Exploratory Factor Analysis of Approaches to Teaching Inventory (ATI): Use in an Evidence-Based Faculty Development Program for Promoting Active Learning Pedagogical Strategies

Kristi Glassmeyer, Arizona State University

Kristi Glassmeyer is a PhD student in Educational Policy and Evaluation at Arizona State University. Her research interests engage the intersection of organizational resources and processes with science and engineering education for the purposes of policy implementation and educational change.

Lydia Ross, Arizona State University

Dr. Lydia Ross is a clinical assistant professor in the Mary Lou Fulton Teachers College. She also serves as the executive director of the Association for Education Finance & Policy. She holds a PhD in Educational Policy and Evaluation from Arizona State University. Her research focuses on equity and access and in higher education, with a focus on STEM.

Dr. Eugene Judson, Arizona State University

Eugene Judson is an Associate Professor of for the Mary Lou Fulton Teachers College at Arizona State University. He also serves as an Extension Services Consultant for the National Center for Women and Information Technology (NCWIT). His past experiences include having been a middle school science teacher, Director of Academic and Instructional Support for the Arizona Department of Education, a research scientist for the Center for Research on Education in Science, Mathematics, Engineering and Technology (CRESMET), and an evaluator for several NSF projects. His first research strand concentrates on the relationship between educational policy and STEM education. His second research strand focuses on studying STEM classroom interactions and subsequent effects on student understanding. He is a co-developer of the Reformed Teaching Observation Protocol (RTOP) and his work has been cited more than 2200 times and he has been published in multiple peer-reviewed journals such as Science Education and the Journal of Research in Science Teaching.

Prof. Stephen J Krause, Arizona State University

Stephen Krause is professor in the Materials Science Program in the Fulton School of Engineering at Arizona State University. He teaches in the areas of introductory materials engineering, polymers and composites, and capstone design. His research interests include faculty development and evaluating conceptual knowledge and strategies to promote conceptual change. He has co-developed a Materials Concept Inventory and a Chemistry Concept Inventory for assessing conceptual knowledge and change for materials science and chemistry classes. He is currently conducting research in two areas. One is studying how strategies of engagement and feedback and internet tool use affect conceptual change and impact on students' attitude, achievement, and persistence. The other is on a large-scale NSF faculty development program and its effect on change in faculty teaching beliefs, engagement strategies, and classroom practice. Recent honors include coauthoring the ASEE Best Paper Award in the Journal of Engineering Education in 2013 and the ASEE Mike Ashby Outstanding Materials Educator Award in 2018.

Dr. Lindy Hamilton Mayled, Arizona State University

Lindy Hamilton Mayled is the Director of Instructional Effectiveness for the Fulton Schools of Engineering at Arizona State University. She has a PhD in Psychology of Learning, Education, and Technology and her research and areas of interest are in improving educational outcomes for STEM students through the integration of active learning and technology-enabled frequent feedback.

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Abstract

While surveys/inventories can be very informative for researchers to better understand latent constructs within social science research, critical analysis of these instruments is essential when they are used outside of their initial contexts. This complete research paper reports on an exploratory factor analysis of the Approaches to Teaching Inventory (ATI) as adapted for use in measuring relational change of engineering faculty's (*N*=65) instructional intent and teaching strategies in their undergraduate engineering classes. Parallel analysis of data collected during the JTFD professional development program, a National Science Foundation (NSF) funded project, suggested an underlying structure of two or three factors. While the survey creators, Trigwell and Prosser [1], claim a two-factor structure, each with two underlying subscales, in the ATI, exploratory factor analyses global model fit suggested a three-factor model to be a better fit. Interpretation of loading patterns and magnitudes indicated concerns with both two- and three- factor models. Although the small sample size presents a limitation to the findings, critical analysis of the ATI's use in other disciplines should be considered.

Introduction

Active learning, or student-centered teaching, is a pedagogical practice where instructors engage students directly in the learning process. This is done through in-class activities, discussions, and fostering an interactive environment. Contrastingly, instructor-centered teaching strategies involve transmission of information from the instructor to the students, often via lecture. In teacher-centered classrooms, the teacher is the central focus, and students just listen to the lecture to receive the information. Teacher-centered practices remain the dominant form of teaching in higher education. However, there is a large body of literature supporting the efficacy of active learning resulting in greater student comprehension and achievement [2, 3, 4]. This research indicates students in active learning classes have improved understanding of class content and are more likely to pass a class [5].

The context for this paper is a professional development program at Arizona State University, an R1 institution in the southwestern United States. The JTFD program is part of the NSF's Improving Undergraduate Science Education initiative. The JTFD program aims to increase faculty awareness and use of active learning strategies in the classroom. To that end, faculty participated in a year-long professional development series. In the fall semester, faculty attended 8 biweekly workshops, and in the spring semester they participated in six communities of practice. As part of the program evaluation, surveys were given to understand shifts in faculty beliefs and attitudes regarding active learning or student-centered teaching strategies. One survey included in our evaluation strategy is the Approaches to Teaching Inventory (ATI), which is the focus of this paper.

The Approaches to Teaching Inventory (ATI) was created based on a phenomenological qualitative study of faculty teaching physical sciences to first year undergraduate students in

Australia [6]. Since its creation, the ATI has been adapted to various contexts in order to relationally measure student- versus teacher-centered intent and strategies of use with regards to faculty instruction [7]. Original analysis of the inventory utilized a principal components analysis indicating the composite scores of the subscales including information transmission intent, teacher-focused strategies, conceptual change intent, and student-focused strategies loaded onto two components [8]. The inventory's subscales of information transfer and teacher-focused strategies were identified as loading onto a teacher-centered component while conceptual change and student-focused strategies subscales were identified as loading onto a student-centered component.

Considering potential correlations across the items of the ATI, we examined the ATI data using an exploratory factor analysis. The purpose of this study was to examine the behavior of the ATI items to provide insight into the use of its findings with regards to professional development interventions. We examined the structure and behavior of the items of the ATI based on the responses from engineering faculty participating in a NSF-funded professional development program aimed at developing active-engagement and student-centered instructional strategies. This study addresses the following research question:

1. What is the underlying factor structure of the Approaches to Teaching Inventory for faculty of engineering disciplines at a large public university?

Methods

Participants

This study utilized self-reported responses on the ATI from engineering faculty from a large, public university located in the southwestern United States. Individuals were participating in a NSF-funded professional development program promoting more effective teaching and learning practices. The JTFD professional development program began in the fall of 2016. Two cohorts of faculty, representing different engineering disciplines each year, participated in a year-long professional development program over two subsequent years. Numbers of participants as well as their engineering disciplines are presented in Table 1.

Table 1

JTFD Participant Characteristics for Cohorts

Cohort	Discipline	Number of Faculty Participants
Cohort One (2015-2016)	Disciplinary Leader Pairs	8
Cohort One (2016-2017)	Civil	13
	Construction	9
	Aerospace & Mechanical	13
Cohort Two (2017-2018)	Disciplinary Leader Pairs	6
	Biomedical	18
	Chemical	7
	Materials	8

The first cohort consisted of participants from the engineering disciplines of mechanical and aerospace, civil, and construction engineering while the second cohort represented the engineering disciplines of biomedical, chemical, and materials engineering.

Measures

In order to measure participants' shifts in attitude, motivation, and use in active learning pedagogical practices, three surveys were administered including the ATI, Education Research Awareness & Use, and Value, Expectancy, and Cost of Testing Educational Reforms Survey (VECTERS). The focus of this study, the ATI, consists of 16 items measuring self-perception of teaching. The scale of each measure is a 5-point Likert-type scale ranging from 0 = "strongly disagree" to 4 = "strongly agree." The inventory contains items identified in a phenomenological study of university science teachers approaches to teaching [9]. The survey is hypothesized to contain two scales representing two fundamentally different approaches to teaching. The inventory consists of eight transmission/teacher-focused approach items (e.g., "I feel it is important that this subject should be completely described in terms of specific objectives relating to what students have to know for formal assessments") and eight conceptual change/student-focused approach items (e.g., "In my class/tutorial for this subject I try to develop a conversation with students about the topics we are studying"). Additionally, these two approaches are each thought to contain two subscales of intention and strategy including teacher focused strategies (TFS), teacher focused intention (TFI), student focused strategy (SFS), and student focused intention (SFI). Initial analysis of the inventory utilized a principal components analysis instead of an exploratory factor analysis [10]. The use of principal components analysis accounting for total variance (unique, common, and error) instead of an exploratory factor analysis has been critiqued in the literature [11].

Procedure

The professional development program, targeting research-based active learning strategies as well as providing support and best practices of how to implement these strategies into the classroom, included 8 workshops during the fall semester and 6 communities of practice sessions in the spring semester. All participants were requested to take the ATI at the beginning (pre), middle (mid), and end (post) of the professional development program. This is one of several instruments used to measure faculty attitudes and beliefs during this research project. The survey, administered through Qualtrics, had 65 respondents for the pre survey, 45 respondents for the mid survey, and 49 respondents for the post survey. This measurement model study focused on the data collected from the pre survey because it contained the greatest number of respondents across collection times. All respondents (N=65) completed the survey in its entirety.

Analysis

Since creation of the survey was not based on prevalent theoretical findings in the literature [12], parallel analysis, which takes sample error into account, was used to estimate the number of factors to be retained. Use of mean eigenvalues from 1000 samples recommended a three-factor extraction while the 95th percentile eigenvalues supported a two-factor extraction.

We used the 16-item correlation matrix as well as calculations of the determinant, Kaiser-Meyer-Olkin measure of sampling adequacy, and Bartlett's test of sphericity to determine initial factorability of the data. There was no missing data because participants completed the inventory in its entirety. In order to determine whether the underlying assumptions of an exploratory factor analysis would be met, measures of central tendency including means, standard deviations, skewness, and kurtosis were calculated for the 16 items. The exploratory factor analysis was performed with MPlus with weighted least square mean and variance adjusted (WLSMV) as an estimator because it is a robust maximum likelihood estimator recommended for use with ordered categorical data. Correlation between items in the inventory and factors underlying the inventory and an oblique rotation of geomin was used [13]. Model fit was evaluated using Chi-square, root mean square error of approximation (RMSEA), confirmatory factor index (CFI), and standardized root mean square residual (SRMR). Factor loadings on the items for each model were also examined for model interpretability.

Results

Descriptive Statistics

Given the Likert-scale used in the inventory, the underlying assumptions of normality were analyzed. We used descriptive statistics and calculations for skewness and kurtosis for each of the 16 items and found several items to be positively or negatively skewed with values greater than 1 and less than -1 indicating a violation of normality (Table 2). Due to the violations of normality of the ordered categorical data, WLSMV was used as an estimator in the analysis.

Table 2

Means, and Standard Deviations for Approaches to Teaching Inventory Items for JTFD Participants (N=65)

Item		*M*	*SD*	Skewness	Kurtosis
1	I feel it is important that this subject should be completely described in terms of specific objectives relating to what students have to know for formal assessments.	2.92	1.035	-0.626	-0.738
2	I feel it is important to present a lot of facts in classes so that students know what they have to learn for this subject/course.	2.20	1.003	0.349	-0.943
3	In this subject/course I concentrate on covering the information that might be available from a good textbook.	2.11	1.161	0.031	-1.032
4	I think an important reason for running teaching sessions in this subject/course is to give students a good set of notes.	1.69	1.045	0.147	-1.064
5	In my class/tutorial for this subject I try to develop a conversation with students about the topics we are studying.	3.17	0.821	-0.851	0.379

6	In this subject/course, I only provide the students with the information they will need to pass the formal assessments.	0.77	0.825	1.32	2.762
7	I encourage students to restructure their existing knowledge in terms of the new way of thinking about the subject that they will develop.	3.06	0.916	-0.753	-0.187
8	I structure this subject/course to help students to pass the formal assessment items.	2.34	1.035	-0.642	-0.218
9	I feel a lot of teaching time in this subject/course should be used to question students' ideas.	2.17	0.945	0.108	-0.104
10	I feel that it is better for students in this subject/course to generate their own notes rather than always copy mine.	2.98	1.082	-1.037	0.428
11	I feel that I should know the answers to any questions that students may put to me during this subject/course.	2.05	1.230	-0.194	-0.959
12	In teaching sessions for this subject/course, I use difficult or undefined examples to provoke debate.	2.05	1.165	-0.092	-0.989
13	I set aside some teaching time so that the students can discuss, among themselves, the difficulties that they encounter in studying this subject.	2.42	1.298	-0.428	-1.005
14	I design my teaching in this subject with the assumption that most of the students have very little useful knowledge of the topics to be covered.	2.18	1.171	-0.311	-0.857
15	I feel that the assessment in this subject should be an opportunity for students to reveal their changed conceptual understanding of the subject.	2.86	0.704	-0.352	0.277
16	I make available opportunities for students in this subject/course to discuss their changing understanding of the subject.	2.60	1.058	-0.353	-0.429

Initial factorability indicated the existence of a linear combination of at least one underlying factor within the data (Table 3) [14, 15].

Table 3

Measures for Assessing the Correlation Matrix

Measure	Value
Determinant	0.01
KMO	0.627
Bartlett's Test of Sphericity	p < .001

First, the determinant of the matrix was not equal to zero indicating the data matrix can be explained by a linear combination. Second, measurement of shared variance in the items, measured using the Kaiser-Meyer-Olkin Test of Sampling Adequacy (KMO), was 0.627 indicating a mediocre degree of common variance among items. Furthermore, Bartlett's test produced a significant test result, $\chi^2(120, N = 65) = 264.57$, $p < .001$, supporting the rejection of the null hypothesis that the observed correlation matrix of the data is equal to the identity matrix. Lastly, the correlation matrix of the 16 items was analyzed (Table 4). Multiple correlations exceeded .30 supporting the existence of enough commonality between the items to justify the existence of a common factor [16].

Table 4

Correlations for Approaches to Teaching Inventory for Engineering Faculty Participants (N = 65)

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1.000															
2	0.346	1.000														
3	0.254	0.424	1.000													
4	0.166	0.283	0.543	1.000												
5	0.163	-0.004	-0.265	-0.121	1.000											
6	0.144	0.132	0.124	0.333	-0.034	1.000										
7	-0.110	-0.048	-0.197	-0.094	0.297	-0.043	1.000									
8	0.185	0.220	0.138	0.329	-0.105	0.349	-0.039	1.000								
9	0.077	0.079	-0.159	-0.057	0.426	0.071	0.204	0.100	1.000							
10	-0.127	-0.040	-0.210	-0.115	0.548	0.048	0.332	0.144	0.385	1.000						
11	0.211	0.246	0.412	0.145	-0.132	0.041	-0.210	0.012	-0.208	-0.035	1.000					
12	-0.075	0.005	-0.050	0.063	0.171	0.109	0.070	0.194	0.220	0.348	0.053	1.000				
13	-0.011	-0.005	-0.248	0.050	0.285	0.208	0.241	0.126	0.184	0.327	-0.042	0.421	1.000			
14	0.063	0.061	0.123	0.009	-0.196	0.287	-0.113	0.167	-0.085	0.027	0.211	-0.075	0.237	1.000		
15	0.007	-0.027	-0.058	-0.080	0.311	0.052	0.255	-0.085	0.271	0.120	0.007	0.274	0.303	0.107	1.000	
16	0.014	-0.071	-0.295	-0.212	0.367	0.054	0.348	0.097	0.350	0.267	-0.106	0.408	0.510	0.061	0.407	1.000

Exploratory Factor Analyses

Global fit indices supported a three-factor model as a being a better fit to the data. Chi-square model fit statistics, $\chi^2(62, N = 65) = 95.61$, $p = 0.055$, (Table 5) indicated the three-factor model does not significantly deviate from the observed data. The RMSEA, being greater than .05, indicates adequate fit for both a two- or three-factor model. However, the comparative fit index, .934, and the standardized root mean square residual, 0.08, support a three-factor model as being a better fit with the observed data as opposed to the two-factor model.

Table 5

Summary of Model Fit

Model	Chi-Square	*df*	RMSEA	CFI	SRMR
2-factor	125.13*	89	0.079	0.884	0.1
3-factor	95.61	62	0.065	0.934	0.08

Note. df = degrees of freedom; RMSEA = Root mean square error of approximation; CFI = Confirmatory factor index; SRMR = Standardized root mean square residual; *$p < .01$

The rotated loadings for both the two- and three-factor models indicated the existence of an underlying factor for the items after having controlled for the effects on other factors. The factor structure coefficients, indicating the correlation between the factor and the items, were compared for the two- and three-factor extractions (Table 6). The rotated and structure matrices have identical patterns so the rotated loadings are presented for clarity purposes.

Table 6

Rotated Loadings of Two- and Three-Factor Extractions of 16 Items in ATI with Geomin Rotation

Extraction	Two-Factor		Three-Factor		
Item	1	2	1	2	3
1	**0.47***	0.07	**0.51***	0.16	0.03
2	**0.56***	0.01	**0.67***	0.17	-0.05
3	**0.74***	-0.34*	**0.83***	-0.20	-0.01
4	**0.70***	-0.07	**0.70***	-0.02	0.17
5	-0.13	**0.66***	0.01	**0.85***	-0.30
6	**0.46***	0.17	0.32*	-0.01	**0.55***
7	-0.20	**0.47***	-0.19	**0.47***	-0.05
8	**0.53***	0.23	**0.41***	0.10	**0.47***
9	0.00	**0.58***	0.05	**0.63***	-0.07
10	0.00	**0.66***	0.00	**0.66***	0.03
11	**0.34***	-0.14	**0.36***	-0.10	0.05
12	0.20*	**0.56***	0.13	**0.48***	0.27
13	0.15	**0.71***	-0.01	**0.52***	**0.52***
14	**0.28***	0.05	0.14	-0.15	**0.51***
15	0.03	**0.55***	0.00	**0.50***	0.15
16	-0.07	**0.76***	-0.17	**0.63***	0.29

Note. Factor loadings and correlations > .40 are in boldface. * $p < .05$

The two-factor model rotated loadings aligned well with the two-factor model upon which Trigwell and Prosser [17] developed the ATI with items identified as information transfer and teacher-focused (e.g., items 1, 2, 3, 4, 6, 8, 11, and 14) predominantly combining to made up factor one. Complementarily, items identified as conceptual change and student-focused (e.g., items 5, 7, 9, 10, 12, 13, 15, 16) largely combined for factor two. Two items, three and twelve, load significantly on both factors while still loading more dominantly on their intended factor in the two-factor model. Item three states, “In this subject/course I concentrate on covering the information that might be available from a good textbook” and loads more heavily on information transfer/teacher-focused (factor one) while item 12 states, “In teaching sessions for this subject/course, I use difficult or undefined examples to provoke debate” and loads more heavily on conceptual change/student-focused (factor two). Together these two items represent components typical of rigorous higher education classes. Additionally, item 14 loads significantly onto the information transfer/teacher-focused factor in the two-factor extraction, it does not exceed the traditional cutoff value of .30. Item 14 states “I design my teaching in this subject with the assumption that most of the students have very little useful knowledge of the topics to be covered.”

In addition to being a better fit, the presence of the third factor splits the loading of some items onto multiple factors suggesting teaching to be more complex than just intention and strategy (Table 7).

Table 7

Rotated Factor Loadings (Pattern Matrix) for 16-item ATI based on Exploratory Factor Analysis with Geomin Rotation (N=65)

Item	2-Factor	Preparation	Instruction	Assessment
1. I feel it is important that this subject should be completely described in terms of specific objectives relating to what students have to know for formal assessments.	ITTF	**0.51***	0.16	0.03
2. I feel it is important to present a lot of facts in classes so that students know what they have to learn for this subject/course.	ITTF	**0.67***	0.17	-0.05
3. In this subject/course I concentrate on covering the information that might be available from a good textbook.	ITTF	**0.83***	-0.20	-0.01
4. I think an important reason for running teaching sessions in this subject/course is to give students a good set of notes.	ITTF	**0.70***	-0.02	0.17
5. In my class/tutorial for this subject I try to develop a conversation with students about the topics we are studying.	CCSF	0.01	**0.85***	-0.30
6. In this subject/course, I only provide the students with the information they will need to pass the formal assessments.	ITTF	**0.32***	-0.01	**0.55***
7. I encourage students to restructure their existing knowledge in terms of the new way of thinking about the subject that they will develop.	CCSF	-0.19	**0.47***	-0.05
8. I structure this subject/course to help students to pass the formal assessment items.	ITTF	**0.41***	0.10	**0.47***
9. I feel a lot of teaching time in this subject/course should be used to question students' ideas.	CCSF	0.05	**0.63***	-0.07
10. I feel that it is better for students in this subject/course to generate their own notes rather than always copy mine.	CCSF	0.00	**0.66***	0.03
11. I feel that I should know the answers to any questions that students may put to me during this subject/course.	ITTF	**0.36***	-0.10	0.05
12. In teaching sessions for this subject/course, I use difficult or undefined examples to provoke debate.	CCSF	0.13	**0.48***	0.27

13. I set aside some teaching time so that the students can discuss, among themselves, the difficulties that they encounter in studying this subject.	CCSF	-0.01	**0.52***	**0.52***
14. I design my teaching in this subject with the assumption that most of the students have very little useful knowledge of the topics to be covered.	ITTF	0.14	-0.15	**0.51***
15. I feel that the assessment in this subject should be an opportunity for students to reveal their changed conceptual understanding of the subject.	CCSF	0.00	**0.50***	0.15
16. I make available opportunities for students in this subject/course to discuss their changing understanding of the subject.	CCSF	-0.17	**0.63***	0.29

Note. Rotated loadings > .4 are bolded. ITTF = information transfer/teacher-focused; CCSF = conceptual change/student-focused, * $p < .05$

While the conceptual change/student-centered items from the two-factor model loaded predominantly on a single factor in the three-factor model, the items aligned with information transfer/teacher-focused in the two-factor model load onto two factors rather than a single factor. Looking closer at the wording of the items as well as their alignment suggest the factors may be more representative of an instructor's preparation for class, instructional strategies, and assessment strategies. Seven of the eight conceptual change/student-centered items (e.g., five, seven, nine, ten, 12, 15, and 16) from the two-factor model load onto factor two in the three-factor model. The items overlap in that they would take place during the class. For example, items five, nine, and 12 engage discussions, questions, or problem-solving which would typically take place during a class. Items one, two, three, four, and eleven with loadings of .51, .67, .83, .70, and .36, respectively, load on the first factor. Wording of these items represent characteristics representative of instructor's preparation or structuring of the course. For instance, item one references the use of objectives to communicate the learning goals of the course. Items six, 13, and 14 with loadings of .55, .52, and .51, respectively, are more aligned with the third factor. These items are either related to assessment or explicitly have the word assessment within them. Although most items load onto a single factor, two items load similarly on two factors. For example, item 13 loads onto the instruction and assessment factors similarly. Item 13 states "I set aside some teaching time so that the students can discuss, among themselves, the difficulties that they encounter in studying this subject." This cross loading could be due to the structure or word selection of the item having resulted in different interpretations and responses from participants. Additionally, item eight states, "I structure this subject/course to help students to pass the formal assessment items" includes terminology overlapping both preparation as well as assessment of the course. The better fit of the three-factor model with this data portrays a picture more aligned with teachers' pedagogical content knowledge rather than the teacher-focused/student-focused two-factor model used to develop the inventory.

Discussion

The better fit of the three-factor model with this data suggests that although we would like to inventory higher education instructors' instructional approaches and shift them to include more active strategies, we must not disregard the pedagogical content knowledge underlying the behaviors of all teachers. According to the three-factor model, the model has more items representing the strategies taking place during instructional time. However, these items don't necessarily present the spectrum of approaches teachers (i.e., more direct instruction to more active engagement) use during instructional time to facilitate learning. Although, this may not be the ideal instrument to measure relational change between more teacher-focused and student-centered approaches, it can inform us about instructors' perceptions of teaching as well as their beliefs and intentions regarding strategies they employ. The use of the ATI in research is indicative of the need for an instrument providing insight into the spectrum of teaching approaches as we look to shift instructional approaches in higher education courses.

While there were no missing data, the small sample size (N = 65) and ordered categorical nature of the items present limitations for the findings of this study and its ability to be generalized. The use of WLSMV as an estimator in the Mplus code should have accounted for the categorical nature of the items but comparison with models using MLM can be performed. Unfortunately, there is no way to increase the sample size which provides a challenge to the interpretation of the findings. As such, future researchers should consider examining the ATI with a new lens of three factors, rather than two. These findings also speak to the complicated nature of teaching and measuring pedagogical practices. While it is important to try to measure the spectrum of teaching being done in higher education courses or the change that may or may not take place over the course of professional development opportunities, it is important to note the limitations of the instruments we use and complement them with other measurements that can give us a more complete picture of the impact any intervention may have. In this particular research project, ATI was one of several instruments used to measure faculty attitudes and beliefs regarding instruction. As such, findings from the inventory were complemented by other instruments to shed light onto changes in faculty beliefs. These findings also speak to the complicated nature of teaching and measuring pedagogical practices. As such, the complexities around teaching need to be accounted for and further addressed in planning of and evaluation of professional development programs aimed at shifting pedagogical practices.

Acknowledgments
The authors gratefully acknowledge support of this work by the National Science Foundation under Grant No. 1524527.

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