, J., & Smith, D. (2000). Students' conceptions of learning, the classroom environment, and approaches to learning. *The Journal of Educational Research, 93*(4), 262–270.
Dolmans, D. H., & Schmidt, H. G. (2006). What do we know about cognitive and motivational effects of small group tutorials in problem-based learning? *Advances in Health Sciences Education*, *11*(4), Article 321.
Drane, D., Micari, M., & Light, G. (2014). Students as teachers: Effectiveness of a peer-led STEM learning programme over 10 years. *Educational Research and Evaluation, 20*(3), 210–230. https://doi.org/10.1080/13803611.2014.895388.
Entwistle, N. J. (1997). *The approaches and study skills inventory for students (ASSIST)*. Edinburgh: Centre for Research on Learning and Instruction, University of Edinburgh.
Entwistle, N., Tait, H., & McCune, V. (2000). Patterns of response to an approaches to studying inventory across contrasting groups and contexts. *European Journal of Psychology of Education*, *15*(1), Article 33.
Felder, R. M., & Brent, R. (2007). Cooperative learning. In P. A. Mabrouk (Ed.), *Active learning: Models from the analytical sciences (ACS symposium series, 970)* (pp. 34–53). Washington, DC: American Chemical Society.
Gibbs, G., & Coffey, M. (2004). The impact of training of university teachers on their teaching skills, their approach to teaching and the approach to learning of their students. *Active Learning in Higher Education, 5*(1), 87–100.
Ginsburg-Block, M. D., Rohrbeck, C. A., & Fantuzzo, J. W. (2006). A meta-analytic review of social, self-concept, and behavioral outcomes of peer-assisted learning. *Journal of Educational Psychology, 98*(4), 732–749.
Gore, P. A. (2006). Academic self-efficacy as a predictor of college outcomes: Two incremental validity studies. *Journal of Career Assessment, 14*(1), 92–115. https://doi.org/10.1177/1069072705281367.
Greene, B. A., Miller, R. B., Crowson, H. M., Duke, B. L., & Akey, K. L. (2004). Predicting high school students' cognitive engagement and achievement: Contributions of classroom perceptions and motivation. *Contemporary Educational Psychology, 29*(4), 462–482. https://doi.org/10.1016/j.cedpsych.2004.01.006.
Hall, S., Lewis, M., Border, S., & Powell, M. (2013). Near-peer teaching in clinical neuroanatomy. *The Clinical Teacher*, *10*(4), 230–235.
Johnson, D. W., & Johnson, R. T. (1989). *Cooperation and competition: Theory and research*. Edina, MN: Interaction Book Company.
Johnson, D. W., & Johnson, R. T. (2009). An educational psychology success story: Social interdependence theory and cooperative learning. Educational researcher, 38(5), 365–379.
Kember, D., & Gow, L. (1994). Orientations to teaching and their effect on the quality of student learning. *The Journal of Higher Education, 65*(1), 58–74.

Lammers, W. J., & Murphy, J. J. (2002). A profile of teaching techniques used in the university classroom: A descriptive profile of a US public university. *Active Learning in Higher Education, 3*(1), 54–67.
Lewis, S. E., & Lewis, J. E. (2005). Departing from lectures: An evaluation of a peer-led guided inquiry alternative. *Journal of Chemical Education*, *82*(1), Article 135. https://doi.org/10.1021/ed082p135.
Liem, A. D., Lau, S., & Nie, Y. (2008). The role of self-efficacy, task value, and achievement goals in predicting learning strategies, task disengagement, peer relationship, and achievement outcome. *Contemporary Educational Psychology, 33*(4), 486–512.
Liu, E. S., Carmen, J. Y., & Yeung, D. Y. (2015). Effects of approach to learning and self-perceived overall competence on academic performance of university students. *Learning and Individual Differences, 39,* 199–204.
Marton, F., & Säljö, R. (1976). On qualitative differences in learning: I—Outcome and process. *British Journal of Educational Psychology, 46*(1), 4–11.
Mazlum, F., Cheraghi, F., & Dasta, M. (2015). English teachers' self-efficacy beliefs and students learning approaches. *International Journal of Educational Psychology, 4*(3), 305–328.
Mega, C., Ronconi, L., & De Beni, R. (2014). What makes a good student? How emotions, self-regulated learning, and motivation contribute to academic achievement. *Journal of Educational Psychology, 106*(1), 121–131.
Michaelsen, L. K., & Sweet, M. (2011). Team-based learning. *New Directions for Teaching and Learning, 2011*(128), 41–51.
Multon, K. D., Brown, S. D., & Lent, R. W. (1991). Relation of self-efficacy beliefs to academic outcomes: A meta-analytic investigation. *Journal of Counseling Psychology, 38*(1), 30–38.
Murphey, T., & Arao, H. (2001). Reported belief changes through near peer role modeling. *Tesl-Ej*, *5*(3), 1–15.
Nichols, J. D. (1996). The effects of cooperative learning on student achievement and motivation in a high school geometry class. *Contemporary Educational Psychology, 21*(4), 467–476.
Nichols, J. D., & Miller, R. B. (1994). Cooperative learning and student motivation. *Contemporary Educational Psychology, 19*(2), 167–178.
Ning, H. K., & Downing, K. (2010). The impact of supplemental instruction on learning competence and academic performance. *Studies in Higher Education, 35*(8), 921–939.
Nota, L., Soresi, S., & Zimmerman, B. J. (2004). Self-regulation and academic achievement and resilience: A longitudinal study. *International Journal of Educational Research, 3*(41), 198–215.
Pajares, F. (1996). Self-efficacy beliefs in academic settings. *Review of Educational Research, 66*(4), 543–578.
Pajares, F. (2002). Gender and perceived self-efficacy in self-regulated learning. *Theory into Practice, 41*(2), 116–125.
Panitz, T., & Panitz, P. (1998). Encouraging the use of collaborative learning in higher education. In J. J. F. Forest (Ed.), *University teaching: International perspectives* (pp. 161–201). London: Taylor and Francis.
Paris, S. G., & Paris, A. H. (2001). Classroom applications of research on self-regulated learning. *Educational Psychologist, 36*(2), 89–101.
Pintrich, P. R., et al. (1991). *A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ)*. Retrieved June 26, 2020 from https://eric.ed.gov/?id=ED338122.
Pintrich, P. R., & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology, 82*(1), 33–40.
Prosser, M., & Trigwell, K. (1999). *Understanding learning and teaching: The experience in higher education*. Buckingham: Society for Research into Higher Education and Open University Press.
Ramsden, P. (2003). *Learning to teach in higher education*. London: Routledge.
Robbins, S. B., Lauver, K., Le, H., Davis, D., Langley, R., & Carlstrom, A. (2004). Do psychosocial and study skill factors predict college outcomes? A meta-analysis. *Psychological Bulletin, 130*(2), 261.
Schraw, G., Crippen, K. J., & Hartley, K. (2006). Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning. *Research in Science Education, 36*(1–2), 111–139.
Schunk, D. H. (1995). Self-efficacy and education and instruction. In J. E. Maddux (Ed.), *Self-efficacy, adaptation, and adjustment* (pp. 281–303). New York: Springer.
Schunk, D. H., & Pajares, F. (2002). The development of academic self-efficacy. In A. Wigfield & J. S. Eccles (Eds.), *Development of achievement motivation* (pp. 15–31). London: Elsevier.
Schunk, D. H., & Zimmerman, B. J. (1998). *Self-regulated learning: From teaching to self-reflective practice*. New York: Guilford Press.
Schunk, D. H., & Zimmerman, B. J. (2003). Self-regulation and learning. In I. B. Weiner, W. M. Reynolds, & G. E. Miller (Eds.), *Handbook of psychology: Educational psychology* (Vol. 7, pp. 59–78). New York: Wiley.

Slavin, R. E., Hurley, E. A., & Chamberlain, A. (2003). Cooperative learning and achievement: Theory and research. In I. B. Weiner, W. M. Reynolds, & G. E. Miller (Eds.), *Handbook of psychology: Educational psychology* (Vol. 7, pp. 177–198). New York: Wiley.

Smith, T. J., McKenna, C. M., & Hines, E. (2014). Association of group learning with mathematics achievement and mathematics attitude among eighth-grade students in the US. *Learning Environments Research, 17*(2), 229–241.

Spada, M. M., Nikcevic, A. V., Moneta, G. B., & Ireson, J. (2006). Metacognition as a mediator of the effect of test anxiety on a surface approach to studying. *Educational Psychology, 26*(5), 615–624.

Sungur, S., & Tekkaya, C. (2006). Effects of problem-based learning and traditional instruction on self-regulated learning. *The Journal of Educational Research, 99*(5), 307–320.

Supanc, M., Völlinger, V. A., & Brunstein, J. C. (2017). High-structure versus low-structure cooperative learning in introductory psychology classes for student teachers: Effects on conceptual knowledge, self-perceived competence, and subjective task values. *Learning and Instruction, 50,* 75–84.

Tien, L. T., Roth, V., & Kampmeier, J. A. (2002). Implementation of a peer-led team learning instructional approach in an undergraduate organic chemistry course. *Journal of Research in Science Teaching, 39*(7), 606–632. https://doi.org/10.1002/tea.10038.

Trigwell, K., Prosser, M., & Waterhouse, F. (1999). Relations between teachers' approaches to teaching and students' approaches to learning. *Higher Education, 37*(1), 57–70.

Usher, E. L., & Pajares, F. (2008). Sources of self-efficacy in school: Critical review of the literature and future directions. *Review of Educational Research, 78*(4), 751–796.

Van Dinther, M., Dochy, F., & Segers, M. (2011). Factors affecting students' self-efficacy in higher education. *Educational Research Review, 6*(2), 95–108.

Van Keer, H., & Verhaeghe, J. P. (2005). Effects of explicit reading strategies instruction and peer tutoring on second and fifth graders' reading comprehension and self-efficacy perceptions. *The Journal of Experimental Education, 73*(4), 291–329.

Volet, S., Summers, M., & Thurman, J. (2009). High-level co-regulation in collaborative learning: How does it emerge and how is it sustained? *Learning and Instruction, 19*(2), 128–143.

Vygotsky, L. S. (1980). *Mind in society: The development of higher psychological processes*. Cambridge: Harvard University Press.

Wilson, S. B., & Varma-Nelson, P. (2016). Small groups, significant impact: A review of peer-led team learning research with implications for STEM education researchers and faculty. *Journal of Chemical Education, 93*(10), 1686–1702. https://doi.org/10.1021/acs.jchemed.5b00862.

Wood, D. F. (2008). Problem based learning. *BMJ : British Medical Journal*, *336*(7651), Article 971. https://doi.org/10.1136/bmj.39546.716053.80.

Zajacova, A., Lynch, S. M., & Espenshade, T. J. (2005). Self-efficacy, stress, and academic success in college. *Research in Higher Education, 46*(6), 677–706.

Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. *Handbook of self-regulation* (pp. 13–39). London: Elsevier.

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory into Practice, 41*(2), 64–70.