TEACHER CONFIDENCE AND CLASSROOM PRACTICES:

A CASE STUDY ON SCIENCE IDENTITY

by

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DEDICATION

This study is dedicated to my students at Hanson High School, of Alexandria, South Dakota. You are absolutely the reason that I love my job and I continue to push myself to be better. Thank you especially to the Hanson Class of 2021 for keeping me on my toes throughout their high school careers and for their participation in countless formative assessments, surveys, and interviews during my time working through the MSSE program. Y'all are weird.

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Thank you finally to the STEAM Team. Thanks to my elementary coworkers, Kris, Rick, Jocelyn, Julie, and Josh, who exposed me to this curious, passionate, loud group of K-5 students who were so excited about every activity we brought for them and reminded me that children are natural scientists. We just have to not squash the wonder out of them.

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ABSTRACT

This study examined the relationship between students' science identity and their teacher's science teacher identity, as well as the influence of teacher confidence and understanding of Next Generation Science Standards and three-dimensional science teaching and learning on science teacher identity. Teacher and student surveys were used to evaluate correlation, while observations and interviews were used to understand the relationship between teacher confidence and science teacher identity. Results showed that there is little correlation between strong science teacher identity and strong student science identity, but there is a relationship between teachers' understanding of Next Generation science teaching and learning and overall science teacher identity. Teachers who have a solid background in science content knowledge and science pedagogy, especially three-dimensional science teaching based on the framework for the Next Generation Science Standards, tend to better see themselves as science teachers.

CHAPTER ONE

BACKGROUND

Context of the Study

This study took place at Hanson School District in Alexandria, South Dakota. In the 2020-2021 school year, there were 411 students enrolled in grades pre-kindergarten through 12th grade; all students are housed in one building. A majority of students were white (94%) with only a few students who were reported as mixed race or of American Indian/Alaska Native descent. Nearly sixteen percent of the district qualifies for free and reduced lunch, with a majority of students coming from the elementary school, where the rate is 22.8% (South Dakota Department of Education, 2020).

At the time the study took place, I had been teaching middle and high school science for six years, all at Hanson School District. During most of these years, I taught between 90-100 students in six different classes. During this time, most graduating students had taken at least three science classes with me.

Despite being the high school science teacher, this study actually focused on elementary and middle school students. In the elementary, there were 155 students enrolled in grades kindergarten through fifth grade. The middle school, which includes grades sixth through eighth, had an enrollment of 103 students. Students in elementary have a main classroom teacher, while middle school is departmentalized in which students move from teacher to teacher for each subject.

Rational for the Study

Teaching multiple science courses in a small district has allowed me to develop strong relationships with most of my students. During my six years of teaching, most of my students took at least three year-long science courses with me. However, despite knowing my students well and developing strong teacher-student relationships, I consistently had a small number of students who simply did not see themselves as science students, which prevented them from being successful in the science classroom.

Even among my students who were considered academic achievers, I noticed that many of them were timid in the science classroom. They wanted to be certain that I told them the correct answer and that they could regurgitate the correct answer on a given assessment, rather than being confident that they could problem solve or apply their understandings to new situations. As someone who was interested in the shift toward the Next Generation Science Standards (NGSS) and three-dimensional (3D) science teaching in learning, I wondered if their academic success was dependent on their ability to learn quickly and memorize, rather than develop deep understanding of concepts. Other students simply conceded defeat upon walking into my class and said there was no point, as they had never been good at science and never would be.

In the spring of 2018, the district's elementary principal approached me with a new challenge. With funding available, he asked if I would be interested in helping to form the Hanson STEAM Team. The program would meet twice a month and be a free opportunity for K-5 students to engage in science, technology, engineering, art, and math (STEAM) activities. I, along with three other elementary teachers, would lead activities

in an effort to keep elementary students excited and engaged in STEAM. He anticipated that 30-40 students would sign up, and we were pleasantly shocked to have almost 100 students attend our first sessions that spring.

Being trained in secondary education methods and having spent the previous four years interacting with sarcastic and sometimes apathetic teenagers made me nervous to spend time with much younger students. I was uncertain when it came to designing projects and activities for them, as I didn't know their previous science background, their skill levels, or even their confidence.

Thankfully, I had few reasons to be nervous. Our STEAM Team sessions went phenomenally; students were excited, engaged, and curious about all of the topics we covered. They participated in all of our activities with questions and enthusiasm, and often went home to tell their families what exciting thing they had done that day.

This significant difference between my STEAM Team participants and my high school students brought up many questions. Why were the STEAM Team participants so enthusiastic, while my high school students were often so difficult to engage? The elementary-aged students seemed to have a natural curiosity and willingness to take risks. They saw themselves as scientists when my high school students seemed to have already made the decision that they were most certainly not science people. I began to wonder, how do students develop a science identity? Do demographic factors influence the development of science identity? Is age or grade band a factor? Could STEAM Team help students develop stronger science identities, and could those identities be maintained until these students came into my classroom as high school students?

The COVID-19 Pandemic

In 2020, the coronavirus pandemic began, forcing my school and others across the United States to make changes to the structure of our educational systems. Once we were allowed to return to learning in-person, group work was abolished, sharing supplies was shunned, and students and staff were asked to mask up and protect each other from a dreadful new virus. Because of this, the difficult decision was made to not have STEAM Team during the 2020-2021 school year. This meant that STEAM Team could no longer be used as a variable in this study, and instead, my research shifted to focus on the role that teachers play in the development of their students' science identities. In particular, I began to wonder if elementary teachers outside of the STEAM Team coaches saw themselves as science teachers and if they felt confident in their ability to teach science. I was curious if their own science teacher identity would impact their students' science identities.

Focus Questions

My focus question was, Does science teacher identity have an effect on students' science identity?

My sub-questions include the following:

1. Does student science identity correlate with science teacher identity? Do teachers who see themselves as science people have students who develop stronger science identity?

2. Does teacher confidence and understanding in NGSS and 3D science teaching correlate with stronger science teacher identity?

CHAPTER TWO

CONCEPTUAL FRAMEWORK

Science Identity

Science identity is described as a set of meanings that define a person's self. These meanings can come from a person's roles, group memberships, or characteristics that make the person a unique individual. Science identity focuses on an individual's role as a student, particularly whether or not someone sees themselves as a science person. A student who thinks of themselves as a science person has developed a science identity; they will typically act in ways that convey this to themselves and to others around them and see themselves as very good science students (Stets et al., 2009). The writers of the *Framework for K-12 Science Education* recognized the importance of science identity, stating that "learning science depends not only on the accumulation of facts and concepts but also on the development of an identity as a competent learner of science with motivation and interest to learn more (National Research Council, 2012).

Development of Science Identity

Development of a science identity does not happen automatically as a student enters school. Three conceptualizations that drive students' development of science identity have been described. First, students must develop a sense of community and feel affiliated with the science community; students who are unable to do so may feel alienated from science. Second, students' science identity must be built by factors that are

intrinsic, such as interest, and extrinsic, such as their belief that science has value. Students must believe themselves capable and have science self-efficacy in order to develop science identity. Inconsistency in these factors inhibits development of a strong science identity; students who are interested in science but do not see themselves as capable "science people" are less likely to pursue further science experiences for themselves. Finally, students must see similarities between the science they do in school and "real world" science. If students do not see the science that they do in school as applicable or similar to real science, or if they fail to see themselves represented as scientists, a mismatch is created that prevents the development of science identity (Vincent-Ruz & Schunn, 2018).

The development of science identity cannot occur without developing an understanding for content knowledge. A research and pedagogical framework has been developed based on this idea, Content Learning and Identity Construction (CLIC). When students are exposed to rigorous, thoughtfully crafted instruction, and they see themselves as successful in the class, they are likely to form strong identifications with such disciplines, including math and science (Varelas et al., 2012).

However, identities are rarely static and consistent. Research on science identity often focuses on assimilation of minority groups into the culture of science. Because identity is dynamic and dependent on the interaction, identity can be portrayed and interpreted differently in various contexts. Not only must a person want to become a science person and eventually see themselves as a science person, they must be socialized into the culture of science. This could include learning accepted behavioral norms and

methods of science discourse, but also the integration of current cultural beliefs and identities into their new science identity. Therefore, it must be recognized that identity is fluid and dependent on a variety of factors (Brown, 2004).

Changes in Science Identity Over Time

Even if students are able to successfully see themselves as science people, and their classmates and teachers recognize them as science people, identity is fluid and can change as a student matures. The transition from elementary to middle school often results in many changes in a student's identity, including their science identity. Students often have significant decreases in their interest in science, as well as their motivation and engagement in science classes (Vedder-Weiss & Fortus, 2010, 2011). Additionally, when students are not exposed to continuous rigorous science instruction, they may not retain their strong science identity, even when their grades appear to show success in science (Carlone et al., 2014).

Factors that Influence the Development of Science Identity

There are specific variables that can determine which students are most likely to develop a science identity. A 2019 study examined the relationship between variables such as participants' childhood science, technology, engineering, and mathematics (STEM) related experiences, their STEM identity in college, and their college career intentions. By surveying students enrolled in required College English courses, rather than STEM courses, the authors captured the expected variation between students who were pursuing STEM degrees and students who were not. After controlling for home

environment, gender, and other relevant factors such as parent education level, variables that stood out as predictive measures of having a well-developed STEM identity in college were talking with friends and family about science and consuming science or science-fiction media (Dou et al., 2019).

Students also have differences in access to such STEM experiences. Students who do well in science courses or have parents who work in a science field tend to have greater science capital, which provides them more access to informal science experiences. Informal science experiences, such as going to zoos or science museums, were much more likely to be accessed by students in affluent families. However, everyday science experiences, such as tinkering during childhood, talking with friends and family about science, and consuming science or science-fiction media are low- or no-cost alternatives that can be used to develop science identity in students from diverse socioeconomic backgrounds (Dou et al., 2019).

Since science identity is fluid, it is possible that certain interventions or experiences during a particular time period of a student's life may be effective only in the short term, or would have been more effective if offered at a different time period of the student's life.

Science Teacher Identity

Just as students bring their multifaceted and fluid identities into the classroom, so do their teachers. While secondary teachers tend to have undergraduate or even graduate degrees in their content areas, many elementary teachers have little formal science education after they graduate high school (Plumley, 2019). Teachers bring with them

their own lived experiences as they prepare for teaching. Many preservice elementary teachers report negative feelings about teaching science, which can range from apprehension or uncertainty to outright dislike. These often stem from negative childhood experiences in science classes, which reinforces the vision of the kind of teacher that preservice teachers don't want to be, but does not help clarify their vision of what a good science teacher does look like (Canipe, 2016). Because of this, many elementary teachers do not see themselves as science teachers and lack confidence teaching science (O'Sullivan, 2019).

For example, South Dakota developed a leadership program called SDMath SDSci which was designed to develop teacher leaders and improve science and math experiences for K-12 students. The invitation to apply for the inaugural cohort of this program was sent out to and addressed to K-12 math and science teachers. In this cohort of 20 individuals, only three applicants who were accepted were teachers in grades K-5. Many outstanding teacher-leaders did not apply for this program simply because they did not see themselves as math or science teachers, but rather as elementary teachers who happen to teach all content areas. After the first cohort, the phrasing of the invitation was changed to K-12 teachers of math and science and an intentional effort was made to recruit and refer elementary teachers. In the following three years, the number of elementary teachers who finished the program grew to six, six, and seven in each cohort of 20 (Reiner, 2021).

This lack of science identity is increased when teachers begin shifting to a three-dimensional method of science teaching and learning, which they may not have been

exposed to as learners and have not yet been adequately trained on how to shift from "traditional" science teaching to three-dimensional science teaching. A well-designed methods course can shift preservice teachers' visions so they are better aligned with an inquiry-based approach to teaching science, especially the three-dimensional style of NGSS (Canipe & Coronado Verdugo, 2020). Unfortunately, not all preservice teachers receive such well-designed instruction and not all veteran teachers are given access to or encouraged to attend professional development in three-dimensional science teaching and learning. This leaves teachers wanting to be competent and engaging science teachers without the resources or knowledge to do so.

CHAPTER THREE

METHODOLOGY

Study Participants

This chapter describes the design of this study and the research procedures used. The context of the study is a rural, K-12 school district. In order to increase the available participants, requests to join the study were also sent to other districts in South Dakota. Research participants included K-12 science teachers and students. A total of 220 students and nine teachers completed the survey, several of whom participated in interviews. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for work with human subjects was maintained (Appendix A).

Mixed Methods Case Study

This study used a mixed method case study approach. To determine if correlation existed between student science identity and science teacher identity, two surveys were utilized. After initial science identity data collection, two teachers were selected for teacher interviews and classroom observations. Of the willing teachers, Mrs. O. and Mrs. B. were selected as the case study participants. Due to the ongoing COVID-19 pandemic, Mrs. B. had to back out of classroom observations, but was still able to participate in an interview via Zoom. Both teachers' interviews and the Mrs. O's sample of classroom observations were recorded, transcribed, and used to support quantitative conclusions.

Data Collection Instruments

The Science Teacher Identity Survey (STIS) was administered to nine teachers of grades pre-kindergarten through 12th grade (Appendix B). The survey used Likert-style questions to gain an understanding of teachers' confidence in teaching science, their enthusiasm for science, and their classroom practices for teaching science. In addition to science teacher identity questions, the STIS asked teachers to rate their confidence and comfort with NGSS and 3D science teaching and learning. To analyze the STIS, the Likert scale was converted to a point value system, where strong agreement to a positive statement was worth four points, agreement was worth three points, disagreement was two points, and strong disagreement was worth one point. For statement that acted as negative stimuli, the points system was reversed so that strong agreement to a negative statement would be worth only one point toward the respondent's overall science teacher identity. For classroom practices, a teacher who said that they always allow their students to question and wonder received four points, whereas a teacher who selected never would receive only one point. The point values were averaged for an overall science teacher identity score. These scores were categorized into three groups. A score of 3.0 or higher was considered a strong science teacher identity. A score between 2.0 and 2.99 was considered moderate, and below 2.0 was considered weak. The results were analyzed and reported using scatter plots and histograms. Open-ended questions were analyzed for common themes.

Of the nine teachers surveyed, six of them also surveyed their students. To measure students' science identity, the Student Science Identity Survey (SSIS) was

administered to students in several classrooms ranging from pre-kindergarten to high school (Appendix C). The SSIS asked students to rate their agreement with statements about their enjoyment for science and their beliefs about their science abilities using a Likert scale. The Likert scale included the choices strongly agree, agree, disagree, and strongly disagree. No neutral choice was included. The SSIS included positive and negative stimuli so that respondents were more likely to evaluate each statement individually, rather than select uniform agreement or disagreement to all statements. To analyze the SSIS, the Likert scale was converted to a point value system, where strong agreement to a positive statement was worth four points, agreement was worth three points, disagreement was two points, and strong disagreement was worth one point. For statement that acted as negative stimuli, the points system was reversed so that a student who strongly agreed that most of their classmates are better at science than them would only receive one point toward the respondent's overall science identity. An average science identity score of 3.0 or higher was considered a strong science identity. A score between 2.0 and 2.99 was considered moderate, and below 2.0 was considered weak. Once scored, the quantitative results were analyzed and reported using scatter plots and histograms. Open-ended questions were analyzed for common themes.

In order to deeply understand how the relationship between Mrs. O's science teacher identity, her understanding of NGSS, and her classroom practices, the Checklist of Science Education Practices for Classroom Observations was used (Appendix D). This list included several science education practices to watch for and the researcher tallied the number of times they occurred in each lesson (Appendix D). These practices included

allowing students to engage with a phenomenon, letting student questions drive instruction, and creating and using models. Mrs. O. selected two lessons to video record and teacher-student dialogue was transcribed. Lesson dialogue and practices were analyzed for common themes.

Teacher Interviews were also used to support quantitative results of this study. Both teachers were asked about their familiarity with NGSS and 3D science teaching and learning practices, their general science teacher background, and their students' science identities and their own science teacher identity (Appendix E). These interviews were recorded, transcribed, and analyzed for common themes. Together, all these data collection instruments were used to answer the focus questions (Table 1).

Table 1. Triangulation matrix.

	Focus Questions	
Data Source	Does student science identity correlate with science teacher identity?	Does teacher confidence and understanding in NGSS and 3D science teaching correlate with stronger science teacher identity?
Student Science Identity Survey	X	
Science Teacher Identity Survey	X	X
Teacher Interviews	X	X
Classroom Observations		X

CHAPTER FOUR

DATA ANALYSIS

Variation in Student Science Identity

The results of the Student Science Identity Survey showed that most students have a moderate science identity with 163 students scoring between 2.00-2.99 (*N*=219). Forty-six students identified as having a strong science identity with a score greater than 3.0 and only ten students identified as having a weak science identity with scores less than 2.0. As shown in Figure 1, their scores somewhat follow a typical bell curve. When asked if they saw themselves as science people, one student with a strong science identity said, "Yes, I do think of myself as a science person because I am good at science and I hope it will help me later on in life," while another said, "Yes, it's definitely a passion in my life. I'm planning to go into a science related field whether it's research or a medical practice." Of the students with moderate science identities, only 35 of them agreed that they saw themselves as science people. Students with lower moderate scores were more likely to say no, while those who said maybe or yes were on the higher end of the moderate range. When asked why or why not, one student with a weak science identity simply said, "Not smart enough."

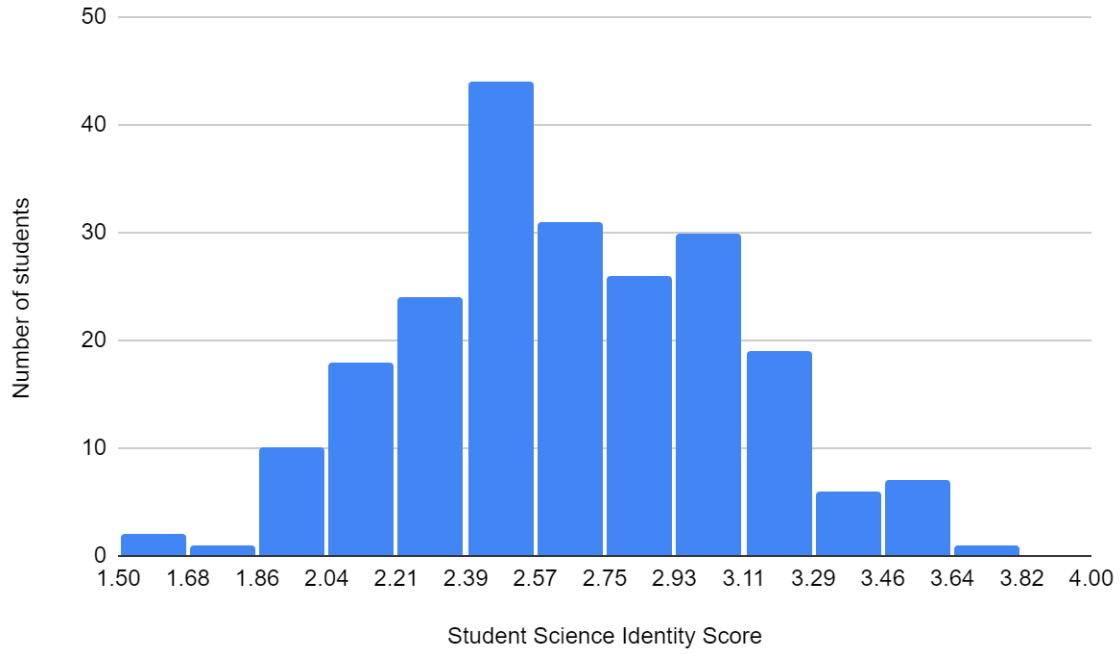


Figure 1. Histogram of student science identity scores, 1.0 being the lowest possible score and 4.0 being the highest, *N*=219.

Variation in Science Teacher Identity

Teachers also exhibited variation in their science teacher identity scores, as well as within the three subcategories of the Science Teacher Identity Survey. Of the nine teachers surveyed, five had strong science teacher identities and the remaining four were moderate. The average scores and ranges among each subcategory were similar, with Classroom Practices & Attitudes having a slightly higher score than the other two subcategories, 3.31 compared to 3.11 and 3.10 for Teacher Confidence & Values and Teacher Perceptions of Students' Science Identity, respectively. Classroom Practices also had a slightly smaller range with the highest score being a 4.0 and the lowest a 3.0 (Table 2). One 4th grade teacher said that since shifting from teaching science just a few days a

week to teaching science every day, her confidence was growing and her students were showing better engagement in their science lessons. Another teacher said that her survey responses were topic dependent; for example, she was more confident in her content knowledge and knowing her state science standards for Life Science and Earth and Space Science than for Physical Science.

Table 2. Teacher science identity subcategory and overall scores, 1.0 being the lowest possible score and 4.0 being the highest.

Teacher	Grade(s) Taught	Teacher Confidence & Values	Teacher Perceptions of Students' Science Identity	Classroom Practices and Attitudes	Overall Science Teacher Identity Score	Score Category
Mrs. B.	7-8th	3.86	4.00	4.00	3.93	Strong
Mrs. C.	4th	2.57	3.00	3.20	2.93	Moderate
Mrs. E.	3rd	3.29	3.00	4.00	3.33	Strong
Mrs. O..	5th	2.86	2.67	3.00	2.73	Moderate
Mrs. S.	9-12th	3.86	3.00	3.00	2.87	Moderate
Mrs. T.	7-11th	2.71	3.33	3.20	3.27	Strong
Teacher A	Pre-Kindergarten	3.00	2.67	3.00	2.80	Moderate
Teacher B	1st	3.00	3.33	3.20	3.07	Strong
Teacher C	Kindergarten	2.71	3.00	3.20	3.07	Strong
Range in scores		1.29	1.33	1.00	1.20	
Mean scores		3.10	3.11	3.31	3.11	

Correlation Between Students' Science Identities and Teacher's Science Teacher Identity

Of the nine teachers surveyed, six of them administered the SSIS to their own students, which allowed for comparison between the six teacher-classroom sets of data. There is little significant correlation between teachers' science teacher identity scores and their students' science identity scores. Figure 3 below shows a scatter plot that pairs

students' scores with their teacher's. Variation among the six teachers is clear, with a row of points at each teacher's teacher science identity score, but the range for students' scores on the x-axis is similar across all six groups. Teachers who surveyed a larger quantity of students had slightly larger ranges for their students' scores.

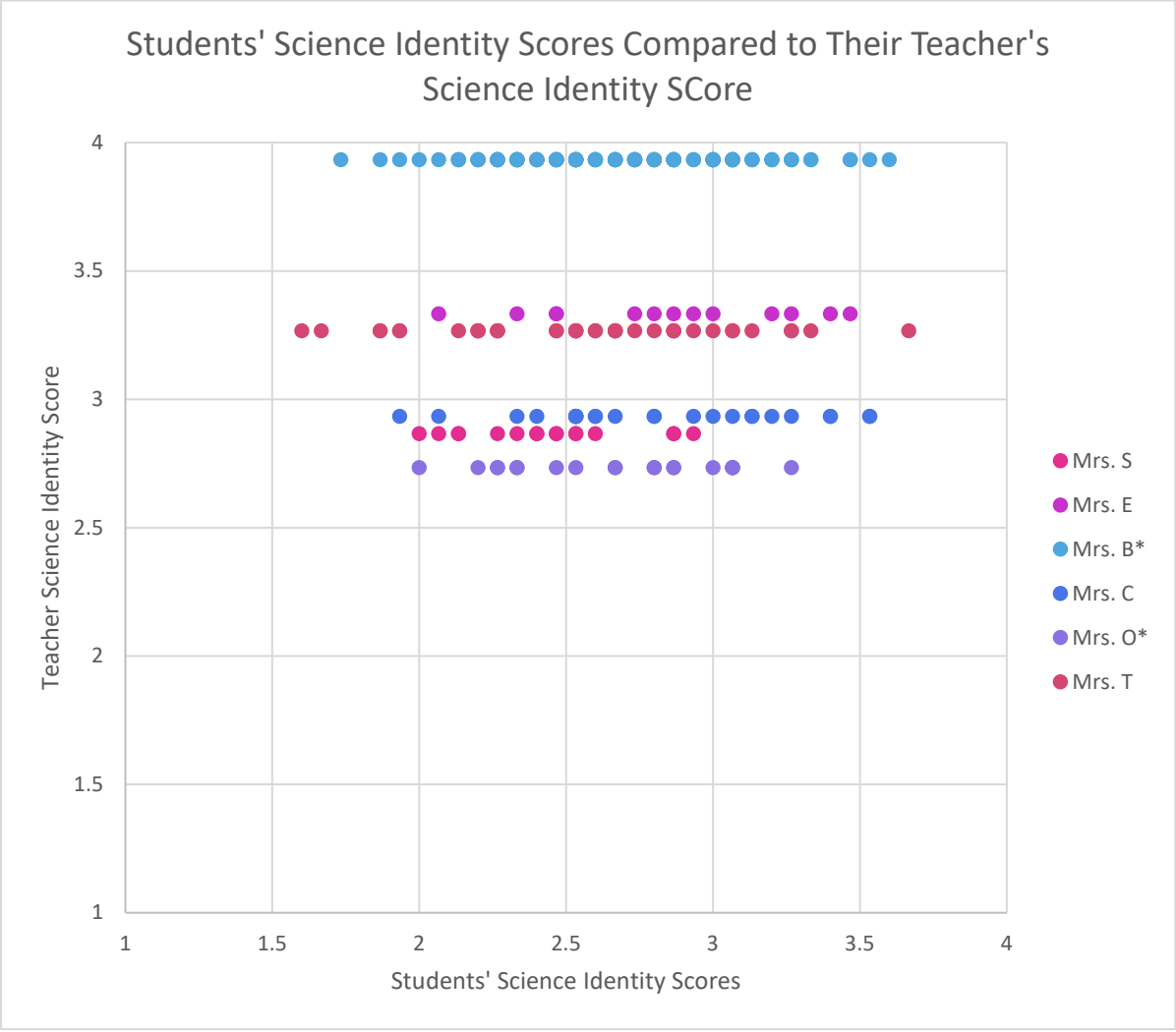


Figure 2. Scatter plot displaying correlation between students' SSIS scores and teachers' STIS scores, 1.0 being the lowest possible science identity score and 4.0 being the highest, (*N*=219). *Mrs. B. and Mrs. O. were selected as primary participants in the case study observations and interviews.

Teacher Confidence and Understanding of 3D Science Teaching and Its Influence on Science Teacher Identity

The second focus question of this research was, does teacher confidence and understanding in NGSS and 3D science teaching correlate with stronger science teacher identity? A subsection of the STIS focused on Teacher Confidence & Values and asked teachers to rate their confidence planning their own science lessons and their familiarity with NGSS and 3D science teaching and learning. Figure 4 paired teachers' scores for the Teacher Confidence & Values subsection with their overall Science Teacher Identity score. In this figure, a positive correlation can be seen, which is emphasized by the data point from Mrs. B., who had a very strong science teacher identity overall (3.93) and a very thorough understanding of NGSS and 3D science teaching and learning practices (3.86). Comparatively, Mrs. O. is the lowest point on this figure, with a moderate science teacher identity (2.73) and a moderate score in the Teacher Confidence & Values subsection (2.57) (Figure 3). Mrs. O. said she was familiar with South Dakota's science standards, but very unfamiliar with the practices behind NGSS and the concept of 3D science teaching and learning.

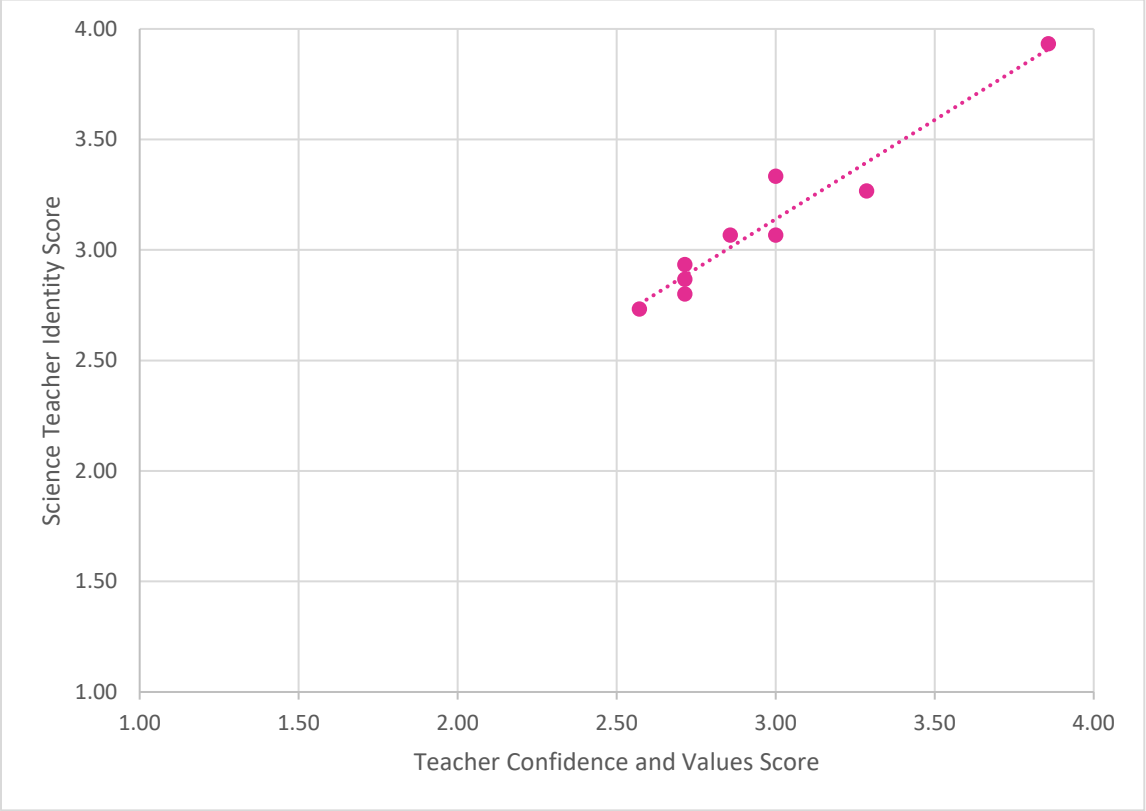


Figure 3. Correlation between teachers' scores on the Teacher Confidence and Values subsection and their overall Science Teacher Identity scores from the STIS, 1.0 being the lowest possible science identity score and 4.0 being the highest, (*N*=9).

Case Study Interviews and Observations

This survey data aligns with themes from each teacher's interview and from Mrs. O's recorded lessons. Both teachers had similar ranges for their students' science identity scores, but Mrs. O. had a weaker science teacher identity and less confidence in her science teaching abilities than Mrs. B. For context, Mrs. O. teaches self-contained 5th grade and Mrs. B. teaches departmentalized middle school science to 7th and 8th graders.

Mrs. O.

When asked to be interviewed and recorded, Mrs. O. said, “I’m not exactly a knock-your-socks-off science teacher.” She said that her students were curious and active thinkers and she always allowed them to ask questions and wonder during class, but they rarely “talked science” outside of science class. When asked about the South Dakota Science Standards, she knew that they were adopted relatively recently but said in her survey that she was unaware that they were closely based on NGSS or what the three dimensions of NGSS were and how they should be used in 3D science teaching and learning.

In her recorded lessons, Mrs. O. checked most of the criteria in the category Traditional Science Teaching & Learning Practices, but only a few under Next Generation 3D Practices (Figure 4). She began the lesson with her teacher edition textbook on her lap, instructed her students to join her on page 530, and asked them to note the yellow-highlighted vocabulary words of this lesson. The lesson consisted mostly of reading and discussing the lesson directly from the textbook, but did include several opportunities for students to share their ideas or current understandings of what a mixture or solution is and how their components could be separated. In particular, several students were very engaged when sharing how their families’ pool filters worked.

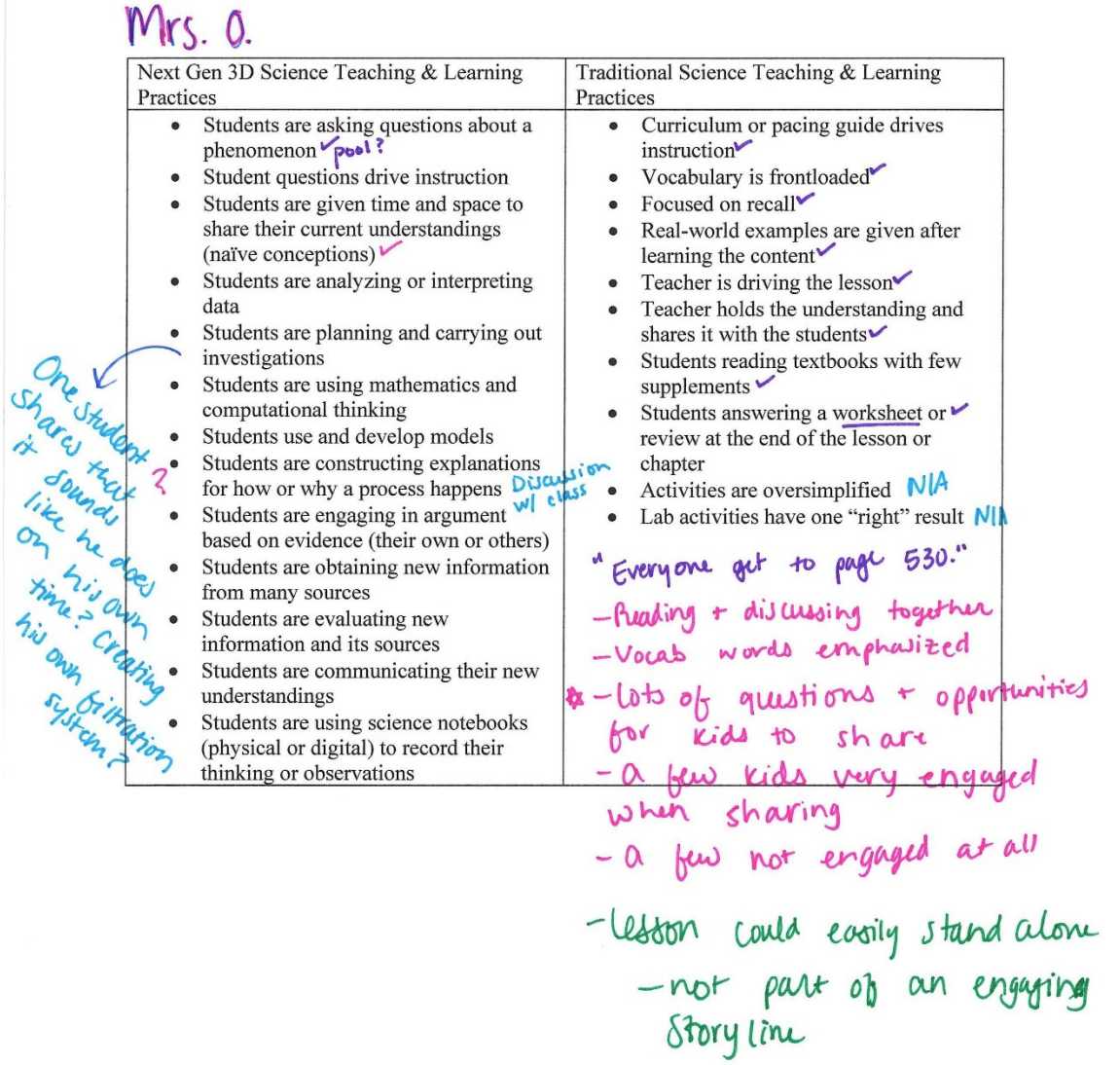


Figure 4. Checklist of Science Education Practices for Mrs. O's recorded lessons.

Instead of allowing her students to engage with phenomena at the start of the lesson, Mrs. O's curriculum provided several examples of the ideas they were discussing as they read. For example, after reading a paragraph on colloids, students looked at pictures of mayonnaise and other examples. The vocabulary was front-loaded at the beginning of the lesson rather than discovered organically by the students. Mrs. O. acted as the keeper of the knowledge and the leader of the lesson.

The district curriculum drove Mrs. O's instruction, rather than students' questions. The topic of her recorded lessons was mixtures, solutions, and how to separate the components of a mixture, which is not directly tied to a 5th grade South Dakota science standard at all. This lesson was a stand-alone lesson, rather than part of an engaging storyline tied to real-world phenomena.

Mrs. B.

Mrs. B. had the highest science teacher identity score, but did not always know that education was in her career path. Prior to becoming a science teacher, Mrs. B. had a master's degree in wildlife and fisheries. She always had a passion for biology, but said that "the lack of being able to share my knowledge and passion in outdoor education" tore her away from the field and eventually led her to teaching.

Mrs. B. was unable to provide video lessons, but gave an explanation of what a typical unit might look like in her classroom. She often begins by assessing her students' prior knowledge through a writing or modelling prompt. This allows her to meet students where they are, based on the depth of knowledge that they already have. Sometimes, her students are given some background vocabulary, but other times, the vocabulary is meant

to be discovered. Mrs. B. would prefer for students to engage with a phenomenon or explore their ideas through activities, then use their own questions and wonders to lead them into the content she is teaching. A lesson like this would check many of the practices I was looking for in the Checklist of Science Education Practices.

She also explained in her interview that the reason her Teacher Confidence & Values score was high is because she sat on the board that helped write the South Dakota Science Standards which are aligned in content and vision of the NGSS. She demonstrated a thorough understanding of the *Framework for K-12 Science Education* and gave examples of how she tied the cross-cutting concepts, science and engineering practices, and disciplinary core ideas into each of her lessons. Her classroom culture of figuring out instead of learning about keeps students engaged when so much information is readily available at their fingertips in the form of the internet.

Contrasting Science Teacher Identities

Mrs. B. demonstrated a strong science teacher identity through her survey and interviews, while Mrs. O. relied heavily on her district's curriculum for her recorded lessons. Mrs. O. also said that earth and space and life sciences were more comfortable for her to teach, while physical science was challenging and intimidating. Mrs. B. had a background in biology but gave several examples of engaging lessons that she teaches in physical science courses. Mrs. B's natural curiosity about the world around her and her desire to get students to demonstrate wonder and awe help her students engage in real science practices and develop relevant understandings. Mrs. O. seems to want her

students to do the same things, but she is lacking the tools and understandings to get her students there.

CHAPTER 5

CLAIM, EVIDENCE, AND REASONING

Claims From the Study

There is a clear contrast between the science teacher identities, confidence, and classroom practices of Mrs. B. and Mrs. O. Mrs. B. described using marble roller coasters and engaging exploration to allow students to discover and figure out content; Mrs. O. used a ready-made curriculum to tell her students what she needed them to know and then assess their ability to recall the information. These teachers' identities encompass their own school experiences, their content knowledge, their comfort and confidence in teaching science, and these identities influence how they choose to teach science and develop the science education foundation of K-12 students.

Despite the lack of correlation between science teacher identity and student science identity, I still believe it is important to continue developing science teacher identity, particularly at the elementary level. Teachers who see themselves as science teachers are more likely to engage in professional development to become better science teachers, which will improve the overall quality of our students' science experiences in all grades, not just at the upper grades. When teachers are confident, engaging, and excited about their content area and the pedagogy supporting it, students are more likely to trust the teacher and engage in lessons, which helps develop their own science identity and reduces the gap between students with strong science identities and those with

weaker science identities. There will always be diversity within students' identities, but all students should see themselves as capable science learners.

Remaining Questions

As I began to understand the challenges of developing teachers' science teacher identities, I began to wonder about the cumulative effects on K-12 students. If students consistently had teachers who had strong science teacher identities throughout their formative elementary school years and on into high school, would their science identities be stronger? Would science identity become a common trait among students' diverse identities, rather than something that some students have, and some do not? Perhaps if students were consistently exposed to confident, capable science teachers, they would walk into my classroom in 9th grade and already have the knowledge and mindset to be successful.

Thinking about my own high school students, I continue to wonder if there is a particular grade or grade band that we should focus on in order to best improve science outcomes for K-12 students. At what age are students shifting from the excited, curious learners that I have in STEAM Team sessions to the discouraged, disinterested or apathetic students that I have in my high school classes? If there is an age group that is particularly at-risk, we should focus on providing quality professional development and resources to teachers of these students.

Connecting Findings with Personal Experience

In my experience, students who see themselves as science people tend to believe that they will be successful, which produces a self-fulfilling prophecy. They are confident enough to ask deeper questions during lessons, which develops a more thorough understanding of the topics we cover. This allows them to form stronger connections to the content in their mental schema, which gives them the ability to show mastery of complex topics on assessments. The importance of developing students' science identity when they are young and continuing to improve their science identity even in their high school years cannot be understated when we look at which students are most successful in rigorous science courses.

Considerations for Further Research

In future research, I would like to separate the Confidence & Values subsection of the Science Teacher Identity Survey into their own parts. If we specifically want to understand the impact of NGSS and 3D science teaching and learning, those variables need to be teased apart even further to better understand which parts of NGSS teachers understand, how their curriculum influences what they teach and what their classroom practices look like, and how teachers envision their students doing science. This will provide a clearer picture of what parts of science education are working and where money and time should be invested to make improvements.

Improvements to the study could include a larger sample size, perhaps limited to elementary teachers, rather than comparing an elementary teacher to a secondary teacher. This could provide more detailed insight into how much variation in science teacher identity exists within the elementary teacher population and inspire additional questions

on what influences the development of their science teacher identity and what resources, training, and experiences can help them develop stronger science teacher identities.

Impact of Action Research on the Author

In her interview, Mrs. B. was asked if she thought that the shift toward three-dimensional science teaching and learning would create better outcomes for students and I was surprised that she answered no. At the high school level, she said absolutely, science teachers are shifting their practices and expectations and this will help students' performance improve. At the elementary level, Mrs. B. expects that teachers will balk at being asked to change their practices or be fearful of making mistakes without the necessary support. To her, this means that remediation falls on her as a middle school teachers. When students come into her classes without a strong science foundation, she is forced to spend time covering content knowledge and skills that students should have learned in previous grades.

I understand Mrs. B's fears, but I also believe that this tells us more about where our efforts should be focused. Elementary science education was high on the priority list when my cohort on the South Dakota Department of Education Science Advisory Council first met. We want students actively engaging in rigorous science throughout all grade levels. In order to do that, school systems must recognize the value of science education at all grade levels and provide funding and time for teachers to collaborate across grade levels. By doing this, we will continue support teachers across all grade bands so that they can provide such rich science experiences and see themselves as science teachers.

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APPENDICES

APPENDIX A

IRB EXEMPTION

MONTANA STATE UNIVERSITY

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MEMORANDUM

TO: Alison Bowers and John Graves

FROM: Mark Quinn Mark Quinn CJ
Chair, Institutional Review Board for the Protection of Human Subjects

DATE: November 24, 2020

RE: *"Teacher Confidence and Classroom Practices: A Case Study on Science Identity" [AB112420-EX]*

The above research, described in your submission of November 24, 2020, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

__X__ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

__X__ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation; and (iii) the information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by section 16.111(a)(7).

____ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

____ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

____ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

____ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX B

SCIENCE TEACHER IDENTITY SURVEY

Science Teacher Identity Survey

This survey will ask you about your confidence teaching science, your teaching style, and your perceived conceptions of students' science identities. There is minimal risk taking this survey and you are free to stop at any time. Thank you for taking the time to respond to this survey!
* Required

1. What grade(s) do you currently teach science to? *

Check all that apply.

- [ ] Pre-K / Kindergarden
- [ ] 1st
- [ ] 2nd
- [ ] 3rd
- [ ] 4th
- [ ] 5th
- [ ] 6th
- [ ] 7th
- [ ] 8th
- [ ] 9th
- [ ] 10th
- [ ] 11th
- [ ] 12th

2. Which best describes your teaching arrangement? *

Mark only one oval.

- ◯ I am a classroom teacher and I teach all content areas to one grade level, including science.
- ◯ I am departmentalized. I teach one or two content areas (including science) to many groups each day.
- ◯ I pull out small groups of students for Title, SPED, Speech, or other lessons, including science help.
- ◯ I do not teach any science.

Teacher Confidence & Values

This section asks you about your familiarity with NGSS and the South Dakota Science Standards (which are based on NGSS), and about your science and classroom values.

3. I am confident in my science content knowledge for my current grade level. *

Mark only one oval.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Agree
- ◯ Strongly agree

4. I am confident teaching science at my current grade level. *

Mark only one oval.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Agree
- ◯ Strongly agree

5. I do not see myself as a science teacher. *

Mark only one oval.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Agree
- ◯ Strongly agree

6. I am passionate about teaching science. *

Mark only one oval.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Agree
- ◯ Strongly agree

7. At my grade level, I think science is *

Mark only one oval.

- ◯ not important.
- ◯ important, but less important than other content areas.
- ◯ as important as other content areas.
- ◯ more important than other content areas.

8. I know my grade level's science standards well. *

Mark only one oval.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Agree
- ◯ Strongly agree

9. I am uncomfortable writing my own science lessons. *

Mark only one oval.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Agree
- ◯ Strongly agree

10. I understand the three dimensions of NGSS (and the South Dakota Science Standards). *

The three dimensions are the Science and Engineering Practices (SEP's), Cross-Cutting Concepts (CCC's), and the Disciplinary Core Ideas (DCI's). If you've never heard of these, please mark "Strongly disagree."

Mark only one oval.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Agree
- ◯ Strongly agree

Student Science Identity

11. I think of my students as scientists in my classroom. *

Mark only one oval.

- ◯ Always
- ◯ Sometimes
- ◯ Rarely
- ◯ Never

12. My students see themselves as scientists or science students. *

Mark only one oval.

- ◯ Almost all of them do.
- ◯ Some of them do.
- ◯ A few of them do.
- ◯ None of them do.

13. My students "talk science" outside of science lessons. *

Mark only one oval.

- ◯ Always
- ◯ Sometimes
- ◯ Rarely
- ◯ Never

Classroom Practices and Attitudes

This section asks about what you do and see in the science classroom.

14. I encourage my students to be curious about the world around them. *

Mark only one oval.

- ◯ Always
- ◯ Sometimes
- ◯ Rarely
- ◯ Never

15. I allow my students to ask questions and wonder during class. *

Mark only one oval.

- ◯ Always
- ◯ Sometimes
- ◯ Rarely
- ◯ Never

16. I use phenomena and hooks to get my students excited about a science lesson. *

Mark only one oval.

- ◯ Always
- ◯ Sometimes
- ◯ Rarely
- ◯ Never

17. I use science notebooks so students can record their sensemaking and data collection. *

Mark only one oval.

- ◯ Always
- ◯ Sometimes
- ◯ Rarely
- ◯ Never

18. I use structured conversation strategies to encourage students to talk about their ideas and to make sense of a problem or phenomenon. *

Mark only one oval.

- ◯ Always
- ◯ Sometimes
- ◯ Rarely
- ◯ Never

19. When you think of students who see themselves as scientists or as science students, what qualities do those students have?

20. Is there anything else you'd like to share on this topic?

21. Would you be willing to share your contact information for a short follow-up interview? *

Mark only one oval.

- ◯ Yes
- ◯ No

Contact Information

If you selected "YES" and you are open to a follow-up interview, please submit your contact information below.

22. Name *

_____

23. School District *

_____

24. Preferred email address *

_____

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APPENDIX C

STUDENT SCIENCE IDENTITY SURVEY

Student Science Identity Survey

Answer the questions below as honestly as you can. This survey involves minimal risk to you and is not a part of your grade. You are free to stop at any time, but your responses are appreciated!

* Required

1. What is your name? *

   Mrs. Bowers won't share your information with anyone else, but she may want to ask you more questions later.

2. What grade are you currently in? *

   Mark only one oval.

   - ◯ 2nd
   - ◯ 3rd
   - ◯ 4th
   - ◯ 5th
   - ◯ 6th
   - ◯ 7th

Agree or Disagree

The next questions will ask if you agree or disagree with the statements, or how often you do certain things.

3. Learning science in school will help me to succeed later in life. *

Mark only one oval.

- Strongly disagree
- Disagree
- Agree
- Strongly agree

4. I can master the skills that are taught in my science classes. *

Mark only one oval.

- Strongly disagree
- Disagree
- Agree
- Strongly agree

5. I consider science topics interesting and engaging. *

Mark only one oval.

- Strongly disagree
- Disagree
- Agree
- Strongly agree

6. My peers and teachers think that I am knowledgeable in science. *

Mark only one oval.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Agree
- ◯ Strongly agree

7. When it comes to learning science, I think of myself as a science person. *

Mark only one oval.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Agree
- ◯ Strongly agree

8. I am certain I can figure out how to do the most difficult science class work. *

Mark only one oval.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Agree
- ◯ Strongly agree

9. My friends and family recognize me as a scientist. *

Mark only one oval.

- Strongly disagree
- Disagree
- Agree
- Strongly agree

10. I struggle with asking science questions. *

Mark only one oval.

- Strongly disagree
- Disagree
- Agree
- Strongly agree

11. It is important to me that I look smart in my science class. *

Mark only one oval.

- Strongly disagree
- Disagree
- Agree
- Strongly agree

12. Most of my classmates are better at science than me. *

Mark only one oval.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Agree
- ◯ Strongly agree

13. One of my goals is to show others that I am good at science. *

Mark only one oval.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Agree
- ◯ Strongly agree

14. I am interested in reading websites, articles or watching TV programs, documentary movies about the science issues. *

Mark only one oval.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Agree
- ◯ Strongly agree

15. I like playing with science or building materials *

Mark only one oval.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Agree
- ◯ Strongly agree

16. I am interested in how complicated things work. *

Mark only one oval.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Agree
- ◯ Strongly agree

17. I don't like exploring outside or looking at plants and animals. *

Mark only one oval.

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Agree
- ◯ Strongly agree

18. Is there anything else you'd like Mrs. Bowers to know?

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APPENDIX D

CHECKLIST OF SCIENCE EDUCATION PRACTICES FOR CLASSROOM OBSERVATIONS

Next Gen 3D Science Teaching & Learning Practices	Traditional Science Teaching & Learning Practices
• Students are asking questions about a phenomenon • Student questions drive instruction • Students are given time and space to share their current understandings (naïve conceptions) • Students are analyzing or interpreting data • Students are planning and carrying out investigations • Students are using mathematics and computational thinking • Students use and develop models • Students are constructing explanations for how or why a process happens • Students are engaging in argument based on evidence (their own or others) • Students are obtaining new information from many sources • Students are evaluating new information and its sources • Students are communicating their new understandings • Students are using science notebooks (physical or digital) to record their thinking or observations	• Curriculum or pacing guide drives instruction • Vocabulary is frontloaded • Focused on recall • Real-world examples are given after learning the content • Teacher is driving the lesson • Teacher holds the understanding and shares it with the students • Students reading textbooks with few supplements • Students answering a worksheet or review at the end of the lesson or chapter • Activities are oversimplified • Lab activities have one “right” result

APPENDIX E

TEACHER INTERVIEW QUESTIONS

Interview Questions:

1. Background: Tell me a little about your science teaching experience.
2. What does teacher science identity mean to you?
3. What does science identity mean when you think about your students?
4. What factors help kids see themselves as scientists or science people, throughout their own lives or specifically in your classes?
5. What does a typical science lesson look like in your classroom? How comfortable are you with the NGSS 3D science teaching and learning style?
6. If you are pretty comfortable, how do you think 3D science teaching and learning will impact students' science identity?