Research

Using Expectancy Value Theory as a Framework to Reduce Student Resistance to Active Learning: A Proof of Concept

Katelyn M. Cooper, Michael Ashley, and Sara E. Brownell*
Biology Education Research Lab, School of Life Sciences, Arizona State University, Tempe, AZ 85281

There has been a national movement to transition college science courses from passive lectures to active learning environments. Active learning has been shown to be a more effective way for students to learn, yet there is concern that some students are resistant to active learning approaches. Although there is much discussion about student resistance to active learning, few studies have explored this topic. Furthermore, a limited number of studies have applied theoretical frameworks to student engagement in active learning. We propose using a theoretical lens of expectancy value theory to understand student resistance to active learning. In this study, we examined student perceptions of active learning after participating in 40 hours of active learning. We used the principal components of expectancy value theory to probe student experience in active learning: student perceived self-efficacy in active learning, value of active learning, and potential cost of participating in active learning. We found that students showed positive changes in the components of expectancy value theory and reported high levels of engagement in active learning, which provide proof of concept that expectancy value theory can be used to boost student perceptions of active learning and their engagement in active learning classrooms. From these findings, we have built a theoretical framework of expectancy value theory applied to active learning.

INTRODUCTION

Active learning is typically defined as instructional practices that are student-centered, so that students are actively engaged in learning the material. There has been a national push to transform undergraduate science courses into active learning spaces because, on average, active learning has been shown to be more effective than traditional lecturing (1). As undergraduate science courses are transitioned away from passive lectures, a frequent instructor concern is that students may resist active learning approaches and may not value the benefits of active learning (2,3). Importantly, if students are resistant to active learning, they may not maximize their learning experience in active learning classrooms.

One way to explore the extent to which students are maximizing their experiences in active learning classrooms is through a lens of expectancy value theory. Expectancy value theory predicts that students will put more effort into activities that they simultaneously perceive to have value and at which they expect to succeed (Fig. 1) (4,5). The

relative value and the probability of success that individuals have regarding certain tasks are critical determinants of the theory and are conceptualized as three components: expectancy, value, and cost. Expectancy is the broad belief
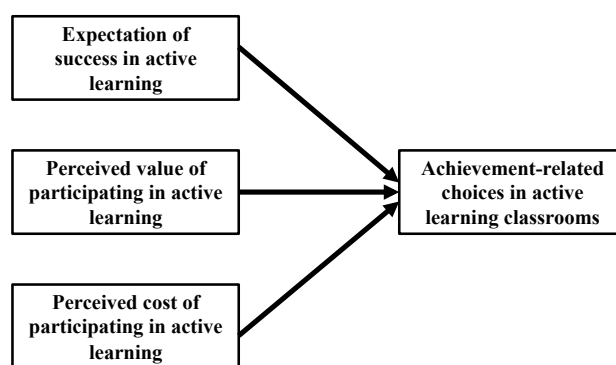
FIGURE 1. Model of expectancy value theory applied to student achievement-related choices in active learning classrooms, adapted from Wigfield and Eccles (5). Expectation of success in active learning relates to student self-efficacy in doing activities in active learning. Perceived value of participating in active learning is the extent to which a student perceives that the activities in which they are asked to engage have value to them. Perceived cost of participating in active learning relates to a student's resistance toward active learning. All of these factors are predicted to influence a student's decision to participate fully in active learning.

*Corresponding author. Mailing address: School of Life Sciences, Arizona State University, PO Box 874501, Tempe, AZ 85260. Phone: 480-965-9704. E-mail: sara.brownell@asu.edu.

in one's competence in a particular area and can be measured as self-efficacy in that domain. An individual's sense of value could take the form of one of the following: (a) attainment value, which is the personal importance of doing well on a task and how this relates to an individual's identity, (b) intrinsic value, the enjoyment an individual gets from undertaking a particular task, and (c) utility value, how well a task relates to current or future goals. Finally, cost refers to the negative results stemming from an individual participating in the task, including costs that come directly from the task, as well as lost opportunities due to the time spent on this task.

Students enrolled in an active learning classroom can choose how to engage with the material: whether they want to do the minimum work possible or whether they want to try to maximize their experience. How are students making this decision about effort? Using a lens of expectancy value theory, if the overall value of the task is perceived to be low, then students are less likely to put forth effort (4). Additionally, if students perceive that the task is too difficult to accomplish, then they are also less likely to put in the needed effort (4). In the context of active learning, this means that students need to perceive value stemming from active learning, as well as have confidence that they can accomplish active learning activities. Further, students need to perceive low costs to participating in order to maximize their active learning experiences.

How do students value active learning? What costs do they perceive? And how confident are they in their abilities to succeed in active learning? Despite the abundance of literature on the benefits of active learning and specific active learning strategies (1,6–10), there is limited research on student perceptions of value, cost, and self-efficacy in participating in active learning (3). A study on student perceptions of active learning exercises in a large-enrollment, general-education college class found that students valued active learning overall, but did not value group work (11). Another study, which examined how expectancy value theory impacts education and communication majors doing active learning found that expectancy and value components of student motivation were correlated with positive learning behaviors during individual learning, but not during collaborative learning (12). Surprisingly, students in both of these studies appear to be differentiating between the value of group work and active learning, even though group work is often a dominant element of active learning classrooms.

In this study we set out to determine whether expectancy value theory could be used to explore introductory biology student experiences with active learning. As an exploratory study, we examined the perspectives of first-year biology majors who had participated in an active learning classroom for the first time. These students engaged in 40 hours of active learning over a two-week biology summer prep program. We use this population of students as a proof of concept case for examining the utility of using expectancy value theory to understand how students' self-efficacy in active learning, their perceived value of active learning, and their perceived costs associated with active learning can affect their experiences in active learning. We then built a novel theoretical framework that instructors can use when considering ways to diminish student resistance and increase student engagement in active learning.

METHODS

Interviews and analyses

We conducted semi-structured interviews with 25 first-year biology students who had participated in learning biology content through 40 hours of active learning, where they answered clicker questions, solved biology problems on whiteboards, completed worksheets, and engaged in group discussion as part of a two-week summer program designed to transition students from high school to college. We determined the extent to which active learning was used in this program through in-person observations that demonstrated that there was some kind of active learning incorporated into every lesson, as well as student self-report of engaging in active learning in every lesson. One-hundred and seven students were eligible to participate in the program, of whom 28 chose to enroll. Upon completion of the program, all 28 students enrolled in an introductory biology course that was taught in an active learning way. Interviews took place during the last week of this introductory biology course at the end of students' first semester in college. We were able to interview all but three of the program participants. We designed interview questions to specifically explore aspects of expectancy value theory in the context of active learning (see Table 1 for interview questions). We also probed the extent to which students participated in active learning in their introductory biology class. To explore students' engagement-related choices, we asked students to talk about their level of participation in active learning during their introductory biology class. We coded students' self-reported engagement in active learning as "low," "medium," or "high," based on the rubric in Table 2. Prior to the program, none of the students had participated in what they perceived to be active learning. However, students learned biology content during the summer program using a variety of active learning approaches, including clicker questions with peer discussions, worksheets, and building models. The summer program is described in more detail in Cooper et al. 2017 (13).

Interviews were audio-recorded, transcribed, and analyzed using a combination of grounded theory and content analysis (14). The authors analyzed student responses for components of self-efficacy, value, and cost pertaining to active learning as well as students' self-described level of engagement in active learning during their introductory biology course. Two of the authors established a coding rubric by iteratively coding a set of student responses. Then each author used the rubric to independently code

TABLE 1.
Interview script used during semi-structured interviews with
the students.

Active Learning
Interview prompt: I'm going to ask about your thoughts on active learning. When I say active learning, I'm referring to in-class activities like clicker questions and worksheets that you do independently or in a group. I'm also referring to activities outside of class for example, when you read or watch videos before coming to class.
What is your opinion of active learning?
During [the summer program], you experienced a lot of different learning activities like clicker questions, working in groups on worksheets, and doing activities outside of class like watching videos or reading. What did you learn about active learning during [the summer program]?
How, if at all, has what you learned about active learning in [the summer program] impacted your experience in introductory biology?
Do you believe that you think differently about active learning than other first-year students who did not complete [the summer program]? Why or why not?
Do you think you get more out of active learning than other first year students who did not complete [the summer program]? Why or why not?
What specific actions do you take, if any, to make active learning more effective in introductory biology?
How resistant were you to active learning when you started [the summer program]? Please explain. Why were you resistant?
How, if at all, did your resistance to active learning change, either way, during [the summer program]?
How, if at all, has your resistance to active learning changed, either way, since you started introductory biology?
How confident were you participating in active learning when you started [the summer program]? Please explain.
How, if at all, did your confidence regarding participating in active learning change, either way, during [the summer program]?
How, if at all, has your confidence regarding participating in active learning changed, either way, since you started introductory biology?
Talk to me about your level of participation in active learning activities in introductory biology.

a subset of responses. To establish coding reliability the authors compared responses and had a consensus estimate over 90% (15). One author then used the rubric to code the remaining interviews. Student quotes were minimally edited using ellipses to indicate unnecessary excluded content and by inserting clarification brackets. Pseudonyms are used to protect students' identities.

This study was done with an approved IRB protocol # 00003820.

Participant demographics

Of the 25 students who were interviewed for this study, 76% identified as female, 56% identified as an underrepresented racial minority, and 40% identified as a first-generation college student.

RESULTS

Changes in components of expectancy value theory related to active learning

We found self-reported changes in the direction of increased self-efficacy, increased perceived value, and decreased resistance toward active learning. Additionally, the majority of students reported high levels of engagement in active learning in their introductory biology course. In Table 3, we provide the specific changes for each student for the principal components of expectancy value theory for active learning as well as students' self-reported level of engagement in active learning. The majority of students indicated that their self-efficacy pertaining to participating in active learning increased, and all students indicated that they valued active learning more after completing the program. Further, all students perceived low cost to active learning at the end of the program; 76% of students reported that they were initially resistant to active learning, but perceived lower costs to participating in active learning after completing the program, and 24% of students perceived a low cost to participating in active learning at the beginning of the program and maintained this perception. Overall, students' increased self-efficacy, increased value, and decreased resistance to active learning seemed to result in high levels of engagement in active learning for 71% of students. Below, we illustrate these changes using student quotes to provide support for using expectancy value theory as a lens to explore student experience and self-reported participation in active learning.

Student self-efficacy in active learning

We explored whether students perceived that their exposure to active learning changed their beliefs about their self-efficacy in active learning. Prior to participating in this program, all students were unfamiliar with active learning, and most were skeptical of the new approach and uncertain of how to engage in active learning. Students reported that they were accustomed to high school instructors lecturing at the front of the room. Some students, like Sofia, were uncomfortable sharing their ideas in front of other students at the beginning of the program for fear that they would not be perceived as intelligent.

> *Sofia: "When I started [the program], I was nervous about asking questions […] Before, I would never ask questions because I felt like I would have been stupid for asking questions because I was afraid others would*

TABLE 2.
Description of levels of student self-reported engagement in active learning and example student interview quotes.

Level of Student Self-Reported Engagement in Active Learning	Description of Level of Engagement in Active Learning	Example Student Interview Quote
Low	The student describes engaging in active learning at a surface level (e.g., participating for points) or participating less than other students in their introductory biology class	NA
Medium	The student describes participating in active learning to the same extent as other students in their introductory biology class.	"I would say [my participation in active learning] is pretty even with the person I'm working with. We'll both discuss [the question], and one person will write down the answers, and discuss it more." – Annie
High	The student describes deeply engaging in active learning (e.g., grappling with questions or extensively discussing problems) and/or perceives that they participate in active learning activities to a greater extent than other students in their introductory biology class.	"I did a lot of participation. Just today, [the instructor] was asking for volunteers to do a little jeopardy review game and I was the first one to shoot my hand up. If it weren't for [the summer program] I probably would have just been another person in the class not really trying to draw attention to myself." – Corinne

think, 'That's not a good question' or I'm going to sound so dumb."

However, students indicated that they felt significantly different about participating in active learning after their exposure to active learning. All students described feeling confident in their ability to approach active learning after the program and many students, such as Jessica, attributed their confidence to their experience with active learning in the summer program.

Jessica: "That was the best thing about [the summer program], we had this two weeks of solving problems, and then you go into this entire new setting of intro bio and you have this confidence, like 'I can do active learning, I know I can,' and then you do it. You're good."

These quotes illustrate the positive changes in student self-efficacy related to their abilities in active learning that were shown in Table 3, self-efficacy being a critical component of expectancy value theory.

Students demonstrated less resistance when they perceived greater value in participating in active learning

Most students were resistant to active learning at the beginning of the program. Specifically, students appeared to be resistant to active learning because they were unfamiliar with the teaching methods, and increased exposure to active learning decreased their initial resistance.

Kordell: "When I started [the summer program], I felt like that whole entire concept of active learning was different than what I was used to in a traditional class. At first I felt like 'I don't know if I want to do this' but as the days progressed it just became easier to do and something that wasn't so foreign. Everyone was doing it, so it just made it easier to pick up."

Eduardo: "I think as time went on, I kind of realized the importance [of active learning]. The first time we did it, it was 'oh this seems kind of childish,' but once you go along with it, you realize it's a good thing."

Although many students indicated that greater exposure to active learning was important in decreasing their resistance to it, they also attributed their attitudinal changes to realizing the value of active learning as evidenced by their own learning gains. The students' more positive perceptions of the value of active learning simultaneously seemed to diminish their resistance to active learning.

Carlos: "To be honest, I didn't really like doing active learning at first. You know, I just got used to it and started liking the results: I was learning more. I retained more that way because I was applying [the biology]."

Isabella: "Everyone at the beginning of [the summer program] was like, 'this active learning sucks—we're actually going to have to do work in active learning.' Then when we started getting into it and I started actually remembering and understanding the informa-

TABLE 3.
Students' perceived changes in each component of expectancy value theory for active learning and self-reported level of engagement in active learning.

Student	Self-Efficacy Pertaining to Participating in Active Learning	Value of Engaging in Active Learning	Cost Associated with Active Learning	Self-Reported Level of Engagement in Active Learning
Annie	NA	0	–	medium
Carlos	↑	↑	–	medium
Juanita	NA	↑	↓	high
Jamal	↑	↑	↓	high
Eduardo	↑	↑	↓	high
Kordell	↑	↑	↓	high
Sofia	NA	↑	↓	medium
Victoria	↑	↑	↓	high
Patrice	↑	↑	↓	medium
Hunter	NA	↑	↓	high
Alexis	↑	↑	↓	high
Jessica	↑	↑	↓	high
Tim	↑	↑	↓	high
Mia	↑	↑	–	high
Luciana	↑	↑	–	high
Ashley	↑	↑	↓	high
Isabella	↑	↑	↓	high
Kaci	↑	↑	↓	NA
Braden	↑	↑	–	medium
Phoebe	↑	↑	↓	high
Marcy	↑	↑	↓	medium
Elena	↑	↑	↓	medium
Bianca	↑	↑	↓	high
Destiny	NA	↑	–	high
Rachel	↑	↑	↓	high

↑ indicates student self-efficacy, value, or cost associated with active learning increased over the course of the program.
↓ indicates student self-efficacy, value, or cost associated with active learning decreased over the course of the program.
– indicates student initially perceived low self-efficacy, value, or cost associated with active learning and it did not change over the course of the program.
NA means that the student response could not be interpreted for that category.

tion better than I have before. I've taken so many bio classes [in high school], and I've never understood the concepts like I did in [the summer program], and so I definitely wanted to get more active learning in college."

Although students reported that they had not participated in active learning classes in high school, all students had engaged in group work, a common element of active learning, prior to enrolling in the summer program. Most students described being resistant to group work at the beginning of the program due to negative experiences they had in high school. Students said that they typically preferred to work alone in the classroom because (1) they felt as if they learned better that way in high school, (2) they felt there was a potential cost of other students influencing their grade,

and (3) they were nervous to engage with other students. The following quotes illustrate students' initial resistance to group work.

Sofia: "I wasn't one for group work before [the program] because I was like, 'I can do this by myself, I don't want to talk to anyone,' or, 'I'd rather do my own stuff' because I don't have to depend on anyone else for a grade. Before, I had issues with that in high school where I was the one stuck with the whole project and everyone else would do nothing."

Bianca: "In the beginning of [the program] I was like 'oh group work, I'm so nervous getting to interact with people and stuff because I'm a shy person if I don't know people.'"

However, the overwhelming majority of students described becoming more open to working with other students after participating in group work during the program. Students acknowledged significant differences between the group work in high school and in the summer program. Students specified that group work in the summer program emphasized equitable exchanging of different thoughts and ideas. The group work was structured so as to encourage different group members to share their ideas, and the instructors often assigned roles for each student in the group, including speaker, recorder, and equity monitor. An equity monitor is a member of the group who ensures that all members have contributed, and, if someone has not contributed, they are tasked with asking them to contribute (16,17). Students worked in different groups multiple times per day.

Many students described high school group work as being primarily implemented as a way to get activities done more quickly that often left students with unequal amounts of work. For example, Sofia describes being reluctant to participate in group work at the beginning of the program due to her fear that she would have to do all of the work herself. She goes on to explain that she became more open to group work once she realized that students could contribute equally and that she could learn from the contributions of others.

Sofia: "With [the summer program] we all contribute. It's not just one person doing everything […] Now I know the importance of group work and how it helps me when I have other people talk to me about [biology]. I feel like I can be very set on one thing and sometimes I don't come up with other ways to think of things. That's why I like listening to other people and see what they say so I can take their perspective on it and think, 'Oh yeah, that's true.'"

Eduardo echoed that he appreciated hearing diverse ideas from people in his group to help his learning and that it took him realizing that he cannot know all the answers himself to really appreciate the contributions of other students.

Eduardo: "I learned that [during group work] it's very important to be able to collaborate with someone else, because obviously they might bring forth ideas that you may not have thought of initially and I think it's always good to be able to take account of someone else's opinion other than your own. I think that was a really helpful part that we carried on throughout the semester, too."

Interviewer: "What helped you learn that?"

Eduardo: "I think it was just doing it every day and actually realizing that they might know what you don't and you can learn from them and they can learn from you."

In contrast to prior studies, where students perceived that group work diminished the value of active learning (11,12), the students in this study highlighted that collaborating with other students in the program helped them see the value of active learning. Further, students differentiated between group work and active learning at the beginning of the program, but they did not differentiate group work from active learning after the program. Juanita illustrates this point when she described that she did not understand a topic until she discussed it in the group.

Juanita: "I'm now more open to active learning. When I started [the summer program] I was just like, 'What is this active learning? Why are we doing this?' Now, I'm super open to it. I'm like, 'Active learning, it's great! This is a new way for me to learn.' Especially if I don't know content and I am totally confused, then I'm all for it."

Interviewer: "What caused you to change your mind?"

Juanita: "In [the summer program] I was totally confused. I was like, 'What are we talking about? I'm super confused about it.' We were watching videos for homework, I was like, 'I still don't get it.' Until we all came together and started doing it on the board and talking about it and discussing it in our groups, that's when I became more open. I was like, 'I get it now.'"

These quotes reveal that there seems to be a relationship between perceived value and resistance. As students perceive greater value in active learning, often seeing their own learning gains, they felt less resistance to active learning; this relationship is shown for individual students in Table 3.

Student participation in active learning

Expectancy value theory suggests that if students value active learning, believe they can successfully participate in active learning, and perceive a low cost to doing active learning, they will make the choice to deeply engage in active learning activities. We found that no students reported low levels of engagement in active learning and most students described a high level of engagement in active learning. Many students described how the components of expectancy value theory (value, self-efficacy, or cost) influenced their level of participation in active learning. For example, Jamal explains that because he enjoys active learning (intrinsic value) and learns more from active learning (utility value), he chooses to engage in active learning activities.

Jamal: "I like participating [in active learning]. I knew how I can benefit from active learning [from the summer program], so I was kind of like more intensely trying to do it compared to other students who kind of would just like try to sit back and semi do it or just not do it at all."

Similarly, Victoria explains that she chose to engage in active learning because she recognized that she learns more

(utility value) and that if she does not participate, she will not learn (cost of *not* engaging).

> Victoria: *"I think most times, I kind of take the lead role [in active learning]. I'm never just that person sitting down and not doing anything. I always want to be doing something, because that's where I learn. From doing things. Sitting back, you're not going to learn anything. I'm trying really hard."*

Students' descriptions of how the value, self-efficacy, and cost associated with active learning influenced their decision to participate in active learning suggests that expectancy value theory provides a useful model to explore student participation in active learning.

DISCUSSION

Using a framework of expectancy value theory in an interview study, we found evidence that the students perceived gains in their self-efficacy, were less resistant to active learning, and perceived increased value in active learning as a result of their experience in a biology summer program that was taught using active learning.

Building a model of student success in active learning using expectancy value theory

Applying Wigfield and Eccles' (5) expectancy value theory to the context of student success in active learning, we identified novel student factors from these interviews that influence student self-efficacy in active learning, perceived value of active learning, and perceived costs associated with active learning, all of which contribute to student engagement in active learning. Figure 2 depicts our novel theoretical framework for expectancy value theory, which includes student factors that influence the components of active learning we propose could be used by instructors to maximize student success in active learning. We found that student familiarity with active learning was important for their self-efficacy in doing active learning, so that increased exposure to active learning appeared to lead to increased self-efficacy.

According to expectancy value theory, increasing the perception of the value of active learning and decreasing students' resistance to participate will increase student motivation to do well in active learning. This means that we, as instructors, should consider trying to enhance student perceptions of the value of active learning, and simultaneously try to decrease their resistance, or cost, as it is described in the framework. We found that students' perception of their ability to learn information better because of active learning, as well as their enjoyment of participating in active learning, positively contributed to their perceived value of active learning. Further, we found that student perceptions of a high workload associated with active learning and discomfort working with other students increase their perceived cost to participating in active learning, which explained much of their initial resistance.

Interestingly, most of the students described their own personal positive experience with active learning as being the primary way they determined that active learning had
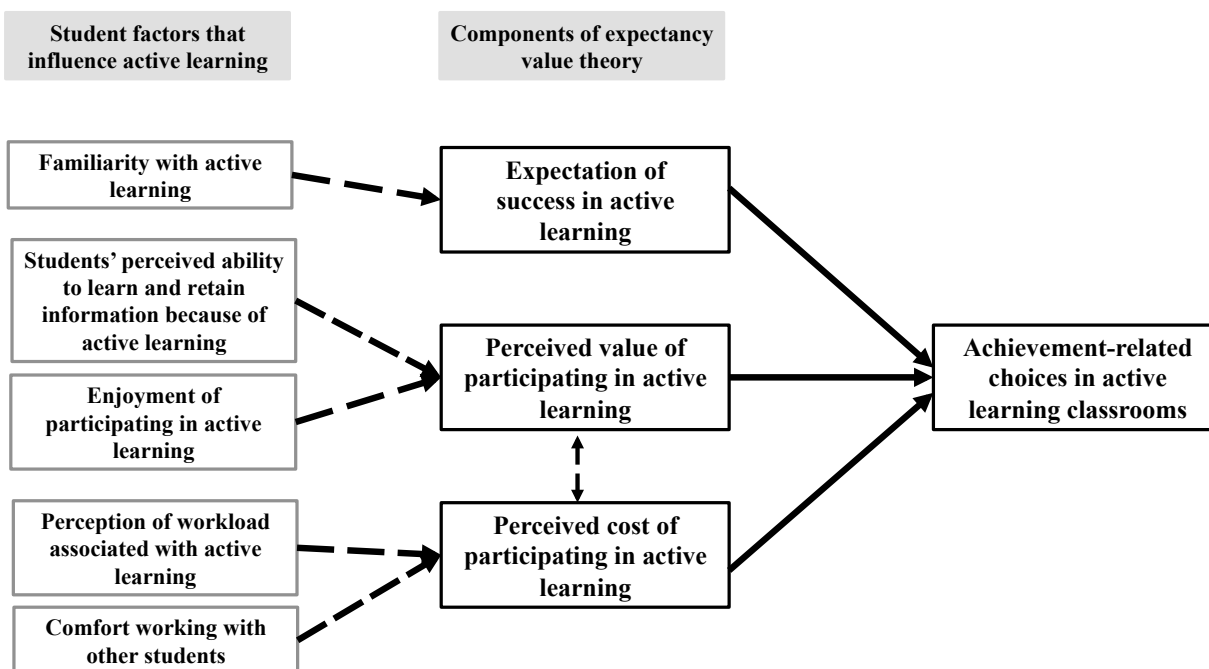

FIGURE 2. Expanded model of expectancy value theory applied to student achievement-related choices in active learning classrooms. Interviews with students identified novel student factors that contribute to the value, self-efficacy, and cost associated with active learning, which subsequently influence students' achievement-related choices in active learning classrooms.

greater value and less cost, while simultaneously increasing their self-efficacy in active learning. Many of the students cited that they saw themselves learning more when they did active learning, so perhaps that individual self-reflection or metacognition about active learning is important for a student to ascribe value to active learning (18–21).

CONCLUSION

This exploratory study suggests that expectancy value theory could be a way to examine student resistance to active learning. After participating in a summer program that was taught in an active learning way, students reported an increased perceived value of active learning, increased self-efficacy in active learning, and decreased cost to participating in active learning, ultimately leading to less student resistance to active learning and greater participation in active learning. We hope that this theoretical framework of expectancy value theory applied to active learning can be useful to instructors who are struggling with student resistance to active learning.

ACKNOWLEDGMENTS

REFERENCES

1. Freeman S, Eddy SL, McDonough M, Smith MK, Okoroafor N, Jordt H, Wenderoth MP. 2014. Active learning increases student performance in science, engineering, and mathematics. PNAS 111:8410–8415.
2. Brownell SE, Eddy SL, Thummaphan P, Lan M, Wenderoth MP. 2015. Caution, student experience may vary: social identities impact a student's experience in peer discussions. CBE Life Sci Educ 14:ar45.
3. Seidel SB, Tanner KD. 2013. "What if students revolt?"—Considering student resistance: origins, options, and opportunities for investigation. CBE Life Sci Educ 12:586–595.
4. Eccles JS, Wigfield A. 2002. Motivational beliefs, values, and goals. Annu Rev Psychol 53:109–132.
5. Wigfield A, Eccles JS. 2000. Expectancy value theory of achievement motivation. Contemp Educ Psychol 25:68–81.
6. Armbruster P, Patel M, Johnson E, Weiss M. 2009. Active learning and student-centered pedagogy improve student attitudes and performance in introductory biology. CBE Life Sci Educ 8:203–213.
7. Eddy SL, Brownell SE, Wenderoth MP. 2014. Gender gaps in achievement and participation in multiple introductory biology classrooms. CBE Life Sci Educ 13:478–492.
8. Freeman S, O'Connor E, Parks JW, Cunningham M, Hurley D, Haak D, Dirks C, Wenderoth MP. 2007. Prescribed active learning increases performance in introductory biology. CBE Life Sci Educ 6:132–139.
9. Linton DL, Farmer JK, Peterson E. 2014. Is peer interaction necessary for optimal active learning? CBE Life Sci Educ 13:243–252.
10. Linton DL, Pangle WM, Wyatt KH, Powell KN, Sherwood RE. 2014. Identifying key features of effective active learning: the effects of writing and peer discussion. CBE Life Sci Educ 13:469–477.
11. Machemer PL, Crawford P. 2007. Student perceptions of active learning in a large cross-disciplinary classroom. Act Learn High Educ 8:9–30.
12. Schoor C, Bannert M. 2011. Motivation in a computer-supported collaborative learning scenario and its impact on learning activities and knowledge acquisition. Learn Instr 21:560–573.
13. Cooper KM, Ashley M, Brownell SE. 2017. A bridge to active learning: a summer bridge program helps students to maximize their active learning experiences and the active learning experiences of others. CBE Life Sci Educ, in press.
14. Glaser BG, Strauss AL, Strutzel E. 1968. The discovery of grounded theory; strategies for qualitative research. Nurs Res 17:364.
15. Stemler SE. 2004. A comparison of consensus, consistency, and measurement approaches to estimating interrater reliability. Pract Assess Res Eval 9:1–19.
16. Mitchell S, Woloshyn V, Elliott A. 2003. Promoting cooperative learning in the classroom: comparing explicit and implicit training techniques. Brock Educ J 12(2):23–39.
17. Tanner KD. 2013. Structure matters: twenty-one teaching strategies to promote student engagement and cultivate classroom equity. CBE Life Sci Educ 12:322–331.
18. National Research Council. 2000. How people learn: brain, mind, experience, and school: expanded edition. The National Academies Press, Washington, DC.
19. D'Avanzo C. 2003. Application of research on learning to college teaching: ecological examples. BioScience 53:1121–1128.
20. Crowe A, Dirks C, Wenderoth MP. 2008. Biology in bloom: implementing Bloom's taxonomy to enhance student learning in biology. CBE Life Sci Educ 7:368–381.
21. Tanner KD. 2012. Promoting student metacognition. CBE Life Sci Educ 11:113–120.