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Assessing K-5 Elementary Teachers Understanding and Readiness to Teach the New Framework for Science Education

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Abstract: With the publication of the Next Generation Science Standards (NGSS Lead States, 2013), science education has been ushered into a new era. However, it is currently unclear how prepared elementary educators are for the NGSS framework. This study sought to establish measures for assessing inservice educators' self-reported understanding of the new framework and readiness to implement the ideas in their science instruction. Designing and validating an instrument to assess these constructs followed procedures established in the literature including item development based on literature, an expert review, a pilot study, and finally a validation study. The results of the study are two valid and reliable instruments that could be used in similar contexts to measure elementary educators' understanding of or readiness to implement the new framework for science education. The unique factor structure of the two scales suggests important differences between understanding and readiness. These differences should inform professional development efforts.
Keywords: Science Education, NGSS, Elementary Education

With a number of states considering or even in the process of adopting the Next Generation Science Standards (NGSS), state agencies, and teacher educators must look to the potential need for professional development because it is unclear how prepared elementary educators are for the framework. This study sought to establish measures for assessing inservice educators' self-reported understanding of the NGSS framework (hereafter referred to as The Framework) and readiness to implement the ideas in their science instruction. The purpose of this study was to identify key constructs of The Framework from which the NGSS emerged. In addition, this study was undertaken to determine inservice elementary teachers' understanding of and readiness to successfully teach the concepts represented. Six themes were identified in the literature and then used to develop and to validate an instrument. Based on the themes identified, an instrument was developed to assess K-5 teachers' self-perceptions of their understanding of the NGSS science concepts and their readiness to teach these concepts.

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Research Questions

1. What NGSS framework constructs are represented in the science education literature?
2. What are elementary teachers' perceptions of their *understanding* of the NGSS framework?
3. What are elementary teachers' perceptions of their *readiness* to teach from the NGSS framework?

Review of Relevant Literature

Throughout the history of science education a number of factors have influenced theories on teaching science as well as actual classroom practice. Contemporary views on the nature of science, philosophy, and psychology largely shaped the curriculum being taught and the methods employed (DeBoer, 1991; Linn, 1982; National Research Council, 1999), though, the presence or absence of national reforms probably has had the most sweeping influences. However, even in the face of national reforms, the ubiquitous discrepancy between the theoretical ideals in science education and actual classroom practices has remained strong (Bentley, Ebert, & Ebert, 2007; Bybee, 1993). From the earliest days of public school science, policy makers, theorists, and educational researchers have promoted a science education that balances both the content and the practice of science (Cattell, 1914; National Education Association, 1920). To date, this lofty notion has not seen popularity in the classroom (Bybee, 1993; National Research Council, 2007). Added to this issue, theorists and policy makers have at times been behind the curve themselves.

Now, over the last 30 years, the value of genuine inquiry has been promoted by contemporary views on the nature of science, current understandings of human learning, national reforms and policies, and teacher education. Yet, predominately, classroom practice remains fact oriented, behaviorally structured, and an exercise in empiricism (Bentley et al., 2007). In an attempt to finally break through all of these issues, the National Research Council (1999, 2007, 2012) has coordinated a massive effort to completely reshape science education. Through this series of reports, the NRC constructed a platform for the development of the new science education standards, the *Next Generation Science Standards: For States, By States.* This platform, formally presented in *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (National Research Council, 2012), attempts to deal with the weaknesses in previous reforms. Evaluation of the current state of science education revealed that there was significant room for improvement due to the progression of science, lessons learned from standards-based education, and expanding knowledge on teaching and learning science (National Research Council, 2007, 2012). Growing concern over the fragmentation of topics and the lengthy lists of facts to be learned in science curricula has led to the popular a mile wide and an inch deep analogy (Bybee, 2006; Coleman & Zimba, 2008; Li, Klahr, & Siler, 2006; Sneider & Workosky, 2009). Attempting to provide a framework that unifies science education and addresses concerns, the NRC (2012) operated from three guiding principles: learning is a developmental progression, core ideas in science and engineering must be limited and both within and across the disciplines, and learning about science involves the integration of knowledge and practices to participate in inquiry or design. Each of these principles are evident throughout both The Framework and the NGSS in content as well as design (National Research Council, 2012; NGSS Lead States, 2013).

The NGSS represent the latest effort in policy reform for guiding science instruction. However, since the new standards are based upon The Framework (NGSS Lead States, 2013), successful implementation of the NGSS will require elementary teachers to understand and be prepared to teach science using the principals found within The Framework. There is little evidence to suggest that teachers understand the constructs represented by the NGSS (e.g., disciplinary core ideas, integration of knowledge and practice, or inquiry) let alone feel prepared to teach science content in their classrooms through these constructs.

Method

A survey consisting of two responses for each prompt was developed to assess elementary teachers' perceptions of the NGSS framework. One set of responses assessed elementary teachers' perceptions of their understanding of the NGSS framework and the other assessed their readiness to implement instruction guided by these concepts. The development of the items began with a thorough review of the literature related to elementary science education including the NRC's (2012) report, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. As the foundational document for the NGSS, this NRC report was given prominent consideration in the review. The themes found in the literature were identified as, (1) Scientific and Engineering Practices; (2) Crosscutting Concepts; (3) Disciplinary Core Ideas; (4) Integration of the Three Dimensions; (5) Best Practices in Science Instruction; and (6) Connections to Common Core.

The steps followed for the development and validation of the survey instrument were guided by recommendations from experts specializing in the field of instrument development (American Educational Research Association, 1999; DeVellis, 2003; Netemeyer, Bearden, & Sharma, 2003). Themes identified in the literature informed the development of draft items which were used to operationalize the themes for assessing elementary teachers' understanding of the NGSS framework and their readiness to implement these concepts. A two-part survey consisting of draft items was then distributed to experts for their review. Based on feedback from these experts, the survey was revised and pilot-tested with a small group of inservice teachers. Following the feedback from the pilot study, a final version of instrument, the *New Framework for Science Education: Survey of Teacher Readiness and Understanding* (NFSE: STUR) was determined and assigned six-point Likert scales (1= No Understanding to 6= Advanced Understanding and 1= No Readiness to 6= Advanced Readiness). This instrument was distributed electronically to over 300 inservice elementary science teachers in Montana, Wyoming, Utah, and Idaho. Finally, the data from the survey was analyzed for internal consistency and both exploratory analyses and confirmatory factor analyses were conducted in efforts to establish evidence for instrument validity on both scales.

RESULTS

One hundred sixty-seven elementary science teachers from the regional states completed the *New Framework for Science Education – Survey of Teacher Readiness and Understanding*. Both principal component and confirmatory factor analysis were used to validate the readiness and understanding scales. The principal component analysis retained 31 items for understanding scale which yielded the five interpretable factors reported in Table 1. Internal consistency reliabilities for the five factors ranged from .88 to .95 with the entire scale yielding a coefficient alpha of .971. The confirmatory analysis yielded a RMSEA of .065 (90% confidence interval = .051-.078) which indicates a good fit to the hypothesized population (Chen, Curran, Bollen, Kirby, & Paxton, 2008; Steiger, 2007) model for the 31 item understanding scale.

Table 1. Factor Structure and Reliabilities for the Understanding Scale

Factor	α
Entire Understanding Scale	.97
Science & Engineering Practices	.95
Teaching Disciplinary Core Ideas	.94
Crosscutting Concepts	.92
Integration of the Three Dimensions	.88
Best Practices in Science Education	.88

Principal component and confirmatory factor analyses were also conducted for the readiness items. The principal component analysis retained a total of 34 items that were interpreted as the four factors reported in Table 2. Internal consistency reliabilities for the four factors ranged from .92 to .96 with the entire 34-item scale yielding a coefficient alpha of .981. The confirmatory analysis yielded a RMSEA of .056 (90% confidence interval = .041-.069) which indicates a good fit to the hypothesized population (Chen et al., 2008; Steiger, 2007) model.

Table 2. Factor Structure and Reliabilities for the Readiness Scale

Factor	α
Entire Readiness Scale	.981
Students Learning as Scientists & Engineers	.964
Integration and Real-World Application of Core Ideas	.950
Best Practices for Student Learning	.949
Challenging Crosscutting Concepts	.917

TEACHER PERCEPTIONS OF NGSS UNDERSTANDING AND IMPLEMENTATION

Overall teacher responses to the understanding scale indicated that they felt that they had a "fair" understanding of Cross-Cutting Concepts (*M* = 3.30, *SD* = .40) and a "solid" understanding of the other constructs: Best Practices for Student Learning (*M*= 4.20, *SD* = .28), Integration of the Three Dimensions (*M* = 3.60, *SD* = .31), Science and Engineering Practices (*M* = 3.70, *SD* = .34) and Teaching Disciplinary Core Ideas (M=4.32, SD = .20). Elementary teachers perceived their readiness to teach Cross Cutting Concepts (*M* = 3.3, *SD* = .40) as only "fair" compared to their perceptions of "solid" readiness to teach science within the context of the NGSS constructs of Students Learning as Scientists and Engineers (*M* = 3.73, *SD* = .34), Integration of Real World Applications of Core Ideas (*M* = 3.97, *SD* = .38) and Best Practices for Student Learning (*M* = 4.4, *SD* = .29).

DISCUSSION AND IMPLICATIONS FOR PRACTICE

This study was designed to answer three research questions. First, What NGSS framework constructs are represented in the science education literature? The answer to this question was found in the six themes identified in the literature and successfully used to design the instrument: (1) Scientific and Engineering Practices; (2) Crosscutting Concepts; (3) Disciplinary Core Ideas; (4) Integration of the Three Dimensions; (5) Best Practices in Science Instruction; and (6) Connections to Common Core.

The second and third questions were posed to determine elementary teachers' perceptions of their *understanding* of the NGSS framework and their perceptions of their *readiness* to teach from the NGSS framework. Answering these two questions is found in the results from the exploratory and confirmatory factor analysis of the two instruments and the descriptive statistics yielded by those instruments. Elementary teachers' perceptions of understanding resulted in a five-factor model from the principal component analysis that was a near match to the themes developed from the literature. Their perception of readiness was markedly different producing a very dissimilar four-factor model from its principal component analysis. However, the descriptive statistics revealed that educators have similar levels of confidence in both understanding and readiness. A "solid" rating was given to nearly all constructs. Only the shared factor of Cross-cutting Concepts resulted with a "fair" rating.

It is interesting that teacher perceptions of understanding and readiness produced factor models with substantial differences. When considering their level of understanding about particular ideas, teachers' thoughts organized in one certain way. However, when pondering the same ideas in light of their readiness to use them in their teaching practice the elements were reorganized into different groups. This result provides further evidence for the fundamental differences between the constructs of understanding and readiness and should serve as a guide to professional developers in science education as they seek to cultivate teachers' understanding of and readiness to implement the NGSS framework. Training designed to develop teacher understandings of a particular construct could be completely successful in growing teacher understandings without having a transfer effect in practical application. The results of this study suggest that planners of professional development need to consider carefully the goal of training and plan accordingly.

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