Understanding and Mitigating STEM Student Resistance to Active Learning

GS 902 Research Project

Christopher Lang

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Department of Pure Mathematics
University of Waterloo

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Introduction

There has been a great deal of evidence demonstrating the effectiveness of active learning in STEM (science, technology, engineering, and mathematics) classrooms (Freeman et al., 2014; Prince, 2004). Despite this evidence, the adoption of active learning by STEM professors has been slow (Jamieson & Lohmann, 2012).

In addition to concerns about the effectiveness of active learning, surveys have identified many other potential barriers to professors adopting active learning in their classrooms: the preparation time, the need to reduce the scope of the syllabus due to the class time taken to implement active learning exercises, and student resistance. The literature addresses these concerns in detail (Felder, 1992, 1994; Felder & Brent, 2009). Only recently has the literature closely examined the latter barrier, which is the focus of this research project. While the literature seems to indicate that most students respond positively to active learning, resistance is still present (Brent & Felder, 2009; Carlson & Winquist, 2011; Yadav, Subedi, Lundeberg, & Bunting, 2011). Fortunately, there are many strategies that can dramatically reduce student resistance (Finelli et al., 2018).

Defining Student Resistance to Active Learning

Active learning is commonly defined as instruction that meaningfully engages students in learning through participation in activities in the classroom during a class session (Shekhar, Prince, Finelli, DeMonbrun, & Waters, 2019). Student resistance to active learning is described as negative reactions towards participation in active learning exercises (Shekhar et al., 2019). This resistance can manifest is many different ways; Weimer (2013) classified student resistance into three types: passive non-verbal, where students pretend to comply or do not participate; partial

compliance, where students put in minimal effort; and open resistance, where students openly object to the activities.

Objectives of this Research Project

The main goal of this research project is to help STEM instructors overcome the barrier of student resistance and implement active learning in their classrooms. To that end, there were originally two main objectives: understand why students resist active learning and identify strategies that instructors can use to mitigate this resistance. Consequently, I have conducted a literature review of these topics and summarized the results. The latter objective is important for instructors as it gives them a list of useful strategies to implement in their own classrooms and the former provides instructors with an understanding of what causes student resistance.

During the course of researching for this project, I identified a third objective: relate the two previous objectives to identify why the strategies work — what exactly each strategy does to address the causes of student resistance. I believe that the benefits of this additional objective are twofold. Firstly, I hope that this explanation for the effectiveness of the given strategies may help persuade instructors to use them, as data alone is not always enough to persuade people — see the slow adoption of active learning, for example. Secondly, I hope that this analysis may also inspire instructors to tweak these strategies to fit their teaching style or develop their own strategies.

Understanding Student Resistance

This section looks at the literature devoted to understanding student resistance. Specifically, this section is focused on identifying the causes of student resistance and understanding why these cause students to resist.

Causes of Resistance

Seidel and Tanner (2013) identify one cause of student resistance: teacher misbehaviours. These include things like teachers being apathetic, inaccessible outside of class, tardy, unresponsive to questions, unorganized, and unfair with grading. More extremely, these include verbal abuse, sarcasm, and put-downs. This serves as a good reminder that an unwelcoming and unsafe classroom is not conducive to learning.

Shekhar et al. (2019) also noted that resistance can be activity dependent. For instance, some people may not participate in group activities, but may participate individually, which may be due to social anxiety or previous experience working in groups. Additionally, students may resist more complex active learning exercises despite the use of milder exercises (Mohamed, 2008). Seidel and Tanner (2013) also note that introverted students may participate more during clicker questions, whereas extroverted students may participate more during pair discussions. Moreover, Ellis (2015) found that student concerns change over the course of a term. These studies demonstrate that instructors must not be complacent when it comes to student resistance, as it may occur regardless of the previous uses of active learning and the resistance may not always come from the same students. In fact, resistance is bound to change over time. With that in mind, we focus now on literature that examines resistance to active learning in general, not just specific exercises.

Ellis (2015) surveyed 172 students, of varying years of study and fields, asking what discourages them from participating in innovative teaching activities. Ellis identified eight main causes of student resistance: experience with methods, incoming instructional conceptions, risk tolerance, environmental constraints, influence of others, perceived risks, perceived workload, and

context-specific motivation. While this case study did not focus solely on STEM students, the themes identified were shared by a variety of university students and appear in other studies featuring only STEM students, like Owens, Sadler, Barlow, & Smith-Walters (2020) and Shekhar et al. (2020). Table 1 in Appendix A lists the various themes identified by Ellis and other papers in the STEM education literature that feature similar findings.

Shekhar et al. (2020) conducted a literature review of 57 STEM teaching articles, looking to identify causes of resistance to active learning. They identified seven causes for student resistance, overlapping with many of the themes identified by Ellis (2015). The causes they identified are perception of limited value, lack of time, difficulty and increased workload, lack of guidance, logistical difficulties, unfamiliarity with active learning, and lack of student preparation and confidence. A description of these causes and their relationship to Ellis' causes are outlined in Table 2 in Appendix A.

Understanding Why Students Resist

While it is useful to know the causes of student resistance, Shekhar et al. (2020) argue that using theory to explain these causes is even more important, as it both helps instructors understand the reasons behind the causes of resistance and provides inspiration for creating strategies that reduce resistance. To this end, Shekhar et al. (2020) use three main theoretical frameworks to explain the causes of student resistance: Expectancy Value Theory, Expectancy Violation Theory, and Zone of Proximal Development.

Expectancy Value Theory explains that student participation is motivated by value and competence beliefs: the belief of students that the activities have a benefit and the belief that they can complete the activity, respectively (Wigfield & Eccles, 2000). Value beliefs can be separated

into utility value — the usefulness of the activity — and cost value — the loss of time and effort required by the activity. Expectancy Violation Theory posits that students may resist active learning as they expect to be passive learners (Gaffney, Gaffney, & Beichner, 2010). Finally, in this context, Zone of Proximal Development implies that students resist active learning, which asks students to take a more prominent role in their own learning, when instructors do not appropriately design and scaffold activities to guide students (Vygotsky, 1987). The links between these theories and causes are quite straightforward and are listed in Table 3 in Appendix B. Following the work by Shekhar et al., we also relate the theories and the causes identified by Ellis (2015) in Table 3. These links are straightforward and therefore only appear in Table 3. This suggests that instructors can reduce student resistance by helping students identify the value of active learning, convincing students of their ability to complete the activities, setting students' expectations early, and scaffolding active learning exercises.

Many other authors explained student resistance using Expectancy Value Theory. For instance, Owens et al. (2020) found that students did not participate because they did not value the goal of the exercise. Mohamed (2008) found that students participated because they perceive that the new paradigm helped them learn in different ways. Seidel and Tanner (2013) suggest that students may resist active learning as they do not perceive the benefits of it. Furthermore, they argue that some students want to maximize grades while minimizing effort, so participation goes against this desire. Finelli et al. (2018) demonstrated that value is a positive predictor of participation, lack of distraction, and course evaluations. These all show that if instructors can justify the value of active learning and help reduce the perceived cost to students, then student resistance should decrease.

Ellis (2015) groups their eight themes into three archetypes: risk of negative consequences, contravention of perceived norms, and perceived lack of control. These archetypes are similar to the three beliefs that inform action: behavioural, normative, and control, respectively (Fishbein & Ajzen, 2011). These archetypes all involve risks taken on by students. Ellis then suggests that resistance can be mitigated by reducing the risks that students take.

White et al. (2010) offer another explanation for student resistance, which can be applied to the Experience with Methods and Risk Tolerance causes given by Ellis: Fixed vs. Growth Mindsets. Students with a fixed mindset believe that people are born with immutable characteristics, like intelligence; whereas students with growth mindsets believe that these characteristics can change over time. White et al. argue that fixed mindset students may resist active learning as it is a new learning paradigm for them where they may fail. These students would have a preference for traditional lectures as they know that they can succeed to some degree with this paradigm. Conversely, growth mindset students see this new paradigm as an opportunity for growth. Thus, helping students gain a growth mindset should help to reduce student resistance. This theory also appears in Table 3 in Appendix B.

Strategies to Mitigate Resistance

This section looks at the literature devoted to identifying and classifying strategies that instructors can use to reduce student resistance. That is, these are strategies that can be used in conjunction with any active learning exercise, rather than specific exercises that garner less resistance. As mentioned previously, student resistance is activity dependent, so strategies that can

be applied to many activities are more useful. Specifically, this section discusses the main archetypes of strategies found in the literature and then lists the strategies for each archetype.

Tharayil et al. (2018) interview 17 engineering professors about strategies to reduce student resistance and identified two categories: explanation strategies and facilitation strategies. Explanation strategies tell students how to complete the activity, how the activities are related to their learning, and the structure of the course. Facilitation strategies involve working directly with students and helping the activity run smoothly. Finelli et al. (2018) demonstrated that students' perceptions of facilitation strategies have a stronger relationship with reducing distraction, improving participation and course evaluations than explanation strategies. Shekhar et al. (2019) also noted that facilitation strategies had a tremendous impact on engagement. A third category was identified during a literature review by Nguyen et al. (2021): planning strategies, those strategies that occur outside of the classroom. Table 4 in Appendix C lists several strategies, including those identified by Tharayil et al., grouped by archetype.

Tharayil et al. (2018) noted that these strategies are often interconnected, for instance, walking around the room helped facilitate other strategies like inviting questions. Furthermore, a single action can make use of multiple strategies. For example, using student feedback can also help to encourage students, by showing that you value their suggestions (Nguyen et al., 2021). Tharayil et al. also noted that there are many possible ways for instructors to reduce student resistance while being consistent with their beliefs. For instance, some instructors may confront students who are not participating, whereas there are many other strategies available for instructors that prefer not to do this, like approaching these students during the activity and asking questions about it. In fact, wandering around and talking to disengaged students is often enough to

improve engagement (Shekhar & Borrego, 2018). Furthermore, Tharayil et al. mention that some students will not participate, despite repeated attempts to encourage them. In these situations, it is better to let a student not participate and use that time to assist other students. Tharayil et al. also note that enthusiastic student participation takes time to build, as students have to adjust to how they should behave in the new paradigm. Therefore, instructors should not expect their strategies to have a dramatic effect immediately.

Understanding Why These Strategies Work

In addition to using theories to explain the causes of student resistance, Shekhar et al. (2020) use these theories to explain the success of the strategies found by Finelli et al. (2018) and Tharayil et al. (2018). Using theory to explain the success of these strategies informs instructors about what makes these strategies work, allowing them to tweak these strategies or develop new ones to fit their teaching style and needs. We extend the work by Shekhar et al. (2020) by including the theory of Fixed vs. Growth Mindset in addition to those used by Shekhar et al. to explain the success of the strategies listed above, which expand on those found by Finelli et al. (2018) and Tharayil et al. (2018). These relationships are summarized in Table 5 in Appendix D, though we discuss them below.

Shekhar et al. (2020) note that the Explanation archetype is closely related to Expectancy Value Theory and Expectancy Violation Theory. Firstly, Expectancy Violation Theory explains the success of establishing expectations for your students, as these strategies want to set expectations early so as to minimize the violation of student expectations during activities. Secondly, Expectancy Value Theory illuminates why explaining the purpose of active learning works to

mitigate student resistance, specifically the utility value aspect of the theory. This is because these strategies explain the benefits of active learning to student learning.

Shekhar et al. (2020) explained that Facilitation strategies are closely related to the theories of Expectancy Value Theory and Zone of Proximal Development. We believe that Fixed vs. Growth Mindsets help explain the success of these strategies as well. Approaching students succeeds based on the theory of Zone of Proximal Development, as these strategies allow instructors to guide students. Strategies that involve encouraging students reduce resistance because of the theory of Fixed vs. Growth Mindsets and the competency beliefs of Expectancy Value Theory. Indeed, these strategies help create a classroom climate where failure is not punished, but an opportunity for growth, helping transform students into having growth mindsets. Furthermore, this encouragement helps students believe in their ability to complete the task.

The Planning archetype consists of a more diverse set of strategies. Note that Shekhar et al. (2020) were unable to address this archetype, as it had yet to be identified by Nguyen et al. (2021). The theories used here cannot explain the success of two strategies from this archetype: creating group policies and logistical factors. Designing appropriate assessments succeeds because of the Zone of Proximal Development and the cost value of Expectancy Value Theory. This is because appropriate activities should be scaffolded, to help students complete them. Furthermore, appropriately designed activities do not take too long and are appropriately difficult for students to complete, reducing the perceived cost to students. Aligning the course mitigates student resistance because of the Zone of Proximal Development and the utility value of the Expectancy Value Theory. Two examples of this strategy are the instructor planning activities around learning and awarding marks for participation. The former's success can be explained with the Zone of

Proximal Development, whereas the latter increases the value for students to participate, increasing the utility value. Finally, reviewing student feedback succeeds because of Fixed vs. Growth Mindsets. This is because this allows the instructor to model how they deal with failure and make students feel like collaborators, guiding them towards having a growth mindset.

Conclusion

Student resistance is not nearly as pervasive as many instructors believe; however, it does exist. There are many causes of this resistance and the resistance may differ from one activity to another. These causes can be explained with the theories of Expectancy Value Theory, Expectancy Violation Theory, Zone of Proximal Development, and Fixed vs. Growth Mindsets. That is, student resistance may be due to students not believing in the benefits of active learning, students not believing in their own competence, active learning violating student expectations of learning, a lack of scaffolding, and students having a fixed mindset. Luckily, there are many strategies that can significantly reduce student resistance, which fall under three main archetypes: Explanation, Facilitation, and Planning. The aforementioned theories can help to explain the success of these strategies and motivate the creation of more.

The previously discussed strategies are vague and general. This allows them to be applied to almost any course or active learning exercise. While instructors concerned about the presence of student resistance may never completely get rid of it, they do not have to be worried, as they have an arsenal of tools and understanding at their disposal that they can use to mitigate it. Hopefully, armed with this information, instructors can overcome the barrier of student resistance and begin to use active learning in their classrooms.

References

Brent, R., & Felder, R. M. (2009). Analysis of fifteen years of the National Effective Teaching Institute. Paper presented at the 2009 ASEE Annual Conference, Austin, TX.

Carlson, K. A., & Winquist, J. R. (2011). Evaluating an active learning approach to teaching introductory statistics: A classroom workbook approach. *Journal of Statistics Education*, *19*(1).

Ellis, D. E. (2015). What discourages students from engaging with innovative instructional methods: Creating a barrier framework. *Innovative Higher Education*, *40*(2), 111-125.

Felder, R. M. (1992). Random Thoughts: How About a Quick One?. *Chemical Engineering Education*, *26*(1), 18-19.

Felder, R. M. (1994). Random Thoughts: Any Questions?. *Chemical Engineering Education*, *28*(3), 174-175.

Felder, R. M., & Brent, R. (2009). Active learning: An introduction. *ASQ higher education brief*, *2*(4), 1-5.

Finelli, C. J., Nguyen, K., DeMonbrun, M., Borrego, M., Prince, M., Husman, J., Henderson, C., Shekhar, P., & Waters, C. K. (2018). Reducing student resistance to active learning: Strategies for instructors. *Journal of College Science Teaching*, *47*(5).

Fishbein, M., & Ajzen, I. (2011). Predicting and changing behavior: The reasoned action approach. Psychology press.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the national academy of sciences*, *111*(23), 8410-8415.

Gaffney, J. D., Gaffney, A. L. H., & Beichner, R. J. (2010). Do they see it coming? Using expectancy violation to gauge the success of pedagogical reforms. *Physical Review Special Topics-Physics Education Research*, *6*(1), 010102.

Jamieson, L. H., & Lohmann, J. R. (2012). Innovation with impact: Creating a culture for scholarly and systematic innovation in engineering education. *American Society for Engineering Education, Washington*, *77*.

McMillan, C., Loads, D., & McQueen, H. A. (2018). From Students to Scientists: The Impact of Interactive Engagement in Lectures. *New Directions in the Teaching of Physical Sciences*, *13*(1), n1.

Mohamed, A. R. (2008). Effects of Active Learning Variants on Student Performance and Learning Perceptions. *International Journal for the Scholarship of Teaching and Learning*, *2*(2), n2.

Nguyen, K. A., Borrego, M., Finelli, C. J., DeMonbrun, M., Crockett, C., Tharayil, S., Shekhar, P., Waters, C., & Rosenberg, R. (2021). Instructor strategies to aid implementation of active learning: a systematic literature review. *International Journal of STEM Education*, *8*(1), 1-18.

Owens, D. C., Sadler, T. D., Barlow, A. T., & Smith-Walters, C. (2020). Student motivation from and resistance to active learning rooted in essential science practices. *Research in Science Education*, *50*(1), 253-277.

Prince, M. (2004). Does active learning work? A review of the research. *Journal of engineering education*, *93*(3), 223-231.

Seidel, S. B., & Tanner, K. D. (2013). "What if students revolt?"—considering student resistance: origins, options, and opportunities for investigation. *CBE—Life Sciences Education*, *12*(4), 586-595.

Shekhar, P., & Borrego, M. (2018). 'Not hard to sway': a case study of student engagement in two large engineering classes. *European Journal of Engineering Education*, *43*(4), 585-596.

Shekhar, P., Borrego, M., DeMonbrun, M., Finelli, C., Crockett, C., & Nguyen, K. (2020). Negative student response to active learning in STEM classrooms: A systematic review of underlying reasons. *Journal of College Science Teaching*, *49*(6), 45-54.

Shekhar, P., Prince, M., Finelli, C., DeMonbrun, M., & Waters, C. (2019). Integrating quantitative and qualitative research methods to examine student resistance to active learning. *European Journal of Engineering Education*, *44*(1-2), 6-18.

Tharayil, S., Borrego, M., Prince, M., Nguyen, K. A., Shekhar, P., Finelli, C. J., & Waters, C. (2018). Strategies to mitigate student resistance to active learning. *International Journal of STEM Education*, *5*(1), 1-16.

Vygotsky, L. (1987). Zone of proximal development. Mind in society: The development of higher psychological processes, 5291, 157.

Weimer, M. (2013). Learner-Centered Teaching: Five Key Changes to Practice. San Francisco: Jossey-Bass.

White, J., Pinnegar, S., & Esplin, P. (2010). When learning and change collide: Examining student claims to have "learned nothing". *jge: the journal of general education*, *59*(2), 124-140.

Wigfield, A., & Eccles, J. S. (2000). Expectancy–value theory of achievement motivation. *Contemporary educational psychology*, *25*(1), 68-81.

Yadav, A., Subedi, D., Lundeberg, M. A., & Bunting, C. F. (2011). Problem‐based learning: Influence on students' learning in an electrical engineering course. *Journal of Engineering Education*, *100*(2), 253-280.

Table 1: Causes of Resistance, Ellis (2015)

Name of Cause	Description of the Cause	Papers that List this Cause
Experience with Methods (EM)	Preference for conventional methods, dislike of specific methods, past dissatisfaction when introduced to new methods, or no experience with the method.	Owens et al. (2020) and Seidel and Tanner (2013).
Incoming Instructional Conceptions (IC)	Preconceived notions of the role of a student or teacher or the appropriateness of the method in a post-secondary course.	Seidel and Tanner (2013) and McMillan et al. (2018).
Risk Tolerance (RT)	Openness to change, the lack of certainty about new method, or the presence of uncertainty.	-
Environmental Constraints (EC)	Class size and class time.	-
Perceived Risks (PR)	The effect on grades, lack of incentives, lack of perceived fairness in grades, effect on learning, lack of relevance to course goals, emotional risk.	Owens et al. (2020).
Perceived Workload (PW)	Difficult method, unclear methods, lack of support to use method, too much time to use or learn method, waste of time, lack of convenience.	Owens et al. (2020) and Seidel and Tanner (2013).
Influence of Others (IO)	Influence of instructor (immediacy), influence of peers (negative response and dysfunctional performance).	Shekhar et al. (2019) and Seidel and Tanner (2013).
Context-Specific Motivation (CM)	Lack of interest in method or subject matter, lack of control over learning environment, lack of confidence connected to a skill.	-

Table 2: Causes of Resistance, Shekhar et al. (2020)

Name of Cause	Description of the Cause	Related Cause(s) in Ellis (2015)
Perception of Limited Value	Did not appreciate the value of active learning in helping them learn, achieve learning outcomes, achieve a good grade, or enhance interest in the topic.	PR
Lack of Time	Active learning exercises were time-consuming.	CM
Difficulty and Increased Workload	Active learning exercises were difficult to complete and increased their workload.	PW
Lack of Guidance	Concerned about limited guidance, lack of scaffolding, low degree of instructor involvement, self-directed learning.	PW, IO
Logistical Difficulties	Concerned about the technology, instruments, and tools used in active learning exercises, classroom features, group work, and quality of videos used in flipped classroom setting.	CM, IO, EC
Unfamiliarity with Active Learning	Not used to actively participating, expected to passively watch lecture.	EM, IC
Lack of Preparation and Confidence	Unprepared to do the activities due to unsatisfactory background knowledge or review material.	EM, CM

Table 3: Relationship Between Theories and Causes

Paper	Cause	Related Theories
Shekhar et al. (2020)	**Perception of Limited Value**	Expectancy Value Theory (utility value)
	Lack of Time	Expectancy Value Theory (cost value)
	Difficulty and Increased Workload	Expectancy Value Theory (cost value)
	Lack of Guidance	Expectancy Value Theory (competence beliefs) and Zone of Proximal Development
	Logistical Difficulties	-
	Unfamiliarity with Active Learning	Zone of Proximal Development and Expectancy Violation Theory
	Lack of Preparation and Confidence	Expectancy Value Theory (competence beliefs)
Ellis (2015)	**Experience with Methods**	Fixed vs. Growth Mindsets
	Incoming Instructional Conceptions	Expectancy Violation Theory
	Risk Tolerance	Zone of Proximal Development and Fixed vs. Growth Mindsets
	Environmental Constraints	-
	Perceived Risks	Expectancy Value Theory (utility value)
	Perceived Workload	Expectancy Value Theory (cost value) and Zone of Proximal Development
	Influence of Others	Zone of Proximal Development
	Context-Specific Motivation	Expectancy Value Theory (competence beliefs)

Table 4: Strategies for Reducing Resistance

Archetype	Strategy	Description	Examples
Explanation	**Establish expectations**	Explaining the routine for the course and activities.	Tell students at the beginning of the term that the course will use active learning. Explain how to complete activities.
	Explain the purpose	Describe why certain activities are used.	Address student concerns about active learning (Owens et al., 2020). Explain pedagogical choices (Seidel and Tanner, 2013).
Facilitation	**Approach students**	Engage with students.	Physical proximity, walking around the classroom, asking about their progress.
	Encourage students	Creating a positive classroom climate.	Learn students names, seem approachable, motivate students.
Planning	**Design appropriate activities**	Ensure that activities are appropriate for the students and course.	Choose activities that are achievable, but challenging. Ensure activities do not take too long to complete. Scaffold activities.
	Create group policies	Discuss rules for group activities.	Frequently change and randomize groups, designate group roles. Facilitate peer evaluations (Seidel and Tanner, 2013).
	Align the course	Connect the activities with grades and other parts of the course.	Award marks for participation, connect assessments with learning outcomes (for instance, use projects). Connect activities with recent course concepts.
	Review student feedback	Use feedback to improve the course and activities.	Tweak activities based on student feedback. Allow students to express what is not working (Seidel and Tanner, 2013).
	Logistical Factors	Modify the features of the class.	Use cluster-style seating (Shekhar and Boerrego, 2018), do not schedule class for the morning (Ellis, 2015).

Table 5: Relationship Between Theories and Strategies

Archetype	Strategy	Related Theoreies
Explanation	**Establish expectations**	Expectancy Violation Theory
	Explain the purpose	Expectancy Value Theory (utility value)
Facilitation	**Approach students**	Zone of Proximal Development
	Encourage students	Fixed vs. Growth Mindsets and Expectancy Value Theory (competence beliefs)
Planning	**Design appropriate activities**	Zone of Proximal Development and Expectancy Value Theory (cost beliefs)
	Create group policies	-
	Align the course	Zone of Proximal Development and Expectancy Value Theory (utility value)
	Review student feedback	Fixed vs. Growth Mindsets
	Logistical Factors	-