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Signals of Teachers' Readiness for Change in Next Generation Science Professional Development

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Abstract: Change in the domain of education is complex. Research has begun to uncover factors that influence the success of proposed initiatives. This paper examines factors influencing science teachers as they wrestle with implementing innovative teaching practices. We present a theoretical framework that unpacks a construct we call *signals of readiness for change (readiness signals).* We define readiness signals as elements of teachers' talk that signal a teacher's sentiment toward a proposed initiative. Signals often reflect tensions that must be resolved for initiatives like the Next Generation Science Standards to succeed and endure. These tensions exist in teacher beliefs, confidence in their ability to implement innovative practices, and motivation to invest in change. The investigation of readiness signals adds insights into struggles surrounding the adoption of change in education.

Keywords: change, readiness, teacher professional development, Next Generation Science Standards

Introduction

The Next Generation Science Standards (NGSS) urge educators to radically transform the way they teach science. To help teachers shift their classroom practices to align with the NGSS vision, researchers and educators have introduced teachers to the new standards through professional development (PD). Despite the learning this PD supports, many teachers struggle to implement innovative NGSS-aligned curriculum in their science classrooms. The tensions teachers experience between traditional science teaching practices and NGSS standards are significant (Shelton, 2021). A shift to NGSS practices requires change at multiple levels and across multiple dimensions (Holt & Vardeman, 2013). Teachers communicate their feelings on the change being asked of them through a myriad of signals. We call these signals: *signals of readiness for change*, or simply, *readiness signals*. This paper examines the readiness signals teachers communicated during a PD focused on creating NGSS-aligned lessons featuring computational modeling activities. We present a theoretical framework that identifies the tensions teachers experienced during the PD. The framework can be used to identify readiness signals, which can be examined to understand teachers' change aptitude, or their inclination and ability to change. Comparing counts of positive and negative readiness signals can provide a measurement for change aptitude. We use Epistemic Network Analysis (ENA) to understand how positive and negative readiness signals co-occur, as a measure for change aptitude.

Understanding the tensions

Teachers work in complex epistemic frames, or ways of knowing in a community of practice (Shaffer and Ruis, 2017). In these frames, the rules that shape their actions and the norms they use to interpret classroom interactions can be established at legislative, district, administrative and personal levels. Common educational epistemic frames have practices that include preparing lessons, delivering lectures, and proctoring assessments. Current research suggests that experiences where students explore phenomena and define their own problems provide richer learning. When teachers attempt to implement innovative research-aligned approaches, the new approach can create tensions for teachers as the rules and norms can require significant shifts in time allocation, teacher, and student roles, and evaluation. Phillips et al. (2021) used Epistemic Network Analysis to show complexity in the teacher decision-making process by illuminating co-connections between tensions. We suggest that readiness signals can capture the tensions that arise when teachers are pressed to adjust rules or norms in their epistemic frames. The overarching goal of this work is to use *readiness signals* to help education leaders identify tensions that need to be addressed before innovations such as the NGSS can be successfully implemented. The specific research questions to be addressed in this paper are:

- What readiness signals do teachers communicate with respect to proposed innovations, when engaging in professional development around NGSS?
- Do our partner teachers' *change aptitudes* shift after participating in PD?

A Framework for assessing aptitude for change

Our work began in the summer of 2020 working with three middle school science teachers in a 4-week synchronous online professional development (PD). The purpose of the PD was for teachers to create and implement novel science curriculum where students construct their own computational models of phenomena. Throughout the training, various remarks from the teachers regarding their thoughts and feelings implementing the novel curricula caught our attention and raised questions about their readiness, or aptitude, for the change we were asking of them. Words connected to their ability, beliefs, and motivation showed up repeatedly in the teachers' utterances. These themes were expressed at the following levels: personal, students, other teachers, the school, and the education system requirements. Some of the facets emerging in our data were mentioned in the change readiness literature (Rafferty et all, 2013). Yet the current change frameworks, mostly focusing on corporate change, failed to represent all the elements found in our science education data. Thus, we integrated frameworks (Bandura, 2001; Grenny et al., 2013) to produce a framework featuring the elements we saw in our data.

Bandura's (2001) framework provided an initial characterization for the emerging readiness signals in our data. Self-efficacy, belief, ability, and motivation appeared to be critical factors for teachers' willingness to innovate. While Bandura's perspective shows the multidimensional influences surrounding agency, the research of Grenny et al. (2013) clarified that ability and motivation must be present at personal, social, and structural levels for individuals to adopt change. Our framework provides a guide for taking a deeper look into the complex system of abilities, beliefs, and motivations associated with the adoption of innovative practices in science education (Jones & Swanson, 2022). The vertical levels in our framework are personal, school (students, staff, administration), and education system. The horizontal dimensions are abilities, beliefs, and motivations. This guide is meant to support reflection and discussion that uncover tensions in how the dimensions intersect, which can then be considered and addressed.

Methods

Participants
The inspiration for this work came from the teachers' talk during a 4-week summer PD with daily meetings conducted by two of the authors. The participants, Katie, Mary, and Rebecca (pseudonyms) were science teachers working at middle schools in a Western United States city with 25, 7 and 17 years of experience, respectively. Katie and Rebecca taught at the same school. For the summer PD, they attended daily online meetings, created lesson plans, and worked with software developers to co-design computational models on a topic included in one of their lessons. Participants explored how they might integrate NGSS practices such as developing and using models, asking questions, conducting investigations, and constructing explanations.

Data sources
As part of the PD, we held daily morning meetings via Zoom to build team connections and to get a daily read on how everyone was doing. The conversations and activities provided an opportunity for teachers to communicate their feelings on the innovations they were being asked to implement. Video recordings of these meetings were transcribed using Otter.ai. Transcripts from Week 1 and Week 4 discussions were analyzed to understand teachers' readiness signals at the start and end of the PD. The themes of Weeks 1 and 4 were different. Week 1 focused on introductions, relationship building and exploration of new teaching goals, classroom interaction norms, and instructional activities. Week 4 focused on curriculum development, feedback, revision, reflection and integrating these new goals, norms, and activities into their classrooms.

Procedures
This study takes a deep dive into the details of the teachers' talk during the PD. It explores their reactions to the new ideas, pedagogies and practices associated with creating and implementing computational modeling lessons. The analytical procedures occurred in four steps.

Step 1. Codebook creation and code refinement. We began with a previous iteration of our framework (Jones & Swanson, 2020). To test and refine the framework, we used it to code readiness signals in the PD data. Utterances were determined by a change in speaker and each one was evaluated for instances of the nine specific readiness signals. The revised codebook is presented below (Table 1). The codebook operationalizes the theoretical framework by specifying the kinds of language associated with each of the nine signals.

Table 1. Readiness signals codebook

This table is meant to be used when the subject of a conversation is proposed innovations or change, and the teacher has communicated a reaction to it.

Personal change signals—Check to see if the statements use personalized words like I, my, we, us, or ours.	
BP	**Belief**, Does the person convey interest, hope, belief, doubt, or disbelief about doing something?
AP	**Ability**, Does the person provide some indication that they are able or not able to do something?
MP	**Motivation**, Does the person provide some indication that they are overwhelmed, hesitant, or stressed?
School change signals—Check to see if the statements discuss students or school personnel. *School* includes students, staff, and administration.	
BS	**Belief**, Does the person indicate that students or school personnel convey disinterest, disbelief, or doubt about doing something?
AS	**Ability**, Does the person indicate that students or school personnel are able or not able to do something?
MS	**Motivation**, Does the person indicate students' or school personnel's willingness to do something?
Education system change signals—Check to see if the statements discuss something like standards, expectations, time, or requirements. The education *system* includes state legislators, district leaders and principal.	
BE	**Belief**, Does the person indicate that the system supports or makes it difficult to do something?
AE	**Ability**, Does the person indicate that the system is able to accommodate to these changes?
ME	**Motivation**, Does the person indicate that the system will adapt to allow them to do something?
Positive or negative - Are the statements communicating a predominantly positive or negative sentiment?	

Step 2. Establish inter-rater agreement and code data. To check for bias in the coding, we trained a person not associated with the research using 3.3% of the data. Codebook revisions, coding practice, comparison and discussion were conducted to reach the desired interrater reliability with a Cohen's kappa of 0.65. The first author coded the remaining data using the revised codebook. Each turn of talk was evaluated according to the nine questions and whether the readiness signals had positive or negative sentiments.

Step 3. Understand shifts in readiness signals. We used Epistemic Network Analysis (ENA) to quantify the readiness signals in teachers' language and illuminate their co-connections for each week. ENA uniquely provides the ability to visualize multiple readiness signals communicated by the teachers, the occurrence frequency (line thickness), and number of connections being made (network density) (Shaffer & Ruis, 2017). By visualizing a teacher's network of readiness signals at different points in time, ENA provides a way to detect subtle shifts in change aptitude.

Findings

What readiness signals do teachers communicate with respect to proposed innovations, when engaging in professional development around NGSS? To answer these questions, we counted all instances of readiness signals demonstrated by each teacher for Weeks 1 and 4. We counted positive and negative remarks for each week to see if teacher's aptitude for change shifted from the first to the fourth week of PD. From the combined participants chart (Figure 1), we can see that eight readiness signals dropped in number, but personal belief (BP) increased. We can see that even though the number of negative change signals dropped greatly, negative signals still outnumber positive signals by about 30%. In Figure 2, which shows utterances featuring readiness signals, we can see that all three personal signals -- belief (BP), ability (AP), motivation (MP), and ability school (AS) -- appeared in a higher percentage of the spoken utterances than the other change signals in both weeks.

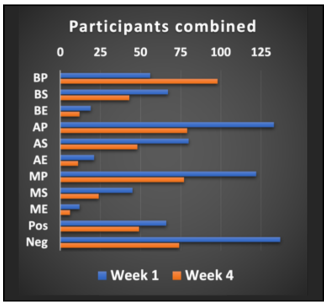

Figure 1. Combined

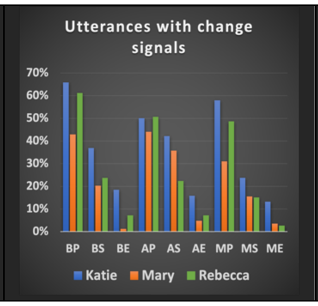

Figure 2. Utterances

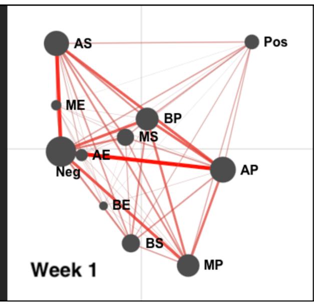

Figure 3. ENA Week 1

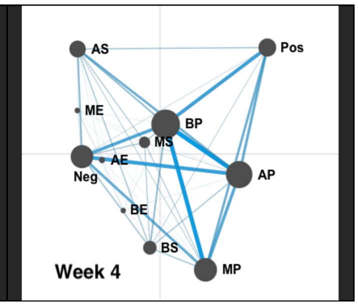

Figure 4. ENA Week 4

Do teachers' change aptitudes shift after participating in the PD? Comparing Figures 3 and 4 shows some shifts in positive connections. The network density from the positive node in Week 4 has decreased yet the strength of the connections co-occurring with all three personal signals (BP, AP, and MP) has increased. An aptitude shift is happening but not across all signals. The negative node maintains dense connections in Week 4, yet some of the links have decreased in frequency. These co-occurrences tell us that teachers continue to evaluate and communicate the challenges they face in adopting these new teaching practices. Readiness for change in the areas of personal belief, ability and motivation have a stronger presence in the conversations.

Limitations

The limitations of this work recommend areas of focus for future work. First, there might exist interpretation bias with a small number of coders. Future studies could follow up with participants, discuss the readiness signals, and address misinterpretations. Second, since the sample size is small, we did not check statistical significance in the analyses and could not validate patterns in readiness signal shifts.

Discussion and conclusion

We have taken an in-depth look at the discussions that occurred during the first and last weeks of a month-long NGSS-based PD that urged three educators to radically transform the way they teach science. We illustrate the feasibility of using our theoretical framework to explore potential tensions in teachers' adoption of curricular innovations. The readiness signals framework helped us see the complexity of teachers' thinking and decision making when introduced to innovative educational approaches. These readiness signals can indicate teachers' feelings towards proposed innovations. The data show an increase in positive readiness signals from the first to final week of a PD. Still, a significant number of negative signals suggest lingering concerns regarding the incorporation of these new norms and practices into their classrooms.

This work provides a framework for assisting those involved in educational innovation. The framework directs attention to readiness signals that communicate teachers' hesitance with adopting change. We have shown that our signals of readiness for change framework is a useful tool for uncovering the kinds of things teachers are considering when faced with the request to innovate in their classrooms. Our investigation of readiness signals can assist innovation leaders in better seeing their group's own readiness for change. Our data reveal that teachers are concerned about changing roles (i.e., teacher to facilitator), gaining new skills, leading learning experiences without seeing exemplars, and facing unknown outcomes that may not work. Teachers experience confusion around the meanings of different standards and their priorities. They struggle to choose what to spend time on and how much time to give each topic. It is our hope that discussions across all dimensions in this framework can help us move science education forward in new and productive ways.

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Acknowledgments

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