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Investigating the Attitudes, Beliefs and Practices of High School Chemistry Teachers Regarding the Differentiation of Instruction

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INVESTIGATING THE ATTITUDES, BELIEFS AND PRACTICES OF HIGH SCHOOL CHEMISTRY TEACHERS REGARDING THE DIFFERENTIATION OF INSTRUCTION

By

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An Abstract of the Thesis
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Differentiation of instruction (DI) is a broad term used for a group of pedagogical tools that teachers use to individualize instruction for students of different abilities and needs. Differentiation of instruction is a practice that has been researched and characterized to have a variety of instructional benefits, some of which include increased student motivation and engagement (Tomlinson, 2001). This study sought to characterize the attitudes, beliefs, and practices of ten high school chemistry teachers in Maine regarding the differentiation of instruction. Through a phenomenological approach, interviews with these teachers were analyzed to understand how high school chemistry teachers define differentiated instruction, what their beliefs and attitudes about differentiation of instruction are, and how they practice differentiation of instruction techniques in the classroom. Additionally, the study probed how differentiation of instruction implementation is understood in school culture and policy as an explicit practice or an implicit understanding, in order to assess the school environment's influence on their practice of differentiating instruction. The study investigated (via a retrospective analysis) the influence of

professional development events geared towards differentiation of instruction during the pre-service and in-service periods on in-service teacher implementation of differentiated instruction techniques in the classroom. Furthermore, the teachers were queried about the communication between teachers of different disciplines about DI. Lastly, the teachers' own experiences with differentiation of instruction as a student were addressed, as well as the change in what they believed about the implementation of differentiation of instruction techniques when the transition to remote instruction in March of 2020 occurred due to the COVID-19 pandemic. Additionally, through a pseudo-grounded theory approach, the connections between differentiation of instruction and student autonomy were investigated, as well as the connection to conceptual hierarchies, grouping and tracking of students, and differentiating mathematics topics in chemistry.

Interview data from this study suggests that teachers do have a common definition of differentiation of instruction, and have common differentiation practices, but there is a general lack of professional development opportunities for teachers and a lack of support from the school administration, despite the implied expectation that teachers should be differentiating their instruction as a good pedagogical practice.

As a result of the study, it is clear that high school chemistry teachers in Maine need effective professional development opportunities to increase their understanding of differentiation of instruction as well as specific training to be able to confidently differentiate the math-related topics in chemistry to be able to provide individualized instruction and support for students learning chemistry. Future work can include the development of professional development opportunities for high school chemistry teachers based on the recommendations given in this work.

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INTRODUCTION

Differentiation of instruction (DI) is a broad term used for a group of pedagogical tools that teachers use to individualize instruction for students of different abilities and needs. Differentiation of instruction is a practice that has been researched and characterized to have a variety of instructional benefits, some of which include increased student motivation and engagement (Tomlinson, 2001). Differentiation of instruction could include providing choice in the way students want to show what they have learned; for example, this could be different ways of making a product on the same topic, such as making a poster or video on atomic structure. DI could also include developing different levels of worksheets for different student abilities or learning preferences, and providing content in multiple ways, such as audio, video kinesthetic, etc. Lastly, DI could be about using different instructional strategies, such as praise, scaffolding, and token systems, based on student abilities, needs and developmental stages. Differentiation of instruction is an umbrella term for these and other practices, and while a wealth of information is available in differentiating instruction in literacy or mathematics, there is a lack of literature on DI in science. This is why this study sought to characterize the attitudes, beliefs, and practices of ten high school chemistry teachers in Maine regarding the differentiation of instruction. Interviews with these teachers were analyzed, through a phenomenological approach, to understand how high school chemistry teachers define differentiated instruction, what their beliefs and attitudes about differentiation of instruction are, and how they practice differentiation of instruction techniques in the classroom. The study probed school culture and policy regarding the differentiation of instruction as an explicit statement or an implicit understanding in order to characterize how the school's environment influences how teachers practice differentiated instruction in the classroom. The study investigated (via a retrospective analysis) the influence of

professional development events geared towards differentiation of instruction during the pre-service and in-service periods on in-service teacher implementation of differentiated instruction techniques in the classroom. Furthermore, the teachers' communication with colleagues in other disciplines about the differentiation of instruction was investigated. Lastly, the teachers' own experiences with differentiation of instruction as a student were addressed, as well as the change in what they believed about the implementation of differentiation of instruction techniques when the transition to remote instruction in March of 2020 occurred due to the COVID-19 pandemic. Additionally, the connections between differentiation of instruction and student autonomy were investigated through a pseudo-grounded theory approach, as well as the connection to conceptual hierarchies, grouping and tracking of students, and differentiating mathematics topics in chemistry.

Teacher attitudes and beliefs about differentiated instruction techniques are an important factor in influencing and shaping they will implement the techniques in the classroom. The purpose of the study was to understand the in-service high school chemistry teacher attitudes, beliefs and practices regarding the differentiation of instruction, which would be helpful in articulating and developing the ways teachers can be supported in the implementation of differentiated instruction techniques in the high school chemistry classroom. The following research questions were investigated with the associated interview questions in parentheses for reference, comprising a total of 12 interview questions relating to the study, with follow up questions used to expand on responses (see Appendix C for the interview protocol):

1) How do high school chemistry teachers define and use differentiated instruction? (Q1,2,4)
2) What are the attitudes, beliefs, and opinions that high school chemistry teachers have about differentiated instruction? (Q3,5,10,11,12)
3) Are there explicit statements or implicit expectations from the administrative team that teachers should be using differentiated instruction techniques? (Q7)
4) Is there exposure to differentiated instruction for teachers through crosstalk between disciplines or professional development events? (Q6,8,9)

The answers to these questions could be a first step in understanding how high school chemistry teachers think about differentiation and how they implement it in the classroom. It will also be helpful to understand the kinds of supports that are available to these teachers and what kinds of supports they would like to see in the future from the school administration and professional development events. This might include how science teachers interact with other disciplines, such as mathematics, considering that few science teachers receive training in math pedagogy. The greater education research community can use this work as a characterization of this group of teachers in order to make generalizations about the greater teaching community and inform future professional development.

As a result of the study, it is clear that although teachers have a common definition of differentiation of instruction and have common differentiation practices, there is a lack of professional development and administrative support, which shows that high school chemistry teachers in Maine need effective professional development opportunities to increase their understanding of differentiation of instruction as well as specific training to be able to

confidently differentiate the math-related topics in chemistry to be able to provide individualized instruction and support for students learning chemistry.

The theory of differentiated instruction has its roots in the Sociocultural Learning Theory of Lev Vygotsky, the Constructivist Learning Theory and Howard Gardner's Theory of Multiple Intelligences (Ernest, 1996; Gardner, 2004; Vygotsky, 1978). These are discussed in greater detail in the first part of the work, laying out the theoretical frame and literature review for the differentiation of instruction. The theoretical frame is based on a similar framework by Pablico, whose work was used as a frame for this research in general (Pablico et al., 2017). The theoretical frame is followed by a description of the methodology of the study, including a description of subjects, research design, and methods of data collection and analysis. This is followed by the results and analysis, which is organized in two groups, the phenomenological approach followed by the pseudo-grounded theory approach. Each section describes the questions the teachers were asked with summaries and analysis of their responses and common themes. The conclusion section recaps the major findings of the study and seeks to answer the research questions posed by the research team as well as propose recommendations for future work.

THEORETICAL FRAME AND LITERATURE REVIEW FOR THE DIFFERENTIATION OF INSTRUCTION

Sociocultural Learning Theory

The first learning theory that supports the differentiation of instruction is Vygotsky's Sociocultural Learning Theory which claims that social interaction is crucial in the process of cognition development (Vygotsky, 1978). One concept that Vygotsky became famous for is the concept of the Zone of Proximal Development (ZPD), which holds as its foundation that learning should be matched in some manner to the learner's developmental level. The ZPD is the area of instructional content that the student is not able to complete alone but also does not need the teacher at every step of the way. It is a zone where the student can grow into the knowledge for which he is already half-prepared (Vygotsky, 1978). In this way, the student is developing autonomy while receiving the help needed from social interaction. While not directly created by Vygotsky, the concept of scaffolding is loosely based on the ZPD and is an important factor in the differentiation of instruction (Schunk, 2012). The Sociocultural Learning Theory, and the ZPD, serve as the theoretical bases for the differentiation of instruction by readiness level.

Constructivist Learning Theory

The second learning theory that supports the differentiation of instruction is the Constructivist Learning Theory, which at its basic level starts with the metaphor of construction. This theory holds that students construct knowledge from the experiences that they have with the outside world (Ernest, 1996). These experiences include interaction with peers, teachers, objects, concepts or their own ideas and perceptions of the world around them. Through the metaphor of construction, the learners "construct" their understanding of the world around them and adapt new information to their existing schemas. The biggest applications of the constructivist learning theory to the differentiation of instruction lies in the attention that is paid to the learner's

previous constructs (theoretical basis for differentiation by interest and readiness) and the attention to metacognition and self-regulation (theoretical basis for the building of student autonomy) (Pablico et al., 2017).

Theory of Multiple Intelligences

The third theory that supports the differentiation of instruction is the Theory of Multiple Intelligences, which claims that humans possess a variety of intelligences (eight to be precise) which are active to varying degrees in each individual (Gardner, 2004). These intelligences are linguistic, logical-mathematical, spatial, musical, bodily-kinesthetic, naturalistic, interpersonal, intrapersonal. Of these, it can be asserted that the logical-mathematical, spatial, interpersonal and intrapersonal intelligences are the ones that could be majorly involved in the learning of chemistry and other science subjects, although it should be stated that the other intelligences are also involved to some degree. These intelligences could be involved in the learning of chemistry due to their application in solving chemistry problems, which often involve interacting with your own thoughts, the ideas of others, mathematical and spatial concepts and logical thinking. Gardner (2004) defined intelligence as a biopsychosocial potential to process information in certain ways. The way that each intelligence is expressed in an individual is highly dependent on a variety of factors. The existence of these intelligences forms the theoretical basis for differentiating by learning preference or interest. Additionally, the Multiple Intelligences theory proposes a way for teachers to get an initial assessment for a particular student (Pablico et al., 2017).

Theoretical Foundations of Differentiated Instruction and Definitions

According to Carol Ann Tomlinson, one of the founders of our modern definition of the differentiation of instruction, teachers can modify the content, process, product, or learning

environment for the students. This modification is guided by the teacher's knowledge of the student readiness, interests and learning profile, which serve as the basis of the differentiation of instruction (ASCD[1], 2011a; Tomlinson, 2001). In this context, 'content' denotes the knowledge, understanding and skills that students need to learn, 'process' is defined as the way students come to understand and make sense of the content, 'product' is the way students demonstrate what they have learned and have come to understand and are now able to do, and 'learning environment' is everything that affects the way students learn content (ASCD, 2011a). Subsequently, 'readiness' is defined as the student's proximity to specific content, understanding or skill, 'interest' is defined as something that engages the attention, curiosity or involvement of the student, and 'learning profile' as the student's preference in partaking in, exploring or expressing content (ASCD, 2011a).

Literature Review of Differentiated Instruction

Even though teachers recognize the differentiated instruction approach as essential to use in the diverse classroom, there are a variety of challenges that teachers face when differentiating instruction for students (Ginja, 2020; Njagi, 2014). For one, it seems to be harder to find materials for the differentiation of instruction in the STEM fields, although they are easily available in English Language Arts (ELA), especially literacy (Aldossari, 2018; Franklin, 2020; Oliver, 2016; Pablico et al., 2017). Some teachers have also expressed that implementing differentiation of instruction techniques takes more time and creativity (Ernst & Ernst, 2005; Pablico et al., 2017). There is pressure to cover everything that is listed in the curriculum and teachers have expressed that implementing differentiation of instruction techniques is sometimes

[1] Association for Supervision and Curriculum Development

time-consuming at the expense of subject content. Other challenges that have been previously cited by teachers in relation to differentiating instruction include lack of support from the school administration, too many students in the classroom, lack of instructional time, and lack of classroom space (Aldossari, 2018). Additionally, there is a lack of professional development in differentiating instruction and difficulties with transforming the traditional way of teaching into a teaching philosophy that allows for differentiation of instruction (Aldossari, 2018; Ginja, 2020). Lastly, some teachers have expressed concerns about the fairness of the differentiated instruction approach in terms of having students complete the same amount of work and be assessed by the same principles (Ernst & Ernst, 2005).

On the positive side, differentiation of instruction increases student engagement and differentiating instruction by learning profile lets the teacher extend the ways that they can support students in learning effectively, in terms of time utilization and goal achievement (ASCD, 2011b, 2011a). In addition, differentiating instruction by interest helps students engage with new information by making connections with concepts or topics they already find appealing or relevant (ASCD, 2011a). Topics that students find relevant and interesting are closely aligned with a student's cultural background, strengths, and personal experiences. Furthermore, readiness differentiation makes the work slightly more difficult than the student can manage on their own and provides the necessary support for the student to succeed at the new level of challenge, thereby placing the student firmly in their ZPD (ASCD, 2011a; Vygotsky, 1978). It is also very important that teachers meet the emotional needs of students, whenever possible, and differentiation of instruction techniques can help teachers meet that need (ASCD, 2011b).

This study was designed based on the qualitative part of a study by Pablico in 2017. Pablico's study aimed to determine the effect of differentiated instruction on learning outcomes

of high school science students through both qualitative and quantitative methods (Pablico et al., 2017). The qualitative part of the study focused on the beliefs, experiences, and perceptions of teachers about differentiation of instruction. A total of six teachers were interviewed about their views on the implementation of differentiation of instruction. The following six major themes evolved from the analysis of the interviews: 1) The teachers claimed that differentiated instruction improves student engagement and academic performance in class; 2) The teachers claimed that differentiated instruction motivates the students and that students enjoyed learning when the lesson was differentiated; 3) Five of the six teachers indicated that they differentiate by choice, making it the most common way to differentiate instruction; 4) The teachers claimed that implementing differentiation of instruction techniques made them more efficient, partly because the students were more engaged; 5) The teachers claimed that administrative support has a major influence in the implementation of differentiated instruction; and 6) The teachers claimed that differentiated instruction takes more time and creativity. The qualitative part of the Pablico study was used as a loose model for the design of this study, while the six major factors serve as a partial road map of the points the research team felt were important to investigate in learning about how high school science teachers perceive the differentiation of instruction. The teachers' beliefs and attitudes toward specific instructional practices often serve as a determining factor in whether or not they will use those practices in the classroom.

As a result of the study, Pablico made several recommendations, namely that more professional development should be conducted focusing on differentiation of instruction strategies for science classes and that teacher professional development should focus more on strategies to differentiate science *content*, as opposed to process or product, as science *content* is seldom differentiated. Pablico also suggests that continued implementation of differentiated

instruction in high school science classrooms should be happening, since it positively impacted the learning process by increasing student engagement in class.

Another study showed that the level of perceived differentiation of instruction implementation by teachers was found to be dependent on a variety of factors, namely teachers' differentiation of instruction sense of self-efficacy, teaching beliefs, teaching experience, professional development, teacher certification and classroom size (Nanang et al., 2017). The study was mainly focused on developing an understanding of the network of variables that affect the extent to which teachers implement differentiation of instruction techniques in the classroom. The six variables that were strongly linked to perceived differentiation of instruction implementation (listed above) were incorporated into the design of this study. The connection between teacher differentiation of instruction sense of self-efficacy and implementation of differentiation of instruction practices is also supported by the Neve study (Neve et al., 2015).

Furthermore, a study about teachers that integrated complex learning profile differentiation strategies[2] showed that technology-enhanced formative assessment played an integral role in planning and implementing lessons that differentiated for readiness and that the teachers' self-efficacy, content knowledge, administrative support and the connection between beliefs and attitudes towards differentiated instruction promoted differentiation practices (Maeng & Bell, 2015).

Some studies developed their own tools to test for the effectiveness of differentiated instruction in the learning of science content. One study developed tiered-labs and activity menus in a high school chemistry course to gauge the effect of differentiated instruction. The topics covered included calculating and interpreting density, percent composition with the mole

[2] Strategies involving differentiation via learning profile, which consists of the student's interests, cultural background, abilities, and needs

concept, stoichiometry, and applying significant figures. The effectiveness of the tools developed was evaluated using pre- and post-test comparisons, student surveys, and in-classroom observations. The study found that differentiated instruction led to significant gains in conceptual understanding and student motivation. Their findings further indicated that leveling the skills and allowing choice, with the goal of achieving the same conceptual understanding promoted student learning, motivation and overall enjoyment of the course (Collins, 2013).

Despite the abundance of literature regarding the differentiation of instruction in ELA subjects in general and differentiation of instruction in math at the elementary or undergraduate levels, there is a lack of literature regarding the differentiation of instruction in the high school classroom setting as pertaining to other STEM subjects. Thus, it is useful to include some studies from outside of the high school level. A study in a Taiwan undergraduate calculus course found that when students participated in a "differentiated" version of the calculus course (student-centered) as opposed to a "traditional" version of the calculus course (teacher-centered), they score significantly higher on final course examinations (Chen & Chen, 2017). Furthermore, a study on student and teacher impressions of a differentiated instruction undergraduate political science course found that students respond favorably to differentiated instruction, while reporting higher levels of interest in the subject, levels of intellectual growth and satisfaction with the course overall than students that were in the non-differentiated version of the course (Ernst & Ernst, 2005). The teachers of the differentiated course also reported generally positive attitudes towards differentiation of instruction.

In summary, research has shown that DI increases student engagement, can be used to develop and use a student's ZPD, helps teachers meet the emotional needs of students, connects teachers to student interests and extends the supports that students might need in the classroom.

Challenges that teachers might face in implementing DI practices in the classroom might be finding materials for DI; increased planning time and creative power; curricular pressure because of standards-based education; lack of administrative support, instructional time, classroom space and professional development; and concerns about the fairness of DI in relation to each student doing the same amount of work and being assessed in the same ways. What is not yet known about differentiation of instruction is how chemistry teachers define and use DI, what experiences they have had with DI and what kinds of supports they currently have in DI implementation as well as the supports they would like to have. This study attempts to fill in this gap in known research. Looking at DI in the context of high school chemistry teachers may help to provide guidelines for the development of future professional development opportunities.

METHODOLOGY

Description of Subjects

The primary participants in this study were 10 high school chemistry teachers (1 male and 9 female) from Maine high schools. Teachers were recruited from the existing Maine STEM Partnership community. The Maine STEM Partnership is a statewide partnership of approximately 1,000 teachers and 140 school districts that collaborate with the University of Maine Center for Research in STEM Education (RiSE Center) in order to improve STEM instruction in their classrooms using research-based instruction practices. For this study, the participants were recruited by reaching out to teachers through the Maine STEM Partnership database. Potential participants were contacted via email (see Appendix A for the recruitment email). Participants were also recruited through professional connections with local high schools. Participants' educational experience ranged from first year of high school chemistry instruction to multiple decades of teaching experience. The geographical location of the schools participants worked at was spread out over the state of Maine. Teachers who participated in the study provided verbal consent to participate through a script that was read out loud at the beginning of the interview (see Appendix C for the interview script). Participants were given an electronic copy of the consent document via email (see Appendix D for the consent document). All teachers were given an alias, which is used in the results and analysis chapter of this work. Real names and identifying information do not appear in this work for reasons of confidentiality.

Data Collection

The study design was loosely based on the Pablico and Nanang studies, with special focus on factors that have been shown to impact to what extent teachers differentiated instruction (for example, professional development experience in DI, sense of self-efficacy in DI, and beliefs of the importance of DI to instructional practice). These factors were incorporated into 12 interview questions, with follow up questions. Interview questions were based on the research questions (see Introduction). Data collection was composed of an interview with each participant (length of interview varied between 45 min and 1.5 hours). The interview was conducted via Zoom and was recorded. For the interview script, see Appendix C. The interviews were semi-structured, often circling back to previous questions or touching on topics in future questions. All questions were asked in the same order for all participants, although some questions were skipped due to the participant having already answered the question earlier in the interview. Once the interviews were recorded and transcribed, the data was analyzed (see Data Analysis). Figure 1 is shown to illustrate the study process.

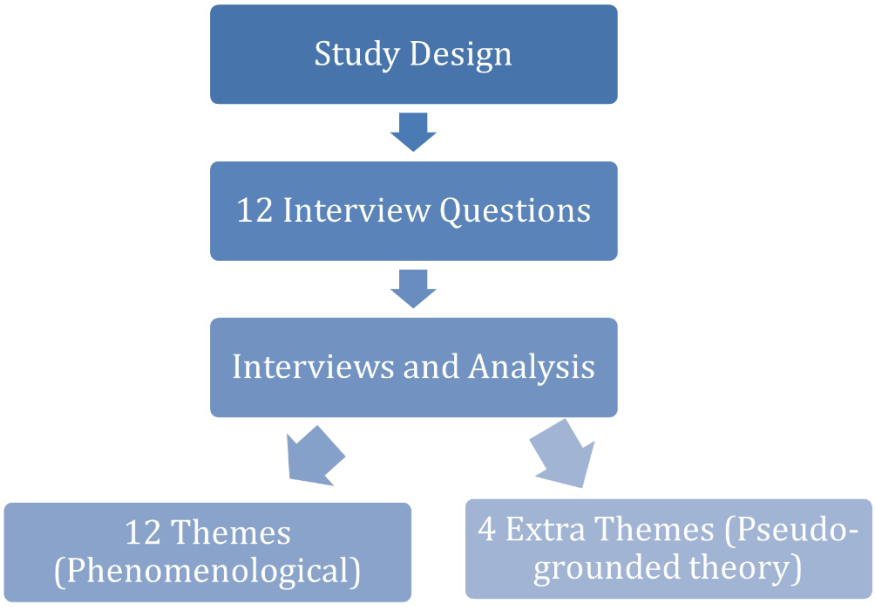

Figure 1: Study design and analysis

Data Analysis

The recorded interviews were transcribed using Otter.ai transcription software with two rounds of editing to reduce the number of grammatical and syntax errors (Liang & Fu, 2016). Once the transcripts were ready, they were uploaded to the Atlas.ti coding software platform and three cycles of coding took place, first coding for the major phenomenological themes (the interview questions), second coding for the pseudo-grounded theory themes, and lastly recoding everything to make sure that nothing was missed during the first two rounds (Muhr, 1993). Phenomenological research is a qualitative approach to summarizing a collective experience, where each participant explains their experience and the collective experience is summarized through data analysis. This part of the research is based exclusively on the interview questions. Pseudo-grounded theory research is another qualitative approach to data analysis, which follows grounded theory, with its inductive theme discovery, but parts from grounded theory in that prior research informs possible themes that the coder may be looking for (Randles et al., 2018). Pseudo-grounded theory was more suitable for this research, because the research design and coding were backed by prior research and literature review, whereas standard grounded theory is completely inductive and does not consult prior research so as not to have suggestive material when looking for themes.

The coding process in Atlas.ti involved the assignment of interview quotations to specific codes, allowing for the grouping of interview segments according to theme. Naming of codes for phenomenology coding was based on the interview question it was coding for (for example, question 6a, which dealt with teachers' sense of self-efficacy in DI was coded by code "Q06a: Self-Efficacy in DI"). Coding for pseudo-grounded theory was coded based on the topic, often combining key words in one code name (for example, using a code like "Student Motivation/Engagement/Involvement" or "Student Autonomy"). The pseudo-grounded theory

themes were coded by frequency of mention. Once a phrase or concept such as “PLCs” or “student autonomy” appeared 3-5 times in different interviews, they were coded for as a pseudo-grounded theory theme. Once the list of pseudo-grounded theory themes was compiled and analyzed, the themes were split into two groups, major and minor. The minor group was set aside because those themes had data from only 2-3 teachers and did not seem to carry over to the majority of the group. From the seven major themes that were left, the most frequently mentioned (top four) themes were selected and analyzed more deeply to see if group characterization of experience was possible. The results of that analysis are presented in the second half of the Results and Analysis section. No inter-rater reliability measurements were taken at the time of coding.

Once the three cycles of coding were done, the interview segments that were related to each code were summarized in tables with the participant’s name, quotation time stamp and notes as one row of the table. This allowed for easier analysis of separate themes. Some codes were then discarded as minor, and others were combined for clarity and conciseness.

RESULTS AND ANALYSIS

This chapter is split into the following sections in order of the interview questions for the phenomenological analysis and in order of decreasing frequency of coded quotations for a given theme for the pseudo-grounded theory analysis. The coding process itself involved the assignment of interview quotations to specific codes, allowing for the grouping of interview segments according to theme. Therefore, the pseudo-grounded theory themes are organized in order of decreasing number of interview quotations, assuming that the number of interview quotations assigned to a specific code (or theme) correlates to that theme's importance, placing the theme that had the greatest number of quotations first (Student Autonomy). Some sections encompass several questions, and some questions were split up in order to separate out topics that required individual consideration. The chapter is organized as follows (correlated with interview questions in parentheses):

1. Phenomenological Analysis
    a. Definitions, Beliefs and Practices Regarding the Differentiation of Instruction
        i. Definition of Differentiated Instruction (Q1, 1a)
        ii. Perception of Benefits of Differentiated Instruction for Students (Q2a)
        iii. Importance of Differentiated Instruction to Teaching Practice (Q3)
    b. Use of Differentiated Instruction Practices in the Classroom (Q4, 4a-d)
    c. Perceived Positive and Negative Aspects of Differentiated Instruction (Q5)
    d. Professional Development in Differentiated Instruction (Q6, 6b)
    e. Teachers' Sense of Self-Efficacy in Differentiated Instruction (Q6a)
    f. School Administration Expectations and Policies Regarding Differentiation of Instruction (Q7, 7a-b)
    g. Cross-Talk Between Teachers Regarding Differentiation of Instruction (Q8, 8a-c)

h. Pre-Service Training in the Differentiation of Instruction (Q9, 9a-b)
i. Impact of Differentiating Instruction on Students and Assessment of that Impact (Q10, 10a)
j. Teacher Experience of Differentiated Instruction as a Student (Q11)
k. Differentiation of Instruction and the COVID-19 Pandemic (Q12)

2. Pseudo-Grounded Theory Analysis
    a. The Connection Between Student Autonomy and the Differentiation of Instruction
    b. Tracking and Student Grouping in the Differentiation of Instruction
    c. Differentiation of Math-Related Topics in Chemistry
    d. Differentiation of Instruction, Concept Hierarchies and Differences in What Students Learn

Phenomenological Analysis

Definitions, Beliefs and Practices Regarding the Differentiation of Instruction

The first three interview questions and the follow up questions associated with them were combined into one analysis category, which focuses on the teachers' definition of differentiated instruction, their practices regarding differentiated instruction in the classroom, whether they think differentiated instruction has a benefit for their students and how important they believe differentiated instruction practices to be to their instruction. The associated interview questions are listed below.

1) How would you define the term "differentiated instruction"? Provide some examples that illustrate the use of differentiated instruction in the classroom.
    a) Explain in greater detail how your examples illustrate differentiated instruction.

2) Do you use differentiated instruction practices in your classroom, if so, how?
    a) If not, do you find that implementing differentiated instruction techniques would benefit your students, and if so, how? What are the reasons you do not implement differentiated instruction in your classroom?
3) How important do you believe differentiation to be to your instructional practices?

The reason for grouping these questions together was to avoid making distinctions between beliefs, attitudes and value judgements (such as question 3), because they tend to be intertwined. It was decided not to pursue the distinction because it would require more extensive research, such as further interviews or classroom observations, but to recognize that all three are present in how the teachers answered these questions.

Definition of Differentiated Instruction

The data for the teachers' definition of differentiated instruction came from a variety of excerpts from the interview, not just the first three questions. The participants tended to circle back to specific questions and add things that they thought they had missed. Therefore, in the four rounds of coding, passages from the entirety of the interview were selected as representing how the teachers defined differentiated instruction. The following table was created based on the frequency of the phrases mentioned, albeit sometimes in slightly different words. Phrases were included based on perceived importance to the definition, as decided by the coder. Several phrases were combined into one phrase when their meaning was roughly synonymous.

Table 1: Frequency of specific phrases regarding how teachers defined differentiated instruction

Phrase	***Alex***	***Blake***	***Charlie***	***Gray***	***Jordan***	***Morgan***	***Robin***	***Sam***	***Skyler***	***Taylor***	***Total***
Providing opportunities	✔	✔									2
Using different strategies	✔	✔	✔	✔	✔			✔	✔	✔	8
Reaching more students	✔					✔					2
Enriching students	✔										1
Supporting individual students	✔			✔	✔	✔		✔	✔		6
Responding to student needs	✔							✔	✔		3
Providing choice		✔				✔			✔		3
Meeting students where they are			✔	✔	✔		✔	✔	✔		6
Providing necessary resources			✔			✔		✔	✔		4
Providing content in multiple ways		✔			✔	✔			✔	✔	5
Providing thresholds			✔				✔				2
Providing access to learning						✔					1
Removing obstacles for learning						✔					1
Engaging students					✔	✔					2
Helping students learn how to learn						✔		✔			2
Incorporating student interests						✔					1

As can be seen from the table, there are some phrases that were mentioned by more teachers (these are bolded in the table). Anything that was mentioned by four or more teachers was put in this category. From this table it can be concluded that if a collective definition of differentiated instruction were to be compiled by this group of teachers, they would include the following statements in their definition of differentiation of instruction:

- ✓ Using different strategies
- ✓ Supporting individual students
- ✓ Meeting students where they are
- ✓ Providing necessary resources
- ✓ Providing content in multiple ways

A collective definition is necessary to define the views of a group of people because it establishes common ground and can be used as a reference for comparisons with established definitions. The other statements (due to the lack of consensus between the teachers, i.e., the lower frequency of mention) are supposed to be applicable only to specific teachers and not to the larger group of teachers. It must be stated, however, that these statements are still very important to each teacher's individual definition of differentiated instruction. Furthermore, it cannot be stated that the teachers do not believe that the statements that they did not mention are unimportant. The table is a representation of *what was mentioned* only, not of a complete picture of each teacher's definition of differentiated instruction, as people do not always state verbally what they really believe.

Since differentiated instruction already has a widely accepted definition, based on the work of Carol Ann Tomlinson, the definition acquired via this study should be compared to the one first instituted by her. In her book "How to Differentiate Instruction in Mixed-Ability

Classrooms," Tomlinson states that "a differentiated classroom provides different avenues to acquiring content, to processing and making sense of ideas, and to developing products so that each student can learn effectively" (Tomlinson, 2001). This definition can be considered a widely accepted definition due to the fact that it is published by the Association of Supervision and Curriculum Development (ASCD). In comparison to this definition, the statements that the participants of this study hold in common are fairly accurate. Each of these statements can be found in Tomlinson's definition as follows:

Table 2: Comparison of Tomlinson's definition of differentiated instruction to the statements that the participants hold in common as part of a definition for differentiated instruction

Tomlinson's Definition	**Teachers' Definition**
"Provides different avenues"	✓ Using different strategies
"So that each student"	✓ Supporting individual students
"Can learn effectively" "Different avenues to acquiring content, to processing and making sense of ideas"	✓ Meeting students where they are
"Provides different avenues to acquiring content, to processing and making sense of ideas, and to developing products"	✓ Providing necessary resources
"Different avenues"	✓ Providing content in multiple ways

The importance of seeing how closely these definitions align is in seeing how specifically high school chemistry teachers define differentiated instruction. This is both important to make sure that common ground is established for the purposes of communication about differentiated instruction and for the purposes of any training that can be developed or has already been developed that is trying to help teachers implement differentiated instruction techniques, whether by a certain district or school administration or by a third-party company. It is also important to consider how the teachers define differentiated instruction individually, as it is a big part of how

they practice it in the classroom. Table 3 includes some excerpts from teachers that show how they define differentiated instruction.

Table 3: Excerpts from how teachers defined differentiated instruction individually

Teacher	Definition
Alex	“It means that you provide lots of avenues and opportunities for learning of concepts to different students. And, you know, in the process, you, you end up reaching a greater variety of students I would say is the idea of differentiation. So you mostly, for me, it's mostly about using lots of different strategies simultaneously to try to teach concepts.” [00:56]
Blake	“So differentiated instruction is, for me, it's going and creating learning opportunities for students who learn in you know, different ways, and thus, can access things through different modalities. And so differentiated instruction is going to be sort of instruction that, you know, really allows students, for example, who are very, you know, auditory learners, visual learners, you know, kinesthetic learners to sort of access the same material. So that would be, you know, providing choice of activities, for example, choice in assessments. And sometimes that's not possible. And so, you know, building a curriculum that has that sort of very thoughtful and deliberate variety of lessons built into it.” [01:00]
Charlie	“I think I would approach differentiated instruction as thinking about how you have a variety of learners and trying to meet those learners, you know, kind of, at their point where you're pushing them, but you're not exceeding their ability. So, differentiation can look for lack of a better word different for different students. I can give you some examples that I think about. You know, differentiation, might be using different lab activities to approach a similar concept. It might be using different mathematical, you know, like equations, or thinking about approaching something using graphs versus using calculations. It could also be something like providing a script or a transcript for a video, or providing an audio book, or not using text at all, but maybe using like a, an interview, or a question and answer. Just different, different approaches to get students to be exposed to similar material.” [00:55]
Gray	“Differentiation of instruction involves the development of learning tools for those who are in need of special attention, regardless of their learning point, like where they're starting from.” [00:15]
Jordan	“The simplistic answer would be that there are different learners in any given classroom and differentiating or changing the instruction and instruction strategies based on the type of learners within the class.” [01:28]
Morgan	“That's designing the instruction in the first place, with the with, like, sort of having this lens on and saying, what are the obstacles to, to learners and trying to think about all the different, really, you can't think of all the different obstacles. But if you're trying to think about obstacles for learners, and try to build into the instruction ways around those obstacles, then you make it more accessible to more learners.” [01:02]

Robin	“Differentiated instruction would be a level- or leveling instruction based on a student's ability or capability. Basically, you want to teach them where they're at, because they can't comprehend and understand difficult concepts without first learning the basics.” [01:02]
Sam	“It's where you don't, you know, you have all levels of ability, there's no tracking going on in a classroom. And so you are trying to in- meet all the individual needs of the students.” [00:53]
Skyler	“So in my perspective of it, differentiated instruction is determining what each student needs it however they, they prefer to learn, or how, how they do learn. Sometimes their preference doesn't always match what actually works for them. But getting to know the students well enough to be able to determine what how, what they need, and how they, how they need it, and finding a way to meet each student's or usually can clump together. And it's a group of students, it's not the same. It's not, if it's a class of 10, it's not 10 different things, maybe three different things, because most, they kind of do a lot of the same sort of stuff. So finding a way to meet the needs of each student. Sometimes it's giving them a choice, oh, would you rather watch this video or read this book, or that's just a simple sort of way to look at it. But providing multiple different ways for students to learn would be this kind of some summary of that. Finding, finding different ways for them to learn the material.” [01:34]
Taylor	“So differentiated instruction, specifically, because the word differentiation, I just think of differences. So differentiated instruction, I haven't really visited the technical term, like how to define it. But it would be to get content to students of all abilities by using different means or methods.” [00:58]

The reason it is important to look at individual definitions is because teachers’ definitions of differentiated instruction could be based on other factors that were examined in this study, such as professional development in differentiated instruction and/or any exposure to it through personal experiences as a student, among many other factors. It is clearly important to establish how these teachers see differentiated instruction as its most basic level before proceeding to other factors.

Perception of Benefits of Differentiated Instruction for Students

Question 2a deals with benefits of differentiated instruction for students as perceived by each teacher. The research team decided that it is important to distinguish between *objective* benefits for students in terms of readily observable or numerical factors, such as academic performance,

and *subjective* benefits as perceived by the teachers. This study examined only subjective (perceived) benefits. Of the ten teachers interviewed, two mentioned benefits directly, stating generically "differentiation of instruction benefits the students in that…" while the other eight teachers alluded to benefits for students without mentioning them directly. Some characteristics of differentiated instruction that the teachers perceive to be a benefit for students were extrapolated and summarized as follows:

- ✓ Differentiated instruction enables a teacher to reach a great variety of students, because heterogeneous classrooms have students with a variety of different needs and needed supports. This includes providing resources to support students that have Individualized Education Plans (IEPs) and 504 plans.
- ✓ Differentiated instruction allows a teacher to provide a different perspective and subject background support as needed for each student
- ✓ Differentiated instruction enables students to work at their own pace and to start at their own level and not feel pressured to be at a level of another student or group of students This also includes thresholds for students, meaning that students don't necessarily need to make it to the end, but they need to progress and show that they have learned something
- ✓ Differentiated instruction allows teachers to provide students with activities that target different modalities, so as to target the different preferred ways of learning of each student
- ✓ Differentiated instruction provides students with choices related to the kind of activity they want to partake in, how they want to be assessed, what products they want to produce and whether they want to work with other students or individually

- ✓ Differentiated instruction provides an avenue for student enrichment, especially in different ways of expressing your knowledge and solving problems, such as understanding a concept conceptually, mathematically, graphically, etc.
- ✓ Differentiation of instruction keeps students engaged and motivated, even with different abilities and end products
- ✓ Differentiation of instruction provides access to the content for all learners and removes obstacles for learning
- ✓ Differentiated instruction helps students learn how to learn and teaches them to communicate with teachers about what they need
- ✓ Differentiated instruction shows students that the teacher cares about their instruction, which fosters positive relationships between teachers and students as well as provides students with a sense of autonomy

The list was extrapolated based on what the teachers mentioned as a benefit and summarized in complete sentences while combining statements from several teachers. It is readily apparent that some of the perceived benefits for students are also part of the teachers' definition of differentiated instruction, which shows how highly the way teachers view differentiated instruction depends on seeing differentiated instruction as a benefit in general.

Importance of Differentiated Instruction to Teaching Practice

Question 3 asked the teachers to explain how important they feel differentiated instruction to be to their teaching practice. Some teachers expressed it via a scale of priorities and put differentiated instruction somewhere in the top, middle or bottom of that list, while others simply stated whether differentiated instruction was important to how they viewed their practice. The

following table summarizes what teachers think about the importance of differentiated instruction to their teaching practice.

Table 4: Summary of differentiation of instruction prioritization

Prioritization	***Alex***	***Blake***	***Charlie***	***Gray***	***Jordan***	***Morgan***	***Robin***	***Sam***	***Skyler***	***Taylor***
Highly important					✔				✔	
In the top 3 priorities										✔
In the top 5 priorities		✔	✔							
Middle of the list of priorities								✔		
Low importance							✔			
No statement	✔			✔		✔				

As can be seen from the table above, teachers prioritize differentiation of instruction differently and may place different aspects of teaching practice in the top 3 or 5 priorities along with or instead of differentiated instruction. Some aspects of teaching practice that one teacher (Sam) prioritized above the differentiation of instruction are as follows:

- ✓ Every student should learn
- ✓ Every student should leave the class feeling good about themselves and feeling like they know something about chemistry
- ✓ Every student should have some good skills
- ✓ Every student should be successful as a future student and member of society
- ✓ Every student should have improved their problem-solving and communication skills

Another teacher (Taylor) described the aspects of teaching practice that are up there in the top 3 priorities *along with* the differentiation of instruction as follows:

- ✓ The teacher should connect with students and make them feel safe and happy, which is not so much about the content
- ✓ The teacher should teach students how to learn and understand how to look at the world, as well as look at it scientifically and question everything

Lastly, it should be mentioned that some teachers who placed differentiated instruction high on the list of their priorities stated that there is a link between how much a teacher cares about their students and how much they differentiate their instruction. Looking back on her experiences as a high school student, Jordan stated that "those individual teachers who, I guess, looking back who I think cared about their students, differentiated by default, because they met me where I was at as a learner." [38:08]

Use of Differentiated Instruction Practices in the Classroom

Questions 4 and 4a-d dealt with what differentiation of instruction practices teachers utilized in their classroom and in what specific ways those practices are expressed. The interview questions that pertain to this topic are as follows:

4) Do you actively consider differentiated instruction methods when developing your lesson plans?
    a) How does differentiation impact what content you teach and how you teach it?
    b) How does differentiation impact the way you arrange the learning environment?
    c) Do you differentiate by readiness, interest or by learning profile?
        i) Readiness is defined as "a student's proximity to specified knowledge, understanding and skills"

ii) Interest is defined as “that which engages the attention, curiosity, and involvement of a student”

iii) A student’s learning profile is “a preference for taking in, exploring, or expressing content”. Four factors are considered here: gender, culture, learning style (solo vs group work, study while sitting still vs moving around, etc.) and intelligence preference (verbal-linguistic, logical-mathematical, etc).

d) Do you actively consider differentiated instruction methods when planning the ways you will assess student learning?

The design of question 4 was based on an ASCD tutorial which listed the possible ways that differentiation of instruction can be used in the classroom (ASCD, 2011a). The definitions from question 4c are taken directly from the tutorial and were used in case a teacher asked the interviewer to define a specific term. The tutorial stated that teachers can differentiate content, process, product and learning environment and that teachers can differentiate by readiness, interest and learning profile (ASCD, 2011a). The following table shows which practices the teachers mentioned that they implement in their teaching.

Table 5: Differentiation of instruction (DI) practices used by the teachers in the classroom

Practice	***Alex (5)***	***Blake (6)***	***Charlie (6)***	***Gray (4)***	***Jordan (5)***	***Morgan (5)***	***Robin (0)***	***Sam (2)***	***Skyler (5)***	***Taylor (3)***	***Total***
Actively considers DI when developing lesson plans	✔	✔	✔	✔	✔	✔			✔	✔	8
Differentiates the content			✔	✔					✔	✔	4
Differentiates the learning environment	✔	✔	✔		✔				✔		5
Differentiates by readiness	✔	✔			✔	✔		✔		✔	6
Differentiates by interest		✔	✔			✔					3
Differentiates by learning profile	✔	✔	✔	✔	✔	✔		✔	✔		8
Differentiates assessment	✔	✔	✔	✔	✔	✔			✔		7

As can be seen from the table above, Robin and Sam have the lowest number of differentiation of instruction practices that they say they implement in their classroom, which makes sense since they had also rated differentiation of instruction lower on the list of priorities for teaching practice than other teachers (see Table 4). Besides this instance, there is little correlation between the rating of differentiation of instruction on the list of priorities and the number of practices implemented in the classroom.

In interpreting Table 5 it is important to define what each of the practices entails and to mention that just because two teachers might use the same practice in the classroom, it does not mean that they use it in the same way, to the same extent or with the same frequency. These

factors make data analysis harder and would require extensive classroom observation. The following table defines each practice and lists some examples mentioned by teachers pertaining to each practice, detailing to some extent the criteria that is required for the placement of a checkmark in a specific box.

Table 6: Definitions of differentiation of instruction practices

Practice	***Definition***	***Examples***
Actively considers DI when developing lesson plans	The teacher considers DI when lesson planning in that they consider opportunities to use DI practices in their lessons.	"I would say yes. I often try to think about how I'm like, I guess I would say, I probably think about like, what's my major like mode? Like how am I going to approach this in a big way?" [Charlie 10:19]
Differentiates the content and process[1]	"Content means the knowledge, understanding, and skills that students need to learn."[2] "To address individual student needs, teachers also provide appropriate scaffolding when working with content- by teaching prerequisite content to some students, allowing advanced students to move ahead of the class, or even changing the content for some students based on their individualized education programs."[2]	"Well, let's see, I would say in my core classes that I probably do not do that unless it is for extension. Right? Or if they come to me with an interest in something related to what we're doing, then I might give them, you know, some hints about a task that might lead them towards a greater understanding of something they're interested in." [Alex 19:54]
Differentiates the learning environment	"For some students, modification of the learning environment is needed to ensure effective learning"[2] This definition includes the physical as well as the emotional environment.	"I generally give seating, like I make up seating charts for my students. And so I try to be cognizant of putting certain people in certain places, and I call them my classroom anchors, like you're an anchor, so you have to sit here. And then that allows me to maybe pair up. Again, sometimes I'll pair up groups of like, differing abilities. Or I'll pair up, you know, a group of people that I think will all you know, like, oh, if they work together, they'll all be able to get to the calculations part." [Charlie 14:47]

Table 6 Continued

Differentiates by readiness	Readiness is "a student's current proximity to specified knowledge, understanding and skills."[2] "The goal of readiness differentiation is to make the work a little too difficult for students at a given point in their growth- and then to provide the support they need to succeed at the new level of challenge."[2]	"So when I'm differentiating in terms of readiness, I might've introduced something to everyone at the same rigor level, and then allow for if you're here, if you're here, if you're here, do this, do this, do this." [Jordan 10:17]
Differentiates by interest	"Interest is defined as that which engages the attention, curiosity, and involvement of a student."[2] "The goal of interest differentiation is to help students engage with new information, understanding, and skills by making connections with things they already find appealing, intriguing, relevant, and worthwhile."[2]	"So I think we do a pretty good job of differentiating in terms of interest from that perspective, maybe not so much within the classroom, but certainly kids have lots of choices. And I think that's important." [Alex 1:08:12]- in reference to the choices that students have for classes that they can take. Alex does not differentiate by interest within the classroom.
Differentiates by learning profile	"A student's learning profile is a preference for taking in, exploring, or expressing content. Four factors help form a learning profile: 1) gender; 2) culture; 3) learning style, such as working solo or collaboratively…; and 4) intelligence preference (Gardiner's intelligences) or creative, analytical, and practical preference (Sternberg's intelligences)."[2] "The goal of learning profile differentiation is to teach in the ways students learn best- and to extend ways in which they can learn effectively."[2]	"I know that, in my unit, that there are opportunities to interact with the content in a variety of ways, the hands on- like using manipulatives, doing, doing science, you know, collecting data, looking at data, discussing data, drawing pictures, reading and writing, and talking, all those different methods of interacting with the content are 100%, yes, built into each of the, each of the units, not each lesson, each lesson will have you know, several different ways of interacting with the content." [Morgan 31:01]

Table 6 continued

Differentiates assessment[3]	"Products are ways for students to demonstrate what they have come to know, understand, and be able to do after an extended period of learning"[2] In general, differentiating assessment gives students opportunities to demonstrate their learning in different ways.	"So some students demonstrate in this case, it was an assessment. So some kids students demonstrate what they know, by talking through it. And some students based on the learning style, might want to sit by themselves and write what they know, to show what they've learned. And other students based on the learning style. They're very kinesthetic. So they might want to go back into lab and demonstrate a reaction to show what they know. So differentiating based on the type of learner they are, and the skills that they have." [Jordan 02:19]

[1] The practice of differentiating *process* was implied in interview questions 1 and 2 and partially implied in the practice of differentiating the learning environment, as this practice partially encompasses how students work individually and alone. Therefore, the practice of differentiating *process* is not listed here individually, although it is listed separately in the ASCD tutorial on the different ways of differentiating instruction, on which the interview questions were based.

[2]These definitions are taken from the ASCD tutorial (ASCD, 2011a)

[3]The practice of differentiating *product* is implied in the "assessment" category, and is not listed separately, although it is listed separately in the ASCD tutorial

Tables 5 and 6 are meant to present an exploration of what practices high school chemistry teachers in Maine use to differentiate their instruction and to what extent they use them. It is not meant to say that the teachers represented use these practices in the same ways or to the same extent. It is used mainly to show that these teachers have some similarities and differences in the ways they differentiate instruction and to characterize a group of people in order to generalize these characteristics in the pursuit of some background information prior to professional development design. In order to improve any facet of how high school teachers differentiate instruction, one must first characterize the population and show what these teachers prioritize and implement in the classroom.

Perceived Positive and Negative Aspects of Differentiated Instruction

Interview question 5 dealt with the positive and negative aspects of differentiated instruction as perceived by the teachers. The interview questions that pertain to this topic are as follows:

5) In your opinion, what are some positive and negative aspects of implementing differentiated instructional practices in the classroom?

Tables 7 and 8 were constructed using the positive and negative aspects that teachers mentioned in relation to the differentiation of instruction. In terms of why an aspect was placed in the positive or negative category, if it is not obvious, it was clarified by the teacher when they placed it in either category.

Table 7: Perceived positive aspects of differentiated instruction (DI)

Aspect	***Alex***	***Blake***	***Charlie***	***Gray***	***Jordan***	***Morgan***	***Robin***	***Sam***	***Skyler***	***Taylor***	***Total***
Teacher can provide tailored instruction	✔		✔		✔	✔	✔	✔	✔	✔	8
Providing options is simple and beneficial for students	✔								✔		2
Different kinds of assessment give students the ability to express what they know they way they want to	✔		✔								2
Increases student engagement		✔	✔						✔		3
Increases student understanding		✔									1
Students can help each other reach certain spots			✔		✔						2
Differentiating makes teaching more fun						✔					1
Helps with classroom management						✔			✔		2

Table 8: Perceived negative aspects of differentiated instruction (DI)

Aspect	***Alex***	***Blake***	***Charlie***	***Gray***	***Jordan***	***Morgan***	***Robin***	***Sam***	***Skyler***	***Taylor***	***Total***
Not practical for the teacher to create many versions of an assignment	✔							✔			2
Takes time to do the planning		✔	✔		✔	✔		✔	✔		6
Rubrics must be created with flexibility in mind		✔									1
Sometimes takes time to start differentiating and doing it well		✔		✔							2
Any project created by students must still cover the same content and/or skills		✔									1
Sometimes there is only one way that a subject can be taught and there is no opportunity to differentiate			✔								1
Creates inequity in the classroom because students notice different levels of work			✔	✔			✔			✔	4
Finding the right materials for differentiation can be hard									✔		1

In analyzing Tables 7 and 8, it is important to point out the most frequently mentioned positive and negative aspects of differentiated instruction. They are as follows, with frequency counts in parentheses:

Positive:

- ✓ Teacher can provide tailored instruction (8)
- ✓ Increases student engagement (3)

Negative:

- ✓ Takes time to do the planning (6)
- ✓ Creates inequity in the classroom because students notice different levels of work (4)

In principle, Tables 7 and 8 summarize the attitudes that this group of teachers has towards differentiated instruction, citing multiple positive and negative aspects as evidence, but it should be pointed out that just because a teacher did not mention a specific aspect, it does not mean that they do not agree with it, it just means that they did not state it during the interview. Similarly to the previous questions, this question is meant to characterize the attitudes of this particular group of teachers in the pursuit of some background information prior to professional development design.

Professional Development in Differentiated Instruction

Questions 6 and 6b of the interview dealt with the teachers' experience with professional development regarding the differentiation of instruction and the possible need for professional development in this area. The reason that question 6a is not included in this section of analysis is because it deals with self-efficacy, which is a significant topic that requires its own section. The interview questions that pertain to this topic are as follows:

6) Have you ever discussed differentiated instruction at a professional development event?
    b) If no, do you believe there is a need for professional development events about differentiation oriented towards in-service teachers?

When asked about professional development specifically focused on differentiating instruction that the teachers might have been exposed to, many of them stated that the professional development events that they had attended revolved around special education requirements and how teachers were supposed to accommodate IEPs, 504s or English Language Learner (ELL) populations. None of the teachers interviewed reported having received any professional development in the area of differentiating instruction in general. Many teachers also stated that they did not find these valuable because they were not focused on content-specific differentiation (chemistry) or even subject area-specific differentiation (science).

While the teachers felt that differentiation was a big buzzword for principals and curriculum coordinators a couple of years back, it no longer seems like that is the case. Other teachers said that there is not a lot of support from the administration in terms of helping to differentiate content, partly because the content itself is intimidating. Additionally, there is a big lack of resources for secondary education in terms of differentiation. There are some organizations, like the Maine Center for Research in STEM Education at the University of Maine, Orono that do provide some resources and programs, like the High School Collaborative program, that some of the teachers in this group either attend now or have attended in the past. In general, most of the teachers stated that despite the expectation from the administration that the teachers should be differentiating instruction, there is no direct district or school-sponsored professional development that has provided training or discussions about ways to differentiate or strategies that could be used.

In terms of the need for professional development in the differentiation of instruction, 9 out of 10 teachers strongly emphasized the need for it, and have included some criteria that could be helpful in the design of future professional development in differentiation of instruction as follows:

- ✓ Must be at least subject area (science) specific, if not content (chemistry) specific
- ✓ Must be differentiated for different grades and/or subjects as needed
- ✓ Must include concrete examples of things that teachers can use right away and that they will find valuable
- ✓ Must be framed in such a way as to not make it seem like it is extra work, but just providing extra resources that students can use or leveling the work so that each student can work on their own level
- ✓ Must not include any additional costs, because some schools cannot afford extra human or material resources
- ✓ Must include an opportunity for teachers to share tips and materials with each other, as many teachers cited that to be a particularly useful part of any professional development event
- ✓ Could include some resources to help engage students in distance learning, as this has been an area of major focus recently because of the pandemic
- ✓ Could include a connection to proficiency-based education, which has been an emerging concept recently because of the acceptance of the Next Generation Science Standards in Maine

Teachers' Sense of Self-Efficacy in Differentiated Instruction

Interview question 6a dealt with the teachers' self-reported sense of self-efficacy in differentiating instruction. The interview questions that pertain to this topic are as follows:

a) What do you think your level of self-efficacy in implementing differentiated instruction techniques is?

Lacking a scaled gradient (such as a Likert scale) on which to place their sense of self-efficacy, the teachers responded in different ways, some reporting that they were somewhere on a scale of 1 to 10, whereas others reported being good at some parts of differentiation and not so good at others. Of the teachers who responded to the question, 3 of them reported that they were on a scale of 1 to 10, 2 of them placing themselves in the 5-8 range and 1 placing herself in the 3-4 range, explaining the low rating by indicating that this was her first year teaching high school and she still felt relatively new with the concept of differentiation in general, also having received no training in differentiation to date.

Some more experienced teachers claimed that they had enough experience and time in the classroom to deduce which students needed differentiation and in what ways, which they provided as needed. One of these, Alex, explained that he felt that he thinks he is very good at responding to the needs of students, but is not very good at *planning* for differentiation. Another teacher, Jordan, while ranking herself as 6-8 out of 10 in terms of how she differentiates, says that sometimes behavioral management takes over within the actual teaching time and that 6-8 is an average, as she can be a 10/10 on the days that she has enough time to plan. Lastly, one teacher, Taylor, thinks that even though she has been teaching for a considerable amount of time, she is getting worse at differentiation due to not having evolved the way she differentiates with

time. There is some basis in research to suggest that teachers attempting to differentiate instruction in general tend to have lower self-efficacy in implementing it (Franklin, 2020).

Generally, all 10 teachers believe that they can be differentiating to a greater extent and in better ways, reinforcing the need for professional development in the area of differentiating instruction (Franklin, 2020). A study done by De Neve also supports the connection between teacher sense of self-efficacy and the reality of whether or not teachers practice differentiation in their classroom (Neve et al., 2015).

School Expectations and Policies Regarding Differentiation of Instruction

Interview questions 7, 7a, and 7b dealt with expectations and policies from the school administration regarding how much and to what extent teachers should be differentiating their instruction, as well as how these expectations and policies were expressed and whether or not there needs to be a policy in place that dictates the extent of differentiation that is expected from teachers. The interview questions that pertain to this topic are as follows:

7) Is there an explicit statement or an implicit expectation from your school's administrative team that teachers should be using differentiated instructional practices in their classroom?
    a) If yes, how is that statement/expectation expressed?
    b) If no, do you think there should be a school-wide policy/expectation that would require teachers to use differentiated instruction techniques in their classroom?

On the topic of school administration policy regarding differentiation of instruction, all teachers said there is no direct school policy regarding whether teachers should differentiate instruction and to what extent they should do so or they are not aware of such a policy. Therefore, the teachers either believe such a policy does not exist or are not aware of such a

policy in the form of an *explicit statement*. What is interesting though, is that all teachers claim that they are still required to differentiate instruction through *implicit expectations* such as:

- ✓ The overall culture of the school wants people to differentiate instruction
- ✓ Principals and curriculum coordinators emphasize differentiated instruction, although there is a lack of support when someone asks for help with differentiating instruction, most likely because the content is intimidating
- ✓ Teacher evaluations often include anywhere from a sentence up to a whole page of items that have to do with differentiating instruction, sometimes from the National Board certification standards
- ✓ Differentiated instruction is discussed during teacher observations
- ✓ It seems to be an assumption that is made by the administrative team and by colleagues as well that teachers should be differentiating- the belief that differentiating instruction is a good teaching practice
- ✓ Emails sent from administration to the teachers that either include statements that differentiation of instruction is expected or information on specific students that might need differentiation
- ✓ Staff meetings that mention the expectation that teachers should be differentiating instruction

On the topic of a possible need for an explicit school policy, the teachers were divided. Of the 5 teachers that answered the question, 2 were in favor of the policy, citing the need for concrete examples, and 3 were against, citing the need for freedom and teacher autonomy. As a result, it can be suggested that schools write some kind of statement about what differentiation of instruction should look like for their teachers but should not make it too constricting as to

remove the teachers' sense of autonomy in the classroom. Lastly, there is some research to suggest that differentiation of instruction becomes more feasible in high school science classes if the school administration encourages teachers to implement differentiation practices (Maeng & Bell, 2015).

Cross-Talk Between Teachers Regarding Differentiation of Instruction

Interview questions 8 and 8a-c dealt with how teachers interact with their colleagues in terms of communicating about the differentiation of instruction and whether they find this kind of cross-talk important, as well as whether other teachers at the school use differentiation of instruction techniques. The interview questions that pertain to this topic are as follows:

8) Do you communicate with teachers of other disciplines about differentiation practices that you use in the classroom?
    a) If yes, what are some positive and negative aspects of this exchange?
    b) If no, do you believe that it is important to have crosstalk between disciplines on the subject of differentiation?
    c) Do you think other teachers at your school use differentiated instruction?

On the topic of cross-talk between teachers of different disciplines, whether within the science department or outside it, teachers explain that there is always cross-talk between disciplines in and outside of the science department, but it is never focused on differentiating instruction per se. The communication is mainly about cool strategies that other teachers can use or about specific students that need help. Despite some teachers stating that their school participates in the use of Professional Learning Communities (PLCs) and despite the PLCs being interdisciplinary, their focus has never been to talk about differentiation explicitly. Some schools

have a yearly focus, which might be something like mathematical literacy or school safety, but the focus has never been differentiation. Some teachers are encouraged to go observe other teachers and to talk about these observations with each other, whereas some schools are so small that they have a necessity for cross-talk because there is only one teacher in each content area, like science. For these teachers, they rely on each other to exchange ideas. Additionally, since the beginning of the COVID-19 pandemic, more effort has been spent on talking about how to differentiate instruction just because of the transition to *remote* instruction, so it might be predicted that there will be an increase in the need to talk about how to differentiate instruction as the pandemic continues, as more waves become a possibility and for developing a protocol for how instruction will be handled in future pandemics. The COVID-19 pandemic and how differentiation of instruction was impacted during this time is discussed later in this work.

In terms of the need for cross-talk, all teachers express the need for it in the area of differentiating instruction, mainly that teachers can exchange ideas about how to differentiate different content pieces and can possibly create inter-disciplinary units, that could join all subject areas that students are exposed to in high school. On the topic of interdisciplinary units, there are many ideas that this group of teachers have, but they also point out that they have tried to voice these ideas in the past and to recruit other teachers who might be interested and were typically met with rejection or avoidance, so they have resolved to only participate in interdisciplinary projects if the other teachers put in some work and are really passionate about the idea.

All teachers stated that cross-talk and interdisciplinary projects are something that is needed and something that they would participate in, given the chance, pointing out that having multiple perspectives on a topic is extremely beneficial, as this can help teachers see the different perspectives of students, which can inform differentiation practices. Some of the factors that

need to be considered when talking about interdisciplinary projects are things like students' schedules, which would need to be taken into account when planning projects, as not all students take the same classes in high school, as well as time limitations.

In the collaboration processes between the math department and the science department, one of the teachers, Blake, pointed out that she thinks these collaborations are very important because they show students that there is continuity between the concepts that they are learning; that if they are learning about isotope abundances, the concept applies to chemistry and math simultaneously and this kind of continuity gives what they are learning relevance and keeps them engaged. She also points out that while their school has been very helpful with increasing literacy in their school because of continuous literacy training for teachers, there has been no math literacy training, which brings into question how a science teacher is supposed to differentiate the more math-heavy science topics (this is discussed later in this work).

That being said, none of the teachers' ideas really dive into differentiated instruction, as it seems that interdisciplinary projects should first come into existence, and only then be differentiated according to student need. Lastly, with a similar sentiment as stated above, because of the COVID-19 pandemic, and the need that teachers had in March of 2020 to quickly assemble materials for students to do at-home activities, talking about differentiation on a more inter-disciplinary level might become a more interesting topic for a lot of schools and districts in the coming months and years.

One negative aspect that was brought up during this interview by Robin, was that the science department has a different mode of teaching than some of the other departments (all teachers have stated that other teachers in their school differentiate their instruction), where science classes typically consist of doing things, having a kinesthetic mode of operation. She

claims that other classes might have an easier time differentiating their content, due to the availability of materials that are already differentiated (such as books that have different reading levels already outlined by the publisher in English class) or due to the subject naturally lending itself to differentiation on a greater scale (she cites history as an example). She claims that this actually prevents chemistry teachers from talking about differentiation of instruction productively and makes it harder to have cross-talk about differentiation of instruction.

Pre-Service Training in the Differentiation of Instruction

Questions 9, 9a and 9b dealt with any pre-service training that the teachers received on the differentiation of instruction, any materials they found helpful when receiving that training and whether or not pre-service training in differentiation of instruction is needed. The interview questions that pertain to this topic are as follows:

9) Did you ever participate in pre-service training in differentiation?
    a) If yes, did you find that you applied the skills you learned as a pre-service teacher when you began teaching? What kinds of materials did you find helpful in the development of your use of differentiated instruction techniques?
    b) If no, do you believe there is a need for professional development in differentiation for pre-service teachers?

When asked about any pre-service training that the teachers might have received on differentiating instruction, 4 teachers said they received training in their teacher certification programs prior to becoming teachers. Another 2 teachers stated that they took a course on educating the “exceptional child” or a course on special education in the regular classroom. The other 4 teachers either stated that they received no training or did not answer the question. In

fact, when asked whether there is a need for pre-service training in the differentiation of instruction, most of the teachers stated that there is a very high need for pre-service training in the differentiation of instruction. Additionally, a few teachers mentioned that during the pre-service training period of a teacher's career, incoming teachers are bombarded by so many different factors of teaching that sometimes differentiation of instruction is neglected in favor of other teaching principles:

> "I think it's beneficial to revisit it again. Because as a pre-service teacher, you're focusing on so many aspects of teaching. And you're trying to make that all, you know, like, fit for you, and you're trying to think about, you know, okay, I've got like this content that I want to teach, and this is how I'm going to approach it. But I also have to have classroom management skills. And I think for me, maybe that was one of those pieces where I was, like, I'm gonna put this on the back burner, until I can manage a few other things. And so being able to come back to it, and have more, like, more professional development, maybe with a year under your belt, or, you know, two years, or just like, constantly, you know, coming back like, every couple years and be like, okay, now how am I how, how has my understanding of differentiation changed? How have my experiences changed? How have my students changed... would be helpful..." [Charlie 35:21]

Many teachers emphasized again that based on the overall culture of what teachers are expected to do, they know that they should be differentiating instruction, yet many of them don't know how to do that or what that looks like. Of the 4 teachers that claimed to have some pre-service training, several stated that this training did not teach them how to *plan* for differentiation specifically, only showed them what a differentiated classroom might look like. Some of the teachers asserted that they learned how to differentiate for students based on learning how students operate in general. In summary, talking about pre-service training with the teachers showed that less than half of them received any kind of pre-service training in differentiating instruction and that they had felt that this instruction did not get into enough detail about how to *plan* for differentiation, reinforcing the need not only for professional development but also pre-service training in the differentiation of instruction.

Additionally, a study was conducted by Goodnough that explored pre-service teachers' developing conceptions of differentiated instruction as well as how their beliefs about differentiated instruction connected to their prior experiences and values found that pre-service teachers (even at the end of their pre-service training for certification) do not have a thorough understanding of differentiated instruction or the challenges teachers face when trying to differentiate instruction (Goodnough, 2010). Therefore, it is critical to provide professional development and/or training in the differentiation of instruction to pre-service as well as current teachers (Holloway, 2000).

Impact of Differentiating Instruction on Students and Assessment of that Impact

Interview questions 10 and 10a dealt with the impact that teachers perceived their use or lack of use of differentiated instruction had on their students and how they assessed that impact. The interview questions that pertain to this topic are as follows:

10) How does differentiated instruction have an impact on how students learn? Is that impact mostly positive or negative?
    a) How do you assess whether differentiated instruction is having an impact on how your students are learning?

When talking about the impact of differentiated instruction on their students, all teachers claimed that the impact was mostly positive, although some negatives were mentioned as well. In order to avoid any overlap with question 5 and the discussion of the positive and negative aspects of differentiation, several of the impacts are not listed in this section but are listed in that section instead. In terms of how this impact is assessed, teachers mention the following methods of assessing the impact of differentiating instruction:

- ✓ Changes in class engagement levels
- ✓ Changes in student participation and understanding of the material
- ✓ Student achievement of threshold goals and evidence of having students that are on the spectrum of achieving higher thresholds
- ✓ Student feedback
- ✓ Student surveys, conversations with students and short class climate quizzes
- ✓ Student attainment of skills and practices

The most important impact that was cited by several teachers was that when teachers differentiate instruction for their students, they create empathy in the classroom. When a student learns a concept or attains some level of understanding in a piece of content, it feels personal because the teacher is personally differentiating the instruction for them. That empathy that comes from personally working with a student is what makes students want to understand, basically seeing that the teachers are meeting them where they are, and that the teachers recognize their strengths.

Teacher Experience of Differentiated Instruction as a Student

Question 11 focused on teacher experiences of differentiated instruction when they were students themselves. This was asked with the intention of looking at how the use or lack of use of differentiated instruction that they might have been exposed to as students may have impacted their own differentiation practices and beliefs as teachers. The interview questions that pertain to this topic are as follows:

11) What were your experiences with differentiated instruction as a student? Did your teachers implement differentiated instruction, and if so, how? Did their use or lack of use of differentiated instruction affect your learning experience?

When question 11 was asked, there was no clarification in terms of the level of schooling that the question was referring to. Teachers could talk about their K-12 experiences as well as undergraduate courses that they took; in short, any experience where they were in the role of a student. Out of the 9 teachers that responded to the question, 5 teachers stated that *their* teachers differentiated instruction and 4 teachers stated that theirs didn't. From the teachers' statements it seemed like it would be interesting to compare the benefits of differentiation that the teachers stated when they were answering this question with what they perceived the benefits of differentiation to be for their own students. The table below compares the two; common statements are underlined, while statements that were not in common are bolded. Common statements are those that appear in both columns, whereas uncommon statements appear only in one column.

Table 9: Comparison of the benefits of DI as remembered by teachers when they were students with the benefits they cited earlier as the benefits of DI for their own students (common statements underlined, not common statements bolded)

Benefits Teachers Cited When *Their* Teachers Differentiated Instruction (Interview Question #11)	Benefits Teachers Cited as Benefiting Their Own Students (Interview Question #2a- shortened for brevity)
✓ Teachers engage students by doing a lot of different activities ✓ **Teachers provide a variety of real-life examples and made learning identifiable for students** ✓ Teachers do hands-on activities and are different from the typical sitting and writing kind of classroom experience	✓ Differentiated instruction enables a teacher to reach a great variety of students ✓ **Differentiated instruction allows a teacher to provide a different perspective and subject background support as needed for each student**

Table 9 Continued

✓ Teachers allow different ways of working on projects: group vs. individual work ✓ Teachers support students in getting to different points in the work ✓ Teachers change assessments depending on the student and what the student needs, strengths and abilities ✓ **Teachers encourage the growth mindset, creativity, self-exploration and intrinsic motivation** ✓ Teachers meet the students where they are at as a learner ✓ Teachers establish relationships with students and understand who they are, and where they are at academically and socially ✓ Teachers recognize students as individuals ✓ Teachers give the students choices on the subject they want to write about or explore, which gives a chance for students to think about what they want and what they are interested in learning ✓ Teachers motivate their students to learn by caring about the students	✓ Differentiated instruction enables students to work at their own pace and to start at their own level and not feel pressured to be at a level of another student or group of students. ✓ Differentiated instruction allows teachers to provide students with activities that target different modalities, so as to target the different preferred ways of learning of each student. ✓ Differentiated instruction provides students with choices related to the kind of activity they want to partake in, how they want to be assessed, what products they want to produce and whether they want to work with other students or individually. ✓ **Differentiated instruction provides an avenue for student enrichment, especially in different ways of expressing your knowledge and solving problems, such as understanding a concept conceptually, mathematically, graphically, etc.** ✓ Differentiation keeps students engaged and motivated, even with different abilities and end products ✓ **Differentiation of instruction provides access to the content for all learners and removes obstacles for learning.** ✓ **Differentiated instruction helps students learn how to learn and teaches them to communicate with teachers about what they need.** ✓ Differentiated instruction shows students that the teacher cares about their instruction, which fosters positive relationships between teachers and students as well as provides students with a sense of autonomy

As can be seen from Table 8, the majority of the benefits that teachers cited as benefits they had as students from their teachers that differentiated instruction for them are also benefits that they cited for their own students when they differentiated instruction for them. This is interesting because it shows partial continuity in the ways that instruction was differentiated for them with the way they differentiate instruction now. As Jordan stated while remembering her high school trigonometry and geometry teacher, "those individual teachers who, I guess, looking back who I think cared about their students, differentiated by default, because they met me where I was at as a learner" [38:08]. In her practice as a teacher, she also strives to build relationships with students and make sure that she is seeing them as individuals. Morgan, on the other hand, admitted that "yeah, as I was like becoming a teacher, I thought, you know, I want to be like, like that person, I want to be like those teachers that I remember that, like, made the learning come alive, that got me excited about the lesson that I maybe want to produce this great product to show them that I can do it. Like I want it to be like them. So yeah, um that was motivating" [1:08:20]. One of the teachers that did not have a teacher that differentiated instruction for her in high school, Robin, also expressed the wish for someone to have challenged her back then when she thought that harder classes were too tough for her and decided to step down to a lower level, despite knowing now that she was fully capable at the time of being successful in those harder math courses. Additionally, it was an interesting observation that (as previously stated) Sam and Robin had rated differentiated instruction as lowest on their list of priorities and when asked whether they had any teachers that had differentiated instruction for them, they had stated that they did not, showing a possible correlation between a lack of differentiated instruction as a student and a subsequent lack of prioritization of differentiation when teaching their own students.

Differentiation of Instruction and the COVID-19 Pandemic

During March of 2020, the U.S. education system, the same as almost all education systems in the world, was hit with a wave of necessary remote instruction transitions due to the COVID-19 pandemic. Since the data for this project was collected in the summer and fall of 2020, it was vitally important to make sure that the teachers could reflect on the transition to remote instruction and the way their ability to differentiate instruction for their students was impacted during the pandemic. This could inform school policy and administrative support in implementing DI in the future as well as characterize how teachers differentiated instruction under the circumstances, providing a different side of how teachers practice DI. The interview question that pertains to this topic is as follows:

12) How has the transition to remote instruction impacted your attitudes, beliefs and practices regarding differentiated instruction?

The teachers' experience with differentiated instruction during the period of remote instruction was mixed. Some teachers thought that they could differentiate more because it was easier to differentiate in the online environment, while other teachers claimed that it was harder to differentiate because emergency plans had been instituted and all students were working on the same activities because there was no time or capacity to make it unique for each student. In order to more thoroughly unpack what happened with the level of instruction differentiation during the beginning stages of the pandemic, it is important to categorize the teachers' experiences in general.

All teachers had a hard time transitioning to online instruction, because they were required to transform what they had been doing (some for decades) into an online, or at the very least remote option for their students. For some, differentiation flew out the window because they were

focused on surviving the rest of the year, and particularly surviving the short window of time that they had to transfer everything online:

> "And so again, when you're making a big change like that, to also think about differentiation or feel like that is another layered piece, like, oh, it's going to take me X amount of hours to like, change this activity that I normally can set up in my classroom. So now I'm going to devote a lot of this time to putting that online or making it easy to access remotely. And now you're asking me also to differentiate that? That's going to be another you know, Y hours, so I feel like that can sometimes feel overwhelming." [Charlie 51:39]

This is a concern that teachers expressed even when asked about when they taught before the pandemic, that lack of time to really add that "layered piece" to the already overflowing list of things that teachers are supposed to consider when teaching in general. Besides the transition to remote instruction, administration and staff of most schools were concerned about the students for a variety of reasons, most having to do with things like:

- ✓ Students being on their computer for most of the day
- ✓ For students that used the school environment to escape from situations at home, their situation became concerning
- ✓ Student social-emotional health without the school social environment
- ✓ Students on the free or reduced lunch program that didn't have the meals that the school used to provide
- ✓ Students needing the background information to progress to next year's classes or to graduate
- ✓ Students having at-home responsibilities, like taking care of younger siblings or sick parents or having to work to help the family
- ✓ Students not having adequate access to internet or resources to complete assignments

- ✓ Students not being motivated when working from home and being distracted on Zoom
- ✓ Students keeping different schedules, staying up all night and skipping classes in the morning

These were just some of the concerns expressed by the administration and staff members when the transition to remote instruction took place. As described by the teachers, the situation was complicated further by several policies that different schools instituted as they were planning for the end of the school year. Some schools said that teachers could not fail students, or at least could not fail students that were not already failing before the transition to remote instruction happened. According to the teachers, this led to some students just not passing in any work after the transition, except for the students that needed the background material for later courses in high school or college. Other schools were told that they could not count virtual student absence against the student, so once the students found out about this, they stopped attending. Yet another policy in some schools was that they could not cover any new material and had to review old material only. Reviewing material was hard because the teacher could not be physically in front of the student to help them organize papers or find notes that they need for the review. For the students that required a step-by-step process review, teachers could no longer provide that kind of support, and if students didn't understand something, they were not going to rock the boat and try to get their questions answered. This happened mainly because the online environment was not as conducive to 1:1 work with the student as the in-person classroom was. Robin describes the way her school handled the transition as follows:

> “Remote learning was so horrible. We, we had a couple of different phases of remote learning. Our first phase, the first, I think, three weeks was we came up with a grade 11 packet. And it wasn't even science. It was emergency learning that we expected the kids to put in about 45 minutes a day into a school activity. So it might have been reading an article from the National Geographic and answering a few questions. Or it might have been... I threw in a periodic table pun fun worksheet for them one day where they had to use the periodic table and find the- find the elements that went with the pun. So that was, we came up with a learning plan that every student could do, no matter their ability. Our second phase of remote learning was content specific, but we only had to do one assignment a week. And it was around 45 minutes to one hour assignment, but we could not introduce new material. So we had to introduce, we had to review and refresh old material. So no, we were not differentiating at all. I would, I would show them a video on something that they had already learned and I would send them a worksheet to go with it. So I think I chose like, I think, I don't know, I can't remember how many weeks we were in the end phase of that. But I think I took like, all of the topics and chose like one big thing from it. So they might have had a review and a worksheet on balancing equations, they might have had a review and a worksheet on stoichiometry, a review and a worksheet on naming ionic and molecular compounds. So I did not differentiate anything. I just, I gave it to them because our grading was differentiated somewhat. We had either a zero, an 80, or 100. It wasn't even zero. It was an incomplete. So if they attempted it, and they did a pretty good job and got the majority of it correct, they automatically got an 80. Not even the majority, if they at least got 50% of it right, they got an 80. And then if they did it all and did very well, maybe not even perfect. But you know, if I gave them 10 questions, they got eight or nine of them right, they'd get a 100. So that's how we approached that. And if they completely bombed it, or they didn't attempt it, then they got an incomplete. It was, it was horrible.” [Robin 34:38]

As can be seen from this example, even if the assignments were not differentiated for each student, because as teachers admitted, the goal was for students to get to some academic threshold in general, the grading could still be differentiated. There is no consistent model that most schools followed when they transitioned to remote instruction, so it would be impractical to generalize, but in terms of differentiation, the teachers were split in their opinions. About half of the teachers said that differentiation was reduced in a lot of ways because of the need to survive the school year. For these teachers, differentiation was placed on the backburner. They had also mentioned that it was much harder to get students to be engaged and to form connections with

them. Some teachers mentioned that students used to talk to them before and after class, which gave teachers an opportunity to get to know their students individually. With the transition to remote instruction, students no longer talked to teachers about personal subjects, which decreased the strength of the relationships that teachers could form with students. Labs were hard to do, because students would have to watch someone else perform the lab and then process the data, which was not as fun. Additionally, when working with more 3D content, like molecular geometry, teachers did not have their physical tools like model kits, and materials to do demos. For other teachers, especially teachers that were already using tools like Google Classroom, differentiation tended to stay the same. For these teachers, Google Classroom provided a way to discreetly assign different assignments or different levels of an assignment to students as needed, avoiding any kind of disparity that can be seen by other students. No teachers claimed that they differentiated instruction *more* after the transition to remote instruction.

For the teachers that tried to differentiate after the transition to remote instruction, there was a variety of obstacles. Some teachers, like Gray, differentiated for student energy, and not necessarily content. They saw some students that were motivated to work, and they pushed these students to learn extra content and progress in their understanding of chemistry, whereas the other students had been given permission to leave if they wanted to. Jordan, as well as some other teachers, ended up being very flexible with the use of Google Classroom, providing multiple opportunities to interact with content and two to three different ways to get to the endpoint, or two to three different activities they could choose from, depending on their headspace. Students that really needed school to keep them going because home life was different required a different kind of approach than students that just needed to get the credit for the class and completed things to get them done. Morgan mentioned that after the transition to

remote instruction, differentiation of instruction had to be approached much more intentionally. Some teachers, like Sam, filled in the gap of not having physical materials by using PhET simulations, which were admittedly less interactive than physical models, but could give the students an idea of what molecules looked like in space. For Taylor, even when she tried to have many options for her students and tried to work with the extent that her students were able to perform experiments, sometimes they were not able to complete them, and she had to either provide data for them to analyze or just ask them to pretend like they did the experiment and imagine the data that they could have gotten. Lastly, teachers were much more involved with parents when the instruction was remote, which was like having twice as many students, putting additional stress on the teachers.

According to the teachers, in trying to engage the students in doing the work and participating in class after the start of the pandemic, differentiation of instruction became more of a buzzword when talking about teaching. As Morgan stated in her interview, teachers are forced to get creative with the experiences that they plan for students outside of the classroom and while physically in the classroom because of these limitations. In summary, it should not be understated how hard and taxing the transition to remote instruction in March of 2020 was for both teachers and students. For many teachers, differentiation of instruction became difficult or even impossible to implement, or at the very least took on a secondary role. However, some teachers still tried to differentiate instruction, with varying levels of success and in different ways. The ways the transition to remote instruction impacted the way teachers differentiated instruction has been described in this section, listing some barriers to differentiation of instruction that could occur under similar circumstances in the future as well as the facets of differentiation that are most important to reinforce in professional development opportunities.

Pseudo-Grounded Theory Analysis

The data analysis additionally revealed four major emergent themes through a pseudo-grounded theory approach (Randles et al., 2018). The pseudo-grounded theory approach differs from the grounded theory approach because literature was consulted prior to data analysis and the deduction of themes. The four major themes are discussed in greater detail below. The themes are organized in order of decreasing mention, where mention is quantified by the number of coded quotations from the interviews.

The Connection Between Student Autonomy and the Differentiation of Instruction

The most important theme that was discovered through a pseudo-grounded theory approach was the connection between the differentiation of instruction and student autonomy. From the list of benefits that teachers cited for their students in relation to differentiated instruction, the following can be picked out that are related to student autonomy:

- ✓ Differentiated instruction enables students to work at their own pace and to start at their own level and not feel pressured to be at a level of another student or group of students. This also includes thresholds for students, meaning that students don't necessarily need to make it to the end, but they need to progress and show that they have learned something.
- ✓ Differentiated instruction provides students with choices related to the kind of activity they want to partake in, how they want to be assessed, what products they want to produce and whether they want to work with other students or individually.
- ✓ Differentiated instruction provides an avenue for student enrichment, especially in different ways of expressing your knowledge and solving problems, such as understanding a concept conceptually, mathematically, graphically, etc.

- ✓ Differentiation keeps students engaged and motivated, even with different abilities and end products
- ✓ Differentiated instruction helps students learn how to learn and teaches them to communicate with teachers about what they need.
- ✓ Differentiated instruction shows students that the teacher cares about their instruction, which fosters positive relationships between teachers and students as well as provides students with a sense of autonomy

For most of the teachers interviewed, differentiation of instruction is a way for students to develop their sense of autonomy, which teachers cite to be highly important for their lives after they finish school, because of such skills as self-advocacy and independent analysis of publicly available information to make informed voting choices. For example, Alex encourages his students to stretch themselves into classes that students maybe don't feel like they are smart enough to take, and he never says no to students wanting to take his AP classes, while at the same time being honest with them about the difficulties of being in those classes. If a student enters his AP classes without the prerequisite information from lower-level courses, he spends extra time with those students going over the missing concepts. He strongly believes (like most teachers) that providing those opportunities for success is important. This is, he claims, the benefit for differentiating instruction, that you can provide success for a student at any point in time, so that you never make them feel like they are behind everyone else, and you can provide a platform for the students where they can shine and feel good about what they have accomplished. The way he can accomplish this is through the use of POGIL (Process Oriented Guided Inquiry Learning) activities that have extension questions, which are not required, but he might encourage students to do them as a challenge. Most students would go ahead and complete them.

Similarly to Alex, Charlie feels that when a teacher differentiates instruction, it allows the students to challenge themselves, but not be overwhelmed. This allows every single student to move across the board and how far they get is determined by them. With this way of looking at instruction, the teacher is putting the onus on the students, of being in charge of their learning path. She claims that if a teacher is teaching in the *traditional* way, that the expectation is that the student would have to meet the teacher where they are at and fill in any gaps that they might be experiencing and to accommodate themselves, as opposed to the teacher finding different ways to approach similar material. However, when a teacher *differentiates* their instruction, it makes it easier for the students to learn and be responsible for their own learning. Everyone has the opportunity to learn, and learning feels more fair. Lastly, she adds that seeing students as people is highly important, because the teacher should understand the person's feelings, how they interact with the content and how their brain learns in general, so that it is easier to personalize learning and reach specific students.

An interesting view on building student autonomy came from Gray, who has just finished her first year of high school instruction. Prior to high school teaching, she taught at the university level in the healthcare field. She drew a parallel between the school environment and the healthcare system and said that there is a big difference between a patient that is motivated to take care of themselves and a patient that is not, just like there is a difference between a student that is very self-motivated to learn the material and do the work and a student that is not. This, as stated by the other teachers as well, is a big problem for teachers in general. Just as a patient might regress in the healing of their disease or might even cause significant damage by not following the doctor's orders, a student will fall significantly behind in the subject matter, which will hurt them in later courses. According to Gray, there needs to be a way for teachers to

motivate students to “take care of themselves” academically and think about their academic future.

The concept of fostering that sense of student autonomy through differentiation of instruction was also connected to metacognitive modeling by Jordan, who constantly models what her brain is doing, and she talks about it out loud. She helps students see the connections and how their brains might be thinking about the concept or how to solve a particular problem at each step. She claims that the metacognitive modeling helps them see their own thinking, making thinking itself very visible:

> “So when, you know, I always tell my students in chemistry, I'm like, I don't like chemistry, but my heart of my teaching is helping my students to understand themselves as learners. So getting to recognize the skills in which they need to use to move themselves forward, and what the little tension is for them and what big tension is. And so when we're differentiating learning, if there's high tension, I'm like, you know, go back to that station. Because if you're, if you're getting overwhelmed, and you're freaking out, you're not ready to be doing that. Let's go back here. And in the example I gave, let's go back here and play the game again and see where you're at. So yeah, I want there I want them to understand their thinking, I want it to be visible. I want it to be explicit. I want it to be transparent, so they understand how to learn for themselves.” [Jordan 12:58]

She is explicit in that she doesn’t expect to produce a hundred chemists every year, but she does expect students to recognize who they are, how they think and how they learn best. This need for students to learn how to learn is seconded by Morgan as well, who believes that sitting down with students and figuring out what are the pieces that need to be put into place for them to be successful has made them better learners. She also agrees with Jordan that chemistry as content is not necessarily as important as the skills and habits that students might develop through the learning of chemistry, citing Next Generation Science Standards (NGSS) as the skill and practice requirement guidelines. For Morgan, content is a way to interact with the NGSS practices, where the proficiency in the NGSS standards is what students are being graded on.

However, ultimately “it's really about giving them an opportunity to, to think like a scientist, to become somebody who will be a citizen that can look at scientific information that might be like in the news. And, and be able to think critically about it, you know, ask questions and be able to read tables and diagrams, so important, because people put those into information that people have to process in order to make decisions. And so we look at those skills as being the most important thing. So it's okay, if we shift around the what they're learning, as long as we're getting back at those bigger thinking skills” [Morgan 27:50]. To achieve the goal of fostering student autonomy, Morgan gives students choices about what they would like to accomplish for the class. Students can take the assessments with or without completing the practice problems, but the only way they can remediate the assessments, or improve their score is if they had done the practice before taking the assessment. This gives the students the choice to understand about themselves whether they need the practice to do well on the assignment, or they can skip it because they are confident they can do well without it. The remediation policy can be a good tool for students to reflect on their work and fix their own mistakes. Ultimately, this is a practice of differentiation, giving the student the ability to choose what and how he should do in order to succeed in the class.

Lastly, Sam and Skyler always want to see their students advocate for themselves, and they will work with any student that is advocating for themselves and is earnestly trying to get the work done to be successful in the class. Sam has some warranted frustration with the standards-based trend in education at the moment, because it lets students endlessly retake assessments, which might mean that students will procrastinate and won’t intrinsically care about doing well. This fails to show students that there are hard deadlines in life and that some things you really can’t redo. However, she will work with any student that works hard and wants to pass her class,

ultimately differentiating for the energy and motivation that each student has, leaving it in their hands as to the level of success that they want to achieve.

It is thus apparent that the majority of the teachers interviewed associate differentiation of instruction with the goal of fostering the students' sense of autonomy, providing a solid reason for teachers to differentiate instruction for their students.

Tracking and Student Grouping in the Differentiation of Instruction

Differentiation of instruction, like any pedagogical tool, is multidimensional, because it can be applied to classes, groups of students or individual students. To understand the different levels of differentiation, a funnel model is proposed by the research team to organize the teachers' experiences with the levels of differentiation:

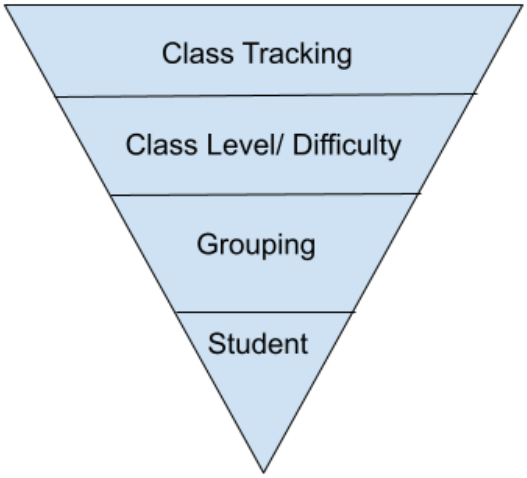

Figure 2: Levels of differentiation of instruction

In Figure 1, there are four levels of differentiating instruction, starting with the top level that encompasses the majority of the students and ending with the bottom level that is composed of each individual student. Class tracking is the idea that students pick their own classes, depending on school requirements, or necessary background they might need for future work or

education. It is likely a typical school already has a science track that most students are expected to follow, such as taking freshman science, then biology and then picking between chemistry and physics for junior year. In this way, students effectively complete the first level of differentiation themselves, by "tracking" themselves into a class that fits their needs, interests, and abilities. According to the teachers, they are typically consulted about the classes to see where a student might fit in, and some teachers might actually encourage students to take certain classes based on what they observe about the student.

The second level of differentiation is class level or difficulty, which is something that is done by both students (when they self-track) and by teachers, when they plan their curricula, seeing as a typical school might offer unlimited levels of chemistry with different intentions. Based on what the interviewed teachers have described, the following levels of chemistry are widely offered in schools, although not every school will offer all levels:

- ✓ Introduction to chemistry
- ✓ Applied chemistry
- ✓ Technical preparation chemistry
- ✓ Academic chemistry
- ✓ College preparation chemistry
- ✓ Regular chemistry
- ✓ Honors chemistry
- ✓ AP chemistry

Upon registering for classes, a student might decide on any of these levels, as they find suitable, depending again on need, interest, and ability. Sometimes, based on the math classes chosen by the students, they might get tracked into certain courses because they are the only ones

that fit into their schedule. Thus, even if students do not purposefully self-track into specific chemistry courses, the math might track them in nonetheless. Teachers typically develop different curricula for each of these classes because they either cover completely different content or they cover it to a different extent, therefore differentiating between courses. Most teachers that work in schools that offer multiple levels of chemistry tend to have pretty homogeneous groups of students, since they get tracked by ability, so students that go into the honors or AP levels are high-performing students that typically don't require a lot of differentiation. As previously mentioned by Alex, when a student joins a high-level course without the prerequisite knowledge, he works with the student to fill in the blanks, otherwise the students would struggle and not get a fair chance at learning the content.

If a school doesn't offer multiple levels of chemistry, the chemistry class is heterogeneous, and students would need more individual supports, although only a few teachers would have students working in different parts of the room on different things at the same time to achieve the same goals, because of the difficulty of monitoring students working on different tasks. As Gray pointed out in her interview, if the school is small and only heterogeneous classes are possible, and different ability students are grouped together, high-performing students might find it boring to be in environment where some things have to be repeated or redone. Similarly, low-performing students might feel pressured to perform at a higher level because they might feel like they are holding back the class. Some teachers that were interviewed are of the strong opinion that all classes should be tracked because of this kind of disparity that puts pressure on all the students and the teacher as well (to differentiate more). However, if tracking cannot be accomplished because the size of the school is small, teachers are forced to differentiate out of necessity. The plus side of *heterogeneous* grouping, according to Jordan, is that students can

watch each other think and process information and might provide different tips and tricks as well as help to other students. Conversely, a negative aspect of *homogeneous* grouping is that depending on the level of the students that you have in the group, it might be quite difficult to teach the group. As Jordan pointed out, a homogeneous group of honors students is very easy to teach, because they are mostly at the same proficiency level. Whereas, if you have a group of low-performing students, then it is harder to teach, because each student would require individualized help.

The third level of differentiating instruction, according to the teachers, is grouping students within a specific class. As Alex admits, sometimes differentiating is having students work in groups that can support each other. There are a variety of ways that teachers might group students, such as grouping students based on ability (or level of understanding of a specific topic), which could go both ways: a teacher might group students based on the same level of understanding, because they want those students to get to the same point in an assignment and feel like their group members are on the same level, or the teacher might group students based on differing abilities, so that the students that are ahead in their understanding can help students that are struggling. Depending on the needs of the students, they can also be grouped according to their preferred method of interacting with content, such as kinesthetic, auditory or visual. Sometimes there are situations when a group of students comes in having already completed the assignment, and they understand the content that the class is learning, so the teacher can provide some sort of extension that might not move the students forward, but will provide enrichment, while the teacher helps the students that are not done with the assignment or that are struggling. Sometimes teachers group students based on personality differences, motivation towards learning the content or math ability (if it is a math-heavy topic, grouping by math ability helps

the teacher to know approximately to which point a group of students will get and which students would need extra help and guidance). A factor in the grouping decision is also whether students are introverts or extroverts, therefore, some teachers leave it up to the students in terms of participating in group work or doing projects individually.

According to the teachers, grouping students is easier when the classroom environment can be arranged in pods or groups of desks. When this is impossible due to the set up of the room, teachers are forced to get creative. Some teachers, like Charlie, make up seating charts for their students. When making the seating charts, she typically thinks about putting certain people in certain places and calls them "classroom anchors." The seating chart allows her to group students as she sees fit or to pair them up depending on who can productively work together. When she makes up the intermediate and stretch goals for her students, she initially starts to think about them in groups and only then individually. Jordan, on the other hand is in a school with a big ELL population, which makes the literacy of her students a challenge in the classroom. She has students that read at the 5th grade level and students that don't have a big vocabulary at all, which makes it hard for her to plan instruction, so she is forced to change her instruction and the extent to which she covers material based on the group of students that she has. She also must consider social-emotional issues that her students might have, because this often changes the whole dynamic and the classroom management of the classroom.

The fourth and most specific level of differentiating instruction is differentiating for the student individually, which allows students to work from the place where they are, without being pressured to be where someone else is. For high-performing students, this might look like enrichment, whereas for low-performing students, this might be extra help from the teachers or peers. Robin had mentioned that one of the problems she has faced in her classes is finding the

time to sit and work with students that are at a lower level, especially those that have special needs (specifically a math disability is hard to work with). It takes time for her to go through assignments and modify them to be less challenging. What she might do on an assignment is circle the problems that she wants specific students to do and let the rest of the class do all of the problems on the worksheet. This allows students to still learn the same concept, but not do it at a level that is too challenging for them. The teachers interviewed all stated that they work with students who have fallen behind individually.

There were two teachers who were against differentiated instruction as a practice, mainly because they assert that it is too much work for the teacher to have to adapt to the different needs of the students and making several versions of each assignment. However, even if they initially stated that they were against differentiation of instruction, they later stated several practices that are parts of instruction differentiation, even if they don't call it that. They do, however, believe that differentiated instruction works better for the lower levels of chemistry and doesn't work well for math-heavy topis (discussed later), citing that when the range of abilities in math is too great, nobody wins, because the teacher becomes too busy to do their job effectively, and might have to wait for longer periods of time when asking questions because of the students that need a longer time to process the question and come up with an answer, as stated by some teachers.

In general, the four levels of differentiation work in unison to encompass all that a teacher truly does when they differentiate instruction for their students, and the connection between tracking and grouping students and differentiation of instruction is very strong. This section described the way this group of teachers differentiates instruction on each of the four levels so as to form a characteristic picture of the way these teachers differentiate instruction in general.

Differentiation of Math-Related Topics in Chemistry

There are several topics in chemistry that require a considerable math understanding in order to be successful, for example: stoichiometry, mole ratios, percent isotope abundance, etc. For this reason, math questions are included frequently on assessments, as a way to demonstrate problem solving ability, which is what a chemistry teacher is most interested in terms of math; a student should be able to take what they understand and use it to explain some phenomenon that has been given to them. The differentiation of math-heavy topics was brought up multiple times during the course of the interviews as something that was difficult and required a lot of planning for teachers. Some teachers, knowing ahead of time that the topic involved calculations, split the students into groups by math ability level, which would give the high-performing students a chance to take off and explore and would also give the teacher a chance to work with all of the struggling students together at the same time.

Most teachers, like Blake, feel that a unit that has a considerable amount of math is harder to differentiate, simply because sometimes there is only one way to perform calculations that teachers were taught themselves. Mathematics topics in general are hard to differentiate into different modalities. How do you make stoichiometry into a kinesthetic activity? As Blake mentioned, it is not something she had any training on how to do. In the training that most science teachers get, there is likely no training on how to differentiate math instruction, even though a lot of the chemistry and physics content is heavily math-based. She also thinks that the reason that the math-heavy portions of chemistry are so difficult for students is because they are ultimately doing two things at the same time: understanding the theoretical content piece and doing calculations. One way that Blake has tried to differentiate the math portions of chemistry is by providing enrichment activities for students that found the calculations too easy. However, the

enrichment activities take the students to new topics that are not directly taught by her. For example, if the base threshold is that each student should understand how to find the molarity of a solution and should be able to do percent by mass or percent by volume calculations, the enrichment topic could require the student to also understand the concept of molality. In this way, some students end up learning something different, but that is above and beyond. It is not like she is teaching two different things to two different groups of students; it is more of a ladder.

Other teachers, like Charlie, sometimes use math as a way to enrich students in general. For example, if they are covering colligative properties, some students will stop at the "why" something happens, whereas some students will work through the why and will get to the calculations, like predicting how far you should change the boiling point to elevate the freezing point depression, etc. Charlie determines when to push students to the calculations part informally: when she is walking from group to group, and a group is done with the "why," she might give them a problem set, but if another group is still talking about the "why," she will discuss it with them. In general, she needs to see that the students understand the basic theoretical concept before she encourages them to do the calculations.

For topics that are on the border between math and chemistry, such as balancing equations, Robin differentiates by deducing which students might struggle with the concept and starting them out on an easier level. For advanced students, they could do the harder problems, that have to do with balancing oxygens and multiplying coefficients. The way you could deduce which students have the higher math ability is by looking at the student Northwest Evaluation Association (NWEA) test scores and leveling out the questions in chemistry based on the math ability. Robin has also come up with some helpful tools for math problems over the years that she has been teaching. For example, she shows students how to color code for stoichiometry, so

that when students see the same color on top and bottom, they will know that the unit will get cancelled out.

For some teachers, like Sam, the prospect of differentiating math-heavy chemistry topics is so daunting that she believes that differentiation of instruction shouldn't be used in chemistry at all and should instead be used in science courses that don't have as much math, such as biology. She claims that the alternative, which would be to teach conceptual chemistry to a part of the class and to teach the math concepts to the other part of the class would be too difficult. This statement is not unfounded, as other teachers also claimed that teaching different topics to different groups in the class can get too chaotic and energy-consuming for the teacher. Skyler and Taylor also mentioned that an additional hardship for them in terms of math is that students typically don't enjoy the math-heavy parts of the unit, so they are forced to skip parts of it completely or find creative ways to make it more engaging.

The difficulty of differentiating instruction in math-heavy units was amplified when the transition to remote instruction happened, because typically the way a teacher would assess student ability to do calculations is a traditional test or quiz, especially if the teacher wants to see the process behind how the student found the answer. However, once the transition to remote instruction happened, it was harder to assess math ability because traditional tests were no longer a possibility. Students now had the ability to look up information, use their phones and copy each other's work. One of the difficulties Gray had with her students was not being able to physically show them the process for doing calculations. These students, she claims, are concrete sequential learners, and they are unable to abstract. Thus, for these students, the most effective method seems to be to sit down with them, write the equations down on paper, watch them write it down

themselves and then plug in the numbers. Since the start of remote instruction, she was unable to do that, and so could not help these students learn in the way that is most suitable for them.

This section, in describing the difficulties of differentiating instruction for the more math-heavy parts of chemistry, is written in the hope of possibly doing some kind of training that would let chemistry teachers interact with math teachers and see what possible tools there are for making math topics in chemistry more differentiated.

Differentiation of Instruction, Concept Hierarchies and Differences in What Students Learn

During the course of the interviews, teachers started talking about concept hierarchies that they had built for their students in their chemistry courses, describing them in ways that warranted extra attention. As a follow-up question, the teachers were also asked how students reacted to the concept hierarchies, and what happened when students noticed that they are learning something different from what other students were learning.

Charlie, for example, differentiates by providing a worksheet or an activity that has different thresholds that she is hoping people will meet. She thinks of it as a progression: if you can run a mile, then you can try running two, if you are still not breathing heavily after two, let's try three, etc. In the classroom, she tries to ask different questions:

- ✓ Can you understand it?
- ✓ Can you understand it conceptually?
- ✓ Can you understand it mathematically?
- ✓ Can you understand it graphically?
- ✓ Can you extrapolate from data?
- ✓ Can you come up with an equation for a chemical phenomenon?

An important piece for her is not necessarily expecting every student to get to the end but hoping that students can make the progression from one point to somewhere in the middle and they're showing that they have learned something. This is the way that she believes differentiation of instruction keeps students engaged, even if they have different levels of understanding and ability. They might be arriving at different end products, but they are still learning and are still interested. Skyler also points out that differentiation of instruction is necessary in classrooms because typically she has students that are going into different professions after high school. If a student is going into the medical field or another chemistry-related field, it is necessary that they learn chemistry at a deeper level than someone who is going into a field that is unrelated to chemistry.

As was mentioned in previous sections, Charlie differentiates by providing math as enrichment. For her, some students do not necessarily need to be able to do a variety of calculations in chemistry, it might be enough just to be able to understand the basic idea behind the chemical phenomenon. Some students will get to the "why" something happens and stop there, while others will proceed to solving mathematical problems. Teacher-student interaction is the way she decides when students are ready to proceed to calculations.

Some teachers, like Alex, have pretty homogeneous classes and therefore don't have a problem with students noticing that other students are doing different work than they are. He claims that students recognize their own level of understanding and therefore issues are minimized. Other teachers, like Charlie, do have students that are pointing out the differences between what the students are doing. The way that she deals with it is by saying that these students have showed already that they understand the material and they are ready to move on, while other students are still learning the material and just need more time. That doesn't mean

that these students will never get to that same point. It just means that they are not getting to this point just yet. Charlie points out to her students that they can move on to the next concept when this one feels comfortable and concrete to them. When approached in this way, the responsibility for how far they get in their own understanding falls on the student (reinforcing the concept of student autonomy).

In general, teachers might have intermediate and stretch goals for their students. For example, they might have the initial threshold of getting all students in the class from point A to point B, and once students get to point B, they might continue to point C (intermediate), and once they get to point C, they might be encouraged to continue to point D (stretch). If a student doesn't get to point C during the class, that doesn't mean that they will never get there, or that they are not capable of getting there, it just means that it might take them some more time or help from the teacher. This kind of attitude makes it seem more fair for students, even though sometimes it feels like teachers are creating inequity in the classroom because students are working on different levels of difficulty. However, a positive aspect of students being at different points is that they can help each other, and they can make connections between concepts that they might not have made connections between if they were all on the same level of work, as stated by teachers. Lastly, not all teachers think of this as a hierarchy, some teachers think that it is more of a spectrum, where students are all over the board in terms of ability.

Robin is one of the teachers who thinks that having students working on different things at the same time is not something that should be done, because some students don't want others to know that they are working on different things. They do not want to be noticed or embarrassed when another student points out the differences, and if their worksheet looks different from everyone else's, they get harassed, because the kids will call them out in front of everyone else.

Keeping this in mind, Robin tries to be as subtle as possible in those instances where she has to differentiate based on student need. If someone speaks out in class about the differences in work, she tells them to mind their own business and points out that everyone's education is individualized. Sometimes even the advanced students complain that they have to do more work than other students, at which point she asks them to try it, but does not push it. Other teachers also echoed this sentiment that if any differences in the work between students exist, they cannot be emphasized by the teacher and need to be proposed as subtly as possible.

According to many of the teachers interviewed, the key characteristic of differentiating instruction is seeing students everywhere in between the minimum threshold goal and the stretch goals. If differentiation of instruction was absent, there would just be students meeting one standard, without really knowing where the students really are and what their individual abilities are. The basis for these thresholds and goals comes from teaching experience, the teachers claim, and understanding what levels of cognition are there and where students are in those levels. According to teachers, the drawback to this is that teachers are assuming that students come in every year with similar knowledge and that is not always the case. This is where differentiation of instruction takes place because teachers might see that this year everyone makes it past the bottom threshold very quickly, so they have to reevaluate their plan to accommodate the students that they actually have in the class that year.

Of course, when the transition to remote instruction happened in March of 2020, the conceptual hierarchies that teachers had built went out the window, because the sole focus of the schools was to get students past the minimum threshold, making differentiation of instruction no longer a priority. However, as the return to normal, in-person instruction is drawing nearer and the prospect of returning to the full-scale differentiation effort is facing the teachers, it is

important to see why differentiation of instruction is necessary in the high school chemistry classroom and why this instructional tool deserves attention and continuing professional development.

CONCLUSION

The study aimed to characterize in-service high school chemistry teacher attitudes, beliefs, and practices regarding the differentiation of instruction, which can be helpful in articulating and developing the ways teachers can be supported in the implementation of differentiated instruction techniques in the high school chemistry classroom.

Definition and Use of Differentiated Instruction Practices

From the study, it can be concluded that if a collective definition of differentiated instruction were to be compiled by this group of teachers, they would include the following statements in their definition:

- ✓ Using different strategies
- ✓ Supporting individual students
- ✓ Meeting students where they are
- ✓ Providing necessary resources
- ✓ Providing content in multiple ways

These statements align closely with the widely accepted definition of differentiated instruction first proposed by Carol Ann Tomlinson, which shows common ground between the teachers' definition and the accepted definition. This can be used to provide a characterization of this group of teachers for the purposes of professional development design. From the investigation of differentiation of instruction practices that the teachers used in the classroom correlated with their prioritization of differentiated instruction in their teaching practice, it can be concluded that teachers who rate differentiation of instruction as lower on their list of priorities have a lower number of differentiation of instruction practices that they report implementing in the classroom. Overall, the group of teachers interviewed had some similarities and some

differences in the differentiation of instruction practices that they used in the classroom, which can be used to further characterize this group of teachers. The practices that were used by the teachers were similar to the practices described in other studies (Nanang et al., 2017; Neve et al., 2015; Pablico et al., 2017). No other studies have presented how teachers define differentiated instruction.

Attitudes, Beliefs and Opinions of Teachers Toward the Differentiation of Instruction

The teachers carry specific attitudes and beliefs toward differentiation of instruction, that inform their practice and characterize to what extent they implement differentiated instruction techniques. While there are positive and negative factors to differentiating instruction, the majority of the teachers emphasize the importance of differentiating instruction. The most frequently mentioned positive and negative aspects of differentiated instruction as cited by teachers are as follows (with frequency counts in parentheses):

Positive:

- ✓ Teacher can provide tailored instruction (8)
- ✓ Increases student engagement (3)

Negative:

- ✓ Takes time to do the planning (6)
- ✓ Creates inequity in the classroom because students notice different levels of work (4)

The teachers' positive and negative aspects of DI closely match aspects mentioned in other studies, although this study cites a greater array of aspects, both positive and negative (Aldossari, 2018; Ernst & Ernst, 2005; Pablico, 2017; Tobin & Tippett, 2014).

Teachers prioritized differentiation of instruction differently and may place different aspects of teaching practice in the top 3 or 5 priorities along with or instead of differentiated

instruction. Some teachers that placed differentiated instruction high on the list of their priorities stated that there is a direct link between how much a teacher cares about their students and how much they differentiate their instruction. It was readily apparent that some of the perceived benefits for students were also part of the teachers' definition of differentiated instruction, which shows how highly the way teachers view differentiated instruction depends on seeing differentiated instruction as a benefit in general. Prioritization of DI as an instructional practice has been linked to DI implementation in other studies as well (Graaf et al., 2018; Neve et al., 2015). Prioritization of practices and their subsequent implementation was explained by the Neve study as closely tied to teacher autonomy, since "autonomy has an enhancing effect on efficacy because it enables teachers to choose tasks that fit their skills and interests. Self-efficacy, in turn, increases teachers' performance" (Neve et al., 2015).

Additionally, the COVID-19 pandemic has been one of the biggest challenges faced by humanity in the last several decades. As everyone was caught unawares with the need to isolate and yet continue operations as normally as possible, the education system was forced to institute emergency education, and part of this study was an attempt to show how ten high school chemistry teachers in Maine faced the challenges that accompanied the transition to remote instruction. At the time of the interview, they were in the middle of planning how they were going to be teaching their courses once school resumed in the fall of 2020. Many of them had decided to send bags or kits home that would contain some materials that would hopefully give the students a chance to recreate some hands-on experiences at home, however, these experiences would not be differentiated, and students would be basically doing the same thing as everyone else. While this is a big improvement over just having students do remote work, like watching videos and answering questions, it is still not using differentiated instruction to its full

extent. Some teachers were looking into kitchen-chemistry labs, which could be differentiated by the types of projects students might want to do in their homes. Additionally, even if students are all in a physical classroom together, there are still safety protocols that must be followed in the fall. Part of the safety protocol is the distance of 6 feet that should be present between the everyone in the room and part of that is that students are not allowed to move freely around the room and are also not allowed to touch the same objects as other people without sanitization.

Expectations from School Administration Regarding the Differentiation of Instruction

On the topic of school administration policy regarding differentiation of instruction, no teachers reported having been given an explicit statement regarding how they should differentiate instruction in the classroom and to what extent. Additionally, all teachers cited a lack of support from the school administration in helping teachers differentiate instruction, possibly because of the difficulty of the content. However, all teachers claim that they are still required to differentiate instruction through *implicit expectations* such as:

- ✓ The overall culture of the school wants people to differentiate instruction
- ✓ Principals and curriculum coordinators emphasize differentiated instruction, although there is a lack of support when someone asks for help with differentiating instruction, most likely because the content is intimidating
- ✓ Teacher evaluations often include anywhere from a sentence up to a whole page of items that have to do with differentiating instruction, sometimes from the National Board certification standards
- ✓ Differentiated instruction is discussed during teacher observations

- ✓ It seems to be an assumption that is made by the administrative team and by colleagues as well that teachers should be differentiating- the belief that differentiating instruction is a good teaching practice
- ✓ Emails sent from administration to the teachers that either include statements that differentiation of instruction is expected or information on specific students that might need differentiation
- ✓ Staff meetings that mention the expectation that teachers should be differentiating instruction

Administrative support was also closely linked to DI implementation in several studies, citing a lack of support as a reason some teachers don't practice DI or struggle with it (Nanang et al., 2017; Neve et al., 2015). As a result of this investigation, it can be suggested that schools provide a statement about what differentiation of instruction should look like for their teachers but should not make it too constricting as to remove the teachers' sense of autonomy in the classroom, and there should be a greater emphasis by the school administration on supporting high school chemistry teachers in differentiating instruction for their students.

Cross-Talk Between Disciplines and Exposure to Professional Development Regarding the Differentiation of Instruction

On the topic of cross-talk between teachers of different disciplines, whether within the science department or outside it, teachers explain that there is always cross-talk between disciplines in and outside of the science department, but it is never focused on differentiating instruction *per se*. However, according to the teachers, since the beginning of the COVID-19 pandemic, more effort has been spent on talking about how to differentiate instruction just because of the transition to remote instruction, so it might be predicted that there will be an

increase in the need to talk about how to differentiate instruction as the pandemic continues, as more waves become a possibility and for developing a protocol for how instruction will be handled in future pandemics. In terms of the *need* for cross-talk, all teachers express the need for it in the area of differentiating instruction, to exchange ideas about how to differentiate different chemistry content or create interdisciplinary units. If interdisciplinary projects were to come into existence, they would need to become part of the school culture, in order to accommodate factors such as the differences in teacher engagement and interest and conflicting schedules for planning and interdisciplinary work. The only productive cross-curricular work that was cited by the teachers was interestingly between the science and the math departments, where the math teachers had asked for examples from science of math problems that they could solve, and this collaboration worked fairly well.

On the topic of pre-service training, seeing as there is an obvious expectation from the school administration and just the culture surrounding teaching that teachers should be differentiating instruction, it is striking that only 4 of the 10 teachers have received any formal training on the differentiation of instruction. Thus, the teachers emphasized the general lack and need for pre-service as well as current teacher professional development and training, which would need to include cross-curricular communication with other departments as well as a targeted training towards differentiating mathematics-related topics in chemistry. The following suggestions were made by the teachers regarding any professional development that would be created in the future:

- ✓ Must be at least subject area (science) specific, if not content (chemistry) specific
- ✓ Must be differentiated for different grades and/or subjects as needed

- ✓ Must include concrete examples of things that teachers can use right away and that they will find valuable
- ✓ Must be framed in such a way as to not make it seem like it is extra work, but just providing extra resources that students can use or leveling the work so that each student can work on their own level
- ✓ Must not include any additional costs, because some schools cannot afford extra human or material resources
- ✓ Must include an opportunity for teachers to share tips and materials with each other, as many teachers cited that to be a particularly useful part of any professional development event
- ✓ Could include some resources to help engage students in distance learning, as this has been an area of major focus recently because of the pandemic
- ✓ Could include a connection to proficiency-based education, which has been an emerging concept recently because of the acceptance of the Next Generation Science Standards

Cross-talk and interdisciplinary collaboration are also factors that should be considered by anyone looking to create professional development opportunities or simply looking to expand their own differentiation practices.

Suggestions for Future Work

It is recommended by the research team that professional development opportunities should be created based on the suggestions outlined in this work, taking into consideration the connection of differentiated instruction to the critical need to foster student autonomy. It is also suggested that the characterization of the teachers' transition to remote instruction during the COVID-19 pandemic informs future efforts of school administrative teams to support teachers in differentiating instruction.

In terms of further research that can be done, case studies on specific teachers' experience can be conducted, pending further interviews and classroom observations. Teacher experiences with DI as students can be investigated in relation to pre-service experience with DI in training and in-service experience during professional development events. Other factors, such as NGSS (Next Generation Science Standards) can be researched in terms of how the relationship between standardized instruction and DI works. The fairness of differentiated instruction as a practice can be investigated, due to the concerns of some teachers that students are doing different amounts of work and are being assessed on different criteria.

The limitation of this work is that the research was focused only on information that can be provided by the teachers themselves, therefore lacking any kind of observational data that can be gathered by observing teachers when teaching. Through observation of the classroom, a researcher can gain insight into whether or not teachers actually practice DI, what DI strategies they use and to what extent. Another suggestion would be to include some demographic information, such as age, race, teaching certification and experience. Research can be conducted in order to determine if there is a link between DI and socioeconomic status of the students or the teacher as well. Lastly, comparisons can be made between language used in the ELA/Math world

regarding DI and the language used in science, in order to see if there is common ground and if terms from the ELA/Math literature on DI can be adapted for science.

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APPENDICES

Appendix A: Recruitment Email for Teachers

Hello, my name is Anna Tyrina. I am a Master of Science in Teaching student at the University of Maine. I am conducting research on the attitudes, beliefs and practices of high school chemistry teachers regarding the differentiation of instruction, and I am inviting you to participate because you are a high school chemistry teacher.

Participation in this study includes participating in a 1-hour interview where you will be asked to talk about your views and experiences regarding the differentiation of instruction. Your total time commitment will be approximately 1 hour. To thank you for your participation, you will be compensated at $25 per hour.

If you have any questions or would like to participate in this research study, I can be reached at anna.tyrina@maine.edu or at (207) 890-3710.

Appendix B: Internal Review Board Approval Application

Investigating the Attitudes, Beliefs and Practices of High School Chemistry Teachers Regarding the Differentiation of Instruction

PI: Anna Tyrina
Faculty Sponsor: Francois Amar
Investigators: Francois Amar, Natasha Speer, Brian Frederick

Application Narrative:

1. **Summary:**

The focus of the study is the understanding of how high school chemistry teachers define differentiated instruction (DI), what their beliefs and attitudes about DI are, and how they practice DI techniques in the classroom. Additionally, the study will seek to find out how DI implementation is understood in the school's culture and policy as an explicit practice or an implicit understanding, in order to assess the school environment's influence on their practice. The study was developed to also investigate the influence of professional development events geared towards DI during the pre-service and in-service periods on in-service teacher implementation of differentiated instruction techniques in the classroom. Furthermore, the communication between teachers of different disciplines about DI will be investigated. Lastly, the teachers' own experiences with DI as a student will be addressed, as well as the change in what they believe about the implementation of DI techniques now that the only learning option is remote learning due to the coronavirus pandemic.

A qualitative study of six high school science teachers and their individual beliefs, experiences and perceptions about the differentiation of instruction showed the following major themes about how teachers *perceive* the differentiation of instruction (Pablico et al. 2017):

1) Differentiated instruction improves student engagement and academic performance in class
2) Differentiated instruction motivated students
3) Differentiating by choice is the most common way to differentiate
4) Administrative support has a major influence on the implementation of differentiated instruction
5) Implementation of differentiated instruction increases teacher efficiency
6) Differentiated instruction requires more time and creativity

Another study linked the following variables with the extent to which teachers feel that they implement differentiated instruction techniques (Suprayogi et al., 2017): teachers' DI self-efficacy, teaching beliefs, teaching experience, professional development, teacher certification, and classroom size.

This research project was based on the abovementioned and other studies that show that teacher attitudes and beliefs about differentiated instruction techniques are an important factor in the likelihood that they will implement the techniques in their classroom. The proposed outcome of the study is the understanding of in-service teacher attitudes, beliefs and practices regarding DI, which will be helpful in articulating and developing the ways teachers can be supported in the implementation of DI techniques in the high school chemistry classroom.

The following research questions are proposed (with references to interview questions):

1) How do high school chemistry teachers define and use differentiated instruction? (Q1,2,4)
2) What are the attitudes, beliefs and opinions that high school chemistry teachers have about differentiated instruction? (Q3,5,10,11,12)
3) Are there explicit statements or implicit expectations from the administrative team that teachers should be using differentiated instruction techniques? (Q7)
4) Is there exposure to differentiated instruction for teachers through crosstalk between disciplines or professional development events? (Q6,8,9)

In order to make the research results more available to the community, the research can be presented at professional development events or published in a journal. The research project can also be developed further to look at the beginning of a collaboration between STEM and ELA in developing a language around the use of DI techniques in the classroom, since ELA has a more developed language base to talk about DI.

The research is composed of 1-hour interviews with high school chemistry teachers from Maine. The sample population size is 10 teachers. The method of analysis is qualitative.

2. Personnel:

Anna Tyrina, Master of Science in Teaching Student, is the PI for this project. This project is her Master's thesis research. Her work will include recruiting participants, conducting interviews with teachers, transcribing and coding interviews, and the analysis of all data that is generated as a result of the project.
Francois Amar, Professor of Chemistry and Dean of the Honors College at the University of Maine, is the Faculty Sponsor and an Investigator for this project.
Natasha Speer, Associate Professor of Mathematics Education at the University of Maine, is an Investigator for this project.
Brian Frederick, Professor of Chemistry at the University of Maine, is an Investigator for this project.

3. Participant recruitment:

The primary participants in this study will be 10 high school chemistry teachers from Maine schools. Teachers will be recruited from the existing Maine STEM Partnership community. The Maine STEM Partnership is a statewide partnership of approximately 1,000 teachers and

140 school districts that collaborate with the Maine Center for Research in STEM Education in order to improve STEM instruction in their classrooms using research-based instruction practices.
For this study, the PI will recruit participants by reaching out to teachers through the Maine STEM Partnership database. Potential participants will be contacted via email (Please see Appendix A for the recruitment email that will go out to potential participants). Participants will also be recruited through professional connections with local high schools. Some teachers have already indicated interest in participating in the study.
Ideal participants will be high school chemistry teachers who are interested in the work of the project (specifically, in investigating the attitudes, beliefs and practices of high school chemistry teachers regarding the differentiation of instruction).

4. Informed consent

Teachers who participate in the study will provide verbal consent to participate through a script that will be read out loud at the beginning of the interview. See Appendix B for interview transcript. Participants will also receive a copy of the consent form via email. See Appendix C for the informed consent form.

5. Confidentiality

Data will be recorded via Zoom audio/video recording. IP addresses will not be collected. Audio and video recordings will be downloaded to the researcher's laptop, which is encrypted, and password protected. In filing and organizing the data, teacher names will be replaced by a pseudonym for the purposes of confidentiality. A key will be generated to link teacher names to the pseudonyms. The key will be used to keep track of audio/video data that relates to each teacher participant. The key will be encrypted and kept on a password protected computer, separate from the data. The key will be kept until August 2022 and then erased.
Interviews with participating teachers will be recorded and transcribed by the PI. Interview data (recordings and transcripts) will be identified by the pseudonyms used in the teacher key. All identifiable data will be kept on a password protected computer and encrypted storage and made available only to the researcher. The video and audio recordings of teacher interviews and all de-identified data including interview transcripts will be kept indefinitely for reference.

6. Risks to participants

Risks from this project include the time and inconvenience to the participants. Some participants may be uncomfortable with answering interview questions and some may be uncomfortable with being recorded during the interview. To mitigate these risks, teachers will be compensated for their time and will also be informed that they may choose not to

answer any interview questions that they do not wish to answer and that they can stop being recorded at any time. Participants will be asked for permission prior to turning on video or audio equipment, and if any participant expresses concerns, accommodations will be made to assure their comfort, including turning off the video or audio equipment.

7. Benefits

Benefits to teachers participating in this research include the opportunity to develop their understanding about the differentiation of instruction and reflect on their teaching practices in the differentiation of instruction. It is hoped that the project will lead to valuable learning for the teachers involved in the study, as well as contributing to general knowledge about the differentiation of instruction in high school chemistry classrooms. This group of instructional strategies has been identified as a needed component in the general understanding of effective teaching methods, given the increased diversity of modern high school classrooms.

8. Compensation

Teachers will be compensated for their participation in research at a rate of $25 per hour. For all teachers this will be a one-time payment of $25 for the 1-hour interview. If a teacher does not complete the entire hour of the interview, they will still be paid for the entire hour.

References:

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Appendix C: Teacher Interview Protocol

"I will be starting the recording of the interview at this time. Is that okay with you?"

Opening Statement: "Thank you for agreeing to participate in this interview. I am a graduate student at the University of Maine, and I am studying the in-service high school chemistry teacher attitudes, beliefs and practices regarding differentiation of instruction. Please feel free to ask for clarification of any question that you do not understand. Also, you should not feel confined to answer only the questions asked. They are meant to be conversation starters. I may also ask follow-up questions. You may choose to not answer questions that you do not wish to answer. You have the right to stop the recording of this interview at any time. It may also be necessary for us to contact you after the interview to follow up on your responses via email. Is that okay with you? Do you consent to my asking you some questions about your attitudes, beliefs and practices regarding the differentiation of instruction?"

1. How would you define the term "differentiated instruction"? Provide some examples that illustrate the use of differentiated instruction in the classroom.
    a) Explain in greater detail how your examples illustrate differentiated instruction.
2. Do you use differentiated instruction practices in your classroom, if so how?
    a) If not, do you find that implementing differentiated instruction techniques would benefit your students, and if so, how? What are the reasons you don't implement differentiated instruction in your classroom?
3. How important do you believe differentiation to be to your instructional practices?
4. Do you actively consider differentiated instruction methods when developing your lesson plans?
    a) How does differentiation impact what content you teach and how you teach it?
    b) How does differentiation impact the way you arrange the learning environment?
    c) Do you differentiate by readiness, interest or by learning profile?
        1. Readiness is defined as "a student's proximity to specified knowledge, understanding and skills"
        2. Interest is defined as "that which engages the attention, curiosity, and involvement of a student"
        3. A student's learning profile is "a preference for taking in, exploring, or expressing content". Four factors are considered here: gender, culture, learning style (solo vs group work, study while sitting still vs moving around, etc.) and intelligence preference (verbal-linguistic, logical-mathematical, etc).
    d) Do you actively consider differentiated instruction methods when planning the ways you will assess student learning?
5. In your opinion, what are some positive and negative aspects of implementing differentiated instructional practices in the classroom?
6. Have you ever discussed differentiated instruction at a professional development event?
    a) What do you think your level of self-efficacy in implementing differentiated instruction techniques is?
    b) If no, do you believe there is a need for professional development events about differentiation oriented towards in-service teachers?

7. Is there an explicit statement or an implicit expectation from your school's administrative team that teachers should be using differentiated instructional practices in their classroom?
    a) If yes, how is that statement/expectation expressed?
    b) If no, do you think there should be a school-wide policy/expectation that would require teachers to use differentiated instruction techniques in their classroom?
8. Do you communicate with teachers of other disciplines about differentiation practices that you use in the classroom?
    a) If yes, what are some positive and negative aspects of this exchange?
    b) If no, do you believe that it is important to have crosstalk between disciplines on the subject of differentiation?
    c) Do you think other teachers at your school use differentiated instruction?
9. Did you ever participate in pre-service training in differentiation?
    a) If yes, did you find that you applied the skills you learned as a pre-service teacher when you began teaching? What kinds of materials did you find helpful in the development of your use of differentiated instruction techniques?
    b) If no, do you believe there is a need for professional development in differentiation for pre-service teachers?
10. How does differentiated instruction have an impact on how students learn? Is that impact mostly positive or negative?
    a) How do you assess whether differentiated instruction is having an impact on how your students are learning?
11. What were your experiences with differentiated instruction as a student? Did your teachers implement differentiated instruction, and if so, how? Did their use or lack of use of differentiated instruction affect your learning experience?
12. How has the transition to remote instruction impacted your attitudes, beliefs and practices regarding differentiated instruction?
13. Are there any materials or resources on the topic of differentiated instruction that you are aware of that could be helpful to the research team?
14. Do you have anything else you would like to add?

Appendix D: Informed Consent Document

You are invited to participate in a research project being conducted by Anna Tyrina, a Master of Science in Teaching student at the University of Maine. The purpose of the research is to understand the attitudes, beliefs and practices of high school chemistry teachers regarding the differentiation of instruction.

What Will You Be Asked to Do?

If you decide to participate, you will be asked to participate in an interview with researchers. Any data with your name or other identifying information will be shared only with the research team. Research presentations, reports, or publications that use this data will not use your name or identifying information in connection with any findings of the research. We estimate that the interview will take approximately an hour to complete. You will be compensated at $25 per hour for time you spend on the interview. In the case that you do not complete the full hour of the interview, you will still be paid for the whole hour. It is possible that you will be contacted via email after the interview with follow up questions about your responses.

Risks

Except for your time and inconvenience, there are minimal tasks to you from participating in this study. There is the possibility that you may feel uncomfortable with answering some interview questions. To minimize this risk, you may skip any questions that you do not wish to answer. You may also feel some discomfort about being video or audio recorded as you answer the interview questions. To minimize this discomfort, you can decide at any time that you would like to have the audio or video equipment turned off. To accomplish this, please let the researcher know your preference.

Benefits

Benefits to you as a participant in this research include the opportunity to develop your understanding about the differentiation of instruction and reflect on your teaching practices in the differentiation of instruction. It is hoped that the project will lead to valuable learning for the teachers involved in the study, as well as contributing to general knowledge about the differentiation of instruction in high school chemistry classrooms. This group of instructional strategies has been identified as a needed component in the general understanding of effective teaching methods, given the increased diversity of modern high school classrooms.

Compensation

You will be compensated at $25 per hour for time you spend on the interview. In the case that you do not complete the full hour of the interview, you will still be paid for the whole hour.

Confidentiality

Your name will be removed from all interview data prior to storage and will be replaced with a pseudonym. This pseudonym will be used to identity all research data that is gathered. Data will not be stored with your name. Identifiable data will only be available to members of the research team for this project. Data will be kept on a password protected computer.

A key linking the pseudonym to your name will be kept separate from the data on a password protected computer using encryption software to provide additional security. The key will be destroyed by August 2022. Interviews will be transcribed, and original recordings will be kept indefinitely for reference.

Voluntary

Participation is voluntary. If you choose to take part in the study, you may choose to stop at any time. You may skip any questions you do not wish to answer and may stop participating in the interview or in video or audio recording at any time.

Contact Information

If you have any questions about this study, please contact Anna Tyrina at anna.tyrina@maine.edu or (207) 890-3710 or Dr. Francois Amar at amar@maine.edu. If you have any questions about your rights as a research participant, please contact the Office of Research Compliance, University of Maine, (207) 581-1498 or (207) 581-2657 (or email umric@maine.edu).

AUTHOR BIOGRAPHY

Anna Tyrina grew up in Syktyvkar, Russia. She received a Bachelor of Science degree in Chemistry from the University of Maine in 2019. In the fall of 2019, Anna joined the Master of Science in Teaching program at the University of Maine in Orono. She teaches chemistry, physics and physical science at Newfound Regional High School in Bristol, New Hampshire. Anna is a candidate for the Master of Science in Teaching degree from the University of Maine in August, 2021.