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Differentiated Instruction: Inclusive Strategies for Secondary Science

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DIFFERENTIATED INSTRUCTION: INCLUSIVE STRATEGIES FOR SECONDARY SCIENCE

by

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TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

"The biggest mistake of past centuries in teaching has been to treat all students as if they were variants of the same individual and thus to feel justified in teaching them all the same subjects the same way" – Howard Gardner (as cited in Siegel, & Shaughnessy, 1994, p. 563)

Educators, as Gardner's quote implies, have had a long history of viewing classrooms as homogenous groups of students in which all were taught in a traditional teacher-centered approach emphasizing the presentation of information by the teacher who tells students what they need to know as they cover the curriculum. This teacher-centered, homogenous view of classrooms and students led many educators to "teach to the middle" (Haager & Klinger, 2005, p. 19), trying to provide instruction within the curriculum to all students simultaneously, while using the same methods and strategies. However, "teaching to the middle" has left many students without the supports or instruction needed to make adequate progress towards essential ideas and skills connected with education standards. Typically, students who did not grasp the content and skills necessary for success were removed from general education classrooms to become the responsibility of a special education teacher, and the advanced learners who grasped the concepts quickly were left unchallenged (Rock, Gregg, Ellis, & Gable, 2008; Tomlinson, 2005a).

In the past six decades of American educational history, diversity within schools and classrooms has increased based on the principle of the Constitution's 14th Amendment which states, "No state shall make or enforce any law which shall abridge the privileges or immunities of citizens of the United States; nor shall any state deprive any person of life, liberty, or property, without due process of law; nor deny to any person within its jurisdiction the equal protection of the laws" (*U.S. Const.* amend. XIV). Based on this principle, the United States Supreme Court recognized that separate was not equal, thus banning racial segregation in public schools (Brown v. Board of Education, 1954). Additionally, Brown v. Board of Education (1954) led civil rights advocates to lobby state and federal officials for greater equality, resulting in the passage of the Civil Rights Act of 1964. The Civil Rights Act (1964) was landmark legislation prohibiting discrimination in several areas including housing, employment, and education. Within this historical legislation Title IV of the Civil Right Act defined the act of desegregation in public schools to mean "the assignment of students to public schools and within such schools without regard to their race, color, religion, or national origin, but 'desegregation' shall not mean the assignment of students to public schools in order to overcome racial imbalance" (Sec. 401.b). However, Congress did not limit civil rights to the confines of the definition above. In Section 410 of Title IV of the Civil Right Act, Congress stated "nothing in this title shall prohibit classification and assignment for reasons other than race, color, religion, or national origin."

Using Section 410 of Title IV of the Civil Rights Act, special education advocates pushed for equal rights for individuals with disabilities through such cases as PARC v. Pennsylvania (1971) and Mills v. Board of Education (1972) which "established the constitutional basis for providing education to children with disabilities" (Rothstein & Johnson, 2010, p. 344). This constitutional basis for the education of students with disabilities led to the enactment of the Education for All Handicapped Children Act (EHCA) of 1975, now known as the Individuals with Disabilities Education Act (IDEA; 2004). EHCA called for schools to provide students with disabilities Free and Appropriate Public Education (FAPE) in the least restrictive environment (LRE) (Rock et al., 2008; Van Garderen & Whittaker, 2006). According to IDEA of 2004, "Each public agency must ensure that to the maximum extent appropriate, children with disabilities, including children in public or private institutions or other care facilities, are educated with children who are non-disabled." (Sec. 300.114). As a result of these legislative acts and court rulings, general education classrooms have become more diverse through the assurance of FAPE for all students, including those with disabilities.

Another issue adding to the diversity of students in general education is the alignment of educational legislation. This move came to the forefront through the enactment of legislation such as IDEA 1997 and 2004, and No Child Left Behind (NCLB) of 2001. Under the IDEA amendments of 1997, requirements were expanded to include higher instructional expectations and academic outcomes by placing emphasis on the integration of students with disabilities in general education classrooms so that they have access to and make progress in the general education curriculum (Cawley, Hayden, Cade, & Baker-Kroczynski, 2002; Lawrence-Brown, 2004; Rothstein & Johnson, 2010). NCLB (2001) expanded on IDEA (1997) by requiring state educational standards to reflect higher expectations for all students, and to have in place a statewide assessment test to measure outcomes. IDEA (2004) further expanded expectations and outcome requirements, and helped align IDEA with NCLB by incorporating some requirements from NCLB, such as the necessity for teacher to be highly qualified within their content area, and the need for teachers to provide scientifically-based practices within instruction.

This legislation and the ever-growing diversity of our society has led to a student population that is not only academically diverse because of inclusion of students with disabilities, English Language Learners, and advanced learners, but one that is diverse due to students' culture, religion, socioeconomic background, life experiences, and interests (Broderick, Mehta-Parekh, & Reid, 2005; Ginsberg, 2005; Guild, 2001; Tomlinson, 2001, 2004b; Van Garderen & Whittaker, 2006). In an effort to ensure physical and cognitive access to an ever-diversifying student population through opportunities to participate in positive educational outcomes and to meet the demands of standards-based education, many educators are looking for teaching and learning approaches that support the needs of a variety of learners. One such approach is Differentiated Instruction (DI), and this paper will examine key issues: what is DI; why is DI important to secondary schooling; DI in secondary science; barriers to DI in secondary science; and implications for future research. Research reviewed within this paper was identified by searching Google Scholar and EBSCOhost with terms: differentiated instruction, differentiated curriculum, differentiation, science, biology, earth science, chemistry, secondary science, middle school, high school, secondary school.

CHAPTER 2

WHAT IS DIFFERENTIATION?

Differentiated instruction has been defined as an instructional design model "ensuring that what a student learns, how he/she learns it and how the student demonstrates what he/she has learned is a match for that student's readiness level, interests and preferred mode of learning" (Tomlinson, 2004a, p. 188). The goal of this proactively planned approach is to maximize the potential educational outcomes for each student by meeting their current educational needs and supporting them through the learning process (Landrum & McDuffie, 2010; Tomlinson, 2005b). Support through differentiation is based on a cycle of assessment, instruction, and reflection (Rock et al., 2008; Tomlinson, 2005a). According to Rock et al. (2008), DI is guided by four principles: (a) a focus on essential ideas and skills in each content area, (b) responsiveness to individual student differences, (c) integration of assessment and instruction, and (d) an ongoing adjustment of content, process and products to meet individual students' levels of prior knowledge, critical thinking, and expression styles. Interestingly, this principle is articulated in Universal Design for Learning (UDL) where teachers develop instruction that supports multiple means of presentation (content), engagement (process), and expression (product) that is responsive to a range of student differences (Jimenez, Graf, & Rose, 2007). Although both DI and UDL share common a goal to progress all students towards essential ideas and skills connected with education standards the scope of this paper will focus of the implementation of DI. Each of the DI principles is examined below.

Focus on essential ideas and skills

To provide a sense of clarity and direction in the classroom, teachers must be able to design instruction around the essential ideas and skills connected to the standards of a given subject, and, thereby, ensure that assessment, curriculum, and instruction are linked to the success of all students (Tomlinson, 1999b). With the passage of NCLB (2001) and its standards-driven accountability, however, many teachers have been vexed on how to prepare students for high-stakes accountability tests while at the same time addressing individual needs in a diverse classroom (McTighe & Brown, 2005). The first step to differentiation is based on these content standards. Teachers must be aware of the essential concepts and big ideas of the curriculum so that instruction can be planned to provide students with a range of opportunities and supports that promotes success for all students (McTighe & Brown, 2005; Tomlinson, 1999b, 2005a). By determining the standard or essential concept that all students must reach, teachers are able to select varying materials that will provide students access to the content. Without this clear understanding of the standards that all students are to progress toward, there is no basis for differentiation (Tomlinson, 1999a).

Responsiveness to individual student differences

In a differentiated classroom, educators have an understanding that culture, gender, socioeconomic status and life experiences affect how and what students will learn (Broderick et al., 2005; Ginsberg, 2005; Guild, 2001; Tomlinson, 2001, 2004b; Van Garderen & Whittaker, 2006). Without an understanding of how these differences, such as an ELL students language proficiency, affect students' knowledge, interest and learning characteristics, a teacher cannot help students' progress towards essential ideas and skills.

Racial and ethnic diversity in public schools has changed in recent years. For example, between 1990 and 2010, the number of public school students who were white decreased by 13% while the number of Hispanic students increased by 11% (Aud et al., 2012). Additionally, students identified as Asian, Native Hawaiian, Alaska Native, Pacific Islander, American Indian, or two or more (Other) increased from 6% to 8%. If demographic trends continue as seen, our school population will be one “in which all races and ethnicities are part of minority groups that make up a complex whole” (Crouch & Zakariya, 2012, p.1). Their differences affect how and what students learn, and without taking into account these differences, the needs of a majority of this diverse population go unmet (Rock et al., 2008; Tomlinson, 1999b, 1999a).

Integration of assessment and instruction

According to Tomlinson (1999b), the goal of assessment is to provide educators with day-to-day data on how to modify tomorrow’s instruction according to student readiness for essential ideas and skills. Students come to each unit, activity, and lesson with varying levels of readiness, interests, and modes of learning. If teachers are to continue to engage students in effective instruction that is supportive and challenging, diagnostic and ongoing assessment of student’s knowledge and skill are needed (Lewis & Batts, 2005; McTighe & Brown, 2005; Rock et al., 2008; Tomlinson, 1999b). Essential ideas and skills connected with standards, as discussed previously, provide teachers with guidance to establish a goal and a path on how to get there. Teachers use assessments to evaluate students’ progress and guide instruction, as students move toward established goals (Levy, 2008; Lewis & Batts, 2005).

Effective differentiated instruction incorporates a variety of formal and informal assessments. Pre-assessment allows teachers to identify students’ knowledge, skills and interests with respect to the upcoming essential ideas and skills (Levy, 2008; McMillan, 2011). Formative assessment include a variety of formal and informal assessments conducted during instruction to provide a view of how students are progressing toward essential ideas and equips teachers with knowledge to adjust instruction to attain essential ideas and skills (Tomlinson, 1999b). Lastly, summative assessment, conducted after instruction, is used to record student growth towards understanding the essential ideas and skills determined prior to instruction (McMillan, 2011; Rock et al., 2008; Tomlinson, 1999b). Schroeder, Scott, Tolson, Huang, & Lee (2007) meta-analysis of the effect of teaching strategies on student achievement showed that assessment strategies (e.g., informal feedback, formative testing, diagnostic testing, testing for mastery) have a positive impact on student achievement. With the use of the information/data collected through these diagnostic and ongoing assessments, teachers can adjust content, process, and product to accommodate for students' knowledge, skills, and interests (McTighe & Brown, 2005; Tomlinson, 1999b).

Despite the importance of assessment to guide instruction, few studies discussed the impact of assessment on instruction. Many results focused on student achievement from pre- to post-assessments and/or high stakes testing to analyze the effect of specific differentiated strategies (Johnson, Zhang, & Kahle, 2012; Mastropieri, Scruggs, & Graetz, 2005; Mastropieri et al., 2006; Richards & Omdal, 2007; Schroeder, Scott, Tolson, Huang, & Lee, 2007). This lack of research on the impact of assessment on instruction shows that researchers remain focused on student performance on high stakes testing and not the ongoing adjustment to instruction to accommodate students.

Ongoing adjustment of content, process and product

At the core of differentiation is teacher ability to connect content, process, and product in a way that creates multiple paths for students of varying ability levels, learning characteristics, and interests to be successful (Levy, 2008; Tomlinson, 1999b). Differentiating content refers to the materials used in reaching essential ideas and skills that are taught. Learning objectives, as laid out by standards, are not varied or expectations lowered for students, but adaptations are provided through an Individual Education Program (IEP) that allow students to work toward proficiency of the essential ideas and skills (Anderson, 2007). To differentiate content, teachers should take into account students current knowledge and how they will proceed toward acquiring essential ideas and skills. For example, teachers use of materials at different reading levels, graphic organizers, flexible grouping with audio text, or cooperative learning groups (Anderson, 2007; Van Garderen & Whittaker, 2006). In a Think-Pair-Share activity, for example, students could work in pairs and be provided two articles on a topic at appropriate reading levels. Each student would complete a summary graphic organizer before pairing with their partner to share their article. In a study investigating the use of differentiated content within peer tutoring, Mastropieri, Scruggs, and Graetz (2005) developed tutoring cards containing questions on key chemistry concepts and incorporating mnemonic and elaborative materials. Results showed that students receiving differentiated content, within peer tutoring, outperformed comparison students receiving traditional teacher centered instruction. All students are entitled to curriculum established by district, state, and federal standards that establish goals for all students (Levy, 2008). Therefore, the goal of differentiating instruction through content is to identify instructional materials that provide a variety of access points through which all students can proceed toward proficiency of essential ideas and skills (Anderson, 2007; Corley, 2005; Levy, 2008).

Process refers to how teachers provide a range of instructional opportunities based on students' ability levels, interests and learning characteristics that allows students to process the concept or skill being taught (Anderson, 2007). Differentiating the process of providing instruction uses strategies and activities designed to provide students with an opportunity to connect with essential ideas and to use learned skills (Anderson, 2007; Tomlinson, 1999b). Since students are at different levels of knowledge and have different learning characteristics, the same instructional strategies will not work for all.

Much like the adaptation of content, teachers may adapt processes/strategies to address students' abilities, interests and modes of learning, through the use of cooperative grouping strategies, activity based instruction, tiered assignments, and enrichment projects. In an inclusive classroom, students vary in readiness. Students may have no prior experience or knowledge of an essential idea, some may have knowledge of it but lack mastery, while others may demonstrate mastery of the idea or skill even before instruction begins.

Based on these varying abilities within a classroom, a teacher can differentiate the process by designing activities assisting students to acquire, develop, and/or extend their prior knowledge of the essential idea or skill (Broderick et al., 2005). For example, in a Biology unit on the hierarchical organization of multicellular organisms, students with no prior knowledge would start with teacher-led instruction on how multicellular organisms begin with one cell and develop into complex organisms. Students with a grasp of hierarchical organization would apply this knowledge through the development of a model illustrating the concept. Students who have mastered the essential idea/concept would be provided opportunities to extend their knowledge through a research activity on the use of stem cells to create transplant organs.

Findings from studies in which process was differentiated suggest that achievement of all student may increase as compared to students in more traditional classes (Mastorpieri, et al, 2006; Richard & Omdal, 2007). Mastropieri, et al. (2006) revealed that students receiving differentiation of process significantly outperformed students receiving traditional instruction on achievement tests. In their study on the effects of tiered instruction on academic performance, Richards and Omdal (2007) reported significant increases in achievement of students with little prior knowledge, and no decrease in students with midrange or high knowledge, as defined by pre-assessment data. With the use of such strategies and activities, teachers adjust instruction to make it relevant and meaningful for students with varying knowledge and characteristics to progress toward essential skills (Anderson, 2007; Van Garderen & Whittaker, 2006).

Product or output refers to how students demonstrate and extend what they have learned during instruction. In demonstrating this knowledge, students should be assessed using a variety of methods (e.g., tests, projects, performance assessments, portfolios) that allow them to exhibit understanding of the essential ideas and skills that is compatible with their learning characteristics (Anderson, 2007; Levy, 2008; Rock et al., 2008).

One way teachers can provide students with a variety of methods to exhibit understanding of essential ideas that is compatible with their learning characteristics is through the construction of choice boards or open-ended lists of final products (Anderson, 2007; Chapman & King, 2005; Levy, 2008; Rief & Heimburge, 2006; Rock et al., 2008). Through choice boards and open-ended lists, teachers provide students with a variety of activities focused on essential ideas and skills that can be differentiated based on readiness, interest, or preferred mode of learning (Anderson, 2007; Kapusnick & Hauslein, 2001; Rief & Heimburge, 2006; Tomlinson, 1999b).

Waters, Smeaton, and Burns (2004) investigated high school students' perception of differentiated alternative assessments as compared to multiple choice tests and found that a majority of students preferred differentiated assessment. In the end, regardless of the products format, the goal of the product is to allow students to demonstrate and extend what they have learned based on abilities, interests, and preferred modes of learning (Anderson, 2007; McTighe & Brown, 2005; Tomlinson, 1999b; 2005a). Differentiation is not a replacement for high quality curriculum and instruction but is a means of refining it. Through the use of this instructional design model and the implementation of effective instructional strategies, teachers can differentiate the content, process, and product of instruction according to student's readiness, interest, or preferred mode of learning to help all students progress toward the essential ideas and concepts.

CHAPTER 3

WHY IS DIFFERENTIATED INSTRUCTION IMPORTANT IN SECONDARY SCHOOL?

NCLB's standards-driven curriculum and high-stakes testing have pushed many teachers to teach to the middle (McTighe, & Brown, 2005; Subban, 2006). Teaching to the middle, also known as the bell curve method encourages teachers to deliver instruction through a single path of learning in an effort to meet required standards focused on high-stakes testing preparation. In discussing standards-driven teaching and its effects on instruction, Tomlinson (2000) noted:

> Teachers feel as though they are torn in opposing directions: They are admonished to attend to student differences, but they must ensure that every student becomes competent in the same subject matter and can demonstrate the competencies on an assessment that is differentiated neither in form nor in time constraints (p. 7).

Although the standards movement, propelled by NCLB and IDEA, evolved in an effort to establish greater accountability and ensure an equal level of education for all students, it has promoted a one-size-fits-all focus in which curricula is to focus on test preparation due to sanctions that can be levied based on a school's adequate yearly progress (AYP) (Guisbond & Neill, 2004; Levy, 2008; Rock et al., 2008). As a result, many students and schools have failed to perform successfully. In a report prepared by the Center On Education Policy, 48% of the public schools in the United States did not meet AYP in 2011(Usher, 2012). In looking at six-year trends in AYP from 2006 to 2011, the national percentage of schools not reaching AYP has increased from 29% to 48% (Usher, 2012). In addition, the National Center on Education Outcomes (NCEO; Altman, Thurlow, & Vang 2010) reported that the average proficiency rate for high schools students with IEPs in reading and mathematics was 27% and 20.7%, respectively, for the 2007 – 2008 school year.

The negative results of a one-size-fits-all approach can also be seen in science education. Scores from the 2009 National Assessment of Education Progress (NAEP) science assessment indicated that 65% of students in 8^{th} and 12^{th} grade scored below proficient (NCES, 2011). Additionally, the Program for International Student Assessment (PISA), administered in 2009 indicated "that 70 percent of U.S. students are unable to connect science to real life situations or integrate science content across disciplines" (Therrien, Taylor, Hosp, Kaldenberg, & Gorsh, 2011, p.188). This poor performance is compounded by students' challenges to access the general education curriculum as can be seen from the results from the NEAP (NCES, 2011) in which students identified with an IEP, and not receiving an alternative state assessment, scored an average of nearly one standard deviation lower than students without a disability on the NAEP Science assessment.

Although data is limited, the traditional teaching to the middle is not providing all students with instruction that allows them to make progress to meet the required standards. In fact, by teaching to the middle, educators disregard the varying backgrounds, interests, and abilities of our ever changing diverse student population. It fails to meet the needs of the majority of students, whether they are gifted or struggling.

In an effort to mend the viewed divide between the demands of standards-based education set forth by NCLB and IDEA and support the educational success of all learners, professional organizations and educators have looked to differentiation and other alternative instructional methods. The push to move away from teacher-centered approaches can be seen in the efforts of professional science organizations such as the American Association for the Advancement of Science (AAAS) and the National Research Council (NRC), to move towards a collaborative, student-centered approach where the teacher is a facilitator addressing students' differences in knowledge, interest, and achievement in science (AAAS, 1993; Johnson et al., 2012; Maeng, & Bell, 2012; NRC, 1996, 2011). Documents such as the National Science Education Standards (NSES), and the Framework for K-12 Science Education assert that all students must have the opportunity to develop the knowledge and skills necessary to reach science standards (NRC, 1996, 2011). Their views are very much in line with DI by taking students' differences into account and providing all students with effective curriculum and instruction that will foster achievement. The question becomes which instructional strategies or instructional approaches are effective in improving student learning within a diverse secondary science classroom (Oliveira et al., 2013; Schroeder et al., 2007).

CHAPTER 4

DIFFERENTIATED INSTRUCTION IN SECONDARY SCIENCE

Legislative and professional reform has pushed science educators to implement effective instructional practices to address students' differences in knowledge, and achievement so that all can make progress towards standards to the best of their ability (NCLB, 2004; NRC, 1996, 2011). To support diverse students, science teachers must have an understanding of a variety of effective strategies that they can select, apply, and evaluate for the support of one student or multiple students (Ernst, Heckaman, Thompson, Hull, & Carter, 2011). Therefore, the following will evaluate the effectiveness of DI as compared to traditional instruction within secondary science for the support of all students.

Mastropieri et al. (2005) investigated the use of differentiated curriculum enhancements within peer tutoring versus traditional teacher-centered instruction in two inclusive high school chemistry classes over a 9 week period. Thirty-nine students participated in the study of which 10 were classified with a learning disability. Students in both conditions received traditional teacher-centered instruction; however, within the treatment condition, time spent on worksheets was dedicated to tutoring. Tutoring materials included cards containing questions on important concepts and incorporated both mnemonic and elaborative materials. Differentiated instruction was provided based on students response; students answering correctly were asked to elaborate on the concept, while those who did not were provided a relevant mnemonic device to support recall. Results showed that students receiving differentiated curriculum enhancements within peer tutoring significantly outperformed control students. Suggesting that students receiving differentiated curriculum enhancements within peer tutoring acquired key concepts at a greater rate as compared to traditional instruction

In another investigation, Mastropieri et al. (2006) compared the outcomes of using differentiated hands-on activities within classwide peer tutoring against traditional teacher-centered instruction. Thirteen inclusive eighth-grade classes were randomly assigned to an experimental or control group, five of which were co-taught and eight were taught by a single teacher. Participants included 213 students (109 males; 104 females) of which 44 were classified with disabilities (37 with learning disabilities and 7 with emotional/behavior disorders). In the control condition and experimental condition, teacher preparation was identical except that within the experimental condition, time typically spent on independent work was spent on peer-assisted learning with differentiated science activities. For the experimental condition, researchers developed three levels of materials that focused on identification (level 1), production with prompts (level 2), and production without prompts (level 3). The strategies developed were implemented over 12 weeks in which teachers and students received training, and students were administered a pretest, posttest, and a survey regarding their attitudes toward instructional material. Mastoropieri et al. results show that students using differentiated hands-on activities within class wide peer tutoring, performed better on unit and high-stakes tests then their peers in a more traditional classroom without peer tutoring. Furthermore, differentiation within peer tutoring had similar benefits for students with and without disabilities, suggesting that students content knowledge improved at a greater rate as compared peers in traditional instruction (Mastropieri et al., 2006). Students' reported attitudes showed preference for the experimental materials that were more game-oriented. Teachers reported they valued how appropriate the experimental materials were in helping students (Mastropieri, et al., 2006). Six of the seven teachers agreed that the experimental materials had increased students' academic performance.

Richards and Omdal (2007) examined the effects of tiered instruction on academic performance as compared to middle-leveled non-tiered instruction in an inclusive secondary astronomy class. Tiered instruction was based on prior knowledge and content and process were adjusted based on background knowledge so all could progress towards the same essential concept. Three hundred and eighty eight students were randomly assigned to seven treatment and seven control classes and administered a pre-assessment to determine prior knowledge. Students within the treatment group were placed in one of three tiered levels based on the pre-assessment, while the control group received middle level non-tiered instruction. Students scoring 10-11% on the pre-assessment were placed in tier 1, 80% in tier 2 and students scoring in the upper 10% were placed in tier 3. Students were placed in tiers based on pre-assessment results and not whether they were a student with an IEP.

Richards and Omdal's analysis of pre-assessment scores showed no significant difference between treatment and control groups prior to tiered instruction. Analysis of post-instruction scores showed significant difference between control and treatment, with students receiving tiered instruction scoring significantly better on the post-assessment as compared to non-tiered peers. The comparison of tier groups showed that lower background knowledge students receiving tiered instruction scored significantly high then peers not receiving tiered instruction, and as students' background knowledge increased, differences between scores of peer groups within the midrange and higher level decreased. These results suggest the use of differentiating instruction through tiered instruction led to increased achievement, especially for students with lower background knowledge, as compared traditional non-tiered instruction.

In an action research study in a secondary science classroom, Waters, Smeaton, and Burns (2004) investigated students' reaction to the implementation of a differentiated alternative assessment model. Participants included 47 freshman enrolled in a high school earth and space science class. Students selected their assessment activity (e.g, models, presentations, writings, newspapers, webpages, live performances) and if they would work in small groups or individually (Waters et al., 2004). Over the course of a semester students were asked to produce assessment activities in at least 3 formats. As they worked on each assessment activity, students would periodically meet with peers in a roundtable format to discuss their activity and receive feedback. At the end of the semester, a forced response survey and an open-ended questionnaire were administered to gather data concerning students' perception of differentiated alternative assessments. The forced response survey included two sets of 12 likert-style questions that were based on 5 a point scale. Students' responses revealed a preference for the ability to choose their assessment type and if they would work individually or with a small group. Survey data also revealed that students believed they worked hard and learned a great deal by completing the assessments (Waters et al., 2004).

Results from these studies (Mastropieri et al., 2005; Mastropieri et al. 2006; Richards & Omdal, 2007; Waters et al., 2004) suggest that DI has positive effects on student achievement and is preferred by students when compared to traditional teacher centered approaches in secondary science classes. These results show promise for DI within secondary science, but focus on one aspect of DI and do not present a picture of how DI fits within effective instruction in secondary science.

Johnson, Zhang, and Kahle (2012) examined the impact effective science instruction had on high school graduation assessments in science. The longitudinal study followed 176 students from sixth grade at Star Middle School in 2002 to tenth grade at Star High School (Johnson et al., 2012). Students completed the Discovery Inquiry Test (DIT) from sixth to eighth grade and were administered the Ohio Graduation Test in tenth. Eleven science teachers from Star Middle School, five sixth grade, three seventh grade, and three eighth grade participated in the study. The Local Systemic Change (LSC) Classroom Observation Protocol rubric was used to define effective instruction as,

> Instruction is purposeful and engaging for most students. Students actively participate in meaningful work (e.g., investigations, teacher presentations, discussions with each other or the teacher, reading). The instruction is well-designed and the teacher implements it well, but adaptation of content or pedagogy in response to student needs and interests is limited. Instruction is quite likely to enhance most students' understanding of the discipline and to develop their capacity to successfully do science (p. 11).

This definition of effective instruction is similar to DI in that it provides instruction designed to respond to students needs and interests while developing essential ideas and skills necessary for success in science.

Teachers were randomly observed by two raters four times throughout the year that students were placed with them (Johnson et al., 2012). The LSC Classroom Observation Protocol focused on four areas of standards-based instruction including: (a) design of lesson, (b) implementation of lesson, (c) science content of lesson, (d) classroom culture. The scores from these observations were compiled into a mean score. Teachers were deemed effective if they had a three or higher, on a 5 point scale, in all four of the LSC domains. Teacher interviews and field notes were also used to provide further evidence of effective teaching components. Results from observations showed that effective instruction had student-centered classrooms conducive to collaborative hands-on inquiry in which students were actively engaged, but non-effective instruction used a more teacher and textbook centered approach focused on drill and practice. Analysis of the DIT showed no significant difference in sixth grade. As students progressed through middle school, data showed a significant difference in science achievement for students who received effective instruction in a more student-centered, inquiry-based environment as compared to students with who received teacher and textbook centered approach. All students who had one year or more of exposure to effective instruction during middle school passed the science portion of the OGT, and "the more exposure the better the performance" (Johnson et al., 2012, p. 11).

Oliveira et al. (2013) took a socio-ecological view using a mixed method study to explore best practices in middle school science. Using eighth grade New York State science exam data and Earth Science Regents exam data from 2006-2008, seven high-achieving schools and three average-performing schools with similar demographics were selected. Case studies were created for each school based on data collected from transcribed interview recordings, documentary evidence, and field observations. Participants, which typically included two to four administrators and four to six teachers from each school, were interviewed for approximately 40 minutes over a two day period. Data collected were sorted and organized using qualitative database management software (HyperResearch), and a matrix was developed to record if instructional practices were present, absent, or in process of being implemented. High-performing schools' practices were compared to average-performing schools. Practices that were of high importance and typical in high performing schools and either not of high importance or nonexistent in average performing schools were identified as best practice

Classroom instructional strategies varied among the high and average performing schools, but Oliveira et al. (2013) identified best practice to include: (a) relevance to and engagement of students, (b) hands-on activity, (c) differentiated instruction, (d) collaborative work, (e) and less instructional time on review and more on new material. In summary, Oliveira et al. observed that "keeping science content and teaching relevant, engaging, hands-on, and collaborative while carefully adapting to students' cognitive needs through inquiry-based and differentiated instruction" resulted in higher student performance (2013, p 310).

Oliveira et al. (2013) and Johnson et al. (2012) do not provide direct casual relationships between specific strategies and student achievement, but provide a definition of effective instruction/best practice in secondary science and conditions found in classroom environments supportive of student achievement. Both studies show positive effects for instruction emphasizing a differentiated approach with instruction connected to interest and current knowledge through collaborative hands-on inquiry, over more traditional teacher centered instruction (Johnson, 2006; Johnson et al., 2012; Oliveira et al., 2013). Furthermore, these studies provide evidence to contradict the commonly held belief that teacher centered instruction focused on drill and practice results in greater achievement for students (Johnson et al. 2012; Oliveira et al., 2013).

These studies do have limitations that must be addressed. One noteworthy limitation is that they only looked at socio-economic, gender and ethnic demographics(Johnson et al. 2012; Oliveira et al., 2013) or did not report student demographics (Richards & Omdal, 2007; Waters et al., 2004) and cannot be generalized to other diverse groups' achievement. Secondly, Oliveira et al. (2013) sought schools that would be representative of New York state schools, yet the higher achieving schools selected served predominantly white students and had student populations that were below the state average poverty level. Furthermore, no data was collected to ascertain if differentiated alternative assessments increased student achievement (Water et al., 2004). The small number and sampling limitations of these studies make it difficult to validate the use of DI in secondary science (Johnson et al., 2012, Mastropieri et al., 2005; Mastropieri et al., 2006; Richards & Omdal, 2007, Waters et al., 2004).

CHAPTER 5

BARRIERS TO DIFFERENTIATED INSTRUCTION IN SECONDARY SCIENCE

The NSES call for changes that must be made for effective science instruction, but the change from a traditional teacher-centered instruction to an effective standards-based instructional approach can “often generate apprehension and anxiety” (Johnson, 2007). Some authors propose science teachers are not adequately knowledgeable in content and inquiry to implement this change (Berns & Swanson, 2000). Lack of preparation time, classroom resources, professional development, and administrative support are additional variables that influence instructional change (Carolan & Guinn, 2007; Goodnough, 2010; Hawkins, 2009; Johnson, 2007; Rock et al., 2008). These views can be seen in survey data from Johnson (2006) in which she conducted a qualitative case study to investigate the barriers encountered by teachers at Glendale and Eastridge Middle schools as they attempted to implement standards-based instructional approaches as called for by the NSES. Both schools were involved in the Discovery Model School Initiative, a science education reform effort that partnered local universities and schools to develop and implement a professional development plan for standard-based teaching (Johnson, 2006). Teachers were observed in their classrooms five times for one hour increments and participated in a formal semi-structured interview (Johnson, 2006).

To identify categories and the magnitude of barriers to implementation Johnson (2006) created a rubric (Barriers to Implementation of the National Science Education Standards Rubric, BINSES) which focused on technical, political and cultural barriers. High cultural barriers included teachers’ lack of buy-in and district administrations push to focus on coverage for the state assessments. Political barriers identified were lack of basic resources including physical space, equipment, consumables, and a lack of collaboration time. Technical barriers centered on teachers' lack of content and pedagogical knowledge also impacted their ability to implement effective science instruction. Though political barriers can impede the reform of instruction they are, for the most part, out of the control of teachers.

These barriers are not limited to certified educators. Goodnough (2010) implemented a problem-based learning experience 32 pre-service teachers the chance to explore differentiated instruction within their advanced science methodology course. Throughout their experience, the 32 pre-service teachers were asked to consider "potential issues and challenges associated with adopting approaches and strategies that support differentiated instruction" (Goodnough, 2010, p255). All 32 pre-service teachers identified the amount of time needed, the high degree of effort, and careful planning needed to DI as challenges to implementation. Additionally, 16 pre-service teachers identified implementing DI across all classes and units, and 11 identified the understanding of differentiation, curriculum, and student abilities as a challenge to implementation. If we are to see lasting reform of science instruction in the classroom, teacher beliefs and technical skills must be the focus (Johnson, 2006).

Despite the increased interest in effective science instruction and differentiation, educators lack of in-depth knowledge regarding the instructional practices associated with this approach signifies a major divide that must be bridged between research and implementation at the secondary level (Goodnough, 2010; Hawkins, 2009; Johnson, 2006; Oliveira et al., 2013; Rock et al., 2008; Subban, 2006). This gap between research and practice is not limited to effective science instruction. A report by the National Research Council concluded that there is a sharp divide between education research and teacher practice in schools (Shavelson & Towne, 2002 as cited in Buysse et al., 2003). Broekkamp and Hout-Wolters (2007) and Greenwood and Abbott (2001) identified some problems that may be at the root of this gap: the divide between research and practice communities and their lack of mutual professional development;

educational research yields few conclusive and practical results; practitioners believe that education research is not conclusive or practical for use in real classrooms; and practitioners make little use of education research. Although there is not a definitive answer as to why there is this gap, it is clear that there is disconnect between research and practice (Buysse et al., 2003).

CHAPTER 6

WORKING TOWARDS A COMMON GOAL: IMPLICATION FOR FUTURE RESEARCH

Efforts by legislation and professional organizations have stressed the importance of improved educational outcomes for all students and set a greater level of accountability to achieve this goal (Schroeder et al., 2007; Scruggs, Mastropieri, Berkeley, & Graetz, 2010; Rock et al., 2008). However, the penalties connected to this greater level of accountability has led many educators to narrow curriculum to prepare students for high-stakes testing with little to no benefit to the students (Guisbond & Neill, 2004; Levy, 2008; Rock et al., 2008).

As data from the NEA report *Failing our Children* (Niell, Guisbond, Schaeffer, 2004), PISA (Therrien et al., 2001), NAEP (2011), COEP (Usher, 2012), and NCEO (Altman, Thurlow, & Vang, 2010) show, our schools and diverse students are falling behind despite the stress on educational outcomes and accountability. Teacher-centered instruction focused on teaching-to-the-test is not providing heterogeneous student populations a learning environment conducive to student achievement. In fact, though limited, research has shown that when students are provided effective instruction within a collaborative student-centered environment addressing students' differences, student achievement is increased as compared to traditional teacher-centered instruction (Johnson et al., 2012; Mastropieri et al., 2005; Mastropieri et al., 2006; Oliveira et al., 2012; Richards & Omdal, 2007; Schroeder et al., 2007). With this in mind, if educators are to provide all students with effective education that allows them to reach ambitious standards and improve outcomes, the instructional practices within schools and classrooms must be addressed.

The aim of differentiation is to create a student-centered instructional practice in which the teacher is a facilitator of learning, and teacher and student have a shared responsibility for the development and success of students (Corley, 2005; Johnson et al., 2012; Oliveira et al. 2013; Tomlinson, 2004a). By attending to differences educators can provide students with effective instruction that provides them with a path towards essential ideas and skills, as compared to teacher-centered instruction which expects students to adjust to a teacher's one path. This change from teacher-centered to student-centered instruction, like any other substantial change to pedagogical practice can be complex and difficult (Hawkins, 2009; Johnson, 2006). Reform of instructional practices, much like a student learning to use a new tool or skill is a process and can be discouraging if one is overloaded (Rief & Heimburge, 2006; Tomlinson, 1999a). Therefore, teachers and schools, like their students, must be met where they are functioning and should have their progress toward implementation and evaluation of DI individually measured against essential goals and skills (Tomlinson, 2005b).

Educators implementing DI within their classrooms identify many barriers including lack of planning time, professional development, resources, administrative support and leadership, and a lack of detailed knowledge of effective science instruction (Goodnough, 2010; Johnson, 2006). At the core of these barriers is an inadequate understanding of how to provide diverse students or groups of students with effective strategies that ensures the progress of all students toward essential ideas and skills (Brighton, 2003; Johnson, 2006). To provide teachers with the understanding of and the tools necessary to differentiate instruction, we must look at sustained professional development that grants teachers the ability to practice and evaluate DI. Without providing the support needed to practice and see the benefit of changing instructional practices many teachers will continue as is (Johnson, 2006).

The limited research on the use of DI in science instruction at the secondary level makes it difficult to support differentiation as an instructional model or to generalize it to a larger population of students (Fisher, & Frey, 2001; Mastropieri, et al., 2006; Noble, 2004; Odgers, Symons & Mitchell, 2000; Tieso, 2005). Though research on DI is promising, additional research is required to move differentiated instruction from a promising theory to a supported instructional model at the secondary level. Research should consider multiple school environments (e.g., rural, suburban, urban, heterogeneous vs. homogenous classrooms, varying content), the use of research based strategies within the differentiation framework, the use of multiple research based strategies to meet the needs of diverse groups, the use of assessment to guide instruction and its impact on student learning, and the impact on educational outcomes for diverse learners including those with disabilities. Do to their common goals current research may be focusing on UDL rather than DI, therefore research questions must clearly distinguish the treatment being applied and investigated and could be the reason for the limited research on DI.

To conclude, the homogenous classroom where all students learn the same way is no longer viable within our current culture and climate. Schools are becoming more diverse educationally and culturally, and the status quo is clearly not providing students with the support needed to equip them with the essential ideas and skills as connected with educational standards. If secondary science teachers are to support all students in inclusive classrooms, as described by the NSES, a new approach is needed. Research has shown that differentiated instruction can have positive effects on students' progress by attending to their varying strengths, needs, and interests. However, additional research is needed to examine its implementation within secondary school, specifically content areas such as science. By utilizing differentiated instruction within our schools we have the opportunity to increase student achievement compared with the traditional teacher-centered approach; thus offering students, especially those in inclusive classroom, a greater chance at success.

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