Luzzo, Hasper, Albert, Bibby, & Martinelli, 1999). This makes motivation a prime focus for educators aiming to support students' long-term interest and accomplishment in science. However, a close look at the literature shows diverse theoretical frameworks and de nitions of motivation across studies that are nebulous and often poorly articulated. To better understand the role of motivation in students conceptualized motivation as a combination of perceived self-efficacy as well as mastery and performance goal orientations. Model 1, in which the three goal orientations and self-efficacy is organized as components of a higher-order motivation construct, is empirically tested to determine the appropriateness of using constructs from goal orientation and social cognitive theory together in reference to a broad motivational construct.

Another point of deliberation relates to whether self-efficacy is a motivational construct, or a separate construct altogether. From one perspective, self-efficacy is considered one of many variables underlying motivation. Model 1 is based on this approach to motivation research that categorizes self-efficacy dilearning (self-efficacy) may necessitate different approaches, compared to teaching that depends on fostering internal drives (motivation).

Finally, although past studies have conflated indicators of intrinsic and extrinsic motivation to refer to a broad umbrella term of motivation (models 1 and 2), in model 3, we propose and test a theoretical framework that categorizes motivational constructs according to similarity with features of intrinsic motivation (an internal desire to learn, enjoyment in the task itself) or extrinsic motivation (an externally driven desire based on rewards, approval, or compliance) (Deci & Ryan, 1985; Marsh, Hau, Artelt, Baumert, & Peschar, 2006; Osborne et al., 2003; Ryan & Deci, 2000a).[1] This intrinsic versus extrinsic framework has been applied in both science education research, with results showing greater evidence for the positive role of intrinsic motivation on science achievement compared to extrinsic motivation (Osborne et al., 2003).

Students who are intrinsically motivated engage in classroom activities with a full sense of autonomy and volition, rooted in the inherent pleasure that is experienced from the process of learning itself (Cerasoli et al., 2014; Ryan & Deci, 2000b). Mastery orientation and self-ef strategies, avoiding seeking help, and cheating (Linnenbrink, 2005; Midgley & Urdan, 2001; Middleton & Midgley, 1997; Murdock, Miller, & Kohlhardt, 2004). Due to the shared external regulation of both performance orientations and extrinsic motivation, as well the empirical support (albeit mixed for performance approach) regarding the negative relationship between externally regulated motivation and academic outcomes, we chose to test both performance orientations under extrinsic motivation in model 3. Practically, this model will inform whether or not science educators should encourage practices that draw upon students' motivation that is externally regulated, such as seeking rewards and gaining praise from teachers, or practices that put greater emphasis on intrinsic factors. Moreover, establishing the nature and role of internal versus external motivation has substantive implications for approaches to grading, testing, and accountability, which heavily rely on external forms of motivation to elicit achievement.

Altogether, motivation and self-efficacy have been demonstrated to be important for students' learning and academic achievement. However, while a series of primary studies has independently examined the impact of different subsets of motivational constructs on student outcomes, a comprehensive test of the relationships among these different motivational constructs is currently lacking. Clarifying these relationships will contribute to advancing our understanding of motivation in science education by moving beyond examining motivational constructs in isolation, or in a atomized way that obscures the underlying meaning, and toward exploring how different sources of motivation may work together in contributing to students' science learning.

Whereas motivation is related to underlying psychological processes, engagement, or the ways in which students connect to learning in the classroom, is operationalized as the lev1.9(g)- e811' 35(o)14.1(f)-394.s70tdents these proposed relationships, with emerging findings pointing to the predictive value of motivation on engagement, and in turn, engagement on achievement (e.g. Lau & Roeser, 2002; Reeve, 2012; Wigfield et al., 2015). As an example, Lau and Roeser (2002) found that motivation was significantly predictive of high school students' engagement in science-related assessment, classroom, and extracurricular experiences. Engagement in turn, predicted science test scores and grades (Lau & Roeser, 2002). Taken together, further exploration of engagement as both an outcome of motivation and a predictor student achievement is worthwhile. Particularly in the field of science education, more complex models that account for multiple motivational and engagement constructs, and the relationships among them to predict science achievement have not been tested.

This study thus builds upon emerging research that suggests engagement as mediating the relationship between motivation and achievement in the context of middle school science. Based on the premise that motivation and engagement together are theoretically participating in the project, across 8 districts and 30 schools in an urban area in the United States. The schools sampled served a diverse student population (Minority percent ranging from 26.3% to 99.3%) with varying levels of socioeconomic status (Free Reduced Lunch percent ranging from 5.2% to 94.5%). The Spring 2014 data were used for examining the factor structure of the long and short versions of the survey subscales (described under measures) and for testing the latent variable models presented in the findings. In addition, the short motivation and engagement survey was administered to an independent sample of 836 students in Fall 2014 from the same school districts to test for measurement validity. A total of 50 minutes (one class period) was provided for students to complete the survey online or on paper forms.

The motivation and engagement survey (the Appendix) consisted of the following three major categories: (1) goal orientations (mastery, performance approach, and performance avoid), (2) self-efficacy, and (3) three types of engagement (behavioral, affective, and cognitive). Items for the student goal orientation and self-efficacy components of the survey were drawn from the Patterns of Adaptive Learning Scales (Midgley et al., 2000), including mastery, performance approach, performance avoid (14 items) and self-efficacy (5 items). All survey items were rated on a 5-point Likert scale, ranging from 1 (*Not true at all*) to 5 (*Very true*). Cronbach's for the goal theory and efficacy subscales in the original research ranged from .74 to .89 (Midgley et al., 2000) and in a separate study, .77 to .89 (Pajares et al., 2000). The engagement items were drawn from the Student Engagement Scale (Fredricks et al., 2004). This scale was adapted from existing measures (Pintrich, Smith, Garcia, & Mckeachie, 1993; Wellborn & Connell, 1987) to assess the three types of engagement: behavioral (5 items), affective (5 items), and cognitive (7 items). Cronbach's were .76, .83, and .77 for the behavioral, affective, and cognitive subscales, respectively (Fredricks et al., 2004). Evidence for concurrent validity was found through moderate, positive correlations among the three engagement subscales and measures of classroom context (e.g. perceived teacher support, peer support, task challenge) (ranging from .23 to .49) (Fredricks et al., 2004).

Regarding face validity, and the argument that these student constructs cannot be separated from contexts (Osborne et al., 2003), the items were adapted to ask students about their motivation and engagement in the context of their science classroom (e.g. 'One of my goals in science class is to learn as much as I can'). In addition to consideration of the face validity based on wording of items, construct validity was established by selecting items from existing measures that are theoretically grounded in the literature on motivation (e.g. Ames, 1992; Midgley et al., 2001; Ryan & Deci, 2000a, 2000b), self-efficacy (e.g. Bandura, 1997; Pajares et al., 2000), and engagement (e.g. Appleton et al., 2006; Fredricks et al., 2004).

To address practical challenges associated with administering a lengthy survey among middle school students (e.g. time constraints, risk of cognitive fatigue; Gogol et al., 2014; Marsh, 2006; Moore, Halle, Vandivere, & Mariner, 2002), the long survey of existing for representing a latent construct reliably (Gogol et al., 2014; Kline, 2011). The following considerations were taken into account during the item selection process including the redundancy of items (analysis of wording as well as inter-item correlations), size of was used to estimate the factor loadings for each item. We assessed model t based on a set of absolute (t from the obtained and implied covariance matrix), relative t (from model test to a null model that speci es no latent variables), and comparative goodness-of-t (GOF) indices (relative t of tested model compared with baseline model), including the root mean square error of approximation (RMSEA), the standardized root mean square residual (SRMR), the comparative t index (CFI), and the Tucker-Lewis Index (TLI) (Kline, 2011). The cut-off values recommended by Hu and Bentler (1999) were used, with RMSEA and SRMR values equal to or below .06, and CFI and TLI values above .90 indicating good model t. We also report the chi-square (χ^2) test statistic with a probability value of = .05, which tests the null hypothesis that there is no signi cant difference between the model

A major aim of this study was to understand how the resultant motivational structures work with student engagement and science achievement, rather than to simply establish that a total effect exists (Hayes & Preacher, 2010). To this end, a SEM was conducted to examine a model in which engagement mediated the relationship between motivation and science achievement, which allows for inferences to be made regarding direct and indirect effects of motivation (Muthén, 2011). The higher-order intrinsic (indicated by first-order mastery and self-efficacy factors) and extrinsic motivation (indicated by first-order performance approach and performance avoid factors) variables were specified as independent variables, and were specified to predict the engagement latent variable (indicated by first-order behavioral, affective, and cognitive engagement factors). Engagement was specified to predict science achievement (indicated by the science CI score). Intrinsic and extrinsic motivation variables (indirect effects) were specified to indirectly affect science achievement through engagement (mediating variable). Mediation was determined to exist if intrinsic and extrinsic motivation directly predicted engagement, if engagement directly predicted science achievement, and if the indirect effect of intrinsic motivation and extrinsic motivation on science achievement was significant (Hayes & Preacher, 2010; Muthén, 2011). Model fit was determined based on the set of absolute, relative, and comparative GOF indices described in the CFA analysis above.

Descriptive statistics of the observed variables in the original sample (who completed the survey in Spring 2014) are presented in Table 1, and for the independent sample (who completed only the short survey in Fall 2014), in Table 2. Skew and kurtosis values were within a reasonable range.

The factor structure of the full and short motivation and engagement surveys were analyzed using the data from the original sample of 2094 students in Spring 2014, as well as an independent sample of 836 students who completed the only the short survey in Fall 2014 (Table 3). The seven factors estimated using CFA included the following

Descriptive statistics of observed variables from original sample in Spring 2014.

Variable	N	M	SD	Min	Max	Skew	Kurtosis
1. Mastery	2092	4.18	0.71	1.00	5.00	0.88	0.81
2. PerfAp	2091	2.59	1.09	1.00	5.00	0.44	0.55
3. PerfAv	2091	3.06	1.07	1.00	5.00	0.01	0.75
4. Efficacy	2071	3.98	0.84	1.00	5.00	0.66	0.12
5. EngBeh	2064	3.95	0.71	1.00	5.00	0.42	0.01
6. EngAffect	2060	3.75	0.88	1.00	5.00	0.56	0.17
7. EngCog	2026	3.02	0.90	1.00	5.00	0.20	0.20
8 Overall CI (%)	2026	43.44	19.20	3.33	100.00	.45	.39

Mastery, mastery orientation; PerfAp, performance approach orientation; PerfAv, performance avoidance orientation; Efficacy, efficacy; EngBeh, engagement behavioral; EngAffect, engagement affective; EngCog, engagement cognitive; Overall CI, overall % correct on Concept Inventory.

constructs from the original surveys: mastery orientation, performance approach orientation, performance avoid orientation, efficacy, behavioral engagement, affective engagement, and cognitive engagement. The seven factor model showed good fit to the Spring 2014 data from the long survey (RMSEA = .04, CFI = .91, TLI = .90, SRMR = .05). However results showed a superior fit of the seven factor model to the data from the short survey (RMSEA = .03, CFI = .97, TLI = .97, SRMR = .03) (Figure 2). In addition, geomin-rotated factor loadings of the items within each of the seven constructs generally increased for items retained in the short survey compared to the long survey (ranging from .33 to .84 versus .57 to .84 for the long and short surveys, respectively). Of note, the factor loadings of items on the short survey exceeded the criteria of a minimum factor loading of .30 to retain valid items (Kline, 2011). Finally, the change in the Satorra-Bentler scale χ^2 test was significant (χ^2 = 3965.74, $p < .001$) between the 7 factor baseline (short survey) and nested (long survey) models, indicating that the short survey model was a superior fit compared to the long survey model (Satorra, 2000; Satorra & Bentler, 2001). These patterns of results were replicated using data from the independent sample of students in Fall 2014 who completed the short motivation and engagement survey, showing additional evidence for the seven factor structure of the survey (RMSEA = .06, CFI = .92, TLI = .90, SRMR = .06; geomin-rotated factor loadings ranging from .49 to .87). All subsequent results presented were analyzed using the data from the Spring 2014 scores from the items included in the short survey.

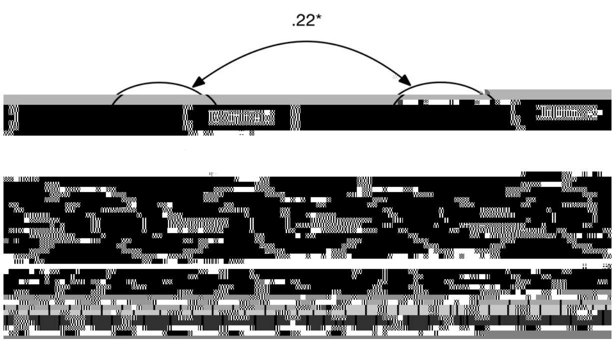
The GOF indices of the three motivation SEM models are presented in Table 4. Model 1, in which all three types of goal orientation and self-efficacy were estimated under a higher-

Comparison of CFA goodness-of-fit indices and standardized factor loadings of items between the long and short survey forms for the motivation and engagement measurement models.

Model	# of items	^{2}	df	p-value	RMSEA	CFI	TLI	SRMR	Satorra-Bentler Scaled ^{2}	Standardized factor loadings	
										Min	Max
Spring 2014 Original Sample (N = 2094)											
Long survey (7 factors)	37	4802.83	573	<.001	.04	.91	.90	.05	–	.33	.84
Short Survey (7 factors)	21	826.96	168	<.001	.03	.97	.97	.03	3965.74*	.57	.84
Fall 2014 Independent Sample (N = 836)											
Short Survey (7 factors)	21	605.02	168	<.001	.06	.92	.90	.06		.49	.87

Note: Short version of survey consists of 3 items per construct assessed. Reported Satorra-Bentler ^{2}, CFI, and RMSEA

Measurement model for the 7-factor, 21-item (3 items per construct) short motivation and engagement survey using data collected in Spring 2014.
*p < .01.



Model 3 of motivational constructs including self-efficacy, mastery orientation, performance approach orientation, and performance avoid orientation.
*p < .01.

approach and performance avoid orientation, and that efficacy should be considered a part of motivation. In contrast to models 1 and 2, results from model 3, in which the four constructs under study are organized by intrinsic and extrinsic categories (Figure 3), showed the good fit to the data (RMSEA = .04, CFI = .98, TLI = .98, SRMR = .03). In addition, examination of the factor loadings showed that all first-order latent variables loaded highly on their corresponding higher-order latent variable; intrinsic motivation which was specified by mastery orientation (.85) and efficacy (.67), and extrinsic motivation which was specified by performance approach (.84) and performance avoid (.94) orientations. Overall, results showed the greatest evidence for model 3, which categorized mastery orientation and self-efficacy under intrinsic motivation, and performance approach and avoid orientation under extrinsic motivation.

We built upon model 3 of motivation to test a mediation model in which engagement mediated the relationship between motivation (intrinsic and extrinsic) and student achievement (Figure 4). Results showed that the mediation model had a good fit to the data (RMSEA = .04, CFI = .96, TLI = .96, SRMR = .04). Intrinsic motivation had a strong, positive significant direct effect on engagement (β = .93, $p < .001$), whereas extrinsiccriF10 1 l3 results, the indirect effect tested between intrinsic motivation and science achievement was significant ($= .32, p < .05$), whereas the indirect effect tested between extrinsic motivation and science achievement was not significant ($= .16, p = .52$). Overall, results showed evidence that engagement mediates the relationship between intrinsic motivation and science achievement.

Based on the premise that students' motivation and engagement are critical factors influencing science achievement in middle school, the goal of this study was twofold: (1) to examine the relationships among commonly studied motivational constructs from goal orientation, social cognitive, and self-determination theories in efforts to move toward theoretical integration and (2) to test a model of engagement as a mediator of the relationship between various motivational constructs and science achievement. This study was conducted among middle school science students, an important population to examine due to documented declines in science interest during middle school (Britner & Pajares, 2006).

In regards to the first aim of this study, results clearly point to a structure of motivation characterized by intrinsic and extrinsic factors. Regarding the debate as to whether self-efficacy should be conceptualized as a construct distinct from motivation or not, our findings provide evidence for conceptualizing students' self-efficacy (confidence in their academic ability) together with students' mastery orientation (drive toward understanding) under a broader drive to learn rooted in the enjoyment of learning science (intrinsic motivation). In addition, this study sheds light on the debate regarding whether performance approach orientation is more closely related to mastery orientation, which is consistently linked to positive student learning outcomes, or more closely related to performance avoid orientation, which has shown to have detrimental effects on students' learning behaviors (e.g. Ames, 1992; Anderman et al., 2001; Linnenbrink, 2005; Midgley et al., 1998; Murdock et al., 2004). Our results indicate that students' orientation toward external accomplishments (performance approach) functions more similarly to performance avoidance in comparison to mastery orientation. Specifically, whereas an intrinsic drive characterized by the desire to understand the material (mastery orientation) predicted engagement, extrinsic motivation characterized by the desire to appear competent (performance approach) or the desire to avoid looking incompetent (performance avoid), did not.

Additionally, this study makes a novel contribution to the literature by examining the joint contribution of intrinsic and extrinsic motivation as well as engagement on students' science achievement. Building on past research that suggest motivation as internal processes that predict engagement (observable learning behaviors), and engagement as both an outcome of motivation and a predictor of achievement (Appleton et al., 2006; Lau & Roeser, 2002; Miller et al., 1996; Reeve, 2012), we empirically tested the mediating role of engagement between two categories of motivation (intrinsic and extrinsic), and science achi14.1(en)12D [(ac)10(g)0(o)13ng 36.937(R3.1(rie)14.ul(in)1510.3(t6(e)1hrie)14ow0(f)-42d achievement, highlight the importance of implementing pedagogies and classroom activities that provide students with a sense of autonomy and con dence in their own learning (self-ef cacy) and develop their interest in mastering the topic of study (mastery orientation). This includes creating a classroom culture that fosters internal forms of motivation through student's curiosity and interest in the topic, and minimizing classroom structures that foster students' orientation toward exhibiting good or avoiding bad performance. For example, common classroom practices such as emphasizing grades and competition draw on extrinsic factors to motivate students; however, our results indicate that this type of motivation is not predictive of students' engagement in learning and subsequent science achievement in middle school. These ndings can be explained by previous studies that showed evidence that extrinsic motivators (e.g. awards, praise) can undermine curiosity, persistence, and interest (Cerasoli et al., 2014; Deci et al., 2001; Ryan & Deci, 2000a, 2000b)—attributes that are associated with behavioral, cognitive, and affective engagement in learning tasks, and ultimal,49x, ttiddle390. 2001t -1.2414(undeall in regards to different indicators of achievement. Additionally, while examining other variables is beyond the scope of this study, we acknowledge that different facets of motivation and engagement are very likely to interact with other important social and contextual constructs to in

1. Ryan and Deci (2000a, 2000b) provide a more detailed gradation of intrinsic and extrinsic motivation in their Self-Determination Theory, which presents motivation on a continuum

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Continued.

Construct	Subconstruct	Motivation and engagement survey item wording
	Performance approach	6. It's important to me that other students in my science class think I am good at my class work.
		7. One of my goals is to show others that I'm good at my science class work.[a]
		8. One of my goals is to show others that science class work is easy for me.[a]
		9. One of my goals is to look smart in comparison to the other students in my science class.[a]
		10. It's important to me that I look smart compared to others in my class.
	Performance avoid	11. It's important to me that I don't look stupid in science class.[a]
		12. One of my goals is to keep others from thinking I'm not smart in science class.
		13. It's important to me that my science teacher doesn't think that I know less than others in class.[a]
		14. One of my goals in science class is to avoid looking like I have trouble doing the work.[a]
Self-efficacy	Self-efficacy	27. I'm sure I can become really good at the skills taught in science class this year.
		28. I'm sure I can figure out how to do the hardest science class work.
		29. I can do almost all the work in science class if I don't give up.[a]
		30. Even if the science class work is hard, I can learn it.[a]
		31. I can do even the hardest work in science class if I try my best.[a]
Engagement	Behavioral	32. I pay attention to all of the learning activities in my science class.[a]
		33. When I am in science class, I just act as if I am working.
		34. I complete my science homework on time.[a]
		35. I follow the rules in my science class.[a]
		36. I get in trouble in my science class.
	Affective	37. I feel bored when I'm learning science.
		38. I feel excited by the learning activities in my science class.[a]
		39. I like being in my science class.[a]
		40. I am interested in conducting science experiments.[a]
		41. My science classroom is a fun place to be.
	Cognitive	42. When I learn a new science lesson, I ask myself questions to make sure I understand what I am learning about.[a]
		43. I look for chances to be part of science events that are related to things we are doing in my science class.
		44. I talk with people outside of school about what I am learning in my science class.
		45. I look for extra information (books or internet) to learn more about things we do in science class.[a]
		46. If I don't understand what I read in science class, I go back and read it over again, look it up, or discuss it with someone.
		47. During science class, I ask questions and offer suggestions.[a]
		48. During science class, I talk, participate, and contribute to the discussion.

[a]Represents items used in the motivation and engagement short survey.