AN EXPLORATORY QUALITATIVE STUDY OF SCIENCE TEACHERS’ INSTRUCTIONAL DECISION-MAKING IN RELATION TO “COHERENCE”

BY

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THESIS

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ABSTRACT

Teachers’ use of strategies to build coherent instructional sequences is important in student learning (Roth et. al., 2011). Previous studies investigated teachers’ ability to design or distinguish coherent instructional sequences. However, teachers’ ability to distinguish coherent instructional sequences in relation to their academic and teaching background needs to be studied further. Therefore, I conducted a qualitative exploratory study with 21 K-12 teachers using self-reported questionnaires and follow-up interviews to investigate teachers’ understanding of coherence, if teachers prefer coherent instructional sequences and their justifications for their selections. According to the findings, nine of the participants preferred the coherent instructional sequence in all questions, nine of the participants preferred the coherent instructional sequences in one of two questions, and finally three of the participants preferred the incoherent version in all questions. Findings showed the participants teaching K-2 grades were less likely to prefer coherent instructional sequences. Analysis of the exemplary cases revealed teachers’ academic and teaching experiences may contribute to teachers having a consistent understanding of coherence. Findings have implications for supporting teachers’ academic and teaching background via professional development so that teachers can have a more consistent understanding of coherence. Only one of the participants mentioned connections between the steps of the instructional sequence as a criterion in his instructional decisions. However, for both questions, the majority of the participants preferred coherent instructional sequences (12 participants for the 13th question and 15 participants for the 15th question). Therefore, teachers may implicitly consider coherence as a criterion in their instructional decisions.
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To my family
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CHAPTER 1: INTRODUCTION

Background and Statement of the Problem

The Next Generation Science Standards: For States, By States (NGSS) suggests what K-12 students are supposed to know or should be able perform in science. Prior to the release of the NGSS, science curricula in the U.S. were developed based on the Framework for K-12 Science Education, which was published by the National Research Council in 2012. The Framework for K-12 Science Education was designed according to current understandings of science teaching and learning: children learn new ideas by “both building on and refining prior conceptions” (NRC, 2012, p. 25); understanding develops over time so that learners need continued opportunities to develop their science ideas; science is not just composed of sets of facts to be learned and remembered, science also involves practices which help to elaborate and revisit/refine those facts; science is not the result of individual endeavor, science ideas proceed by collaboration with other scientists or other students; science education should be tied to learners’ previous experiences and interests; and finally all learners should be given “equitable opportunities to learn science and become engaged in science and engineering practices” (NRC, 2012, p.28)

NGSS was developed out of the Framework for K-12 Science Education. NGSS emphasizes three dimensions in science learning: science and engineering practices, disciplinary core ideas, and cross cutting concepts. Science and engineering practices are practices performed by scientists to discover our world and practices which engineers perform to build things. Disciplinary core ideas are the important ideas constructs in science which all people should know. Lastly, crosscutting concepts assist learners in seeing relations between four sub clusters of science: life science, earth science, atmospheric? science and engineering design.
NGSS suggests a classroom in which students utilize science ideas and engage in science and engineering practices to discover natural phenomena, and science storylines are tools to achieve this vision. Across the literature published mostly after NGSS was released, two dominant understandings of science storylines have been promoted: 1) an understanding of science storylines advocated by Hanuscin, Lee, Lipsitz, Arnone, and de Araujo (2015) (see also Hanuscin, Cisterna, & Lipsitz, 2018); Hanuscin, et al. (2016), and Lipsitz, Cisterna-Alburquerque, and Hanuscin (2017); 2) an understanding of science storyline advocated by Fortus & Krajcik (2012); Fortus, Sutherland Adams, Krajcik, and Reiser (2015); Reiser, Novak, and McGill (2017); Shwartz, Weizman, Fortus, Krajcik, and Reiser (2008). To be concise, I will call the former as Group A, and the latter as Group B in this remainder of this thesis.

According to Group B’s understanding (Reiser, Novak, McGill, 2017) a coherent storyline refers to an entire unit in which students engage in science and engineering practices to answer the questions that they derive from a phenomenon, so that each investigation (may) lead to the next one by generating more questions (Reiser, Novak, & McGill, 2017). According to Group A (Hanuscin, Lee, Lipsitz, Arnone, & de Araujo, 2015), coherent storylines refer to a single lesson or instructional sequence in which science ideas are ordered and connected to each other and to the instructional activities to assist students in developing a coherent ‘story’ which is meaningful to them (Hanuscin, Lee, Lipsitz, Arnone, & de Araujo, 2015). According to my understanding, Group A’s definition of coherent storylines is a subset of Group B’s understanding in terms of scope and level of complexity. Even though Group B’s understanding of coherent storyline is more compatible with the NGSS vision of storylines, Group A’s understanding is important too in the sense that they emphasize the connection between science ideas and the connection between science ideas and activities to support students’ development of a coherent story which are properties that must exist in NGSS aligned storylines. This study focuses on Group A’s
understanding of the storyline; however, findings will be also linked to Group B’s understanding. Also, in order to prevent confusion, I will use “coherent instructional sequences” when I am writing about Group A’s understanding and I will use “coherent storylines” when I am talking about Group B’s understanding.

Roth et. al. (2011) listed strategies to build coherent instructional sequences such as linking science content ideas and activities or linking science ideas to other science ideas. In this research study, Roth et. al. (2011) found that teachers’ use of these strategies to build coherent instructional sequence predicted students’ achievement in science. Therefore, it can be concluded that if teachers apply strategies to build coherent instructional sequences, student learning is improved.

According to previous studies, teachers have difficulties in developing coherent sequence of lessons (Ermeling & Graff-Ermeling, 2016; Hanuscin, Lee, Lipsitz, Arnone, & de Araujo, 2015; Hanuscin, et al., 2016; Plummer & Tanis Ozcelik, 2015; Wiebke & Park Rogers, 2014). In a study of mathematics teachers designing coherent lessons, Ermeling and Graff-Ermeling (2016) found that teachers focused on developing engaging activities rather than prioritizing building a coherent storyline which sets a clear relation between the learning goals and classroom activities. Hanuscin et al. (2016) investigated difficulties teachers encountered while they were designing coherent instructional sequences for their students and they found that most of the teachers had difficulty in building connection between activities at the conceptual level. Instead they were connecting those activities in a superficial and basic level, such as all activities are related to magnets (which is a broad topic). Hanuscin, Lee, Lipsitz, Arnone, and de Araujo (2015) found that “only 7 of the 33 teachers (21%) submitted lessons that exhibited coherence in terms of all activities aligning with a specific conceptual understanding that served as a central goal for the lesson” (p.8). However, none of the studies reviewed above compared teachers who
were able to develop coherent instructional sequences with those who were not in terms of their academic and professional backgrounds. Hanuscin et al. (2015) also found that when teachers were given two instructional sequences (one is coherent one is incoherent) 22 out of 33 teachers chose the coherent storyline. Again, there was no comparison between the teachers who chose coherent instructional sequences and teachers who chose incoherent instructional sequences in relation to their academic and professional background. Therefore, I am interested in investigating differences between teachers who preferred coherent instructional sequences and those who preferred incoherent instructional sequences in terms of their academic, teaching, and professional development experiences.

In the study conducted by Hanuscin, Lee, Lipsitz, Arnone, and de Araujo (2015), it was found that although most of the teachers (22 out of 33) preferred the lessons with coherence, they did not state coherence as criterion in their instructional decisions. Most often the participants stated that they chose this lesson over the other because it provided opportunities for student collaboration or it had hands-on activities. This is a critical issue, because as Bybee stated, “When translating those educational reform policies into teachers’ practical science teaching, their individual pedagogical decisions are the most uncertain factor regarding the success of those reform efforts” (Lee & Lin, 2005, p. 453). Therefore, in an effort to move science instruction towards a more coherent structure, understanding the place of “coherence” in teachers’ instructional decision is important. As a result, I am interested in learning whether or not teachers consider coherence of the lesson as a criterion in their instructional decisions.

**Research Questions**

Thus, this explorative qualitative study addresses the following two questions:
1) Are there differences between teachers who preferred coherent instructional sequences and who preferred incoherent instructional sequences in terms of their academic and teaching background?

2) Do teachers consider coherence as criterion in their instructional decisions?

In order to investigate these research questions, I used two data sources: self-reported questionnaires and follow-up interviews with teacher participant. The questionnaire was composed of 17 questions (see Appendix): the first 12 questions asked about participants’ academic, teaching, and educational background, and the last four questions were related to participants’ lesson selection and their justification for their selection. In the follow-up interview, the participants were shown two lesson plans and asked which of the versions is coherent. Finally, the participants were requested to provide a definition for coherent instructional sequences.

**Organization of the Thesis**

In chapter 2, I will present the literature review. I will begin by grounding the concept of coherence in its theoretical underpinnings, namely social constructivism, as well as previous studies showing the importance of coherence in student learning, teachers’ experiences with designing coherent storylines or lessons, and scarcity of research studying teachers’ understanding of coherence in terms of their academic and educational background. In chapter 3, I will present my methods section, including the research context, and participants’ backgrounds, the study design, data sources, and data analysis techniques. In chapter 4, I will present the results of the analysis of the survey and the interview and finally in chapter 5, I will discuss the findings, limitations of the study and future directions.
CHAPTER 2: LITERATURE REVIEW

In my literature review, I used the EBSCO database via the University of Illinois Library to find peer-reviewed articles focused on coherence in science teaching. Since I wanted to present the most current findings in the field, most of the studies I cited were published between 2005 and 2017. To present a complete understanding of the topic, I benefited from different kinds of sources: reports, conference papers, book chapters, and articles from various journals, including *Education, Educational Leadership, International Journal of Educational Psychology, Journal of Curriculum Studies, Journal of Research in Science Teaching, Journal of Science Teacher Education, Science and Children, Science Education, Studying Teacher Education, and The Elementary School Journal*. The purpose of this study is to investigate if there are differences between the teachers who preferred a coherent storyline over the incoherent storyline and vice versa in terms of their academic and teaching background. I also investigated if teachers consider coherence as a criterion while they are making instructional decisions.

In this literature review, I will begin by grounding the concept of coherence in its theoretical underpinnings. In order to further contextualize my research questions, I will present levels of coherence discussed across the literature and review how scholars have defined coherence. To explain the rationale behind my study, I will discuss several evidence-based findings showing the importance of coherence in student learning, teachers’ experiences with designing coherent storylines or lessons, and scarcity of research studying teachers’ understanding of coherence in terms of their academic and educational background. Finally, I will present existing research on whether teachers use this concept as a criterion in their instructional decisions.
Learning Theories and Coherence

Constructivism states that “learning is a process of constructing meaning; it is how people make sense of their experience” (Caffarella & Merriam, 1999, p. 260). According to Piaget (1977), people are not passive receivers in their learning process, they are rather actively constructing knowledge from their experiences. Learners have existing knowledge and when they start to learn new knowledge, they relate it to their pre-existing knowledge (which is called assimilation). When they are not able to make this connection, they reconstruct their existing knowledge by using accommodation. Social constructivism is the “most general extant perspective of constructivism” (Amineh & Asl, 2015, p.12) which also gives an importance to social interactions. Social constructivism was developed by Lev Vygotsky (1978) who argued that meaning is constructed by the interaction and cooperation between individuals. Thus, knowledge is socially and culturally constructed, or co-constructed. According to social constructivism, the role of a teacher is to be a facilitator, helping the student to construct meaning from her/his experience in collaboration with others (Powell & Kalina, 2009).

As previously mentioned NGSS was developed based on the Framework for K-12 Science Education which itself drew on various theories of learning. One of the ideas addressed in this framework social constructivism (NRC, 2012). The concept of coherence in storylines is grounded in constructivist and social constructivist theory in the sense that students build a deep understanding of ideas being learned in interaction with their peers. Constructivism and social constructivism suggest that learning should draw from students’ existing knowledge learners try to make sense of their experiences, they ask questions and try to find answers to those questions by interaction and collaboration with others. In the same vein, in a coherent storyline, students encounter a naturally occurring phenomenon, they ask questions to engage in practices to answer
these questions and interpret the results of these practices together with other students in the aim of understanding the anchoring phenomena (Reiser, Novak & McGill, 2017).

**Levels of Coherence Across the Literature**

In the literature, four kinds of curriculum coherence were described: content standards coherence, learning goal coherence, intra unit coherence, and inter-unit coherence (Fortus & Krajcik, 2012). Content standards coherence refers to a meaningful alignment of topics and practices within a grade and across the grades. Learning goals coherence requires a small number of unpacked content standards which are sequenced to flow from simple to more developed levels of comprehension. Inter-unit coherence requires an alignment in the same discipline across different grades (e.g., coherence in chemistry across grades 10, 11, and 12) and also across the different disciplines (physics, chemistry, and biology). Finally, intra-unit coherence requires “coordination between content learning goals, scientific practices, inquiry tasks, and assessments within a project-based framework” (Fortus & Krajcik, 2012, p.788). Coherence which will be discussed in this study falls under this final category.

According to my literature review, there are multiple definitions of coherence within the storylines: these definitions both have similarities and differences in terms of their scope and complexity. I will compare and contrast two groups of researchers’ understandings of coherent storylines: 1) an understanding of science storylines advocated by Hanuscin, Lee, Lipsitz, Arnone, and de Araujo (2015) (see also Hanuscin, Cisterna, & Lipsitz (2018); Hanuscin, et al. (2016), and Lipsitz, Cisterna-Alburquerque, & Hanuscin (2017); 2) an understanding of science storyline advocated by Fortus and Krajcik (2012), Fortus, Sutherland Adams, Krajcik, and Reiser (2015); Reiser, Novak, and McGill (2017), Shwartz, Weizman, Fortus, Krajcik, and Reiser (2008), 2). To be concise I will call the former as Group A, and the latter as Group B.
These were the two most common understandings I encountered throughout my literature review and that is why I will compare them.

I will give one example of a storyline from each group to illustrate their respective understandings of storylines. Firstly, an example of Group A’s storyline is the following:

As a group, students brainstorm everyday items they know that use magnets. They discuss what the item is, how it works, and what role magnets play.

The teacher then provides each pair of students with a magnetic object to explore (e.g., magnetic fishing game).

S/he asks them to focus on the types of interactions (attracting/repelling) and whether magnets are interacting with other magnets or other objects. Afterward, pairs present their items to the class, explaining how they work.

The teacher then shares a proposal for a ‘magnetic recycling sorter’ that claims to sort metal and nonmetal items for recycling, and asks groups to discuss whether they think the invention would work.

Students critique this product and decide that it would not attract all metals and might accidentally trap nonmetals between the magnet and iron objects.

Each student is then challenged to come up with their own working magnetic invention. They build prototypes and create a ‘product pitch’ to share at an Invention Convention.

Picture 1: An Example of Group A’s Coherent Storyline (Hanuscin et al., 2016, p.410)

An example of a storyline which is aligned with Group B’s understanding is called “Why is Our Corn Changing?” and the objective of the unit is for students to learn what resources a plant needs to survive and how different parts of plants function. The unit starts with a teacher bringing decorative corn into the class and telling the students that the corn got wet due to the rain. The students become curious about what will happen to wet corn, and they start to observe...
it. They see that small and green things grow out from the decorative corn and wonder if they are growing from the cobs or kernel. To test their argument, the students put a part of the cob in one cup and some kernels in another cup and then they observe that nothing changes in the cob, but green things continue to grow out from the kernels. Then they discover that the green parts are bending toward the sun and they argue if the plants need the sun to grow. To test their argument, the students leave some part of the corn in the sunlight and some part of the corn in the dark. They also wonder if the plants need water to grow. In order to test their new question, they put some corn in water and some corn in an empty cup. The students observe that plants need water to grow (Farkash et al., 2018). This storyline continues with student-driven questions. Briefly, in coherent science storylines, the instruction starts with an anchoring phenomenon, grows deeper through the student-driven questions and the students engage in science and engineering practices to answer their questions.

There are similarities and differences between these two understandings of storylines. According to both understandings, in a storyline, there should be a link between science ideas. Again, according to both understandings, storylines should be meaningful to students. However, there are also some differences between Group A’s and Group B’s understandings of the storyline in terms of scope and level of development (complexity). Firstly, Group A mentioned storylines within a lesson or instructional sequence that might consist of several activities and experiences, whereas, Group B discussed storylines in a bigger scope: in units- and sometimes even in curricular level (Fortus, Sutherland Adams, Krajcik & Reiser, 2015; Schwartz, Weizman, Fortus, Krajcik & Reiser, 2008). Secondly, although both groups stated that storylines must be meaningful to students, Group B articulated it in more detail which requires further description (see Table 1 to see the comparison of Group A’s understanding of coherent storylines with Group B’s understanding of coherent storylines).
<table>
<thead>
<tr>
<th>The term that they used</th>
<th>Group A</th>
<th>Group B</th>
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<tbody>
<tr>
<td>“conceptual storylines.”</td>
<td></td>
<td>“storylines.”</td>
</tr>
<tr>
<td>Conceptual storylines are smaller and “grain size” (Hanuscin, Lee, Lipsitz, Arnone, &amp; De Araujo, 2015, p.2) compared to “storylines.” By conceptual storylines, they mean a single lesson or instructional sequence which may consist of several activities and experiences (Hanuscin et al., 2016).</td>
<td>Storylines refer to an entire unit (Reiser, Novak, &amp; McGill, 2017).</td>
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<tr>
<td>Their understanding of coherent storylines</td>
<td>Science ideas ordered and connected to each other and to the instructional activities to assist students in developing a coherent ‘story’ which is meaningful to them (Hanuscin, Lee, Lipsitz, Arnone, &amp; De Araujo, 2015).</td>
<td>Coherent units in which students engage in science and engineering practices to answer the questions that they derive from a phenomenon, so that each investigation (may) lead to the next one by generating more questions (Reiser, Novak, &amp; McGill, 2017).</td>
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Table 1: Comparison of Group A’s Understanding Coherent storylines with Group B’s Understanding of Coherent storylines.

Reiser, Novak, and McGill (2017) argue that in this knowledge-building process, students should be able to comprehend the current findings and point out the gaps in the current situation, and as a result, they can decide on what to do or where to go as the next step(s). Lastly, science practices should stem from understanding a naturally occurring phenomenon: the students should be stimulated by presenting a challenging phenomenon and then they define the required questions which they need to answer to understand the phenomenon, rather than starting with a statement such as “explain photosynthesis” (Reiser, Novak, & McGill, 2017, p.5).

On the other hand, even though Group A stated storylines should be meaningful to students, they do not give any detail about how storylines should make sense to the students.
Therefore, Group A’s understanding of storylines is a subset of Group B’s understanding of storylines in terms of scope and level of development (complexity) (see Figure 1).

![Diagram showing commonalities and differences between Group A's and Group B's understanding of coherent storylines]

Figure 1: Commonalities and Differences between the Group A’s and Group’s Understanding of Coherent Storylines

**Importance of Coherence**

There are studies which showed teachers use of strategies such as connecting science ideas to science activities or connecting science ideas to each other improves student learning. Roth et. al. (2011) investigated if a yearlong professional development (PD) focusing on videos of teaching practices helped elementary teachers to improve their science content knowledge and their teaching practices related to using strategies to build coherent science instructional sequences. They also studied if these improvements promoted their students’ science content knowledge. Forty-eight elementary teachers and 1460 students, most of whom were Hispanic and designated as English Learners (ELs) at different public schools in Los Angeles partook in the study. Two groups of teachers were formed for this study and teachers self-selected their
groups: content instruction only group - Group 1- (just a 3 weeks content instruction from scientists) (N=32) and content instruction+video case analysis group-Group 2-(3 weeks content instruction followed by a yearlong video case analysis) (N=16). The backgrounds of two groups (year of teaching experience, science content knowledge etc.) compared and no significant difference was found. In Group 2, the teachers studied video excerpts from outside of their classroom by using science content storyline lens in which teachers aimed to learn ways to design coherent instructional sequences. The teachers’ science content knowledge and ability to analyze teaching were measured before PD, in the middle of the PD and after PD. The participants in Group 2 videotaped their lesson before and after PD. The students’ science content learning was measured before and after PD. According to the results, in the mid-test and post-test, Group 2 outperformed Group1 in terms of their science content knowledge. According to the comparison of videotapes, after the PD the Group 2 teachers were more likely to integrate Science Content Storyline Strategies into their instruction. Even though the students taught by Group 1 and Group 2 both showed increased levels of content knowledge, the students taught by the teachers in Group 2 gained more. Briefly, this study shows that “Carefully designed and implemented a one-year science PD program can build elementary teachers’… PCK about the science content storyline … and improve their ability to use that content a PCK in teaching science, and as a result, enhance their students’ science learning.” (p.141).

Thus, this research showed that using strategies (such as linking science content ideas and activities or linking science ideas to other science ideas) to build coherent instructional sequences promotes students’ achievement.

There are studies which investigated the relationship between curricular coherence and students’ learning. In Shwartz, Weizman, Fortus, Krajcik, and Reiser’s (2008) study, 6th grade physics unit called “Can I believe my eyes?” and a 6th grade chemistry unit called “How can I
smell things from a distance?” were developed taking the curriculum coherence (learning goal coherence, intra unit coherence, and inter-unit coherence) into consideration. The physics unit was implemented in 12 schools in Michigan. The total number of participants was 248 students. The chemistry unit was implemented in two schools in Michigan. The number of participants was 60 students. In order to check the outcomes of the study, the following data collection tools were used: pre-and post-tests for students (the validity and reliability of the test were checked), interviews with students and classroom observations. According to the results, a curriculum with intra and inter-unit coherence was found to be beneficial for students to improve their inquiry skills, for students from diverse backgrounds and for students to acquire science content.

Another research investigation studied the importance of coherent curriculum in student learning (Fortus, Sutherland Adams, Krajcik, & Reiser, 2015). The researchers developed a coherent science curriculum composed of 12 units: four units were developed for each middle school grade and these units covered different disciplines (physics, chemistry, biology, and earth science). The common point across these 12 units was the concept of “energy” in science. These units were applied by dozens of teachers from different school contexts around the USA. Student outcomes were measured by pre/posttests at the end of the school year. The results showed that a coherent curriculum helps the students to have a more developed understanding of the energy construct. Fortus et al. (2015), explained that students gained a “…deeper understanding of energy by providing repeated exposure over years rather than weeks, enabling knowledge to be built upon ins subsequent units...” (p.1408). Briefly, Schwartz et al. (2008) and Fortus et al. (2015) investigated the effects of a coherent curriculum on student learning and showed that coherent science curriculum improves student learning. Certainly, a logical sequence of topics within a curriculum is beneficial for students’ learning, but as Sikorski (2017) stated: “Curriculum cannot do the work of sense-making for the students” (p. 940). Therefore, we
should also look at teachers’ experiences in designing coherent units or sequence of lessons, since they are the major agents in implementing the curriculum.

**Teachers’ Experiences with Designing Coherent Units or Sequences of Lessons**

In a more recent paper from a different discipline (mathematics), Ermeling and Graff-Ermeling (2016) shared their experiences in which they observed how elementary and secondary teachers developed lesson plans. They observed that most of the teachers gave priority to activities which were engaging for the students rather than giving priority to building coherent instructional sequences which sets a clear relation between the learning goal and classroom activities. The students’ engagement is certainly important, but just “getting students out of their seats” (Ermeling & Graff-Ermeling, 2016, p. 24) would not necessarily guarantee their learning. This study showed that connections between the activities and scientific ideas are not always considered by teachers while they are building and instructional sequence.

Another study found that the teachers have problems in developing a coherent unit (Wiebke & Park Rogers, 2014). In a method course for teaching elementary science methods at Indiana University, Heidi Wiebke supported 20 elementary preservice teachers in their either third or last year in designing and implementing coherent science lessons in their classrooms. Before starting to design a sequence of lessons, pre-service teachers engaged in the following practices: they reviewed state science standards and analyzed how a science concept taught and learned throughout the grades. They also engaged in a practice in which they randomly ordered five lessons and try to order them coherently and meaningfully by paying attention to student thinking and state science standards. Heidi Wiebke reported that after these practices, she was expecting preservice teachers to develop a unit composed of meaningfully sequenced coherent lessons, but she noticed that preservice teachers had difficulty in developing a coherent lesson sequence.
Similarly, Hanuscin et al. (2016) conducted a study to investigate difficulties teachers encounter when they try to design a coherent instructional sequence. The participants were thirty-three 3rd-grade science teachers from diverse school settings in the Midwest. Each of them was asked to design a coherent instructional sequence, and the lesson plans were evaluated by the authors independently. The authors listed two common mistakes which teachers made when they are developing coherent instructional sequences: ‘More is Better’ and ‘One and Done’. In the former, the teachers were likely to include many concepts in their storylines, but there was a superficial connection between those concepts. Instead of connecting these activities in the conceptual level, they were more likely to link them in the topic level: for example, all of the activities were related to a broad topic like ‘magnets’. In the ‘One and Done’ typology, the teachers were relying on one single activity and were expecting it would be enough for students to understand the big idea.

Plummer and Tanis Ozcelik (2015) conducted a study with 30 pre-service teachers from an elementary education science methods course. They investigated the relationship between the pre-service teachers’ understanding of scientific inquiry and their development of coherent inquiry-based science lesson plans. In this research, a coherent science experience was defined as the following: students are faced with a scientific question and they engage in scientific and engineering practices to develop an evidence-based explanation to that scientific question (NRC, 2012). In this process, each evidence piece may generate a new question and those pieces of evidence all come together and build a connection across the scientific question. In the methods course, the participants took part in five weeks of scientific investigation about celestial objects. For the other five weeks, they experienced fieldwork in pairs where they designed and taught lesson plans about celestial objects. Plummer and Tanis Ozcelik collected five lesson plans which the participants wrote and taught and five reflections on those lesson plans from each
participant. The findings showed that the participants who were able to design coherent lessons were more likely to have normative scientific ideas (ideas aligned with reforms documents’ description of student engagement in science inquiries), such as students should make evidence-based explanations to understand the phenomena or students should be able to see the relation between question, evidence, and explanation. On the other hand, the participants who had failed to develop coherent lesson plans were more likely to hold alternative science ideas (ideas not aligned with reforms documents’ description of student engagement in science inquiries) such as a hands-on activity will be enough for the students to engage in a scientific investigation”. However, since this research study conducted with preservice elementary teachers only, an investigation about the differences between teachers developing coherent storylines and teachers developing incoherent storylines in terms of their background (for example years of teaching experience or grades that teachers teach) was not possible. Thus, differences between teachers’ understanding of coherence in relation to their academic and teaching backgrounds is an open question.

Hanuscin, Lee, Lipsitz, Arnone, and de Araujo (2015) investigated teachers’ ability to design coherent lesson and distinguish a coherent lesson from an incoherent lesson in relation to their content knowledge, pedagogical knowledge, and pedagogical content knowledge. Participants included 33 participants who teach 3rd-grade science in urban, suburban and rural parts of a Midwestern state. The participants were assigned to prepare a lesson related to magnets. The researchers also presented two instructional sequences to the teachers one with the coherent flow and one without. The participants were asked to choose one of these storylines and state the rationale behind their selection. Hanuscin et al. (2015) found that most of the teachers (22 out of 33) preferred the lessons with coherence. Hanuscin et al. (2015), also found that participants who preferred the coherent version had significantly higher content knowledge of
magnetism, compared participants who preferred the incoherent version. Hanuscin et. al. (2015)
also found that “only 7 of the 33 teachers (21%) submitted lessons that exhibited coherence in
terms of all activities aligning with a specific conceptual understanding that served as a central
goal for the lesson” (p.8). However, again they do not mention if these participants were
different than the other participants in terms of their academic and professional background.

In the same study, Hanuscin, Lee, Lipsitz, Arnone, and de Araujo (2015) also found that
although most of the teachers (22 out of 33) preferred the lessons with coherence, most often
they stated that they chose this lesson over the other because it provided opportunities for student
collaboration or it included hands-on activities. They did not state “coherence” as the reason for
their selection. The Framework for K-12 Science Education tries to promote more coherent US
science education (NRC, 2012). However, “When translating those educational reform policies
into teachers’ practical science teaching, their individual pedagogical decisions are the most
uncertain factor regarding the success of those reform efforts” (Bybee, 1993, in Lee & Lin, 2005,
p. 453). Therefore, teachers’ instructional decisions are important in achieving NRC’s vision
toward a more coherent science education. The study conducted by Hanuscin et al. (2015), points
out that teachers do not consider coherence as a criterion in their instructional decisions, but still,
22 out of 33 participants preferred coherent instructional sequences. Therefore, it may be that the
majority of the teachers preferred the coherent version by chance, or that even though the
teachers do not mention coherence explicitly or they are considering it in their minds without
being aware. My study will replicate this part of Hanuscin et al.’s (2015) study and test if a
majority of my participants would choose the coherent version and if they mention coherence in
their justification for their selection.

Since the study conducted by Roth et al. (2011) showed the teachers’ use of strategies to
develop coherent instructional sequences predicted improved student achievement, teachers’ use
of coherence as a criterion in their instructional decisions is an important issue, as is determining
the factors (academic and educational) which influence teachers’ understanding of coherence in
storylines. This review of the literature demonstrated the need for additional research that
explores the relationship between teachers’ academic and teaching background and their
instructional choices, as well as their overall understandings of coherence. The following chapter
presents the research methodology developed for this study.
CHAPTER 3: METHODOLOGY

This is a qualitative exploratory study that investigates if there are differences between the teachers who preferred coherent instructional sequences over incoherent instructional sequences in terms of teachers’ academic and teaching background. It also aims to investigate if teachers consider coherence as a criterion while they are making instructional decisions. The following sections includes a description of the setting, the participants, data sources used, how data analysis was conducted, and researcher positionality.

The Setting

I conducted my study at the PRIMES (Practices integrated across Mathematics Engineering and Science) Professional Development Workshop which was held at a University in the Midwest. PrIMES offered one and a half years of professional development which was started in the summer of 2017. PrIMES aimed to improve teachers’ content knowledge of mathematics, science and engineering practices and it also aimed to improve teaching aligned with disciplinary core ideas, science and engineering practices, and cross-cutting concepts. Lastly, PrIMES intended to create a lasting professional learning community (PLC) and of course improve student learning. At the first year’s summer institute, the participants focused on how to integrate mathematics and science practices into their teaching and they were taught how to design NGSS aligned storylines. During the following academic year (2017-2018), the participants applied their storylines in their classrooms and occasionally they met with their core professional development group to discuss the implementation of the storylines. In the 2018 summer institute, the returning participants improved their existing storylines and created new ones. In both summer institutes (2017 and 2018) the participants attended science and engineering laboratories.
I collected my data during the 2018 summer institute which was held on a Midwestern University campus and at an off-campus meeting site between June 11th-23rd (nine days). I did not participate in the workshop actively: I did not join the discussions or build storylines with the participants. During the first week of the 2018 summer institute, teachers focused on revising their storyline that they worked on last year. During the second week, they focused more on developing Professional Learning Communities (PLC) within smaller groups.

**Participants**

Twenty-one teachers participated in this study. Four of the participants were male, and 17 of them were female. Five of the participants taught kindergarten to second graders, eight of them taught grades third to fifth graders, and eight of them taught middle school science. Four of the participants had less than three years of teaching experience, four of the participants had 4-8 years of teaching experience, seven of the participants had 9-15 years of teaching experience and finally, six of the participants had more than 16 years of teaching experience. Fifteen of the participants held bachelor’s degrees in education-related majors: elementary and early childhood education (N=12), middle school education (N=1), secondary education (N=1), and physical education (N=1). Six of the participants held their bachelor’s degrees from other disciplines. Fourteen of the participants held master’s degrees and 13 of those 14 were master’s degrees from educational related fields (for illustration of participants’ academic and teaching background see the Charts below and aggregated table below).
Chart 1: Gender Distribution

Chart 2: Distribution of Grades that the Participants Taught

Chart 3: Distribution of the Participants’ Years of Teaching Experience

Chart 4: Distribution of the bachelor’s degree that Participants Held
Chart 5: Distribution of the master’s degree that Participants Held

Chart 6: Distribution of Teaching Certificates Participants Had (most participants had more than one teaching certificates)
Table 2: The Participants’ Academic and Teaching Backgrounds

<table>
<thead>
<tr>
<th>Participants (Pseudonym)</th>
<th>Grades they teach</th>
<th>Years of Teaching Experience</th>
<th>Bachelor’s degree</th>
<th>Highest Degree</th>
<th>Certifications they have</th>
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<tbody>
<tr>
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<td>Master's-Curriculum and Instruction</td>
<td>Elementary/Early Childhood Certification</td>
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<td>Nancy</td>
<td>Grades 3 to 5</td>
<td>3 or less</td>
<td>Elementary/ Early Childhood Education</td>
<td>Bachelor's</td>
<td>Elementary/Early Childhood Certification</td>
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<td>Bachelor's</td>
<td>Elementary/Early Childhood Certification</td>
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<td>Bachelor's</td>
<td>Elementary/Early Childhood Certification-Middle School Teaching Certification</td>
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<td>Elementary/Early Childhood Certification</td>
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<td>Judy</td>
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<td>Elementary/Early Childhood Certification</td>
</tr>
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<td>Bachelor's</td>
<td>Middle School Teaching Certification-Secondary Teaching Certification</td>
</tr>
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<td>Elizabeth</td>
<td>Grades 6 to 8</td>
<td>9-15 years</td>
<td>Secondary Education</td>
<td>Master's- Mathematics and Science Education</td>
<td>Middle School Teaching Certification-Secondary Teaching Certification</td>
</tr>
<tr>
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<td>9-15 years</td>
<td>Elementary/ Early Childhood Education</td>
<td>Master's-Curriculum and Instruction</td>
<td>Elementary/Early Childhood Certification-Middle School Teaching Certification-National Board Teaching Certification</td>
</tr>
<tr>
<td>Name</td>
<td>Grades</td>
<td>Years</td>
<td>Degree</td>
<td>Certification</td>
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</tr>
<tr>
<td>Beth</td>
<td>K to 2</td>
<td>3 or less</td>
<td>Art</td>
<td>Master's-Education</td>
<td>Elementary/Early Childhood Certification</td>
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<td>Elementary/Early Childhood Education</td>
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<td>Elementary/Early Childhood Certification</td>
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<tr>
<td>Thomas</td>
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<td>9-15 years</td>
<td>Middle School Education</td>
<td>Master's-Education Administration</td>
<td>Elementary/Early Childhood Certification-Middle School Teaching Certification-Administration/Supervision Certification</td>
</tr>
<tr>
<td>Peter</td>
<td>K to 2</td>
<td>4-8 years</td>
<td>Elementary/Early Childhood Education</td>
<td>Bachelor's</td>
<td>Elementary/Early Childhood Certification</td>
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<td>Gloria</td>
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<td>Elementary/Early Childhood Certification</td>
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<td>4-8 years</td>
<td>Biological Sciences</td>
<td>Master's-Education</td>
<td>Elementary/Early Childhood Certification-Middle School Teaching Certification</td>
</tr>
<tr>
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<td>16+ years</td>
<td>Elementary/Early Childhood Education</td>
<td>Master's-Curriculum and Instruction</td>
<td>Elementary/Early Childhood Certification-Middle School Teaching Certification-Administration/Supervision Certification</td>
</tr>
<tr>
<td>Joe</td>
<td>6 to 8</td>
<td>3 or less</td>
<td>Physical Education</td>
<td>Master's-Education</td>
<td>Elementary/Early Childhood Certification-Middle School Teaching Certification-Secondary Teaching Certification</td>
</tr>
<tr>
<td>Marry</td>
<td>6 to 8</td>
<td>9-15 years</td>
<td>Communications</td>
<td>Master's-Other Discipline</td>
<td>Elementary/Early Childhood Certification</td>
</tr>
<tr>
<td>Margaret</td>
<td>K to 2</td>
<td>16+ years</td>
<td>Elementary/Early Childhood Education</td>
<td>Master's-Education</td>
<td>Elementary/Early Childhood Certification-Middle School Teaching Certification-Other</td>
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<td>Teaching Discipline: Reading</td>
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</tr>
<tr>
<td><strong>Bob</strong></td>
<td>Grades 3 to 5</td>
<td>9-15 years</td>
<td>Art</td>
<td>Master's-Education</td>
<td>Elementary/Early Childhood Certification-Other Teaching Discipline: Reading</td>
</tr>
<tr>
<td><strong>Julia</strong></td>
<td>Grades 6 to 8</td>
<td>16+ years</td>
<td>Elementary/Early Childhood Education</td>
<td>Master's-Special Education</td>
<td>Elementary/Early Childhood Certification-Middle School Teaching Certification</td>
</tr>
</tbody>
</table>
Data Sources

I used two data sources for my study: questionnaires and follow-up interviews. I used questionnaires because they allowed me to gather data about participants’ academic and teaching background, their instructional decisions and their justifications for their decisions in a timely manner. However, since the survey data is self-reported, in order to establish validity of my findings, I also decided to triangulate data sources by conducting a follow-up interview which allowed me to have “control over the line of questioning.” (Creswell, 2014, p. 241). For example, in the interview, I was able to ask for elaboration and clarification or repeat the question for the purpose of maintaining focus.

Survey. The survey was composed of 17 questions beginning with questions asking about the participants’ past teaching-learning experiences, including years of teaching experience, grades and subjects taught, teaching certifications they held (see APPENDIX for details). In the 13th and 15th questions, the participants were given two instructional sequences (see Picture 2 and Picture 3) and asked to choose which one they would prefer for their instruction. They were then asked to give at least three detailed reasons for their choice.
### Version 1

As a group, students brainstorm everyday items they know that use magnets. They discuss what the item is, how it works, and what role magnets play.

The teacher then provides each pair of students with a magnetic object to explore (e.g., magnetic fishing game).

S/he asks them to focus on the types of interactions (attracting/repelling) and whether magnets are interacting with other magnets or other objects. Afterward, pairs present their items to the class, explaining how they work.

The teacher then shares a proposal for a ‘magnetic recycling sorter’ that claims to sort metal and nonmetal items for recycling, and asks groups to discuss whether they think the invention would work.

Students critique this product and decide that it would not attract all metals and might accidentally trap nonmetals between the magnet and iron objects.

Each student is then challenged to come up with their own working magnetic invention. They build prototypes and create a ‘product pitch’ to share at an Invention Convention.

### Version 2

As a group, students brainstorm everyday items they know that use magnets. They discuss what the item is, how it works, and what magnetic interactions are involved.

The teacher then provides each student a compass and asks them to explore and determine whether the compass is magnetic.

Building on students' observation that the compass needle moves when a magnet is brought near it, the teacher asks students to record the maximum distance from the compass that different magnets influence its direction.

Students then use this as evidence to support their arguments about which magnet is the strongest. Students agree that the farther the distance from which a magnet affects the compass needle’s direction, the stronger it is.

Students then watch a video on YouTube from the National High Magnetic Field Laboratory called *the World’s Strongest Magnet*. In this video, scientists share how they build an electromagnet.

Afterward, students are able to build their own electromagnets by wrapping wire around steel bolts and attaching these to a battery.

**Picture 2:** Two versions used in the 13th question. In Version 1 all activities are about a single science concept whereas in Version 2 jumps from a concept to another like magnetic poles, magnetic interaction etc. Thus, Version 1 is the coherent version and Version 2 is the incoherent version. (Hanuschin et. al, 2016)
Picture 3: Two versions used in the 15th question. Version 2 is a coherent storyline whereas Version 1 is not (Lipsitz, Cisterna-Alburquerque, & Hanuscin, 2017).

For the 13th question, in Version 1 all activities were about a single concept whereas Version 2 jumped from one concept to another like magnetic poles, magnetic interaction, etc. (Hanuscin et al., 2016). For the 15th question, in Version 2, at each step students needed to use what they learnt in the previous step(s). However, in Version 1, the steps were disjointed: at first step students discussed factors influencing change of matter, then the students started to discuss
how to distinguish a matter from a non-matter, and then the students switched back to exploring factors influencing change of matter. Thus, Version 2 presents a coherent instructional sequence and Version 1 presents an incoherent instructional sequence (Lipsitz, Cisterna-Albuquerque, & Hanuscin, 2017).

**The Follow-up Interview.** The interview was semi-structured and focused on participants’ definitions of coherence. During the interview, the participants were again shown the 13th and 15th questions from the survey which included coherent and incoherent instructional sequences and they were asked: “Which one of the versions do you think is more coherent and explain why?” Then, the participants were also asked to provide their definition of coherence.

**Data Collection**

At the first day of the workshop, I introduced myself and my project. I asked the teachers if they were willing to participate in the study. There were 20 teachers during the first week of the workshop and all of them agreed to take part in my study. In the second week of the workshop, I met one more participant and he agreed to participate in my study too. I gave each of them two copies of the Social and Behavioral Research consent form: they signed and returned one of the consent forms to me and kept the second one for their records. I sent them an e-mail with the survey created via Survey Monkey. At the end of the survey, they were asked if they wanted to participate in a follow-up interview. Eleven of the participants who took the survey wanted to participate in follow-up interviews. However, I could only conduct interviews with 10 of them due to the time limitation. I contacted the participants who wanted to take part in follow-up interviews by e-mail and in person to set-up time for the interview. The interviews were either conducted during the lunchtime of the workshop or at the end of the workshop, and they were done in a private classroom in the building where the workshop was being held. The follow-up interviews took about 15 minutes and they were audio recorded and later transcribed by me.
Data Analysis

Survey. As my first research question, I wanted to investigate if there are differences between teachers who preferred coherent instructional sequences and who preferred incoherent instructional sequences in terms of their academic and teaching backgrounds. Therefore, I divided the participants into four groups: $V_1V_2$ (the ones who preferred the coherent instructional sequence in both questions), $V_1V_1$ (the ones who preferred the coherent instructional sequence in the $13^{th}$ question only), $V_2V_2$ (the ones who preferred the coherent instructional sequence in the $15^{th}$ question only), and $V_2V_1$ (the ones who preferred the incoherent instructional sequence in both questions). Then, I compared these groups in terms of the group members’ academic and teaching background: grade levels that they taught, years of teaching experiences, bachelor’s degrees that they held, master’s degree that they held, and finally the teaching certificate(s) that they had.

To investigate my research question (do teachers consider coherence as a criterion in their instructional decisions?), I analyzed the participants’ answers to the $15^{th}$ and $17^{th}$ questions in the survey: “Please explain the reason for your preference. Give at least three reasons and try to give as much detail as possible.” I analyzed if participants argued coherence of the versions when they were justifying why they chose what they chose.

The Follow-up Interview. All audio records were transcribed using a web-based application called Temi. Since there were still errors in the transcription, I listened to them from the beginning and corrected the errors.

The follow-up interview helped me to bring breadth and depth to the analysis of my two research questions. For the first research question (are there differences between teachers who preferred coherent instructional sequences and who preferred incoherent instructional sequences
in terms of their academic and teaching experiences?), I chose three exemplary cases which have relatively different academic and teaching backgrounds.

For the second research question (do teachers consider coherence as a criterion in their instructional decisions?), I compared participants’ answers from the survey and interview and investigated whether or not participants mention coherence in their justifications in the survey, and if they mentioned coherence when they were pushed to elaborate their justifications in the interview.

**Researcher Positionality**

I am an international second-year master’s student at the University of Illinois, Urbana-Champaign. I studied my undergraduate degree at Boğaziçi University in Istanbul, Turkey and my major was mathematics education. During my undergraduate studies, I went to Sweden to study as an exchange student at Mid Sweden University. In Turkey and in Sweden, I had opportunities to observe mathematics, science, English, and Swedish classes as an intern teacher. After graduation, I worked as a mathematics teacher in a public school in Turkey for one and a half years. I taught 5th, 6th, 7th and 8th graders, the majority of whom had low socio-economic backgrounds and were culturally diverse (e.g., Kurdish, and Syrian). Finally, I came to the USA in 2016 to start studying for my master’s degree in Curriculum and Instruction. As Creswell (2014) stated, “the background of the researchers actually may shape the direction of the study” (p. 234) and since I am an international student and I have never taught in the US classrooms, my outsider perspective might affect data collection, analysis, and interpretation. However, having outsider perspective might also allow me to interrogate finding with more objectivity and greater depth than if I shared my participants’ backgrounds and experiences.
CHAPTER 4: FINDINGS

In this section, I will describe the results of the survey and the follow-up interview. My research questions are:

1) Are there differences between teachers who preferred coherent instructional sequences and who preferred incoherent instructional sequences in terms of their academic and teaching experiences?

2) Do teachers consider coherence as criterion in their instructional decisions?

Differences in Teachers’ Academic and Teaching Background

Both in the 13th and 15th questions the participants were given two lesson plans (Version 1 and Version 2) and requested to choose one of them. Four categories emerged: the participants who chose the coherent version in both questions $V_1V_2$ ($N=9$), the participants who chose the coherent version in the 13th question, but chose the incoherent version in the 15th question $V_1V_1$ ($N=3$), the participants who chose the coherent version in the 15th question, but chose the incoherent version in the 13th question $V_2V_2$ ($N=6$), and finally the participants who chose the incoherent version in both questions $V_2V_1$ ($N=3$) (see Table 3).
Table 3: The Participants’ Academic and Teaching Backgrounds and Their Answers to the Survey and Interview Questions

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<thead>
<tr>
<th>Name</th>
<th>Grades taught</th>
<th>Years of Teaching Experience</th>
<th>Bachelor’s Degree</th>
<th>Highest Degree</th>
<th>Certifications they have</th>
<th>Survey 13th Question: Which one of the storylines would you prefer?</th>
<th>Survey 15th Question: Which one of the storylines would you prefer?</th>
<th>Interview 13th Question: Which one of the versions is more coherent?</th>
<th>Interview 15th Question: Which one of the versions is more coherent?</th>
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<tbody>
<tr>
<td>Rose</td>
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<td>Elementary/Early Childhood Education</td>
<td>Master's-Curriculum and Instruction</td>
<td>Elementary/Early Childhood Certification</td>
<td>Version 1</td>
<td>Version 2</td>
<td>Version 1</td>
<td>Version 1</td>
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<td>Elementary/Early Childhood Education</td>
<td>Bachelor's</td>
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<td>Version 2</td>
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<td>No interview</td>
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<td>Elementary/Early Childhood Education</td>
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<td>Elementary/Early Childhood Certification</td>
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<td>Version 2</td>
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<td>Version 2</td>
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<td>Version 1</td>
<td>Version 2</td>
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<tr>
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<td>Grades 6 to 8</td>
<td>3 or less</td>
<td>Elementary with Endorsement</td>
<td>Bachelor's</td>
<td>Elementary/Early Childhood Certification</td>
<td></td>
<td>Version 1</td>
<td>Version 2</td>
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<td>Emily</td>
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<td>Bachelor's</td>
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<td></td>
<td>Version 1</td>
<td>Version 2</td>
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</tr>
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<td>Elizabeth</td>
<td>Grades 6 to 8</td>
<td>9-15 years</td>
<td>Secondary Education</td>
<td>Master's-Mathematics and Science Education</td>
<td>Middle School Teaching Certification-Secondary Teaching Certification</td>
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<td>Version 1</td>
<td>Version 2</td>
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Table 3 (cont.)
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<td>Version 1</td>
<td>Version 1</td>
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<td>Master's-Education</td>
<td>Elementary/Early Childhood Certification</td>
<td>Version 1</td>
<td>Version 1</td>
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<td>No interview</td>
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<td>Master's-Education Administration</td>
<td>Elementary/Early Childhood Certification-Middle School Teaching Certification-Administration/Supervision Certification</td>
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<td>Version 1</td>
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<td>No interview</td>
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<tr>
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<td>K to 2</td>
<td>4-8 years</td>
<td>Elementary/Early Childhood Education</td>
<td>Bachelor's</td>
<td>Elementary/Early Childhood Certification</td>
<td>Version 2</td>
<td>Version 2</td>
<td>Version 1</td>
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<td>4-8 years</td>
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<td>9-15 years</td>
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<td>Gloria</td>
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<td>Version 2</td>
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<td>Version 1</td>
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<tr>
<td></td>
<td>Miranda</td>
<td>3 to 5</td>
<td>Elementary/Early Childhood Education</td>
<td>Master's-Curriculum and Instruction</td>
<td>Elementary/Early Childhood Certification-Administration/Supervision Certification</td>
<td>Version 2</td>
<td>Version 2</td>
<td>No interview</td>
<td>No interview</td>
</tr>
<tr>
<td></td>
<td>Joe</td>
<td>6 to 8</td>
<td>Physical Education</td>
<td>Master's-Education</td>
<td>Elementary/Early Childhood Certification-Middle School Teaching Certification-Secondary Teaching Certification</td>
<td>Version 2</td>
<td>Version 2</td>
<td>No interview</td>
<td>No interview</td>
</tr>
<tr>
<td></td>
<td>Marry</td>
<td>6 to 8</td>
<td>Communications</td>
<td>Master's-Other Discipline</td>
<td>Elementary/Early Childhood Certification</td>
<td>Version 2</td>
<td>Version 2</td>
<td>No interview</td>
<td>No interview</td>
</tr>
</tbody>
</table>

Table 3 (cont.)
### Table 3 (cont.)

<table>
<thead>
<tr>
<th>Name</th>
<th>Grades</th>
<th>Years</th>
<th>Education</th>
<th>Master's Education</th>
<th>Certification</th>
<th>Version</th>
<th>Version</th>
<th>Interview</th>
<th>Interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Margaret</td>
<td>K to 2</td>
<td>16+</td>
<td>Elementary Education</td>
<td>Master's Education</td>
<td>Elementary/Early Childhood Certification-Middle School Teaching Certification-Other Teaching Discipline: Reading</td>
<td>Version 2</td>
<td>Version 1</td>
<td>No interview</td>
<td>No interview</td>
</tr>
<tr>
<td>Bob</td>
<td>3 to 5</td>
<td>9-15</td>
<td>Art</td>
<td>Master's Education</td>
<td>Elementary/Early Childhood Certification-Other Teaching Discipline: Reading</td>
<td>Version 2</td>
<td>Version 1</td>
<td>No interview</td>
<td>No interview</td>
</tr>
<tr>
<td>Julia</td>
<td>6 to 8</td>
<td>16+</td>
<td>Elementary/Early Childhood Education</td>
<td>Master's Special Education</td>
<td>Elementary/Early Childhood Certification-Middle School Teaching Certification</td>
<td>Version 2</td>
<td>Version 1</td>
<td>Version 1</td>
<td>Version 1</td>
</tr>
</tbody>
</table>

Table 3: This table displays the participants’ academic, teaching, and professional development experiences. It also shows the participants’ answers to the 13th and 15th survey questions: Which one of the storylines would you prefer for your instruction? Finally, the table shows the participants’ answers to “which one of the versions is more coherent?” which was asked in the follow-up interview (Remark: in 13th question, Version 1 is the coherent version and in the 15th question Version 2 is the coherent version).
To investigate if there are differences between groups in terms of their academic and teaching experiences, I separated the Table 3 into smaller sub-tables and each sub-table displays one aspect of academic and teaching background.

<table>
<thead>
<tr>
<th></th>
<th>Number of the participants teaching K-2</th>
<th>Number of the participants teaching grades 3-5</th>
<th>Number of the participants teaching middle school science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of the participants in Group $V_1V_2$</td>
<td>1</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Number of the participants in Group $V_1V_1$</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Number of the participants in Group $V_2V_2$</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Number of the participants in Group $V_2V_1$</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 4: This table displays number of participants in each $V_xV_y$ group in relation to grades that the participants taught.

As seen from Table 4, half of the participants teaching grades 3-5 were in $V_1V_2$ and half of the participants teaching middle school science were in $V_1V_2$. However, only 20% of the teachers teaching K-2 were in $V_1V_2$. Thus, compared to K-2 teachers, more teachers teaching 3-5 and middle school science preferred the coherent instructional sequences in both sequences.

**Table 5: Number of participants in each $V_xV_y$ group in relation to the participants’ years of teaching experience.**

<table>
<thead>
<tr>
<th></th>
<th>Teachers with 3 or less years of teaching experiences</th>
<th>Teachers with 4-8 years of teaching experiences</th>
<th>Teachers with 9-15 years of teaching experiences</th>
<th>Teachers with 16 or more years of teaching experiences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of the participants in Group $V_1V_2$</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

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As seen from Table 5, half of the teachers with 3 or less years of teaching experience were in group $V_1 V_2$, 60% of the teachers with 4-8 years of teaching experiences were in group $V_1 V_2$, half of the teachers with 9-15 years of teaching experiences were in group $V_1 V_2$. However, 16.6% of the teachers with 16 or more years of teaching experiences were in group $V_1 V_2$. Thus, teachers with more years of teaching experiences rarely preferred the coherent instructional sequences in both questions.

**Exemplary Cases**

In order to investigate if the participants’ academic and teaching backgrounds are related to their understanding of coherence, I decided to choose three exemplary cases. For deeper analysis I wanted to include the participants’ interview responses and since I had interviews with 10 participants, I had to choose my three exemplary cases from these 10 participants. My first intention was choosing one participant from each group (I reunited group $V_1 V_1$ and $V_2 V_2$ under one group, since these two are both preferred coherent instructional sequences in one of the questions), however I had only July in group $V_2 V_1$ and her interview responses were unfocused. In her interview, she kept talking about engineering practices and when I asked her “Why do you think that Version 1 is more coherent because it has more building?”, she answered “I don't know. I think right now I have like the engineering challenge kind of thing on the brain for me, I'm kind of thinking about, you know, like segue to that in a lesson. So, I don't know…” (Interview, June 15, 2018). It seems that agenda of the PrIMES Professional Development
Workshop affected her response. Therefore, her interview response was not appropriate for further analysis.

Then I decided to choose three teachers with relatively different academic and teaching backgrounds and compare their understanding of coherence by analyzing their survey and interview answers. My three exemplary cases are Alicia, Peter, and Emma (see Table 6).

<table>
<thead>
<tr>
<th></th>
<th>Alicia</th>
<th>Peter</th>
<th>Emma</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grade Taught</strong></td>
<td>Teaching Middle School Science</td>
<td>Teaching K-2nd graders</td>
<td>Teaching Middle School Science</td>
</tr>
<tr>
<td><strong>Years of Teaching Experiences</strong></td>
<td>9+</td>
<td>4+</td>
<td>4+</td>
</tr>
<tr>
<td><strong>Bachelor’s Degrees</strong></td>
<td>Elementary/Early Childhood Education</td>
<td>Elementary/Early Childhood Education</td>
<td>Bachelor’s Degree in Non-Educational Field</td>
</tr>
<tr>
<td><strong>Master’s Degrees</strong></td>
<td>Curriculum and Instruction</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Teaching Certificate(s)</strong></td>
<td>Elementary/Early Childhood Certification-Middle School Teaching Certification-National Board Teaching Certification</td>
<td>Elementary/Early Childhood Certification</td>
<td>Middle School Teaching Certification-Secondary Teaching Certification</td>
</tr>
</tbody>
</table>

Table 6: This table displays academic and teaching backgrounds of three exemplary cases.

**Case 1: Alicia.** Alicia had between 9-15 years of teaching experience. She taught science classes at a rural middle school in the Midwest. She held bachelor’s degree in elementary/early childhood education and master’s degree in curriculum and instruction. Alicia had the following teaching certifications: Elementary/Early Childhood Certification, Middle School Teaching Certification, and National Board Teaching Certification.

**The Survey: Which of the versions would you prefer? Explain Why.** In the survey, she preferred the coherent versions for both questions (the 13th and 15th question). When she was requested to provide justifications, Alicia did not explicitly mention about coherence as a rationale for her selection. For the 13th question, she shared that she preferred the first version...
because in that version students are exploring the material (the magnet) first, then they talk about their explanations to an authentic audience, and students are creating an engineering device (magnetics) sorting machine as a solution to a problem. For the 15th question, she preferred the second version and she gave the following rationale: because students work together to brainstorm their ideas and because the activity (designing brochure) involves using Language Arts skills.

*The Follow-up Interview: Can you give more detail about your selection in the survey?*

The survey with Alicia yielded little evidence which shows Alicia talked about coherence while she was explaining her rationale for her decision. However, in the follow-up interview, her elaborations revealed some clues that indicate she might consider coherence in her selection. For example, for the 13th question, she stated that she chose Version 1, because “the fact that they (students) were critiquing it was important because that's showing that they're actually thinking about the design carefully and that they need to have an understanding of how it's going to work.” She continued, “the part where they're creating the product pitch that's bringing in speaking and listening and things like that. They have to really understand how it works in order to sell it” (Interview, June 19, 2018). She argued that in order to critique an invention and later create and sell their invention, the students need to have a strong understanding of the design. Thus, she pointed out the connection between the activities that students engage in and the science concepts behind them. In other words, she emphasized that completing this activity will give them a strong understanding of the science idea behind it. Since making a connection between activities and science ideas is one of the factors to achieve coherence (Hanuscin, Lee, Lipsitz, Arnone, & de Araujo, 2015), her rationale aligns with how a coherent instructional sequence should be.
Alicia was then asked to elaborate on the rationale behind her preferences for the 15th question. She answered that she preferred Version 2 because she did not like the “ice cream in a bag” activity in Version 1. Alicia stated “whereas in Version 2 there against their still brainstorming and coming up with examples, but they're working collaboratively, collaboratively in groups again, to complete a challenge of melting something, so showing that they understand the states of matter and phase change in that way…the students then had to come up with a better way to melt ice and design themselves without being told exactly what to do.” (Interview, June 19). Her rationale reveals some clues that the aspects which she liked in Version 2 are similar to how Group B described coherent storylines: students are faced with a problem, they ask questions to discover it, and design some inquiry to answer their questions (Farkash, et al., 2018).

*The Follow-up Interview: Which one of the versions is more coherent?* In the follow-up interview, this time Alicia was explicitly asked to pick which one of the versions is more coherent. Alicia answered she could not choose either of them without knowing the performance expectations, disciplinary core idea, and standards behind those storylines. This may mean that she considered that there must be a connection between the activities and learning goals which is an important consideration to set intra unit coherence, drawing on Fortus and Krajcik’s (2012) definition.

*The Follow-up Interview: How would you define coherence?* Finally, in the follow-up interview Alicia was asked to provide her definition of coherence. She presented an understanding of coherence from a student perspective: “Students should move from one understanding to the next and know why they are going where they are going and how they got there.” (Interview, June 19, 2018). Reiser, Novak, and McGill (2017) advocated that storylines must be coherent from students’ perspective and articulated that scientific practices should be
meaningful for students: students should not perform an activity because the activity sheet told them to do so; they should be aware of why they are performing this activity. In this sense, Alicia’s understanding also argued coherence from a student perspective since she stated, “Students should…know why they are going where they are going and how they got there.” And she also explicitly added, “Again, it is not coherent if the students do not see coherence in it.” (Interview, June 19, 2018)

Briefly, Alicia did not explicitly use coherence as criterion in her instructional decisions, but implicitly used coherence as criterion in her instructional decisions. When she was asked about which of the versions is more coherent, she could not choose either of them, but she raised an important concern that she needs to know learning expectations to decide which of the versions is more coherent. This concern may show that she was considering the alignment between learning goals and instructional activities which is a requirement for establishing intra-unit coherence (Fortus & Krajcik, 2012). As mentioned in the beginning, Alicia had a considerable amount of teaching experience, she held a bachelor’s degree from an education related field, and she held a master’s degree in Curriculum and Instruction. Also, Alicia taught middle school science, in contrast to some other elementary teachers who teach several subjects in addition to science. Furthermore, Alicia had the following teaching certifications: Elementary/Early Childhood Certification, Middle School Teaching Certification, and National Board Teaching Certification. All of these academic and experiences may contribute her to having an understanding of coherence that she applied in her instructional decisions.

**Case 2: Peter.** Peter had more than four years of teaching experience. He taught science for K-2 graders in a rural school in the Midwest. He held a bachelor’s degree in elementary/early childhood education, and he did not hold a master’s degree. Peter had Elementary/Early Childhood Certification.
**The Survey: Which of the versions would you prefer? Explain Why.** Peter chose Version 2 and Version 1 for the 13th and 15th question respectively. He was the only participant who mentioned coherence when he was asked to provide the rationale behind his choices. He explained the rationale behind his preference in the 13th question as: “It seems like each lesson builds directly upon previous lessons and the experiences contained. It seems much more well connected.” For the 15th question, again he preferred Version 2, and he explained “It seems much more connected and authentic. There is a real reason for the final project.” This is interesting, because even though he was the only participant who used coherence as a criterion at his instructional decision, he chose the incoherent version in the 13th question. However, in the follow-up interview, I asked him to elaborate on his selection and he became hesitant about his answer. Finally, he changed his mind and picked Version 1 because in Version 1, at each step students were supposed to use what they learned in the previous step(s).

**The Follow-up Interview: How would you define coherence?** In the follow-up interview Peter was asked to provide his definition of coherence. He explained that to develop a coherent storyline, the teacher needs to work backwards:

> The best way to do it is to work backward. Start with what you want them to do and then work backward to see how can we get there, you know, what would the step before this be, what would, what do they need to know to be able to do this, what sort of experiences they've had that would connect to all of this to begin with. And then when you go forward with it, you know, it's A to B to C. I don't know if that's a good answer or not, but” (Interview, June 20, 2019).

Thus, he mentioned the connection between each step within an instructional sequence. He also added, “You can have things that are about the same topic but not really connected to each other and I think it’s much better for students when each individual lesson connects to all other lessons
in the unit” (Interview, June 20, 2019). Since he advocated having activities which are about the same general topic does not necessarily mean that this instructional sequence is coherent, his understanding of coherent storylines is aligned with Hanuscin et. al. (2016) understandings since Hanuscin et. al. (2016) stated “…simply having activities connect via a broad topic (e.g., ‘magnets’) does not provide coherence; rather, coherence is important in terms of a key concept or idea that is emphasized throughout a lesson” (p.398).

Peter presented relatively consistent understanding of coherence: in the beginning, he chose the incoherent version, but later in the interview he changed his mind and preferred the coherent one (in this context consistent understanding of coherence can be defined as maintaining correct and stable understanding of coherence. Correctness of understanding means being aligned with Group A’s and Group B’s understanding of coherence and stability of understanding means remaining in the same line of understanding during different time points: survey and interview). For example, when he was talking about how one version is coherent, he explained, “They (students) talk about the pattern they found. It connects to the next activity” and “They (students) used what they just learned from the original activity.” Also, when he was claiming that another version is incoherent, he explained, “In this one each little activity is kind of their own lesson. It doesn’t all connect together” (Interview, June 20, 2019). However, compared to Alicia he was more inconsistent in his answers since he claimed incoherent version was the coherent one at first place. Also, Alicia largely discussed an understanding of coherence from students’ perspective, but Peter did not articulate any concern about this issue. Compared to Alicia, Peter had fewer years of teaching experiences, did not hold a master’s degree, and had fewer teaching certificates. Furthermore, while Alicia taught middle school science, Peter taught K-2 grades. Thus, Alicia focused on science teaching throughout the day, but Peter taught other
subjects too. These difference between their academic and teaching background might cause Alicia to have a more consistent understanding of coherence.

**Case 3: Emma.** Emma had more than four years of teaching experience. She taught science classes at a rural middle school in the Midwest. She held a bachelor’s degree in a field outside of education, and she did not hold a master’s degree. Emma had the following teaching certifications: Middle School Teaching Certification and Secondary Teaching Certification. Emma provided an inconsistent understanding of coherence in her survey and interview responses.

_The Survey: Which of the versions would you prefer? Explain Why._ Emma preferred the coherent versions for both questions (the 13th and 15th question). When she was asked to provide justifications, she did not explicitly mention coherence as a rationale for her selection. For the 13th question, she preferred Version 1 and she wrote in the questionnaire: “It allowed the students to have more self-exploration and less guided exploration,” and “students in Version 1 are allowed to evaluate what makes a successful magnet and how it truly works.” For the 15th question, she preferred Version 2 and she wrote in the questionnaire: “I also like the aspect where the students notice patterns within their data (referring the second step in Version 2).”

_The Follow-up Interview: Can you give more detail about your selection in the survey?_ In the follow-up interview, Emma was asked to provide more detailed explanation about her preference in the survey, she mentioned the similar rationale to the ones in the survey which are “It allowed the students to have more self-exploration and less guided exploration,”, “students in Version 1 are allowed to evaluate what makes a successful magnet and how it truly works.”, and “I also like the aspect where the students notice patterns within their data (referring the second step in Version 2).”
The Follow-up Interview: Which one of the versions is more coherent? In the follow-up interview, this time Emma was explicitly asked to pick which one of the versions is more coherent according to her. She said that she cannot say that either of them because they are both coherent. Also, for the 13th question, she criticized that “(In Version 2) They (students) are not making their own questions, the teacher still kind of doing that.” (Interview, June 20, 2018). This criticism may show that her understanding of a coherence was aligned with Group B’s understanding of coherent storyline in the sense that storyline is progressing with students’ questions. However, when she was asked to provide her definition of coherence, she argued an opposite understanding of what she mentioned in here.

The Follow-up Interview: How would you define coherence? Lastly, Emma was asked to give her definition of coherence, she argued in coherent instructional sequences, the material needs to be clear and then she continued, “It may not be explicitly clear to the students, it should be clear to the teacher at least” (Interview, June 20, 2018). Later in her interview, she also added that “From the teachers perspective teacher’s perspective it is always going to be coherent but not necessarily always going to be to the student” (Interview, June 20, 2018). In the earlier part of the interview, she claimed that the lesson should move forward with students’ questions and students need to notice the pattern in their data, but now she argued somehow an opposite understanding and advocated that a unit need not to be clear and coherent from the students’ perspective. She also added that teachers should inform students why they are doing what they are doing, which again contradicts with what she argued earlier: a lesson in which students engaging more free exploration and less guided exploration, progressing with students’ own questions, and students discovering the pattern in their data.

Briefly, Emma did not mention the connection between learning activities and learning expectations. On the other hand, Emma raised some points that can be interpreted as her
advocating coherence from students’ perspectives. However, when she was asked to talk about her understanding of coherent storylines, she gave contradictory answers to her earlier comments. It seems Emma is unstable in her understanding of coherent instructional sequences compared the participant Alicia who showed a more stable understanding. The differences between their understanding may stem from participants’ relatively different academic and teaching experiences. Firstly, Alicia had more years of teaching experience than Emma had. Secondly, Alicia held a bachelor’s degree from an educational related field and master’s degree from curriculum and instruction, however Emma held her bachelor’s degree from another discipline and she did not hold a master’s degree. Thus, among all three exemplary cases, Alicia was the one with more academic, and teaching experience and she was the one with the most consistent understanding of coherence. She also, articulated an understanding of coherence from students’ perspective.

Do teachers consider coherence as criterion in their instructional decisions?

The second research question I investigated was if teachers consider coherence in their instructional decisions. In the research study investigating teachers’ ability to design coherent lesson and distinguish a coherent lesson from an incoherent lesson in relation to their content knowledge, pedagogical knowledge, and pedagogical content knowledge, Hanuscin, Lee, Lipsitz, Arnone, and de Araujo (2015) found that although most of the teachers (22 out of 33) preferred the lessons with coherence, most often they stated that they chose this lesson over the other because it gave opportunities for student collaboration or it has hands-on activities. They did not state “coherence” for the reason behind their selection. Similarly, in my study for both questions the majority of the participants preferred the coherent instructional sequence (12 participants for the 13th question and 15 participants for the 15th question). However, only Peter mentioned coherence as criterion in his rational behind his preference. He wrote in the
questionnaire, “It seems like each lesson builds directly upon previous lessons and the experiences contained. It seems much more well connected.”

On the other hand, Alicia did not mention coherence in her justification. However, in the follow-up interview, when she was asked to elaborate her justification, she mentioned her rationale was including clues which show that she might have considered coherence implicitly. Thus, not mentioning coherence explicitly, do not necessarily mean that the participants did not consider coherence as a criterion in their instructional decisions.

Summary of Findings

To conclude, in this chapter, I divided participants in to four groups: $V_1V_2$, $V_1V_1$, $V_2V_2$, $V_2V_1$, I found that there were less percentage teachers teaching K-2 and preferring the coherent instructional sequence in both questions. I also found that lower percentage of teachers having more than 16 years of teaching had preferred the coherent instructional sequence in both questions. In order to have further understanding about teachers’ understanding of coherence in relation their academic and teaching background I chose three exemplary cases: Alicia, Peter and Emma. I found some differences in their understanding of coherence and differences in their academic and teaching backgrounds. Also, to investigate my second research question, I analyzed participants’ justifications for their selections to see if they mentioned coherence, and I found that even though most of the participants preferred the coherent versions they did not mention coherence as criterion in their selection explicitly. In the final chapter, I will present a discussion of the findings, as well as implications and directions for future research.
CHAPTER 5: DISCUSSION AND CONCLUSIONS

In this chapter, I will synthesize and interpret the findings which I have presented in Chapter 4. Even though I have a relatively small sample size, I will still make several reasoned judgements and conclusions corresponding to the findings.

Throughout the literature about coherence, there are studies investigating the difficulties teachers face when they were designing coherent instructional sequences (Ermeling & Graff-Ermeling, 2016; Hanuscin et. al, 2016; Plummer & Tanis Ozcelik, 2015; Wiebke & Park Rogers, 2014). Studies investigate if teachers could distinguish a coherent instructional sequence from an incoherent instructional sequence (Hanuscin, Lee, Lipsitz, Arnone, & de Araujo, 2015). However, none of these studies explore teachers’ ability to distinguish a coherent instructional sequence in terms of the teachers’ academic and teaching background. Studying this issue is important because if, for example, middle school science teachers are less likely to prefer coherent instructional sequences, this finding may prompt policy makers to promote professional development emphasizing the importance of coherence in lessons specifically for this population.

As seen in the findings section, a relatively lower percentage (20%) of teachers teaching K-2 grade preferred the coherent instructional sequences. The reason for this might be that compared to middle school science teachers, K-2 teachers on average teach fewer hours of science in a week. Therefore, teachers who taught fewer hours of science may not distinguish a coherent instructional sequence from an incoherent instructional sequence and choose the coherent one. However, since this is an exploratory study with a relatively small sample size, I cannot make conclusive statements about this point. The second finding was that only 16.6% (1 participant) of the participants with more than 16 years of teaching experiences (N=6) had preferred the coherent instructional sequences in both questions. Interestingly, the majority of participants with more years of teaching experience chose the incoherent instructional sequences.
This stands in contract to earlier research that showed that teachers with more experience in teaching science are more likely to prefer coherent instructional sequences. Therefore, this issue needs to be studied further.

I analyzed three exemplary cases (Alicia, Peter, and Emma) in order to obtain a more enhanced understanding of possible influences of teachers’ academic and teaching background on their understanding of coherence. I chose these three participants because, firstly these participants participated in the follow-up interview so that in addition to the participants’ survey responses, I could also analyze their follow-up interview responses. Secondly, these participants had relatively different academic and teaching backgrounds so that I could compare teachers’ understanding of coherence in terms of their academic and teaching experiences. Among my three exemplary cases, Alicia had the most consistent understanding of coherence, Emma had the least consistent understanding of coherence, and Peter’s understanding of coherence was somewhere between Emma and Alicia. Considering the differences between these participants’ academic and teaching, having more years of teaching experience, having more teaching certificate, teaching just science instead of teaching all the subject, holding a bachelor’s degree from an educational related field, and holding master’s degree from an education related field, the more consistent understanding of coherence they got. These findings showed the importance of academic and teaching experiences in increasing teachers’ tendency to be consistent in their understanding of coherence.

In my study, the majority of the participants preferred the coherent instructional sequence in the 13th (N=12) and 15th (N=15) question, but only one (Peter) of the participants mentioned coherence in his justifications. Similarly, in the study conducted by Hanuscin et. al. (2015), although most of the teachers (22 out of 33) preferred the lessons with coherence, most often the participants’ stated that they choose this lesson over the other because it gives opportunities for
student collaboration or it has hands-on activities. They did not state “coherence” as a reason for their selection. However, in contrast to Hanuscin et. al (2015), I cannot conclude that teachers do not consider coherence as criterion in their instructional decisions. The participants might not mention coherence, but it might be the case that they considered it implicitly, since in both studies a majority of the participants preferred the coherent version but did not state “coherence” in their rationale behind their preferences. For example, Alicia did not state “coherence” in the survey, but when she was asked to elaborate on her justifications in the interview, as seen in the exemplary cases, there were clues which showed she considers the connection between science activity and the science idea behind it. There were also clues which showed her understanding of how a storyline should proceed aligned with understanding of coherent storyline defined by Reiser, McGill and Novak (2017). Also, Alicia was the one who had the most consistent understanding of coherence. In this sense, determining if a teacher uses coherence as a criterion in her/his instructional decisions is a more complex issue that cannot be fully understood by survey questions asking about teachers’ rationale behind their preferences.

Since both in my study and the study conducted by Hanuscin, Lee, Lipsitz, Arnone, and de Araujo (2015), the majority of the participants preferred the coherent version, it is possible that the teachers mostly prefer coherent storylines even though they are not explicitly stating “coherence” in their justifications. However, I cannot conclude that each and every teacher who preferred coherent storylines have a consistent understanding of coherence. For example, Emma was in the $V_1V_2$ group (the group who preferred coherent version in both questions), but she was inconsistent in her understanding of coherence. Another example would be Kathy and Rose (see Table 1) who were initially in group $V_1V_2$ (the group who preferred coherent version in both questions), but when they were asked to which of the versions is more coherent, they fell into the group $V_1V_1$. 
Finally, as mentioned in Chapter 2, this research study is based on the learning theories used while preparing Framework for K-12 Science Education and NGSS. In case 1, Alicia started that in coherent instructional sequences students should understand the purpose behind components of a lesson, and she added that an instructional sequence will not be coherent if students do not see coherence in it. However, in case 2, Emma stated a coherent instructional sequence does not have to be coherent from a student’s perspective, but it should be coherent form a teacher’s perspective. However, according to the learning theories behind coherent instructional sequences and coherent storylines, students should be building on their own experiences and the teacher should act as facilitator. In this case, storylines which are only coherent from teachers’ perspective wouldn’t align the learning theory behind it. Since Alicia’s understanding of coherence is more consistent compared to Emma’s understanding, knowing that one of the underlying meanings of consistency in this context is true (in addition to stable), this study aligns with learning theories behind Framework for K-12 Science Education, NGSS, coherent storylines, and coherent instructional sequences.

In summary this study adds to the existing research on revealing teachers’ understanding of coherence in relation to their academic and teaching background and teachers’ use of coherence as criterion in their instructional decisions. To conclude, teachers’ academic and teaching background may contribute to their understanding of coherence, however the question of whether teachers use coherence as a criterion in their instructional decisions remains inconclusive. The participants barely mentioned coherence in their justifications. However, knowing that in both my study and the study conducted by Hanuscin et. al. (2015), the majority of the participants preferred the coherent instructional sequences, it is conceivable that that even though participants do not mention coherence, they might have implicitly considered it and preferred coherent versions.
Limitations

There are several limitations to the present study. First of all, the sample size for the survey and for the follow-up interview is small. Secondly, this study is conducted by teachers working in Illinois schools. These two limitations restrict the external generalizability of the study. Therefore, a future study could examine a larger sample of teachers’ responses within one state, or across a range of states or regions. However, since this study is exploratory in nature, I believe that small sample size and limited geographical context is acceptable.

Also, the participants’ teaching background is quite diverse. Some of my participants teach elementary graders, and therefore they probably teach science in couple of hours a week. On the other hand, I have other participants who teach middle and high school science for roughly 30 hours a week. In summary, it is difficult to compare elementary school teachers with middle school teachers since they are exposed significantly different amount of science teaching.

Finally, data collected for this research study was self-reported. Even though, the question in the survey was objective such as “What is the highest degree that you hold?” or “What certification(s) do you currently possess?”, there might still be some errors in the data due to participants’ inattention when they were filling the survey. Therefore, using self-reported survey might affected the validity of this research study.

Implications for Future Research

This study explored whether or not teachers use coherence as a criterion in their instructional decisions and teachers’ understanding of coherence in relation to their academic and teaching background. However, preferring coherent instructional sequence, stating coherence as criterion in instructional decisions and/or having a consistent understanding of coherence do not necessarily mean that these teachers are also able to develop a coherent science storyline and apply it in their instruction. Therefore, the future research can study the relationship between
teachers’ understanding of coherence and their ability to develop coherently organized lesson sequences via classroom observations. Furthermore, student learning should be also observed and measured via pre and posttests. Future research could explore whether or not coherently sequenced instruction help students to build a coherent understanding of science ideas. Lastly, this study was conducted by the participants who took part in PrIMES professional development workshop and who has recently developed science storylines. A replication study could be conducted with teachers who did not take part in professional development.
REFERENCES


APPENDIX A: THE SURVEY

Survey

Summer, 2018

* 1. What is your name?
   (This is only to reach you if you want to participate a follow-up interview. We will not use your name in any reports.)

   [Name]

* 2. Which of the following best describes your current assignment?
   - Full-time classroom teacher
   - Hybrid (partial release) teacher (e.g., department head/classroom teacher, classroom teacher, coach/classroom teacher)
   - Full release from classroom – Administrator
   - Full release from classroom – Department head, subject specialist, coach, or program director
   - Other (please specify)

* 3. Which subject(s) do you currently teach, or did you teach?
   (Please mark all that apply)
   - Elementary/Early Childhood (self-contained teaching including multiple subjects)
   - Mathematics
   - English/Language Arts
   - Science
   - Social Studies
   - Interdisciplinary course (e.g., includes math and science)
   - Career and Technical Education
   - Other (please specify)

   - Foreign Language
   - Special Education
   - Technology
   - Engineering
   - Computer Science
   - Visual/Performing Arts
   - Health and Physical Education
4. For how many years have you been teaching at your current school, or the last school where you were teaching?

(Check one.)

- 3 or less
- 4-8
- 9-15
- More than 16

5. In what grade level band is your current teaching assignment?

(Please check all that apply.)

- K-2
- 3-5
- 6-8
- 9-12
- Not currently assigned as a teacher

6. What is the highest degree you hold?

(Check one.)

- Associate degree
- Bachelor's
- Master's
- Doctoral
- Other (please specify)

7. What was your major field of study for the Bachelor’s degree?

(Check one.)

- Elementary/Early Childhood Education
- Middle School Education
- Other Discipline (Science, History, English, Foreign Language, etc.)
- Secondary Education
- Special Education
8. If applicable, what was your major field of study for the highest degree you hold beyond the Bachelor's degree?

(Check one)

- Not applicable (Bachelor's is the highest degree I hold)
- Early childhood education
- Curriculum & Instruction
- Education Administration/Supervision
- Mathematics or Science Education
- Special Education
- Other Education
- Other Discipline (Science, History, English, Foreign Language, etc.)

9. What certification(s) do you currently possess?

(Please mark all that apply)

- Provisional or Temporary Certificate
- Elementary/Early Childhood Certification
- Middle School Teaching Certification
- Secondary Teaching Certification
- Other Teaching Discipline (please specify)

- National Board Teaching Certification
- Special Education
- Administration/Supervision certification

10. Specific to mathematics or science, how many hours have you spent participating in professional development or professional learning activities in the past 12 months?

<table>
<thead>
<tr>
<th>Activity</th>
<th>None</th>
<th>1-5</th>
<th>16-35</th>
<th>36-59</th>
<th>60+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content knowledge in science or engineering</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science teaching practices, methods</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Content knowledge in mathematics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math teaching practices, methods</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**11. To what extent do you agree with the following statements regarding teaching and teacher roles?**

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am interested in trying out new instructional strategies or approaches</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>to improving learning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teachers in my school often share instructional ideas or materials</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I am supported by other teachers in my school to try out new ideas or</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>approaches to teaching a subject</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I am supported by administrators in my school to try out new ideas or</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>approaches to teaching a subject</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In this school teachers should have a greater role in making decisions</td>
<td>○</td>
<td></td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>about curriculum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have adequate time during the school week to work with my peers on</td>
<td>○</td>
<td></td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>curriculum and instruction</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All students can learn challenging subject content, e.g., in science or</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>math</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I have opportunities to use my leadership skills</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

**12. As a teacher, have you collaborated with other teachers with regard to the following?**

<table>
<thead>
<tr>
<th>Collaboration Type</th>
<th>No</th>
<th>Yes, within past week</th>
<th>Yes, within past month</th>
<th>Yes, within past 6 months</th>
<th>Yes, within past 12 months or more</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professional learning community (i.e., regular meeting of teachers to improve</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>instruction, often with others of same subject or grade level)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analysis and interpretation of data</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Engagement in a virtual teacher network</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Co-teaching a course, subject, or unit</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Mentoring another teacher (informal)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Observation of a peer and providing feedback</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Last professional development session</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>
Please read the following storylines carefully.

**Version 1**

As a group, students brainstorm everyday items they know that use magnets. They discuss what the item is, how it works, and what role magnets play.

The teacher then provides each pair of students with a magnetic object to explore (e.g., magnetic fishing game).

She asks them to focus on the types of interactions (attracting/repelling) and whether magnets are interacting with other magnets or other objects. Afterward, pairs present their items to the class, explaining how they work.

The teacher then shares a proposal for a ‘magnetic recycling sorter’ that claims to sort metal and nonmetal items for recycling, and asks groups to discuss whether they think the invention would work.

Students critique this product and decide that it would not attract all metals and might accidentally trap nonmetals between the magnet and iron objects.

Each student is then challenged to come up with their own working magnetic invention. They build prototypes and create a ‘product pitch’ to share at an Invention Convention.

**Version 2**

As a group, students brainstorm everyday items they know that use magnets. They discuss what the item is, how it works, and what magnetic interactions are involved.

The teacher then provides each student a compass and asks them to explore and determine whether the compass is magnetic.

Building on students’ observation that the compass needle moves when a magnet is brought near it, the teacher asks students to record the maximum distance from the compass that different magnets influence its direction.

Students then use this as evidence to support their arguments about which magnet is the strongest. Students agree that the farther the distance from which a magnet affects the compass needle’s direction, the stronger it is.

Students then watch a video on YouTube from the National High Magnetic Field Laboratory called *the World’s Strongest Magnet*. In this video, scientists share how they build an electromagnet.

Afterward, students are able to build their own electromagnets by wrapping wire around steel bolts and attaching these to a battery.

* 13. Which one of the storylines would you prefer for your instruction?

☐ Version 1

☐ Version 2

* 14. Please explain the reason for your preference. Give at least three reasons and try to give as much detail as possible.
Please read the following storylines carefully.

**Version 1**

The teacher challenges students to come up with examples from everyday life where matter changes from one form to another (e.g., solid to liquid). The class discusses factors involved in these changes.

Students, in groups, visit a variety of stations (with solids, liquids, and gases) for the purpose of determining whether all matter (a) has a definite shape; (b) takes up space/has volume; and (c) has mass. For example, students use a scale to compare the mass of a balloon that is inflated with one that is deflated.

Students are asked to generate a list of things that are/are not “matter.” Each group presents a chart to the class and discusses their reasoning.

Students make “ice cream in a bag,” exploring factors that affect changes in state (liquid to solid) that the ingredients undergo. They experiment with the recipe to try to shorten the time required for the ice cream to be ready.

Students are provided cards depicting common objects and are asked to sort these based on whether they are solid, liquid, or gas—then to describe why they placed objects where they did. The class tries to reach consensus on how each object should be classified. Some interesting items provoke discussion—such as ice cream. It can be frozen solid but left out it melts. Similarly, chocolate sauce is liquid when heated but becomes solid when it cools.

**Version 2**

The teacher challenges students to brainstorm examples from everyday life where matter changes from one form to another (e.g., solid to liquid). The class discusses factors they think are involved in these changes.

Students work in groups to complete a challenge—be the first team to melt the ice cube you’ve been provided (in a resealable bag). Students think about factors they brainstormed and how these relate to ice melting. They come up with a plan to test their ideas.

Groups share results of their investigation, and the teacher asks them to notice patterns. The class agrees that temperature and surface area are two factors that were important for ice melting. One group also notices that color played a role (they put theirs in the sun on top of black paper). The teacher indicates that black objects absorb more heat energy from the sun. She relates this to students’ experiences with a black car parked in the sun versus a white car. She asks students to identify other sources of heat energy (from the light/sun/their bodies) that helped melt the ice.

The teacher next performs a demonstration and discusses how salt can be used to melt ice in driveways and sidewalks—but notes that this can damage lawns. She challenges groups to use what they know to come up with a way to melt ice on sidewalks and driveways without using salt. Students gather materials and test their plans.

Students create a brochure to distribute to the school and local community that explains how to melt ice on sidewalks and driveways without using salt. They describe their method and explain how it works using the concept of energy and changes to states of matter.
15. Which one of the storylines would you prefer for your instruction?

- Version 1
- Version 2

16. Please explain the reason for your preference. Give at least three reasons and try to give as much detail as possible.

   

17. Do you want to attend a 15 minutes follow-up interview?

- Yes
- No
APPENDIX B: THE FOLLOW-UP INTERVIEW

The questions at the follow up interview will be determined according to the teachers’ answers to the survey. Possible questions will be like the following:

-In the survey you have said that you choose the X because it was fun. What do you mean by fun? Can you explain it? Etc.

By the end of the interview the teachers will be asked to provide a definition for coherence.

The interview will be approximately 15 minutes.

The interview will be audio recorded.
APPENDIX C: IRB APPROVAL

Notice of Approval: New Submission

May 7, 2018

Principal Investigator: Liv Thorstensson Davila

CC: Gozde Tosun

Protocol Title: Instructional Decisions of Science Teachers

Protocol Number: 18806

Funding Source: Unfunded

Review Type: Exempt

Status: Active

Risk Determination: no more than minimal risk

Approval Date: May 7, 2018

This letter authorizes the use of human subjects in the above protocol. The University of Illinois at Urbana-Champaign Institutional Review Board (IRB) has reviewed and approved the research study as described.

Exempt protocols are approved for a five year period from their original approval date, after which they will be closed and archived. Researchers may contact our office if the study will continue past five years.

The Principal Investigator of this study is responsible for:

- Conducting research in a manner consistent with the requirements of the University and federal regulations found at 45 CFR 46.
- Requesting approval from the IRB prior to implementing modifications.
- Notifying OPRS of any problems involving human subjects, including unanticipated events, participant complaints, or protocol deviations.
- Notifying OPRS of the completion of the study.

Office for the Protection of Research Subjects
University of Illinois at Urbana-Champaign
(217) 333-2670
irb@illinois.edu