Students' Understanding and Perceptions of Assigned Team Roles in a Classroom Laboratory Environment

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Using a cooperative learning framework in a quantitative reasoning laboratory course, students were assigned to static teams of four in which they adopted roles that rotated regularly. The roles included: team leader, protocol manager, data recorder, and researcher. Using a mixed-methods approach, we investigated students' perceptions of the team roles and specifically addressed students' understanding of the roles, students' beliefs in their ability to enact the roles, and whether working with assigned team roles supported the teams to work effectively and cohesively. Although students expressed confidence in their understanding of the team roles, their understanding differed from the initial descriptions. This suggests that students' understanding of team roles may be influenced by a variety of factors, including their experiences within their teams. Students also reported that some roles appeared to lack a purpose, implying that for roles to be successful, they must have a clear purpose. Finally, the fact that many students reported ignoring the team roles suggests that students do not perceive roles as a requirement for team productivity and cohesion. On the basis of these findings, we provide recommendations for instructors wishing to establish a classroom group laboratory environment.

Traditional laboratory environments involve students working either individually or in pairs. However, given the benefits associated with involving students in laboratory experiences (Jordan et al., 2014; Lopatto, 2004, 2007; Seymour, Hunter, Laursen, & DeAntoni, 2004), institutions are under pressure to consider increasing the capacity of laboratory classes and authentic research experiences. Group laboratory experiences are one mechanism to address this issue.

Two widely adopted group-based pedagogical approaches are team-based learning (TBL; Michaelsen, Knight,& Fink, 2004; Michaelsen & Sweet, 2008) and cooperative learning (Johnson & Johnson, 1989; Johnson, Johnson, & Smith, 1991, 2010). These approaches are based on social constructionist theories of learning (Berger, Luckmann, & Zifonun, 2002; Gergen, 2003), which hold that learning occurs in and through social interactions. Hence, both approaches involve students working in groups within the context of a class and focus on the development of teamwork skills and critical thinking and problem-solving abilities (Frame et al., 2015; Huitt, Killins, & Brooks, 2015; Johnson & Johnson, 1989; Johnson et al., 2010; Michaelsen, Knight, & Fink, 2004; Sandi-Ureña, Cooper, & Stevens, 2010, 2012). Cooperative learning involves the establishment of highly structured teams with membership that rotates regularly throughout a course. One type of structure often used in cooperative learning is the assignment of team roles to help foster positive interdependence within a team. Common roles include manager, recorder, reader, and spokesperson (Johnson & Johnson, 1989; Johnson et al., 1991; Shimazoe & Aldrich, 2010). In TBL, however, static teams are allowed to determine for themselves how to work together efficiently and productively without the added structure of assigned team roles (Michaelson et al., 2004). Moreover, TBL is designed for classroom-based course learning, whereas cooperative learning has been adopted in a variety of educational settings, including laboratory courses (Cooper, 2012) and research groups (Gates et al., 1999; Villa, Kephart, Gates, Thiry, & Hug, 2013).

Sandi-Ureña, Cooper, Gatlin, and Bhattacharyya (2011) investigated student perceptions of a cooperative learning laboratory environment. They found that students in a cooperative general chemistry laboratory engage in a three-part process that ultimately involves them taking control of the learning environment. The three stages include: (a) the affective response, where students have an initial response to the environment that

may involve confusion or negative feelings, followed by acceptance; (b) understanding the experience, where students come to recognize the purpose of the learning environment; and (c) strategic response, where students develop specific skills to excel in the learning environment. Regardless of whether students have positive or negative perceptions of the cooperative learning environment, completion of this three-stage process results in both increased problem-solving abilities and metacognition (Sandi-Ureña et al., 2010, 2012; Sandi-Ureña et al., 2011).

Anecdotal evidence has suggested that potential benefits of team roles in relation to promoting positive team interdependence include counteracting social loafing, promoting student interactions, enhancing learner autonomy, and promoting learning for all students, especially underrepresented groups (Brewer & Klein, 2006; Cohn, 1999; Rosser, 1998). Despite the popularity of using team roles in a cooperative environment, little is known about how specifically team roles promote team interdependence or how students perceive team roles in a learning environment. Herein, we describe implementation of a structured team approach in a classroom laboratory that is modeled after cooperative learning and involves students enacting assigned team roles. Students in an introductory, STEM-focused, quantitative reasoning laboratory worked in semester-long teams consisting of four students who each rotated through the following roles: team leader, protocol manager, data recorder, and researcher. The purpose of assigning these roles was to help teams develop positive interdependence and also provide students with exposure to the various roles that research scientists enact.

Because our study is grounded in theories that foreground the role of the social context and social interactions in learning, we chose a mixed-methods approach involving both quantitative surveys and qualitative focus groups to investigate students' perceptions of assigned team roles in a classroom laboratory setting. The specific questions that we investigated include:

1. How well did students understand the roles?
2. How well did students believe they were able to enact the roles?
3. Did working within structured teams with assigned roles promote team cohesion and productivity?

Methods

Course description

This study was implemented in SCI 101L: Quantitative Reasoning—Measurement and Skills Laboratory in the fall of 2015 at a public university with primarily undergraduate enrollment and higher research activity (R2). SCI 101L is a two-credit laboratory course that met weekly for a 4-hour laboratory session. The course counted as a general education requirement for laboratory sciences.

In SCI 101L, students complete five 2-week laboratory modules from an interdisciplinary array of STEM fields: biology, chemistry, environmental science, mechanical engineering, and physics. Students worked in teams of four that remained constant throughout the semester. Each module involved students formulating experimental questions and hypotheses, developing and executing an experimental procedure, analyzing and interpreting data, and presenting their data in a written laboratory report format.

TABLE 1

Demographics of student teams.

Team	Majors	Gender	Race/Ethnicity
1	Biochemistry & Molecular Biology (1) Biological Sciences (3)	Female (3) Male (1)	African American (3) Two or more (1)
2	Biochemistry & Molecular Biology (1) Biological Sciences (2) Pre-Chemical Engineering (1)	Female (2) Male (2)	African American (3) Asian(1)
3	Biochemistry & Molecular Biology (1) Biological Sciences (2) Pre-Engineering (1)	Female (3) Male (1)	African American (3) Asian(1)
4	Biochemistry & Molecular Biology (1) Biological Sciences (3)	Female (2) Male (2)	African American (4)
5	Biochemistry & Molecular Biology (1) Biological Sciences (2) Pre-Chemical Engineering (1)	Female (3) Male (1)	African American (1) Hispanic/Latino (2) Asian (1)

Students completed lab reports individually, but they were encouraged to consult their team when writing their reports. At the end of the course, each team participated in a 3-week final project, for which they formulated their own measurement-based question of interest, designed and implemented an experiment to answer their question, analyzed and interpreted data, and presented their findings in an oral format.

The instructor included several team-building components in the course. At the beginning of the semester, students were exposed to various team participation types and engaged in an activity designed to help them better understand their own participation tendencies when working in teams. Students also deliberately practiced teamwork skills at the beginning and midpoint of the course with nongraded team-building activities.

At the conclusion of each module and the final project, students completed a graded team evaluation. Team evaluations were implemented as a way for students to address any issues with team cohesion or individual contributions, including the enactment of assigned roles. Team evaluations were also implemented to avoid social loafing and student frustration with working on a team (Aggarwal & O'Brien, 2008; Pfaff & Huddleston, 2003).

Student demographics, team organization, and team roles

All of the students in the fall 2015 section were participants in a STEM student success initiative (LaCourse et al., 2017). Students were admitted into this initiative based on high school GPA (3.0–3.4) and SAT (MSAT ≥550) performance and had to have interests in the biomedical and behavioral sciences. SCI 101L is a required course for the students during their first year in the initiative. Other requirements of the initiative include participation in a Summer Bridge Program before they matriculate into the university and residence in a STEM Living and Learning Community. Therefore, the student population of this study is atypical compared with most general laboratory education courses, given that they had established relationships with one another before taking SCI 101L.

The fall 2015 section of SCI 101L consisted of five teams of four that were assigned by the instructor and remained consistent throughout the duration of the course. Team assignments were made on the basis of student performance on Summer Bridge assessments, with at least one high- and one low-achieving student per team. Further, the teams each included at least one male. Refer to Table 1 for a description of the demographics of each team. Fifteen of the 20 students enrolled in the course agreed to participate in this study, which was granted exempt Institutional Review Board approval.

Students rotated among each of four roles that they were required to enact at least once during the semester. Refer to Table 2 for a

TABLE 2

Description of team roles.

Role	Description
Team leader	This person manages the team and ensures that members of the team are fulfilling their assigned roles. This person also ensures that the team is staying on task and that each member of the team is participating and contributing to the activity.
Protocol manager	This person is in charge of the experimental design and ensures that the experimental protocol is being followed appropriately. He or she will guide the team through the protocol and reach out to the peer mentor or instructors for any clarification needed. This person will gather and keep track of reagents and materials for the experiment and ensure that they are used effectively and appropriately.
Data recorder	This person is in charge of recording data generated by the team. This person will neatly collect and organize data and share with the rest of the team members. Although each team member should be involved in data analysis, this person will take the lead in data analysis and delegate tasks.
Researcher	This person is in charge of researching items required to complete the laboratory experiment and reporting back to the team. This may include gathering outside content information, looking up unknown terms, or researching protocols. This person will communicate and share these resources with the rest of the team.

description of the team roles. At the start of the semester, the instructor reviewed the team roles and explained that all members of the team should be involved in conducting the experiment, with specific tasks determined by the group. Teams also signed a contract that described the team roles and asked them to denote who would enact which role for each module at the start of the semester. The instructor reviewed the purpose and duties of the team roles with the class at the start of each module.

Data collection and analysis

At the midpoint and end of the semester, each student was asked to provide a description of each role to evaluate students' apprehension of the purpose and responsibilities of each team role. The students' descriptions were compared with the original descriptions of the team roles found on the team contract (Table 2), and the degree of similarity between the two was compared using a rubric (Table 3). Two investigators independently and blindly reviewed the students' role descriptions. Tests of interrater reliability determined a high degree of concordance (87% overall) between these independent ratings: 95% agreement for the data recorder role, 88% agreement for team leader role, and 83% agreement on both protocol manager and researcher roles.

At the conclusion of the course, an anonymous survey was conducted to gauge student perceptions of the team roles and whether students felt that the roles benefitted their teams. The survey, administered through Qualtrics, asked students' opinions of the value of having team roles and changing the roles for each module using a 5-point, Likert-type scale. It also required students to rank the roles in terms of their preferences for fulfilling them and their perceptions of the degree of difficulty involved in fulfilling them.

Focus groups were also conducted at the conclusion of the course, on the same day that the survey was administered, to gauge student perceptions of the purpose and value of having team roles. Four focus groups were conducted, each by a different facilitator. Thirteen of the 15 study participants participated in the focus groups. Each group consisted of 2–4 students, drawn from different teams so that the students felt free to speak candidly about how team roles played out in their respective teams. The interviews were audio-

TABLE 3

Team role description rubric.

Role	Grading criteria
Team leader	*3 points*: describes all aspects of the role—(1) ensures team roles are fulfilled, (2) team remains on task, and (3) members are participating and contributing *2 points*: one aspect of role described above is missing *1 point*: two aspects of role described above are missing *0 points*: no aspects of role described above are provided
Protocol manager	*4 points*: describes all aspects of the role—(1) in charge of experimental design, (2) ensure experimental protocol is followed, (3) guide team through protocol and seek help when needed, and (4) gather and keep track of reagents and supplies and ensure proper use *3 points*: one aspect of role described above is missing *2 points*: two aspects of role described above are missing *1 point*: three aspects of role described above are missing *0 points*: no aspects of role described above are provided
Data recorder	*3 points*: describes all aspects of the role— (1) recording data, (2) share data with the team, and (3) lead in data analysis *2 points*: one aspect of role described above is missing *1 point*: two aspects of role described above are missing *0 points*: no aspects of role described above are provided
Researcher	*2 points*: describes all aspects of the role— (1) research items relevant to experiment, and (2) share information found with the team *1 point*: one aspect of role described above is missing *0 points*: no aspects of role described above are provided

recorded and transcribed, and resulting transcripts were analyzed through iterative readings, each focusing on one of the three research questions to identify recurrent themes that addressed the research questions.

The instructor of the course was also the lead investigator of this research project. To avoid conflicts of interest, the course instructor did not facilitate focus-group sessions. Moreover, the survey data were not reviewed or analyzed until after course grades were submitted. Student recruitment to participate in the study was facilitated by a member of the research team who was not a course instructor.

Results

Students' understanding of team roles

Survey results revealed that students felt confident in their understanding of the team roles (Table 4). Students reported that they best understood the role and responsibilities of the data recorder and least understood the researcher role. The focus group data corroborated these findings, as most students didn't refer to a lack of understanding of the roles as causing problems in completing the work or working well together. Nevertheless, in two of the focus groups, students indicated that they had problems understanding certain roles. For example, Student A suggested that in some experiments, there was a gap between work to be done and the assigned roles: "Sometimes the job you're given was not clearly defined. So you were given a role and it had a name and label, but you didn't know what that label exactly entailed. What you had to do sometimes wasn't clear."

Student B, from a different focus group, pointed specifically to the protocol manager role, suggesting that that role didn't make sense to her: "I wasn't sure what their role was because I just couldn't imagine someone just sitting or standing there just saying what we were supposed to do next . . . I didn't understand the purpose of it at times." These were the only comments from the focus group interviews where students indicated that they did not understand the roles and that a lack of understanding made it difficult to fulfill the role or complete the work. Instead, students seemed to suggest that the rigidity of the roles, the lack of relevance of certain roles in specific modules, or the lack of fit between the roles and students' strengths and personalities caused more difficulties.

To directly measure students' apprehension of the team roles and responsibilities, we evaluated the similarity between the students' descriptions and the descriptions provided in the team contract. An evaluation of student descriptions of the team roles demonstrated that they differed markedly from the original descriptions. Moreover, students' descriptions did not change much between the midpoint and end-of-semester assessments (Table 5), demonstrating consistency in students' understanding of the team roles over the duration of the semester.

TABLE 4

Student confidence in their understanding of each team role, its responsibilities, and their own ability to enact it.

Agreement statements:	I clearly understood the role and its responsibilities.	I felt confident in my ability to fulfill the demands of the role.
Roles	Average Likert-type score (+/- *SD*)	Average Likert-type score (+/- *SD*)
Team leader	4.07 (+/- 1.03)	3.93 (+/- 1.03)
Protocol manager	3.80 (+/- 1.01)	3.93 (+/- 0.59)
Data recorder	4.33 (+/- 0.62)	4.33 (+/- 0.62)
Researcher	3.53 (+/- 1.19)	3.47 (+/- 1.06)

Note: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*.

TABLE 5

Summary of student description of team roles assessment.

Role	Midpoint assessment	End-of-semester assessment
Team leader	50.88% (+/- 27.52%)	50.88% (+/- 20.23%)
Protocol manager	27.63% (+/- 14.68%)	30.26% (+/- 17.91%)
Data recorder	45.61% (+/- 16.75%)	50.88% (+/- 27.52%)
Researcher	52.50% (+/- 25.52%)	55.00% (+/- 22.36%)

Students' perceived abilities enacting the roles

Survey data revealed students were most confident enacting the role of data recorder and least confident in enacting the researcher role (Table 5). That said, based on the mean response on the survey, students preferred to enact the team leader role most frequently, followed equally by data recorder and researcher. Interestingly, data recorder and researcher were most frequently ranked lowest in students' preferences of roles to enact. Students ranked data recorder as the easiest to fulfill, followed by team leader, with the researcher role ranked as the most difficult to fulfill.

Focus group results revealed that students felt they were able to fulfill the roles, but that some roles didn't seem relevant to certain experiments. The researcher role, for example, was mentioned repeatedly as not being relevant in the majority of the experiments: "Researcher was only helpful in the final project," Student C indicated. Student D added: "So what were they supposed to do?" Student D continued, saying that she and her teammates made sure that the researcher had something to contribute by reapportioning the work of the other roles: "[Another student] and I did that where . . . she'd be in charge of one really big thing, and I'd be in charge of another big thing if I was researcher. But we'd work cohesively and it would work. But technically, I'm not really following my role because my role is not relevant in this case."

Students' feelings about effectiveness of team roles

The survey data revealed that students had mixed feelings about whether having team roles for each module benefitted teams or helped teams to be productive or unified (Table 6). Additionally, although students indicated enjoyment in changing roles for each module, they expressed mixed feelings regarding whether changing roles helped teams to be unified and productive (Table 7). Student responses were also mixed about whether changing team roles provided perspective on the unique contribution each role provided to the team.

An overarching theme that surfaced in the focus group interviews was that students generally did not feel that having assigned roles helped them to complete the experiments in an efficient manner, nor did it help with team cohesion. In each of the focus groups, at least one student suggested that the roles didn't facilitate getting work done. In fact, some students even suggested that the roles hindered their process because they were too focused on what each person was supposed to do to fulfill

TABLE 6

Student perceptions of having team roles for each module.

Question	Average Likert-type score (+/- *SD*)
I liked having assigned team roles to play in SCI 101L	3.07 (+/- 1.22)
Having assigned team roles helped my team to be productive	3.33 (+/- 1.35)
Having assigned team roles helped my team build unity and have a sense of purpose	3.40 (+/- 1.30)
Having assigned team roles was beneficial to my team	3.00 (+/- 1.20)

Note: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*.

TABLE 7

Student perceptions of changing roles in SCI 101L.

Question	Average Likert-type score (+/- *SD*)
I liked changing team roles for each module in SCI 101L	4.13 (+/- 0.74)
Changing team roles for each module helped my team to be productive	3.60 (+/- 0.83)
Changing team roles for each module helped my team build unity and have a sense of purpose	3.47 (+/- 0.92)
Changing roles for each module was beneficial to my team	3.47 (+/- 0.92)
Changing roles for each module gave me perspective on the unique contribution each role provides to the team	3.80 (+/- 1.01)

Note: 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*.

their role, distracting them from the overall point of the lab. For example, Student E said, "For my group, it never actually worked because we were too focused on what we should do, like our roles, so it caused tension sometimes."

Students also mentioned a mismatch between the roles and the students' skills. In one focus group session, Student C suggested that the roles didn't always match their team members' personality types: "If that [introverted person] . . . became team leader and just didn't really talk—they just sat there—maybe one or two extroverted people in our group [would] you know, take over." Student F, in the same focus group, said that readjusting the roles helped make sure the work got done, while also ensuring everyone could contribute: "Some [roles] just aren't a good fit for everybody. That's the thing about the team roles. Just because that introverted person wasn't taking the lead doesn't mean that they can't contribute in some way." Thus it appears that creating and maintaining positive team dynamics and a commitment to fulfillment of the broader laboratory task superseded fulfilling the roles in some teams. These teams chose to ignore the roles or make adjustments to them if they perceived that they were getting in the way of maintaining harmony or completing the work.

Discussion

Our study elucidates student understanding and perceptions of assigned team roles in a classroom laboratory environment. In the literature, team roles are thought to enhance team interdependence and promote student autonomy and deeper learning in a cooperative environment, yet little empirical evidence is available to support these claims. Further, most cooperative learning pedagogies structure roles around team process skills and not disciplinary functions, such as laboratory research.

Our survey and focus group results revealed that although students felt confident in their understanding of the roles, as a group, their understanding of the team roles contradicted somewhat the original descriptions they were given (Table 4). Sandi-Ureña and colleagues (2011) reported similar findings, as students were confused about the nature of a cooperative learning laboratory environment even after the instructor provided a description. This suggests that students' understandings and/or perceptions of aspects of a cooperative laboratory learning environment may be the result of a combination of factors, such as unique structures of the learning environment, experiences within their teams or with previous group work, prior laboratory experiences and their perceived value, and/or relationships with other team members. Further, the fact that students were forced to take SCI 101L because of programmatic requirements might have influenced their overall perceptions of the course, including the team roles aspect. Regardless, students may gain valuable skills even when they have negative perceptions of elements of the learning environment (Sandi-Ureña, 2011), and we are confident that students in our study gained valuable teamwork and research skills, as measured both by team evaluations and course performance.

Students' understanding of the roles could have also been affected by the fact that for some modules, students did not see a clear purpose for the roles. Hackman (1989) found that high-performing teams need to use task performance strategies that are appropriate for the work and be motivated to exert appropriate levels of work to complete the task. This implies that for teams to be high performing, the various tasks enacted by individual group members must have a specific niche. Thus, the students' perceived lack of purpose for the roles likely resulted in frustration and ultimate abandonment of the roles. Therefore, if team roles are to be required in a group laboratory environment, the roles need to be clearly aligned with the specific tasks to be accomplished.

Our results also suggest that students do not perceive roles as a requirement to obtain team productivity and cohesion, given that many students reported ignoring the roles altogether. Interestingly, lack of team cohesion is associated with students' negative feelings toward teamwork, whereas team stability over time promotes team cohesion (Birmingham & McCord, 2004; Feichtner & Davis, 1984). Further, nonstructured groups still achieve a high-level of group interaction (Woods-McConney, Wosnitza, & Sturrock, 2016), suggesting that neither group structure nor enactment of team roles necessarily promotes team production and cohesion. Thus, our findings and those of others suggest that teams may naturally develop strategies to work efficiently and cohesively, particularly when team composition remains constant for an extended time. This suggests that the added structure of required team roles may interfere with static teams' natural development toward cohesion and productivity.

An important aspect of our study population is that the participants had

established relationships prior to and outside of this course because they were all members of the same cohort of a student success initiative and living and learning community. Because of these prior relationships, students had already formed impressions of each other's strengths and weaknesses, and some students indicated that they intentionally readjusted the roles to fit the personalities of individual members. Team dynamics literature has recommended against creating teams in which students have previous relationships, as they tend to prohibit cohesion (Michaelsen, 2004). In our case, the instructor made the team assignments, and there were no indications that the students' established relationships prohibited team cohesion, as assessed by successful completion of all laboratory modules and laboratory reports. However, forcing teams to enact roles that didn't align with their preconceptions of each other's strengths and weaknesses may have led students to intentionally ignore the team roles and instead enact roles that felt more comfortable. As Sandi-Ureña and colleagues (2011) found, students in cooperative settings act in such a way as to gain control of the learning environment. This suggests that students in our study may have intentionally ignored the roles or assigned roles that best fit each student's personality/strengths to assert control within the learning environment.

Cooperative learning was the primary influence for the structured team roles that were adopted in SCI 101L because they had been previously adopted in laboratory environments (Cooper, 2012; Gates et al., 1999; Villa et al., 2013). Our results suggest, however, that in a classroom laboratory environment, this aspect of cooperative learning may not be effective. In hindsight, because TBL is designed for a classroom setting in which static teams self-manage in the absence of predefined team roles, it may be a more suitable approach for a classroom laboratory (Birmingham & McCord, 2004; Michaelsen et al., 2004; Michaelsen & Sweet, 2008). The rationale for not assigning roles in TBL is that teams naturally determine how best to work together without the added structure of assigned roles. This may be particularly useful for typical student populations consisting of heterogeneous levels of academic abilities, as the lack of structure will likely foster an environment in which high-achieving students promote the learning and skill development of lower achieving students (Michaelson, Watson, & Black, 1989). Further, teams remain static in TBL because changing team composition regularly, as performed in cooperative learning in classrooms, requires teams to spend time getting to know one another and may impede a team's ability to learn how to interact effectively. Laboratory environments typically involve students working together for extended periods of time, often the duration of an entire course or semester. Thus, given time to form relationships, it is likely that students in laboratory environments would behave in a similar manner as those in this study. That is, they would resist enacting assigned team roles as a means to promote cohesiveness. ■

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References

Aggarwal, P., & O'Brien, C. L. (2008). Social loafing on group projects structural antecedents and effect on student satisfaction. *Journal of Marketing Education*, *30*, 255–264.

Berger, P. L., Luckmann, T., & Zifonun, D. (2002). *The social construction of reality*. New York, NY: Random House.

Birmingham, C., & McCord, M. (2004). Group process research: Implications for using learning groups. In L. Michaelsen, A. Bauman Knight, & L. D. Fink (Eds.), *Team-based learning: A transformative use of small groups in college teaching* (pp. 73–93). Sterling, VA: Stylus Publishing.

Brewer, S., & Klein, J. D. (2006). Type of positive interdependence and affiliation motive in an asynchronous, collaborative learning environment. *Educational Technology Research and Development*, *54*, 331–354.

Cohn, C. L. (1999). Cooperative learning in a macroeconomics course. *College Teaching*, *47*, 51–55.

Cooper, M. (2012). *Cooperative chemistry laboratory manual* (6th ed.). New York, NY: McGraw-Hill.

Feichtner, S. B., & Davis, E. A. (1984). Why some groups fail: A survey of students' experiences with learning groups. *Journal of Management Education*, *9*(4), 58–73.

Frame, T. R., Cailor, S. M., Gryka, R. J., Chen, A. M., Kiersma, M. E., & Sheppard, L. (2015). Student perceptions of team-based learning vs traditional lecture-based learning. *American Journal of Pharmaceutical Education*, *79*(4), Article 51.

Gates, A. Q., Teller, P. J., Bernat, A., Delgado, N., & Della-Piana, C. K. (1999). Expanding participation in

undergraduate research using the affinity group model. *Journal of Engineering Education*, *88*, 409–414.

Gergen, K. J. (2003). Social construction. In *The Corsini Encyclopedia of Psychology*. New York, NY: Wiley.

Hackman, J. R. (1989). *Groups that work (and those that don't): Creating conditions for effective teamwork*. San Francisco, CA: Jossey-Bass.

Huitt, T. W., Killins, A., & Brooks, W. S. (2015). Team-based learning in the gross anatomy laboratory improves academic performance and students' attitudes toward teamwork. *Anatomical Sciences Education*, *8*, 95–103.

Johnson, D. W., & Johnson, R. (1989). *Cooperation and competition: Theory and research*. Edina, MN: Interaction Book Company.

Johnson, D. W., Johnson, R. T., & Smith, K. A. (1991). *Active learning: Cooperation in the college classroom*. Edina, MN: Interaction Book Company.

Johnson, D. W., Johnson, R. T., & Smith, K. A. (2010). Cooperative learning returns to college: What evidence is there that it works? *Change: The Magazine of Higher Learning*, *30*(4), 26–35.

Jordan, T. C., Burnett, S. H., Carson, S., Caruso, S. M., Clase, K., DeJong, R. J., … Hatfull, G. F. (2014). A broadly implementable research course in phage discovery and genomics for first-year undergraduate students. *mBio*, *5*(1), e01051-13.

LaCourse, W. R., Sutphin, K. L., Ott, L. E., Maton, K. I., McDermott, P., Bieberich, C., Farabaugh, P., & Rous, P. (2017). Think 500, not 50! A scalable approach to student success in STEM. *BMC Proceedings, 11,* 105–115.

Lopatto, D. (2004). Survey of Undergraduate Research Experiences (SURE): First findings. *Cell Biology Education*, *3*, 270–277.

Lopatto, D. (2007). Undergraduate research experiences support science career decisions and active learning. *CBE—Life Sciences Education*, *6*, 297–306.

Michaelsen, L. K. (2004). Getting started with team-based learning (Chapter 2). In L. K. Michaelsen, A. B. Knight, & L. D. Fink (Eds.), *Team-based learning: A transformative use of small groups in college teaching* (pp. 73–93). Sterling, VA: Stylus Publishing.

Michaelsen, L. K., Knight, A., & Fink, L. (2004). *Team-based learning: A transformative use of small groups in college teaching*. Sterling, VA: Stylus Publishing.

Michaelsen, L. K., & Sweet, M. (2008). The essential elements of team-based learning. *New Directions for Teaching and Learning*, *2008*(116), 7–27.

Michaelson, L. K., Watson, W. E., & Black, R. H. (1989). A realistic test of individual versus group consensus decision-making. *Journal of Applied Psychology, 74,* 834–839.

Pfaff, E., & Huddleston, P. (2003). Does it matter if I hate teamwork? What impacts student attitudes toward teamwork. *Journal of Marketing Education*, *25*, 37–45.

Rosser, S. V. (1998). Group work in science, engineering, and mathematics: Consequences of ignoring gender and race. *College Teaching*, *46*, 82–88.

Sandi-Ureña, S., Cooper, M. M., Gatlin, T. A., & Bhattacharyya, G. (2011). Students' experience in a general chemistry cooperative problem based laboratory. *Chemistry Education Research and Practice*, *12*, 434–442.

Sandi-Ureña, S., Cooper, M. M., & Stevens, R. H. (2010). Enhancement of metacognition use and awareness by means of a collaborative intervention. *International Journal of Science Education, 33*, 323–340.

Sandi-Ureña, S., Cooper, M. M., & Stevens, R. H. (2012). Effect of cooperative problem-based lab instruction on metacognition and problem-solving skills. *Journal of Chemical Education*, *89*, 700–706.

Seymour, E., Hunter, A.-B., Laursen, S. L., & DeAntoni, T. (2004). Establishing the benefits of research experiences for undergraduates in the sciences: First findings from a three-year study. *Science Education*, *88*, 493–534.

Shimazoe, J., & Aldrich, H. (2010). Group work can be gratifying: Understanding & overcoming resistance to cooperative learning. *College Teaching*, *58*, 52–57.

Villa, E. Q., Kephart, K., Gates, A. Q., Thiry, H., & Hug, S. (2013). Affinity research groups in practice: apprenticing students in research. *Journal of Engineering Education*, *102*, 444–466.

Woods-McConney, A., Wosnitza, M., & Sturrock, K. L. (2016). Inquiry and groups: Student interactions in cooperative inquiry-based science. *International Journal of Science Education, 38,* 842–860.

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