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An Analysis of an Instructional Development Workshop to Promote the Adoption of Active Learning in STEM: Potential Implications for Faculty Developers*

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We developed an instructional development workshop for science, technology, engineering, and math (STEM) instructors in higher education to promote their adoption of active learning. Our workshop design was based on a proposed framework for motivating adult learners consisting of five elements: (1) expertise of presenters, (2) relevance of content, (3) choice in application, (4) praxis, and (5) group work. We assessed the participating instructors' attitudes (i.e., motivation to use active learning and intentions and motivation to use strategies to reduce student resistance to active learning) immediately before and after the workshop and again five to six months later. We also assessed participants' satisfaction with the workshop. Analyses of our data provided evidence of a change in participants' motivation to use active learning and both their intentions and motivation to use strategies to reduce student resistance to active learning following the workshop. Our quantitative findings and thematic analysis of survey results support the use of the proposed framework for designing instructional development workshops for STEM faculty. The results also show short-term instructional development workshops can be effective and suggest caution in extrapolating immediate post-workshop assessment to the longer-term.

Keywords: professional development; instructional development; instructional change; active learning; student resistance

1. Introduction

Instructional development programs (IDPs) seek to support instructors in enhancing their teaching to improve student learning [1]. In science and engineering, higher education instructional development is often delivered in a workshop format [2–4], which have been found to range in effectiveness.

Qualitative [1, 3–6] and quantitative [7] literature reviews identify themes, such as program duration, that emerge in studying the impact or effectiveness of IDPs, including workshops, in higher education. Even with these thorough systematic reviews, we still lack a complete understanding of what makes IDPs effective [1, 2, 5, 6]. In large part, this knowledge gap stems from a need for both quantitative and qualitative research evidence demonstrating the impact of these programs, particularly within science, technology, engineering and mathematics (STEM) [1, 2, 4, 6–8].

In this exploratory study, we describe in-depth the development of an instructional development workshop designed to change instructors' attitudes about active learning. We present our observations of instructors' attitudinal changes (i.e., intentions and motivation) after attending the workshop because changes in instructors' attitudes are theoretically linked to changes in their behavior [9]. Our thorough literature review of STEM instructional development workshops, integrated with descriptions of our workshop design, development, and the associated findings, provide insights for future instructional development workshops and research studies.

2. Research Aims

This research study contributes to the STEM higher education field by examining STEM instructors' change in attitudes, i.e., intentions and motivation to adopt active learning and strategies to reduce student resistance to active learning, after attending a short-duration instructional development workshop. Using a multi-methods approach, we investi-

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gate the effectiveness of a workshop designed to promote STEM instructors' use of active learning and identify the workshop elements that contribute to its effectiveness. In our analysis, we define an *effective* workshop as one in which participants' attitudes are different (in a positive way) after attending the workshop compared to their attitudes prior to attending.

In this paper, we summarize the literature on IDPs, focusing on short-duration workshops, and consider it in relation to our findings. Next, we describe our active learning workshop's design and our evaluation of three workshop offerings. We backdrop the workshop elements identified as valuable by participants with Wlodkowski's [10] adult learning theory, which has been hypothesized by Felder and coauthors [3] as a framework for effective IDPs in STEM. We refer to this framework throughout the paper as the *IDP Design Framework*.

3. Literature Review

Our literature review synthesizes aspects related to instructional development workshop effectiveness (i.e., impact, duration, and evaluation) and workshop elements (e.g., clear learning objectives) that contribute to instructional development workshop effectiveness. The latter is necessary to contextualize our research questions. Then, we provide background on instructional change and active learning in STEM because this pedagogy is our workshops' focus.

3.1 Instructional Development Workshops

Typically, IDPs are evaluated by three assessment levels [3]. Based on the work of Van Note Chism and Szabó [11], Felder and colleagues [3] define Level 1 as an assessment of participants' satisfaction with the IDP. Level 2 is an assessment of "the impact on participants' teaching knowledge, skills, attitudes, and practices through self-reports" or third-party observations and Level 3 is an evaluation of "the impact of the program on the participants' students' learning" [3 , p. 105].

Evaluating a workshop's impact is challenging [3, 12, 13]. Workshops are typically evaluated by measuring participants' satisfaction (Level 1) or self-reports of learning or instructional change (Level 2), rather than through independent assessments of pre- and post- measures of participants' learning or instructional change (Level 2) or student learning (Level 3) [3, 6, 12–14]. Although participants' self-reports of instructional methods can differ from independent assessments [14], aggregated measures of self-reported change are generally representative of independent assessments [12]. Further adding to the challenge of workshop evaluation is that instructors must not only learn new knowledge/skills, but also successfully integrate them into their classroom [4, 5, 15]. For example, two years after the program, instructors of a week-long biology summer institute reported they were continuing their efforts to improve their instructional practices, indicating time and effort are involved in implementation [16].

3.1.1 Effectiveness

Despite the difficulty in evaluating workshops, IDPs can be effective and have a sustained impact on instructors' teaching [6, 7, 13]. For workshops with a STEM-discipline focus, participants often report being satisfied with the workshop [17–19], meeting workshop learning objectives [15, 16, 19], and implementing workshop knowledge/skills in their classrooms [15–17, 19]. For example, instructors participating in a four-day physics and astronomy education instructional development workshop later reported increased knowledge and classroom adoption of the instructional techniques [15]. In another study, Felder and Brent [19] assessed a multi-day workshop for engineering and engineering technology instructors aimed to improve participants' teaching practices; several years after the workshop, participants reported using more evidence-based instructional practices and receiving higher student ratings.

It has been hypothesized that short-term instructional development workshops are less effective than longer-duration programs [3, 4, 6, 7, 20]. Specific to STEM IDPs, Henderson and coauthors [4] reported that programs lasting four weeks or more were generally more effective than shorter-term workshops. However, a recent meta-analysis of the impact of IDPs from a broad range of disciplines is seemingly in conflict with Henderson et al.'s conclusion [7]. Based on ten studies, Ilie and colleagues [7] found that shorter-term, i.e., 15 hours or less, instructional development programs had a larger effect size than longer programs. Ilie and colleagues [7] suggest that the larger effect size may be attributed to the focus on skills in shorter-term programs and not necessarily the shorter duration. Specific to active learning IDP workshops, Houseknecht and coauthors [8, p. 394] found a discipline-specific, three-hour active learning workshop "effectively changed participants' knowledge, beliefs, and teaching practices", although to a lesser degree than a comparison four-day workshop.

3.1.2 Elements of Effective Workshops

Researchers attribute the success of STEM discipline-specific instructional development workshops to multiple factors (e.g., motivating participants and having clear learning objectives), outlined in a compilation of published results from individual studies in Table 1 and from reviews of the literature in Table 2. Some of these factors include content relevance, praxis, groupwork [3], organizational support [15], promotion of instructors' self-efficacy [18], changed beliefs of participants [4], and content that supports the established learning objectives [2].

Motivating participants is a key aspect of effec-

Table 1. STEM Instructional Development Workshops and Keys to Effectiveness in Reverse Chronological Order

Author/s (year)	**Discipline**	**Workshop duration**	**Goal**	**Effective (sustained)**	**Workshop components**	**Keys to effectiveness (Attributed by author/s)**
Henderson [15]	physics	~ 3 days	improve teaching in physics	yes (varying)	expert presenters, groupwork, research evidence, effective strategies	single discipline, choice in application, expertise of presenters, motivation, organizational support, groupwork
Prather & Brissenden [22]	astronomy		student-centered instruction			*situated apprenticeship* (includes praxis and reflection)
Pfund et al. [16]	biology	5 days	student-centered instruction	yes (2 years)	focus on student learning, develop course materials, activities, and assessments	
Felder & Brent [19]	engineering	3 day	effective instruction, continued development	yes (>1 year)	research evidence, instructional methods, modeling and discussion of instructional methods, opportunities to practice	expertise of facilitators, relevance (discipline, classroom, and research), choice in application, praxis and reflection, groupwork
Ebert-May et al. [14] assessment of Pfund et al. [16] & Lundmark [26]	biology, science	6–12 days over 3 years, 5 days	student-centered instruction	no, independent observations	teaching instruction, opportunities to practice, create course materials, activities, and assessment	absence of praxis (attributed for lack of success)
Baker et al. [17]	chemistry	2 days	student-centered instruction	yes (1 year)	awareness, motivation, implementation support, hands-on activities, groupwork, modelling instructional methods, praxis, choice in application	choice in application, praxis, implementation support, groupwork, networking/peer interaction encouragement
Carnes et al. [18][a]	medicine, science, engineering	2.5 hours	behavioral change (gender-bias)	yes (3 months)	motivation (through awareness, research-evidence, reflection), self-efficacy development, additional resources	providing strategies/ behavior to practice
Stegall et al. [27]	chemistry	2 days	laboratory instruction	yes	hands-on activities, praxis, groupwork, feedback	modeling instruction, collaboration/networking encouragement, continued implementation support
Estes et al. [21]	civil engineering	5 days	effective instruction	yes	awareness, learning objectives, modelling instruction, praxis, groupwork, hands-on activities	praxis (practice classes)
Houseknecht et al. [8]	chemistry	(1) 4 days (2) 3 hours	active learning	yes	active learning, acknowledged barriers, motivation, best practices, praxis, subject-specific	community of practice, opportunity to experience active learning as students, active learning and chemistry expertise of facilitators, continual workshop assessment

[a] The findings of Carnes et al. [18] are from a professional development workshop promoting behavior change.

Table 2. Elements of Effective Instructional Development Identified in Literature Reviews

Author/s (year)	Discipline	Focus	Findings for effective professional development
Connolly & Millar [2]	science, technology, engineering, mathematics	instructional development	awareness, feedback, practice, groupwork, backward design, content relevance, clear and focused learning goals, program evaluation
Stes et al. [1]	higher education	instructional development	one-time programs are less effective
Henderson et al. [4]	science, technology, engineering, mathematics	instructional development	longer-term programs, change in participants' beliefs, and practice with feedback
Felder et al. [3]	engineering	instructional development	institutional support, motivation, expertise of presenters, relevance of content, choice in application, praxis, and groupwork
DeRijdt et al. [5]	higher education	staff development (transfer of learning)	motivation, practice and feedback, content relevance, active learning, longer duration, clear learning goals, modeling instruction
Steinert et al. [6]	medical education	faculty development	program design (evidence-based), relevance, praxis, encouragement of continued collaboration, institutional support
Ilie et al. [7]	higher education	instructional development	skill-focused instructional strategy/methods, shorter duration, single-occurrence

tive workshops. Motivation plays a critical role not only in adult learning [10], but also in the transfer of learning to classroom instruction [4, 5]. Thus, workshop elements that increase participants' motivation are essential to creating effective workshops [3, 6]. Further, instructional development workshops that motivate participants to improve teaching practices may serve as a "gateway" to continued instructional development [15, p. 183]. Motivation [5] and continued instructional development may sustain instructors in their efforts to implement new instructional practices in their classroom successfully [3, 6, 16]. Given the necessity of considering participant motivation in crafting effective workshops, how can we motivate instructional development workshop participants?

3.1.2.1 Instructional Development Program Design Framework

Felder and Brent [19, p. 128] and Felder and coauthors [3, p. 108] hypothesized (in what we refer to as the *IDP Design Framework*) essential aspects of effective instructional development based on Wlodkowski's [10] five criteria that motivate adult learning: (1) expertise of presenters, (2) relevance of content, (3) choice in application, (4) praxis, and (5) groupwork. As a way to satisfy the first criterion, *expertise of presenters*, workshop leaders' expertise should include disciplinary and educational content knowledge [3, 19]. These benefits derive from the facilitators' ability to demonstrate how the relevant educational theories or research apply within the participants' discipline [3, 19]. To address the second and third criteria, *relevance of content* and *choice in application*, the presented material should be relevant to the participants' teaching practices and instructors should be enabled to apply strategies or learnings they deem appropriate for their teaching, respectively [3, 19]. Attending to *praxis*, the fourth criterion, involves giving participants opportunities to practice what they are learning, consider the associated outcomes, and receive feedback [3, 19]. A workshop that addresses the fifth criterion, *groupwork*, includes opportunities to learn through group activities and exercises [3, 19].

Researchers have repeatedly recognized praxis as a critical element of successful IDPs [4, 5, 14, 17, 21, 22]. Praxis is important for the transfer of instructors' new learning to their classrooms [5, 22]; its absence has also been linked to instructors' lack of classroom implementation [14, 22]. Prather and Brissenden [22] found enhanced instructor learning with in-workshop role-playing of classroom teaching (a form of praxis), which they contend promotes instructors' adoption of instructional techniques. In their earlier workshops, they found that presenting supporting research and modeling effective teaching alone did not effectively promote instructors' in-depth learning [22].

3.2 Instructional Change

Instructional change is a complex process, and sustained changes typically require efforts (or at least attitude changes) on both the individual and organizational level [4]. While a focus on changes in instructor behaviors is important to evaluating the effectiveness of IDP interventions such as workshops, changes in instructor attitudes may actually be a better indicator of long-term sustainability of new teaching practices. Multiple change theories and prior research support this assertion. For example, diffusion of innovations theory [23] describes five stages (*knowledge*, *persuasion*, *decision*, *implementation*, and *confirmation*) through which an individual progresses in the innovation-decision process. Importantly, persuasion is a distinct step in which an individual's attitude toward the innovation (e.g., instructional change) is described as either *favorable* or *unfavorable* [p. 167] and linked to the third process stage, decision (e.g., to adopt an instructional change).

In STEM, Henderson and coauthors [24, p. 7] identified a four-stage process through which instructors progress in their adoption of evidence-based instruction: *knowledge versus no knowledge, trial versus no trial, continuation versus discontinuation, and high versus low use*. During the continuation vs. discontinuation phase, the instructor's attitudes toward the change are developed through experience, interactions with colleagues, and other interactions such as exercises conducted as part of IDP workshops. Instructor surveys based on this four-stage process indicated that the greatest loss (i.e., the main reason most instructors are not using active learning) is at the discontinuation stage, both in physics [24] and engineering [25]. Thus, two important aspects to sustained instructional change are changes to instructors' attitudes and giving instructors strategies to overcome challenges that arise in their use of active learning, both of which are addressed in the workshops described here.

3.3 Active Learning in STEM

To provide the reader with the necessary context of our workshop, we will briefly review the premise of active learning. Research in higher education has established that active learning in STEM improves a multitude of student outcomes [28–30]. Active learning, as defined here, moves beyond traditional lectures in which students listen and take notes; instead, students actively engage in learning (e.g., think-pair-share activities, in-class problem solving, and project-based learning) [28, 31]. Numerous studies show that active learning in STEM engages students [28, 32–34] and improves student learning [28–30, 32]. A meta-analysis of 225 studies [29] found increased academic performance and higher pass rates for students in active learning STEM courses than traditional lecture courses. In addition to improved student learning, a study of a large enrollment physics course that integrated active learning found increased class attendance [32]. Furthermore, students in science courses that integrated active learning exhibited enhanced conceptual understanding and problem-solving skills [20, 35–37].

Active learning also increases retention in STEM fields [29, 30, 38, 39] and improves students' attitudes toward STEM [20, 28]. Pedagogies that use active learning support a diverse group of students [38], especially students in STEM who come from low-income backgrounds or who are from traditionally underrepresented groups [30].

3.3.1 Instructors' Adoption of Active Learning in STEM

Despite the well-documented advantages of active learning [28–30], many STEM classes in higher education remain lecture-based [20, 40]. Stains and coauthors report that "Didactic practices are prevalent throughout the undergraduate STEM curriculum despite ample evidence for the limited impact of these practices" [40, p. 1469]. This limited use of active learning by STEM college instructors prevents its benefits from reaching as many students as possible [40–42].

The limited adoption of active learning in part results from instructor-perceived *barriers* [4, 43, 44], including concerns about time constraints, the efficiency and effectiveness of active learning, a lack of incentives, institutional/departmental support, and student resistance [15, 43–49]. Concerns about the efficacy of active learning and about preparation and class time have been addressed by others (e.g., [28, 29, 48, 50]) to a greater extent than the barrier of student resistance to active learning. Although researchers have identified strategies that instructors use to reduce student resistance to active learning [51–53], instructors have not widely adopted them.

3.3.2 Strategies to Reduce Student Resistance to Active Learning

Student resistance is grounded in the literature [e.g., 51–53]. In using the term "student resistance", we are simply acknowledging that students have behavioral and attitudinal responses to active learning, some positive and some negative from the standpoint of the instructor. Student resistance encompasses the negative responses or those that are likely to discourage instructors' future use of active learning strategies; however, in using this term, we do not imply a negative intent or that fault lies with the student. There is no assumption as to the cause or blame.

Strategies instructors use to reduce student resistance to active learning, also grounded in the literature and shown in Table 3, have been categorized into *planning*, *explanation*, and *facilitation* [52, 53]. Planning strategies pertain to developing, organizing, and evaluating an activity [52]. Explanation strategies focus on framing the goals and purpose of activities for students and providing clear directions [51–53]. Facilitation strategies involve promoting

Table 3. Strategies Instructors Use to Reduce Student Resistance to Active Learning

Planning (six strategies)	Explanation (four strategies)	Facilitation (five strategies)
• Plan the activity based on how well a similar activity worked in the past	• Explain what students are expected to do for the activity	• Walk around the room to assist students with the activity if needed
• Structure the activity with small steps that students can accomplish confidently	• Explain the purpose of the activity	• Encourage students to engage with the activity through demeanor, body language, or interactions with students
• Specifically design the activity to maximize student engagement	• Discuss how the activity relates to student learning	• Approach students who are not participating in the activity
• Design the activity to connect with the rest of the class period or lesson plan	• Describe how the activity relates to graded assignments	• During the activity, invite students to ask questions about it
• Use feedback from students to design the activity		• Solicit feedback from students about how the activity went
• Following the activity, think about what did and did not work		

Note. Adapted from [52, p. 946] and [53, p. 85].

and supporting students' participation in classroom activities [51–53]. The use of explanation and facilitation strategies correlates with lower student resistance, offering promise for lowering this barrier to adoption and increasing the use of active learning in STEM classrooms [53].

3.3.3 *Our Active Learning Workshop*

To support instructors' adoption of active learning in STEM college classrooms and overcome the barrier of student resistance, we created an active learning instructional development workshop. This workshop aimed to provide instructors with the foundations of active learning and to motivate them to incorporate active learning in their classrooms. Our explicit focus went beyond simply conveying information about how to do active learning, by applying instructional change stage theories to change instructors' attitudes and promote sustained adoption of active learning. Thus, the workshop advances instructors through the first three stages of the diffusion of innovations stage model (knowledge, persuasion, and decision) [23]. In accordance with the diffusion of innovations theory [23], instructors' attitudes toward (e.g., intentions and motivation) and decisions to implement active learning are important precursors to their actual implementation of active learning, and according to Henderson and coauthors' [24] four-stage model, attitudes are important factors in sustained adoption through potentially difficult trial periods. Through in-workshop praxis, we also aimed to support instructors' implementation and confirmation (stage four and five of diffusion of innovations) and trial versus no trial and continuation versus discontinuation (stage two and three of Henderson and coauthors' process [24]).

One version of the workshop, Active Learning-Only (AL-Only), addresses the foundations of active learning in a 3½-hour workshop. A second version, Active Learning-Plus (AL-Plus), includes the AL-Only module plus a two-hour segment on the planning, explanation, and facilitation strategies to reduce student resistance to active learning. Both workshop versions employ a backward design process driven by their instructional objectives [54], and both provide STEM instructor participants with guidance, practice, and feedback on each objective.

4. Research Questions

This paper focuses on the effectiveness of instructional development workshops by evaluating three offerings of AL-Only and AL-Plus workshops. We aim to address three research questions:

Research Question 1: Is there a change in participants' motivation to use active learning or their motivation and intention to use strategies to reduce student resistance to active learning after attending the AL-Only or AL-Plus workshop?

Research Question 2: Does the additional time and explicit instruction provided by the AL-Plus workshop, compared to the AL-Only workshop, relate to instructors' motivation to use active learning or their intentions and motivation to use strategies to reduce student resistance to active learning?

Research Question 3: Does incorporating the five elements of adult learning theory (*expertise of presenters, relevance of content, choice in application, praxis, and groupwork*) in workshop design contribute to workshop effectiveness?

5. Theoretical Framework

The AL-Only and AL-Plus workshops' design and development are based on Expectancy Value Theory (EVT) [9]; therefore, we will briefly review its elements. EVT posits that the motivation to engage in an activity (e.g., to use active learning or the strategies to reduce student resistance to active learning) depends on an interaction between the *value* associated with the activity and one's *expectancy* of success (the degree to which an individual expects to succeed). Both value and expectancy are comprised of sub-factors including *intrinsic value* and *self-efficacy* [9]. The combination of value and expectancy is a determinant for *motivation*, which influences behavior [9]. Using EVT as a lens, we examine workshop participants' (STEM instructors) motivation to use active learning and strategies to reduce student resistance to active learning. We anticipate that increases in motivation will lead to increases in *intentions to use* active learning and strategies to reduce student resistance to active learning. Thus, our active learning workshop's primary goal is to increase participants' motivation (i.e., intrinsic value and self-efficacy) for using active learning and the strategies to reduce student resistance, thereby increasing the use of both.

6. Methods

6.1 Workshop Descriptions

Our active learning workshop design drew primarily from our team's extensive professional development experience within STEM and from the critical elements hypothesized for effective instructional development (IDP Design Framework) [3]. To address the *expertise of presenters* criterion, the two workshop facilitators were engineering instructors, each with more than 20 years of experience teaching undergraduate engineering courses and conducting professional development programs. For *relevance of content*, the facilitators provided discipline-specific examples of active learning and strategies to reduce student resistance to active learning in STEM courses. The workshop design also addressed the *choice in application* criterion by presenting options and encouraging participants to generate lesson plans that suited their personalities, comfort levels, instructional objectives, and professional environments, rather than dictating specific instructional methods. The facilitators addressed the *praxis* criterion by integrating opportunities for participants to practice creating their own course materials. Further addressing *praxis*, in the AL-Plus Workshop, participants wrote and practiced a short script based on explanation strategies and talked about implementing facilitation strategies. While some lesson plan development was done individually, several small-group activities were also incorporated into the workshop to stimulate new ideas and to provide participants with feedback on their initial plans (through *groupwork*).

6.1.1 Active Learning-Only

The AL-Only workshop version had four instructional objectives: Upon completion of the workshop, participants should be able to (1) define active learning, (2) explain its benefits for both themselves (instructors) and students, (3) list and address common concerns instructors have about using active learning, and (4) develop plans to successfully use active learning in their own courses. An overview of the workshop components and the associated IDP Design Framework elements is provided in Table 4. The following paragraphs provide additional detail.

Table 4. Workshop Components and Associated IDP Design Framework Element

Timeline of Active Learning Workshop Activities	IDP Design Framework Element
Participants brainstorm benefits of active learning	Groupwork, Relevance of content
Facilitators define active learning	
Facilitators provide active learning examples	Choice in application
Facilitators review research on active learning	Expertise of presenters
Facilitators provide additional active learning examples	Choice in application
Participants design lesson plans specific to their course/s	Praxis, Relevance of content
Participants share their lesson plans	Groupwork, Relevance of content
Facilitators discuss barriers to adopting active learning	Relevance of content
Participants brainstorm student responses to active learning[a]	Groupwork
Facilitators review research about students' responses[a]	Expertise of presenters
Participants discuss factors influencing students' responses[a]	Groupwork
Facilitators review research about strategies that reduce resistance[a]	Expertise of presenters
Participants critique videos of student responses and instructor strategies[a]	Groupwork
Participants develop plans to implement strategies[a]	Relevance of content, Praxis, Choice in application
Participants refine their lesson plans	Praxis, Groupwork
Participants identify (and implement) next steps	Relevance of content, Choice in application

[a] Only in AL-Plus Workshop.

The facilitators began the workshops by having the participants engage in active learning (i.e., reflect individually and write about workshop goals) and then asking them to work with a partner to identify some of the benefits of the technique. Early in the workshop, this activity enabled participants to see the difference in how the material is presented traditionally and via active learning. It also enabled them to generate their own list of the benefits of active learning.

The facilitators then formally defined active learning, clarified its essential components, and provided a broad spectrum of active learning approaches. Participants were encouraged to think of specific approaches (e.g., inserting clarification pauses, having students brainstorm in pairs, and using in-class problem solving) as tools and to thoughtfully adopt approaches that supported their educational objectives, rather than considering any particular technique as inherently superior to others. Next, the facilitators offered a brief review of the research on the effectiveness of active learning versus traditional lectures using a combination of lecturing and group and individual active learning exercises. After participants understood the nature of and rationale for active learning, the facilitators provided additional examples of specific active learning practices. The facilitators then encouraged participants to develop lesson plans to adopt specific active learning approaches for their own courses. Sharing these initial lesson plans with other workshop participants enabled feedback and enhancement of their initial plans.

Following this, the facilitators provided an overview of some common instructor concerns about adopting active learning, such as extra preparation time and the ability to cover the syllabus. The facilitators attempted to ensure that all participants left the workshop with specific tools or ideas to address these concerns, thus alleviating barriers to active learning adoption.

The workshop concluded with a series of integrative individual and group exercises encouraging further development of participants' initial ideas for implementing active learning in their courses. In addition, participants were asked to consider modifying their syllabi, inputting calendar reminders to use active learning, and making appointments with their institution's teaching and learning centers that would further enhance their chances of following through on their current intentions of integrating active learning into their teaching.

6.1.2 Active Learning-Plus

In addition to the AL-Only workshop's material on active learning foundations, the AL-Plus workshop featured an additional module on reducing one of the key barriers to adopting active learning: student resistance. This module included three additional learning objectives: (1) identify ways students respond to active learning, (2) articulate strategies to reduce student resistance and describe how to implement several of them, and (3) develop plans to reduce student resistance successfully. This additional module presented research on why students resist active learning and research on instructor strategies to overcome and proactively prevent that resistance. It also provided opportunities to practice some of the strategies and develop concrete plans to reduce student resistance to active learning. The following paragraphs briefly describe the strategies module's components. An overview linking them to the associated IDP Design Framework element is provided in Table 4.

To begin the two-hour segment on strategies to reduce student resistance to active learning, participants brainstormed ways students might respond to active learning. Then, the facilitators shared research about students' responses to active learning. Next, participants discussed factors that might influence students' responses to active learning. After this step, the facilitators presented research about different instructional strategies shown to reduce student resistance to active learning effectively.

The bulk of this module focused on planning, explanation, and facilitation strategies to reduce student resistance (Table 3). Participants critiqued video clips to identify common student responses to active learning and strategies the instructor used to reduce student resistance. They also completed a series of worksheet activities to explore the strategies in greater depth and to reflect on ways to implement them in their classrooms. For instance, the worksheets included activities such as, "Write a short script based on explanation strategies that you could use when introducing the activity and describing its purpose," or "From the following list of possible planning strategies, place a check mark next to the ones you can see yourself doing in your own class."

The AL-Plus workshop concluded with time for participants to generate and refine an action plan for introducing active learning and strategies to reduce student resistance in their own classrooms. This step was followed by an activity in which participants identified specific actions to increase the odds of implementing active learning and the strategies to reduce resistance (e.g., setting calendar reminders to use some of the strategies or scheduling regular coffee meetings with a colleague to discuss active learning).

6.2 *Participant Recruitment*

6.2.1 *Location 1 – AL-Plus*

During the spring of 2019, the workshop facilitators coordinated with the Center for Teaching and Learning in the engineering college at Location 1 (a public, 4-year institution in the U.S. Midwest) to offer an initial pilot of the AL-Plus workshop version. Staff from the Center emailed engineering instructors who had previously worked with the Center, advertised the workshop in the Center's electronic newsletter, and posted an advertisement in Location 1's College of Engineering's weekly communication from the Dean. Twenty-five engineering instructors from Location 1 registered to attend the AL-Plus workshop, and 21 of them attended.

6.2.2 *Location 2 – AL-Only and AL-Plus*

The AL-Plus module was refined and offered one month later, along with the AL-Only workshop at Location 2 (a public, 4-year institution in the U.S. Southwest). To recruit workshop participants, we identified all of the college districts or institutions of higher education within 150 miles of Location 2 that offered at least one STEM degree program (computer & information sciences, engineering, life sciences, mathematics & statistics, physical sciences, and technology; [55]). Then, we emailed administrators (when contact information was available on institutional websites) to request that they forward our invitation to instructors to participate in our active learning workshop. When no point of contact was available for a department, we emailed individual instructors from each institution to invite them to participate in our active learning workshop (see [56] for more details). Thirty-nine STEM instructors who planned to use active learning in teaching an introductory STEM course in the Fall of 2019 (eligibility condition for our larger research study) responded to the invitation. They were either assigned to the workshop scheduled on the date they were available or randomly assigned to the AL-Only or AL-Plus workshop (if available on both dates). Fourteen STEM instructors attended the AL-Only workshop, and 16 attended the AL-Plus workshop.

6.2.3 *Workshop Participants*

Altogether, 51 instructors participated in one of the three workshops (AL-Plus, Location 1; AL-Only, Location 2; AL-Plus, Location 2). Table 5 provides an overview of participant characteristics, including institution type, institution category, and discipline of the workshop participants. All 21 participants of the AL-Plus Workshop at Location 1 were instructors at the same institution. The 30 participants who attended a workshop at Location 2 came from multiple institutions across the South, comprised mostly of public institutions and a nearly equal split of 2- and 4-year institutions. At Location 1, participants mostly taught in the engineering discipline, while those from Location 2 taught in a variety of STEM disciplines, including computer & information sciences, engineering, life sciences, mathematics & statistics, physical sciences, and technology. Research procedures were governed by approved human subjects IRB protocols, and all participants signed informed consent forms.

6.3 *Data Collection*

We collected data using the Active Learning Survey (described in *Instruments*) in three waves, as shown in Table 6. Wave 1 of data collection occurred just before the workshop, and Wave 2 took place immediately after the workshop for participants at both locations. For participants at Location 2, Wave 3 data collection occurred during the subse-

Table 5. Participant Characteristics

	AL-Plus: Location 1 (*n* = 21)	**AL-Only: Location 2 (*n* = 14)**	**AL-Plus: Location 2 (*n* = 16)**
Institution Type			
Public	21	12	14
Private		2	2
Institution Category			
2-year		6	8
4-year	21	8	8
Discipline			
Computer & information sciences		1	1
Engineering	19	1	1
Life sciences		1	6
Mathematics & statistics		4	4
Physical sciences	2	7	3
Technology			1

Table 6. Data Collection Schedule and ANOVA Comparisons Between Wave and Workshop Condition

Location	Workshop	Wave 1: Before workshop	Wave 2: After workshop	Wave 3: During fall semester
1	AL-Plus	AL	AL / WS	–
2	AL-Only	AL	AL / WS	AL
2	AL-Plus	AL	AL / WS	AL

Notes. Active Learning (AL) Survey and Workshop Satisfaction (WS) Survey.
AL Survey: Wave 1 compared to Wave 2 (n = 35 and n = 32).
AL Survey Location 2 only: AL-Plus (n = 11) compared to AL-Only (n = 12).

quent academic term, approximately five to six months after the workshop. For each data collection wave, most participants completed the survey using a secure online data collection website. For Wave 2, a small number of Location 2 participants (n = 4) took a paper version of the survey. We collected data for the Workshop Satisfaction Survey (described in *Instruments*) after all three pilot workshops before participants left the classroom.

6.4 Instruments

6.4.1 Active Learning Survey

To provide data to address Research Questions 1 and 2, we developed a survey to assess workshop participants' motivation to use active learning, their intentions to use the strategies to reduce student resistance, and their motivation to use the strategies. As described earlier, we assessed motivation through a combination of items related to value and self-efficacy. The Active Learning Survey items drew from the literature on active learning (e.g., [57–58]) and research-supported strategies to reduce student resistance to active learning (e.g., [51–53]). We piloted the scales on a convenience sample of university instructors to evaluate item function, internal consistence, and factor validity of each of the instrument's subscales [59].

6.4.1.1 Active Learning

The two *motivation to use active learning* subscales – *value* and *self-efficacy* – each included five items that measure participants' value and self-efficacy related to different active learning approaches (e.g., "ask students to solve problems in a group during class"). To measure value, the prompt asked participants how valuable they think each active learning approach is to student learning in a specific first- or second-year STEM class they are teaching. To measure self-efficacy, the prompt asked participants how confident they are in their ability to successfully use each active learning approach in a specific first- or second-year STEM class they are teaching. All items are measured on an 11-point Likert scale. The Cronbach's alphas [60] for the two *motivation to use active learning* subscales across all participants and data collection waves were acceptable (active learning: value, α = 0.84 – 0.86; active learning: self-efficacy, α = 0.89 – 0.90).

6.4.1.2 Planning Strategies to Reduce Student Resistance

The *intentions to use planning strategies* subscale is measured by six items asking participants about their likelihood of using different planning strategies (i.e., one item for each of the planning strategies listed in Table 3). The two *motivation to use planning strategies* subscales (*value* and *self-efficacy*) each have six items asking instructors how valuable they think the different planning strategies are to student learning and how confident they are in successfully using the planning strategies, respectively. Items are measured on an 11-point Likert scale. The Cronbach's alphas for all three planning strategy subscales (intentions, value, and self-efficacy) across all participants and data collection waves were acceptable (planning strategy: intentions to use, α = 0.73 – 0.89; value, α = 0.81 – 0.91; self-efficacy, α = 0.81 – 0.86).

6.4.1.3 Explanation Strategies to Reduce Student Resistance

Intentions and motivation (*value* and *self-efficacy*) *to use explanation strategies* subscales are measured with four items (corresponding to the explanation strategies in Table 3), each having prompts similar to those for the planning strategies (likelihood of using a given strategy, how valuable they think a given strategy is, and how confident they are in successfully using a given strategy). Again, items are measured on an 11-point Likert scale, and the Cronbach's alphas for all explanation strategies subscales across all participants and data collection waves were acceptable (explanation strategy: use, α = 0.63 – 0.85; value, α = 0.77 – 0.89; self-efficacy, α = 0.83 – 0.94).

6.4.1.4 Facilitation Strategies to Reduce Student Resistance

Five items (listed in Table 3) each measure *intentions and motivation* (*value* and *self-efficacy*) *to use facilitation strategies* to reduce student resistance, again using prompts similar to those for the planning and explanation strategies subscales. As for the planning and explanation strategies, items are measured on an 11-point Likert scale. The Cronbach's alphas for all facilitation subscales across all participants and data collection waves were again acceptable (facilitation strategy: use, α = 0.77 – 0.89; value, α = 0.84 – 0.93; self-efficacy, α = 0.75 – 0.86).

6.4.2 Workshop Satisfaction Survey

To address Research Question 3, a survey, comprised in part of four open-ended questions, was administered to assess participants' satisfaction with the workshop. The four open-ended questions asked participants about (1) the most valuable aspects of the workshop, (2) the least valuable aspects of the workshop, (3) barriers they anticipated to implementing active learning, and (4) any additional comments or recommendations for improving the workshop.

6.5 Analytical Plan

These analyses aimed to evaluate the active learning workshop's effectiveness and to suggest areas for further refinement of the workshop. As mentioned previously, we define an *effective workshop* as one in which participants' attitudes are different (in a positive way) after attending the workshop compared to their attitudes prior to attending. Although our statistical analyses may not be sufficient to understand the influence of workshop version on each factor measuring instructors' intentions and motivation, they provide useful insights for data-based workshop development.

To address Research Question 1 (Is there a change in participants' motivation to use active learning or their motivation and intention to use strategies to reduce student resistance to active learning after attending the AL-Only or AL-Plus workshop?), we conducted a series of one-way within-subjects repeated measures analysis of variances (RM-ANOVA; [61]) using Bonferroni's correction to account for the increase in familywise Type I error rate [62]. These analyses examined differences in participants' motivation to use active learning, and their intentions and motivation to use the strategies to reduce student resistance, immediately preceding (Wave 1) to immediately after (Wave 2) the workshop. For this research question, our analytical sample included all participants at both locations and versions of the workshop (AL-Only and AL-Plus) who completed the Active Learning Survey (n = 35, motivation to use active learning; $n = 32$, intentions and motivation to use strategies). For these one-way within-subjects RM-ANOVAs, we conducted a post hoc power analysis using *G*Power* [63] to determine the observed power. This analysis indicated that we had sufficient power (1-β error probability > 0.80) to identify the main effect of the active learning workshop on changes in participants' motivation to use active learning and their intentions and motivation to use strategies to reduce student resistance to active learning.

To address the second research question (Does the additional time and explicit instruction provided by the AL-Plus workshop, compared to the AL-Only workshop, relate to instructors' motivation to use active learning or their intentions and motivation to use strategies to reduce student resistance to active learning?), we conducted a series of two-way RM-ANOVAs with workshop version (AL-Only or AL-Plus) as a between-subjects factor using Bonferroni's correction to account for the increase in familywise Type I error rate [62]. Because the AL-Only workshop was offered only at Location 2 and did not have a direct comparison group at Location 1, only participants from Location 2 were included in the two-way RM-ANOVAs (n = 23). A post hoc power analysis using *G*Power* [63] indicated that these analyses were underpowered (1-β error probability $\cong$ 0.40) to see the anticipated effect of the workshop version on the differences in change (f = 0.10; Cohen's f; [64]) before accounting for the decrease in statistical power due to our use of Bonferroni's correction. In addition to statistical significance, we determined the effect size (partial η^2) of the between-within interaction of the condition (workshop version, AL-Only or AL-Plus) on change over time (Wave 1 to Wave 3). Cohen [64] indicates that a strong effect is 0.14, a medium effect is 0.06, and a small effect is 0.01. To assess differences in participants' intentions and motivation to use strategies to reduce student resistance to active learning in Wave 2 and Wave 3, we calculated the within-wave mean-difference effect size (Cohen's d; [64]) between the AL-Only and AL-Plus conditions. For Cohen's d, a small effect is 0.2, a medium effect is 0.5, and a large effect is 0.8 [64].

To address Research Question 3 (Does incorporating the five elements of adult learning theory (*expertise of presenters, relevance of content, choice in application, praxis, and groupwork*) in workshop design contribute to workshop effectiveness?), we conducted a qualitative analysis using the open-ended responses from the Workshop Satisfaction Survey. To understand what workshop elements contributed to its effectiveness, we placed a particular emphasis on the first open-ended question (What aspects of the workshop were most valuable to you? Why?). We analyzed the 38 responses to this survey question, plus eight related responses to the question asking for additional comments to improve the workshop, taking an inductive approach to develop 12 themes. We then mapped the themes to the five criteria of the IDP Design Framework [3] using a deductive approach and counted the number of times each theme was mentioned in a response.

7. Results

7.1 Workshop Effectiveness

We evaluated the AL-Only and AL-Plus workshops with a Level 2 assessment of impact on participants' teaching attitude [3]. Specifically, data from the Active Learning Survey provides information about participants' attitudes about active learning in their teaching. We also collected participant feedback about the workshops as a Level 1 assessment, finding that 90% of participants agreed (or strongly agreed) that they were satisfied with the workshop, 94% agreed that the content was appropriate and helpful, 88% agreed that activities were well designed, and 90% agreed they had accomplished the objectives of the workshop.

7.1.1 Active Learning Survey

Table 7 shows the RM-ANOVA results that examined differences in participants' motivation to use active learning and their intentions and motivation to use the strategies to reduce student resistance, before and after attending the workshop. In addressing Research Question 1, we found that all of the motivation (value, self-efficacy) and intentions to use active learning and strategies to reduce resistance were higher post workshop. The effect size for each comparison was large. After Bonferroni corrections, only self-efficacy (motivation) to use active learning ($F(1, 34) = 12.27$, $p < 0.0045$, $\eta^2_p = 0.27$), value (motivation) to use facilitation strategies ($F(1, 31) = 15.33$, $p < 0.0045$, $\eta^2_p = 0.33$), and intentions to use explanation ($F(1, 31) = 13.87$, $p < 0.0045$, $\eta^2_p = 0.31$) and facilitation ($F(1, 31) = 23.10$, $p < 0.0045$, $\eta^{2p} = 0.43$) strategies to reduce student resistance were statistically significantly different. Overall, our results suggest our active learning workshop was effective, consistent with our definition.

Table 8 shows the results of the two-way RM-ANOVA analyses conducted to assess differences in participants' change in motivation to use active learning and their intentions and motivation to use the strategies to reduce student resistance, based on whether they attended the AL-Only or AL-Plus workshop. Despite the additional two-hour module on strategies to reduce student resistance in the AL-Plus workshop, we observed no (statistically significant) evidence of differences by workshop version in the pattern of relations for participants' motivation (value and self-efficacy) to use active learning pre- to post-workshop.

In contrast, participants' intentions to use different strategies to reduce student resistance to active learning across the three waves did differ by workshop version. We observed a medium-sized effect of the workshop version on differences in intentions to use planning ($\eta^2_p = 0.07$) and facilitation ($\eta^2_p = 0.08$) strategies across the three waves (mean and standard deviations in Table 8). We observed a

Table 7. Repeated Measures-ANOVA Table Comparing Pre- (Wave 1) and Post- (Wave 2) Workshop Motivation to Use Active Learning ($n = 35$) and Intentions to Use and Motivation to Use Strategies to Reduce Student Resistance ($n = 32$)

	Means (*SD*)		**Within-subjects Change**	
Measures	**Wave 1**	**Wave 2**	***F*(*df*)**	η_p^2
Active Learning				
Value	7.97 (1.61)	8.56 (1.42)	8.86 (1, 34)	0.21
Self-efficacy	7.96 (1.79)	8.70 (1.28)	12.27* (1, 34)	0.27
Planning Strategies				
Intentions to use	7.85 (1.71)	8.53 (1.13)	6.04 (1, 31)	0.16
Value	8.59 (1.30)	8.95 (1.00)	6.14 (1, 31)	0.17
Self-efficacy	8.11 (1.33)	8.64 (1.09)	8.11 (1, 31)	0.21
Explanation Strategies				
Intentions to use	7.72 (2.10)	8.88 (1.18)	13.87* (1, 31)	0.31
Value	8.45 (1.86)	9.18 (0.86)	7.23 (1, 31)	0.19
Self-efficacy	8.11 (1.97)	9.12 (0.96)	8.57 (1, 31)	0.22
Facilitation Strategies				
Intentions to use	7.81 (1.90)	8.69 (1.38)	23.10* (1, 31)	0.43
Value	8.56 (1.64)	9.14 (1.21)	15.33* (1, 31)	0.33
Self-efficacy	8.36 (1.45)	8.98 (1.30)	5.85 (1, 31)	0.16

Note. All items are measured on an 11-point Likert scale. η^2 effect size (partial eta-squared).
* $p <$ Bonferroni-corrected α (0.0045).

Table 8. Two-Way Mixed-Effects ANOVA Table for Intentions and Motivation Factors by Group

	Means (*SD*)						**Two-way ANOVA Change*Condition**	
	Wave 1		**Wave 2**		**Wave 3**			
Measures	**AL-Plus**	**AL-Only**	**AL-Plus**	**AL-Only**	**AL-Plus**	**AL-Only**	***F* (*df*)**	η_p^2
Active Learning								
Value	8.80 (1.01)	8.03 (1.31)	9.35 (0.72)	8.53 (0.92)	–	–	0.01 (1, 21)	< 0.01
Self-efficacy	8.67 (1.35)	8.24 (1.20)	9.11 (0.87)	9.08 (0.86)	–	–	0.57 (1, 21)	0.03
Planning Strategies								
Intentions to use	8.62 (0.98)	7.82 (1.42)	8.82 (0.93)	8.58 (0.95)	8.95 (0.75)	7.67 (1.77)	1.67 (2, 42)	0.07
Value	9.02 (1.14)	8.61 (1.07)	9.32 (0.68)	8.99 (1.01)	9.33 (0.64)	8.29 (1.56)	1.62 (2, 42)	0.07
Self-efficacy	8.64 (1.03)	8.29 (0.79)	8.94 (0.92)	8.65 (1.06)	8.41 (1.47)	8.00 (1.65)	0.03 (2, 42)	<0.01
Explanation Strategies								
Intentions to use [a]	7.84 (2.35)	8.02 (1.67)	8.77 (1.32)	9.08 (0.81)	8.98 (0.89)	7.27 (2.16)	4.90 (1.39, 29.27)[a]	0.19
Value	8.80 (1.64)	8.77 (1.38)	9.43 (0.73)	9.04 (0.92)	8.75 (1.21)	7.94 (1.85)	1.01 (2, 42)	0.05
Self-efficacy	7.98 (2.04)	9.02 (0.73)	9.30 (0.97)	9.10 (0.68)	8.57 (1.67)	7.85 (1.74)	3.12 (2, 42)	0.13
Facilitation Strategies								
Intentions to use [a]	8.16 (1.57)	8.37 (0.68)	9.07 (1.02)	9.02 (0.58)	8.85 (1.42)	7.65 (2.26)	1.78 (1.28, 26.82)[a]	0.08
Value [a]	9.35 (0.85)	8.88 (0.87)	9.62 (0.52)	9.42 (0.62)	9.07 (0.96)	8.17 (1.90)	0.99 (1.50, 31.43)[a]	0.05
Self-efficacy	8.33 (1.42)	9.02 (0.44)	9.56 (0.67)	9.00 (1.05)	8.75 (1.43)	7.90 (1.86)	2.65 (2, 42)	0.11

Notes. Data are reported on an 11-point Likert scale. η^2 effect size (partial eta-squared). AL-Only participants from Location 2 (n = 12) and AL-Plus participants from Location 2 (n = 11).

[a] Assumption of sphericity not tenable – Greenhouse-Geisser correction reported.

No analyses were significant using $p <$ Bonferroni-corrected α (0.0045).

strong effect in the AL-Only and AL-Plus participants' intentions to use explanation strategies across the three waves, $F(1.39, 29.27) = 4.90$, $\eta^2_p = 0.19$. Additionally, the differences in participants' motivation to use strategies to reduce student resistance across the three waves were also dependent on workshop version (AL-Only or AL-Plus). We observed medium-effect sizes for differences in participants' self-efficacy to use explanation ($\eta^2_p = 0.13$) and facilitation ($\eta^2_p = 0.11$) strategies across the three waves based on the workshop they attended, AL-Only or AL-Plus. The interaction between time and workshop version in participants' intentions to use and motivation was not practically significant for any strategies to reduce student resistance to active learning.

We calculated the effect size for observed differences in intentions to use and motivation to use the strategies to reduce student resistance to active learning between AL-Only and AL-Plus participants in both Wave 2 and Wave 3, shown in Table 9. A larger effect size suggests a greater difference in intentions and motivation to use active learning between the AL-Only and AL-Plus groups. In Wave 3, multiple differences in instructors' intentions and motivation to use the strategies to reduce student resistance by workshop condition had a medium to large effect size. These differences were more pronounced at Wave 3 than differences observed between groups at Wave 2, particularly for instructors' intentions to use the strategies. We observed a large effect in Wave 3 differences in participants' intentions to use planning and explanation strategies between AL Only (planning, M = 7.67, SD = 1.77; explanation, M = 7.27, SD = 2.16) and AL Plus (planning, M = 8.95, SD = 0.75; explanation, M = 8.98, SD = 0.89), Cohen's d = 0.95 and d = 1.03, respectively. We also found a large effect in instructors' value for using planning strategies (d = 0.88).

In addressing Research Question 2, we found evidence to support the additional time and explicit instruction in the AL-Plus workshop was effective. The means of the participants' intentions and motivation to use strategies to reduce student resistance increase immediately following the workshop (Wave 2) for both AL-Only and AL-Plus participants. However, only AL-Plus participants retained this increase in the long-term (Wave 3). The AL-Only participants' initial increase in intentions to use strategies decline, as does their self-efficacy for using explanation and facilitation strategies. A larger sample size and further statistical analysis are necessary to examine the generalizability of these findings.

7.2 Value of Workshop Elements

7.2.1 Most Valuable

We analyzed participants' open-ended responses on the Workshop Satisfaction Survey to assess aspects contributing to the effectiveness of the workshops, to address Research Question 3. The participants' responses to the question "What aspects of the workshop were most valuable to you?" relate to

Table 9. Effect Size (Cohen's d) for Differences in AL-Only Participants' (n = 12) and AL-Plus Participants' (n = 11) Intentions to Use and Motivation to Use Strategies to Reduce Student Resistance

	Wave 2 Cohen's *d*	**Wave 3 Cohen's *d***
Planning		
Use	0.26	0.95
Value	0.38	0.88
Self-efficacy	0.29	0.26
Explanation		
Use	0.28	1.03
Value	0.47	0.52
Self-efficacy	0.24	0.42
Facilitation		
Use	0.06	0.64
Value	0.35	0.60
Self-efficacy	0.64	0.51

Table 10. Themes for the Most Valuable Aspect of the Active Learning Workshop

Wlodkowski's [10] Five Criteria	**Workshop Element (theme)**	**Times Mentioned**
Expertise	Research evidence	7
	Facilitators' expertise	1
	Resources for further learning	1
Relevance	Classroom application	13
	Ease of implementation	11
	General relevance	2
Choice in Application	Active learning options	10
Praxis	Practice (planning active learning)	3
	Feedback[a]	0
	Reflection	1
	Implementation	1
Groupwork	Collaborative learning	4
	Networking	1

Notes. Criteria from [3].

[a] This theme emerged from the additional comments for improving the workshop, although it wasn't explicitly described in the open-ended comments related to the most valuable aspect of the workshop.

Wlodkowski's (1999) five criteria on which the IDP Design Framework is based [3]: (1) *expertise of presenters*, (2) *relevance of content*, (3) *choice in application*, (4) *praxis*, and (5) *groupwork*. We further divided responses relating to each of these criteria into themes, and we report the number of times a theme was mentioned as being most valuable in Table 10. In some cases, a response addressed multiple themes and was counted in multiple criteria/themes.

We found three themes that relate to the first criterion (expertise): research evidence, facilitators' expertise, and future learning opportunities. Of these, the most frequently cited as being most valuable was the presentation of evidence in support of active learning. For example, one participant shared, "Seeing the data supporting active learning- convincing and it made my [sic] buy into the ideas. Solid advice how to carry out active learning exercises – makes it easy to plan and design." Another response related to the facilitators' expertise and another related to resources for future learning.

The second criterion, relevance, had three themes: classroom application, ease of implementation, and general relevance, and collectively the themes in this criterion were most commonly cited as the most valuable aspect. Participants cited two themes most often: classroom application (13 responses) and ease of implementation (11 responses). One participant's response aligned with both of these themes, "Actual easy & quick active learning techniques that I can use in my class." Additionally, two responses referred to the workshop's general relevance but did not offer specifics.

Participants shared most valuing elements aligned with the third criterion (choice in application); they appreciated the many active learning options shared. Ten responses identified the many active learning options as the workshop's most valuable aspect. For example, one participant shared, "Learning different types of active learning techniques and how impactful they can be for even small measures is very valuable to me."

Several responses describing the workshop's most valuable aspect related to praxis. We found three themes that related to this criterion: practice, reflection, and implementation. Three responses indicated that time for practice, specifically for the planning strategies, was most valuable, whereas one response referenced each reflection and implementation.

Lastly, several participants considered aspects related to groupwork as the most valuable part of the workshop. The responses related to two themes, collaborative learning and networking. Three responses indicated that collaborative learning was most valuable, while one response cited networking.

7.2.2 Suggestions for Improvement

Some participants shared additional comments for improving the workshop. Eight of these suggestions aligned with a criterion from the responses regarding the workshop's most valuable aspect. Two cited relevance; more specifically, they suggested providing additional workshop content or a separate workshop for participants more experienced with active learning, and five responses related to praxis (four addressed implementation and one focused on feedback). Some participants felt they could have benefited from additional praxis. One participant requested additional feedback from the workshop facilitators, and three suggested additional workshop content or more workshop time related to planning and implementing.

8. Discussion

8.1 Theoretically-based Framework for Workshop Design and Development

Our findings support the use of the IDP Design Framework [3], based on an adult learning theory [10], in the design of short-duration STEM instructional development workshops. The framework is supported in two ways: (1) participants' attitudes (intentions and motivation) shifted in the positive direction after attending the workshop, and (2) participants' feedback identified elements of the framework as most valuable.

We found nuances to developing instructional development workshops using the five criteria of the instructional development framework (*expertise of presenters*, *relevance of content*, *choice in application*, *praxis*, and *groupwork*). First, relevance should fully consider context, beyond discipline to include instructors' teaching environment. Second, in-workshop praxis should vary according to both degree and type. These findings have implications for instructional development personnel.

8.1.1 Relevance of Content

Our workshop content and design inadvertently focused on content more relevant to STEM university instructors, but a more nuanced approach to relevance of content would more fully incorporate the diversity of higher education teaching environments (e.g., emphasizing content more relevant to two-year colleges). One participant noted that high teaching loads were a barrier to adopting active learning, highlighting the importance of the teaching environment. The value of incorporating content for a diverse range of teaching environments is not surprising. Professional teaching environments differ among institutions, disciplines, and even departments (e.g., instructors at two-year colleges may have higher teaching loads than those at large research universities [65]).

To incorporate the diversity of teaching environments in our active learning workshop, we plan to encompass to an even greater extent content that reflects this diversity for lecturers, instructors, and faculty members. Furthermore, we plan to allocate time for open discussions of equity gaps (e.g., opportunities for professional development and classroom resources) and related barriers and options for overcoming these barriers. We may also address differences in institutional support and instructors' autonomy in designing courses.

8.1.2 Praxis

The type of praxis integrated into a workshop and the amount of time dedicated to it is a key factor in workshop design. Although our workshop included opportunities for praxis (e.g., generating lesson plans, writing and practicing a script on explanation strategies), our qualitative and quantitative findings suggest a potential benefit of additional types and opportunities for in-workshop praxis. Following Prather and Brissenden [22], we plan to introduce additional opportunities for praxis through role-playing or micro-teaching in our active learning workshop.

8.2 Short-Term Instructional Development

There are questions in the literature about the effectiveness of short-term instructional development workshops [5]. Several reviews suggest that longer-term interventions are more effective than shorter-duration programs [1, 4–6]. Yet, the findings of a recent meta-analysis seemingly suggest the opposite [7]. Our study provides one more data point of a sustained shift in instructors' attitudes after attending a short-duration instructional development workshop, thereby supporting the utility of a well-designed, short-duration workshop.

There are also questions in the literature surrounding the instructional goals for which short-term workshops are effective. Based on a recent meta-analysis, Ilie and coauthors [7] proposed that the effectiveness of short-term workshops they analyzed is related to their predominant focus on skills. Henderson and coauthors [4] also suggested that program objectives play a role in short-term workshop effectiveness, noting that programs promoting "very localized changes in instruction" are an exception to the general consensus that longer-duration programs are more effective. [p. 973] Although our workshops did address instructional skills, skill development was not their primary focus. As such, our results support the idea that instructors' attitudes about active learning can also change after attending a short-duration workshop.

8.3 Long-Term Evaluation of Instructional Development

Participants' self-reports immediately following an IDP are often used for program evaluation [2, 7, 12]. Fewer studies consider both short-term and longer-term differences when evaluating program effectiveness [2, 7], as is done in this study. A recent review of IDPs found few studies with sufficient quantitative data to analyze both short- and long-term impact [7].

Our active learning workshop evaluation found differences in short- and long-term self-reports of instructors' attitudes. Had we not collected longer-term data, we may have concluded there was no evidence to suggest differences in participants' intentions and motivation by workshop version. Yet, participants in the AL-Plus workshop maintain higher motivation for using strategies five or six months after the workshop. Although further data is necessary to bolster the evidence behind these claims, our findings suggest that researchers should use caution in drawing conclusions from assessments immediately following a workshop or in using short-term assessments to predict long-term differences or performance. Although this is not surprising, a limited number of research studies collect sufficient data to analyze such differences [2, 7].

8.4 Limitations

Our findings suggest short-duration workshops designed using the IDP Design Framework can be effective, but faculty developers need to take care in applying these findings to other short-duration workshops. While these findings may transfer, our small sample size led to underpowered statistical analyses, which may under- or over-estimate the true effect size of our workshop's impact [66]. The lack of a control group prevents us from testing a causal relationship between the active learning workshop and the differences in instructors' attitudes after attending the workshop (Table 7). We can only claim that our workshop participants' attitudes (intentions and motivation) changed positively after attending the workshop compared to their attitudes before attending. Without a control group (i.e., a group of participants who did not attend a workshop), we can only make inferences between the AL-Only and AL-Plus workshop (Table 8) without making comparisons to not attending our active learning workshop.

Our statistical analysis has other limitations. First, we did not conduct a retrospective assessment of participants' pre-workshop measures. Thus, our survey measures may exhibit a response shift associated with workshop learning [12]. Secondly, our study uses self-reports of participants' intentions and motivations (instructors' attitudes). Independent third-party classroom observations of participating instructors' use of active learning and strategies to reduce student resistance to active learning during classroom instruction may have provided a more accurate measure of workshop effectiveness. Previous studies of IDPs have found that participants' self-reports do not necessarily align with independent observations [14].

8.5 Implications

We do not yet have a comprehensive picture of what makes instructional development workshops effective in promoting instructional change and, ultimately, result in improved student learning. Multiple studies (Table 1) and literature reviews (Table 2) focus on instructional development. However, to the best of our knowledge, there are no large-scale, randomized control trials in STEM higher education that study change in instructors' teaching practices resulting from instructional development workshops. This paper provides additional justification for such studies and adds to the growing body of literature on instructional development workshops for STEM instructors.

Our evaluation of our active learning workshop provides insights for other short-term instructional development workshops. We examine the relationship between a proposed framework for IDP design [3] and the positive outcomes and areas for improving our active learning workshop. Our findings suggest that there are nuances to designing a workshop using the five adult learning theory criteria. First, the relevance of content should fully incorporate the context of instructors' teaching and, second, the type and amount of in-workshop praxis is important.

This study provides another data point for understanding unanswered questions in the literature about the effectiveness of short-term workshops and the extrapolation of short-term workshop evaluations to longer-term predictions. Our study suggests that instructors' attitudes change positively after attending a short-term workshop, a change sustained five to six months later. It also suggests workshop evaluations immediately following the intervention may not be predictive of longer-term evaluations. We are engaged in on-going efforts to address these issues further.

9. Conclusions

Our short-term, instructional development workshop draws on EVT and incorporates the IDP Design Framework [3] elements (expertise of presenters, relevance of content, choice in application, praxis, and groupwork) to change STEM instructors' attitudes about active learning. Participants identified most valuable workshop aspects related to the IDP Design Framework elements and recommended broader application of relevance of content (to the diverse array of professional teaching environments) and additional focus on praxis. After attending our workshop, participating instructors' attitudes about active learning (motivation to use active learning and both their intentions and motivation to use strategies to reduce student resistance to active learning) changed compared to their attitudes prior to attending. Our findings suggest that short-term workshops can be effective, however, post-workshop assessments immediately following the workshop are not necessarily consistent with longer-term assessments.

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Declaration of Conflicting Interests

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