

Effects of Differentiated Instructional Techniques on High School Biology Academic
Achievement

By

Susan L. Akina

Submitted in partial fulfillment of the requirements

for the degree of Master in Education (M. Ed.)

at Carthage College

Kenosha, Wisconsin

Spring 2018

Abstract

The purpose of this study was to investigate if consistent use of differentiated instruction techniques, including differentiated vocabulary and reading strategies, would improve student performance on a common summative assessment in Biology. This study was conducted with high school freshman in a southeastern Wisconsin urban high school. All students that were freshman and enrolled in 9th grade Biology participated in this study. Three years of data were used from 2014-15 (pre-treatment group/control) and 2015-16 & 2016-17 (post-treatment groups) to observe if test scores increased after the use of differentiated vocabulary and reading strategies. The researcher performed an analysis of variance (ANOVA) and two tailed t-test to determine if there was a difference among group means between pre-treatment (2014-15) and post-treatment groups (2015-16 and 2016-17). The results show that the use of the chosen techniques did have a significant impact on test scores overall and specifically in the area of vocabulary retention.

Acknowledgements

First, I would like to thank my husband and children. Without your love, support, and understanding I would have never completed this major milestone. Thank you for understanding when I was feeling overwhelmed and crabby, when I did not have a meal prepared, and the laundry was not folded and neatly put away. I love you all.

My family has been a huge inspiration and support system for me. Thank you for pushing me to continue my education and follow my dreams. My hope is that you will see the value in education and its path to success regardless of your age or road blocks you may encounter. Education can open doors and provide opportunities not found anywhere else, so through hard work embrace its wonder.

Furthermore, I would like to thank Dr. Lara Christoun for her support, guidance, motivation, and unwavering patience as I worked through the research process. Her professionalism and dedication to my successful completion of this thesis was absolutely valued by me. You have made this experience a joyful and fulfilling research experience. Furthermore, I would like to thank Dr. Aaron Trautwein and Dr. Andrea Henle for serving on my committee and providing me with insightful feedback, encouragement and guidance, and Dr. Jun Wang for helping me with the data analysis. Having access to professors like you sets Carthage College apart from its peers.

Table of Contents

Abstract.....		i
Acknowledgements.....		ii
Table of Contents.....		iii
Chapter		
1	Introduction	
	Overview.....	1
	Statement of Problem.....	2
	Purpose of the Study.....	3
	Research Questions.....	4
	Hypotheses.....	5
	Definition of Terms.....	7
	Chapter Summary.....	7
2	Review of Related Literature	
	Differentiation & Cultural Responsiveness.....	9
	Instruction.....	13
	Literacy Strategies.....	14
	• Rote Memorization.....	17
	Vocabulary Strategies.....	20
	• Mnemonics.....	20
	Reading Strategies.....	23
	• Annotating.....	23
	• Prefix/Suffix/Root Words.....	24

	• Graphic Organizers/Concept Maps.....	25
	Chapter Summary.....	27
3	Methodology	
	Purpose of the Study.....	29
	Research Questions.....	29
	Study Design.....	30
	Students.....	30
	Instruments.....	32
	Procedure.....	33
	• Pre-treatment Group.....	34
	• Post-treatment Group.....	34
	Data Analysis.....	36
	Confidentiality and Consent.....	37
	Chapter Summary.....	37
4	Results	
	Purpose of the Study.....	39
	Data Analysis.....	39
	Summary.....	42
5	Discussion, Strengths/Limitations, and Recommendations	
	Overview.....	43
	Discussion.....	44
	Strengths and Limitations.....	47
	Suggestions for Further Studies.....	48

References.....50

Appendices

A Common Summative Assessment

B Venn Diagram/T-chart

Chapter 1

Introduction

Overview

Student learning and achievement are the focus of discussion at the beginning of each school year. With the implementation of a new state assessment (American College Testing: ACT) to measure student's college readiness in the state of Wisconsin, the urgency to find an answer has increased. Not only are these test results used for accountability and to create school report cards, they are also used by students for college admission, scholarships, course placement and NCAA eligibility. There are many ideas about how to improve student achievement but the use of differentiated instruction is a widely used and respected pedagogy, if executed correctly, and is overwhelmingly becoming the benchmark in education across the United States. Today's high school classrooms are more culturally and academically diverse than any other time in the history of public education. Differentiated instruction is a method of designing and delivering instruction to best reach the needs of this culturally and academically diverse population. There is no one single roadmap or route for student learning as students vary in their learning styles, level of readiness and ability, come from differing socioeconomic status, diverse cultural backgrounds, whose first language is not English, and are either motivated or unmotivated.

Differentiation begins with the principle "that every student in the class is extremely important" (Wu, 2013, p. 127). In response to the fact that many

educators lack the ability to attend to the broad range of a learner's readiness, interest, and learning profile, a large number of school districts have provided financial support and professional training in the area of differentiated instruction and have developed systematic approaches to ensure student data are being used to guide instruction. Differentiation is a responsive and fluid teaching practice where methods are chosen in response to student needs. It is not a prescribed set of strategies, but "occurs as teachers become increasingly proficient in understanding their students as individuals, increasingly comfortable with the meaning and structures of the disciplines they teach, and increasingly expert at teaching flexibly in order to match instruction to student need with the goal of maximizing the potential of each learner in a given area" (Tomlinson, 2003, p.3).

Some educators do not believe that differentiated instruction can impact student learning and believe it is just another method of ability grouping students within the classroom, if not executed correctly that may be the case. "Many educators today lack the ability to attend to the broad range of a learner's readiness, interest, and learning profile. Unless we understand and address the systemic issues, it appears unlikely that any students with learning needs shaped by readiness, interest, or learning profile will be well served on a consistent basis in today's schools" (Tomlinson et al., 2003, p. 121).

Statement of Problem

When implemented effectively, differentiated instruction serves all students in a heterozygous classroom and takes into account their educational,

emotional, and cultural needs. A continued increase in the number of failures on a common assessment given in our district resulted in a change in teaching methodologies. Resources were allocated for professional development and training in our district to educate teachers on the methods of differentiated instruction and data analysis as a large percentage of students continued to underperform. Traditional direct instruction techniques were replaced with differentiated instruction methods. Differentiated vocabulary and reading strategies were employed and formative assessments were analyzed to modify and drive instruction.

Additional information is needed to determine if differentiated instruction methods have an impact on student retention of content information and skill acquisition, and how that translates to performance on a common summative assessment. Numerous studies have examined the impact of differentiation in classrooms in general, but this study will focus solely on a Biology classroom and explore the relationship between the chosen differentiated techniques and their direct impact on student performance and skill acquisition on a common summative assessment.

Purpose of the Study

The purpose of this study is to investigate if consistent use of differentiated instruction including differentiated vocabulary and reading strategies and data to inform and modify instruction would help to increase the following student abilities: understanding of science concepts when reading

scientific information, improving retention of scientific vocabulary, and analysis of scientific data. Performance will be compared to a control group that did not receive differentiated techniques in the classroom but whom were given the same common assessment. The study will be conducted with high school freshman students from a southeastern urban community located in Wisconsin. All freshman students enrolled in 9th grade Biology will participate in the study. Three years of data will be used from 2014-15 (pre-treatment/control group) and 2015-16, 2016-17, (post-treatment) to determine if an increase in understanding and skill acquisition will have an impact on test scores after the implementation of differentiated vocabulary and reading strategies and the use of data to inform and modify instruction. A proportional analysis of the data will be performed and results will be analyzed by Carthage Noyce Grant supervisors.

Research Questions

The questions that guided this study included:

1. Do specific differentiated instructional strategies focused on comprehension with regard to vocabulary retention, and reading with comprehension, impact student performance?
2. Is there a significant difference between pre-treatment test scores and post-treatment test scores for students overall?
3. Is there a significant difference between pre-treatment test scores and post-treatment test scores for students in the area of vocabulary retention?
4. Is there a significant difference between pre-treatment test scores and post-treatment test scores for students in the area of literacy?

5. Is there a significant difference between pre-treatment test scores and post-treatment test scores for students in the area of analysis of scientific data?

Hypotheses

This study investigated the following hypotheses sets:

Hypothesis One:

H₀: The combined use of differentiated instructional strategies focused on comprehension with regard to vocabulary, and reading with comprehension will result in scores that will not exceed what they were before on overall student performance in both the 2015-16 and 2016-17 school years compared to the 2014-15 school year on the same common assessment.

H₁: The combined use of differentiated instructional strategies focused on comprehension with regard to vocabulary, and reading with comprehension will result in higher scores on overall student performance in both the 2015-16 and 2016-17 school years compared to the 2014-15 school year on the same common assessment.

$$H_0: X_{\text{Overall15-16 and 16-17}} \leq X_{14-15} \quad H_1: X_{\text{Overall15-16 and 16-17}} > X_{14-15}$$

Hypothesis Two:

H₀: The combined use of differentiated instructional strategies focused on comprehension with regard to vocabulary, and reading with comprehension will result in scores that will not exceed what they were before with regard to vocabulary retention in the 2015-16 and 2016-17 school year compared to the 2014-15 school year on the same common assessment.

H₁: The combined use of differentiated instructional strategies focused on comprehension with regard to vocabulary, and reading with comprehension will result in higher scores on student performance with regard to vocabulary retention in the 2015-16 and 2016-17 school year compared to the 2014-15 school year on the same common assessment.

$$H_0: X_{\text{Vocabulary15-16 and 16-17}} \leq X_{14-15} \quad H_1: X_{\text{Vocabulary15-16 and 16-17}} > X_{14-15}$$

Hypothesis Three:

H₀: The combined use of differentiated instructional strategies focused on comprehension with regard to vocabulary, and reading with comprehension will result in scores that will not exceed what they were before with regard to literacy in the 2015-16 and 2016-17 school year compared to the 2014-15 school year on the same common assessment.

H₁: The combined use of differentiated instructional strategies focused on comprehension with regard to vocabulary, and reading with comprehension will result in higher scores on student performance with regard to literacy in the 2015-16 and 2016-17 school year compared to the 2014-15 school year on the same common assessment.

$$H_0: X_{\text{Literacy15-16 and 16-17}} \leq X_{14-15} \quad H_1: X_{\text{Literacy15-16 and 16-17}} > X_{14-15}$$

Hypothesis Four:

H₀: The combined use of differentiated instructional strategies focused on comprehension with regard to vocabulary, and reading with comprehension will result in scores that will not exceed what they were before with regard to analysis

of scientific information in the 2015-16 and 2016-17 school year compared to the 2014-15 school year on the same common assessment.

H₁: The combined use of differentiated instructional strategies focused on comprehension with regard to vocabulary, and reading with comprehension will result in higher scores on student performance with regard to analysis of scientific data in the 2015-16 and 2016-17 school year compared to the 2014-15 school year on the same common assessment.

$$H_0: X_{\text{Analysis15-16 and 16-17}} \leq X_{14-15} \quad H_1: X_{\text{Analysis15-16 and 16-17}} > X_{14-15}$$

Definition of Terms

- **ACT** is a standardized test used for college admission and the new state assessment to measure student's college readiness in the state of Wisconsin; defined as American College Testing.
- **Differentiation** is defined as the way a teacher anticipates and responds to a students' needs in the classroom.
- **Common Assessment** is a summative assessment created by a group of district teachers that aligns with the content standards and is given by all teachers in the building.

Summary of the Chapter

In this chapter, the researcher introduced the topic of differentiated instruction in a classroom setting. In the educational world, where division exists on the use of differentiation in the classroom, this study was designed to yield insight into the effectiveness of chosen strategies in the area of vocabulary and literacy in an urban high school Biology classroom. The study will also provide

insight as to how differentiation may impact a student's performance on a common assessment.

Chapter 2

Review of the Literature

Background

The purpose of this study is to investigate if consistent use of specific differentiated instructional techniques would help to increase the following student abilities: understanding of science concepts, improving retention and skill acquisition, and improved biology academic achievement on the same common assessment that did not use these differentiated techniques.

Differentiated instruction is a philosophy and framework for effective teaching. It provides all students with varying avenues to learn while the teacher tailor's instruction to meet individual needs often in the same classroom. The incorporation of differentiating content, process, learning environment, and the use of ongoing assessment makes this approach to instruction successful. Differentiated instruction requires a teacher to develop a genuine respect and relationship with their students. As Tomlinson, Brimijoin, & Narvaez (2008) state:

“Respecting individuals looks, sounds, or feels like the following:

- Listening
- Asking for input
- Making time for the person
- Using positive humor
- Accentuating the positive
- Accepting the person “as is,” while helping him or her grow

- Learning and demonstrating an appreciation for each person's culture and background
- Providing the best (respectful tasks-everyone's work is equally important and equally engaging)
- Expecting the best-always, teaching up-pushing the student beyond where he or she believes achievement is possible
- Holding the person to a high standard
- Ensuring a positive environment for growth" (p. 4).

By changing the approach to include each individual in the classroom, instruction needs to remain flexible and frequent analysis of learning needs to occur. The teacher needs to adjust instruction at any given moment to ensure the atmosphere of the classroom engages students far beyond the traditional sit and get approach. In the attempt to reach every student in the classroom, and by the complex nature of this task, student's needs can be met through the vast and different approaches taken by the educator.

Strahan, Kronenberg, Burgner, Doherty, & Hedt, (2012) found that successful differentiating educators "embrace individual differences, learn more about individual students as learners, and structure activities in ways that help students create connections with new information" (p. 5). Their research also indicated that within this framework it is important to "encourage student engagement with ideas and foster their interest in the material being presented. Differentiation is more of an approach to teaching rather than a set of strategies, especially in regard to promoting engagement with ideas" (p. 6).

Responsive teaching is a direct result of this student centered approach by the educator and is not limited to a strict set of best practice methods, but rather helps students to build academic and social-emotional competence.

Thomlinson, Gould, Schroth, & Jarvis (2006) indicate “factors that influence achievement include the school setting and vision for students’ academic progress; teachers’ understanding of the needs of the student population; the curriculum, instruction, and assessments used; and the role of the teacher.” (p. 11)

Alternatively, differentiation can cause educators to become frustrated as they try to navigate their way through the implementation process. Carolan and Guinn (2007) state that “studies have demonstrated that notions of differentiation vary considerably, and implementation is often complex” making it important to define how to implement differentiation in the classroom and what characteristics need to be present to improve student outcomes. Teachers need to be flexible in their approach to student’s ever changing needs and have an overabundance of tools to respond effectively. Research has shown that this is especially true for students of color, English Language Learners (ELLs), and low economic status, as there are many outside factors affecting their learning.

According to Tomlinson and Jarvis (2014) “underachievement can be attributed to the failure of teachers and schools from the dominant culture to offer culturally responsive curriculum and instruction that acknowledges and values diverse perspectives and serves as a bridge between individual students and academic content” (p. 194). A study conducted by Mette, Nieuwenhuizen, and Hvidston (2016) concludes that “culturally responsive pedagogy (CRP)

professional development effort highlights that teachers and principals have an ethical and moral obligation to challenge the status quo of school systems to lead to better outcomes for historically disenfranchised groups” (p. 16) Teachers and administrators need to reflect on their own biases and cultural restraints to ensure that they do not create a barrier or hinder a student’s academic success. Armed with an awareness, teachers can implement changes to make their classrooms more culturally responsive.

Today’s classrooms are more culturally diverse than they have ever been in the history of public education. As noted by Martins-Shannon and White (2012), “For diverse students, an inclusive and culturally responsive classroom represents a direction toward success. In this environment, all students have opportunities to express themselves freely during class discussions” (p. 6). Rajagopal (2011) states, “teachers must use the cultural capital available in their classrooms to capture attentions, engage students, and make the academic curriculum relevant. The goal is for students to have increased access to the standards-based content they will need to take and pass district and national tests” (p. 26). Once standards are identified and goals have been established, educators can brainstorm various activities that allow for numerous options to be used in the classroom. By carefully choosing these strategies with the students and various demographics in mind, the teacher can find the activities that will allow for student learning and the best outcomes.

Instruction

When creating curriculum, it is important to have a framework that helps to encourage responsive teaching. Hedrick (2012) offers four questions to help educators develop curriculum and assessments that will drive student led instruction. The first question is “Are we clear about what matters in the curricula?” (p. 27); this question encourages educators to focus on essential questions and/or curriculum standards to drive their teaching practices.

Differentiated instruction goes hand in hand with backwards design by helping students find overarching goals and having the educator find creative and varied activities to help them meet that goal. Backward design is a paradigm shift that requires teachers to go beyond the traditional method of teaching via a textbook. Developing opportunities that allow a student to connect to previous experiences provides a framework to learn and understand new ideas.

The systematic approach of building or scaffolding information and skills can move students beyond rote memorization of concepts and lead to a deeper understanding of content and skill acquisition. Creating a final assessment prior to implementation of the curriculum allows for the identification of overarching curriculum goals, standards, and learning activities. The goals can be easily matched to various activities to meet student needs. Childre, Sands, & Tanner (2009) show that “Designing curriculum that both accommodates learning needs and targets deeper levels of understanding is possible. Through the use of the backward design approach, learning can become relevant and meaningful for all students, supporting their mastery of general curricular standards. When

standards, assessment, and inquiry-oriented activities drive the curriculum, learning can be transformed” (p. 9).

The idea of backwards design leads to the next question, posed by Hedrick (2012). “Do teachers have a variety of instructional models and strategies to use in developing, refining, and differentiating the curriculum?” (p. 29). Once goals have been established, educators can collaboratively brainstorm various activities that allow for numerous options to be used in the classroom. By carefully, choosing these strategies with the students and various demographics in mind the teacher can find the activities that will allow for student learning and the best outcomes. Once the goal is established the next question will guide teachers to look at the complexity of these goals. “Is the curriculum rich- conceptually based, meaningful to the learner and built upon complex ideas?” (p. 28). The standards and goals need to be analyzed to ensure they foster deep and complex thinking and content standards are met while allowing for interest and inquiry by the student. Lastly, “is there a clear distinction between assessment and evaluation?” (p. 29). In order to be responsive you need to continually use formative assessment of student learning through various means. The use of formative assessments will help drive decision making on activities and strategies for the classroom, therefore impacting student retention and acquisition of skills.

Literacy Strategies

Reading is a crucial component for all students’ academic success. It is widely known that reading comprehension has been linked to academic success, but unfortunately many students are not expert readers. National test scores

indicate a reading proficiency issue in the United States, where only about one third of all students are proficient in reading by the eighth and twelfth grade. (Hall et al., 2013) This is further compounded by the fact that there has been an exponential growth in the number of ELLs in the United States. Successfully educating students therefore becomes much more complex and the role of academic language demands grows from year to year. As defined by Bowers and Keisler (2012) academic language is “Any and all language structures and vocabulary that students must be able to use in order to successfully engage in school-based literacies” (p. 4). Focusing on academic language when designing lessons is imperative to ensure that the proper scaffolds are put in place to support ELLs and increase the success of content understanding.

Multiple studies suggest that a teacher’s content knowledge directly correlates to the academic success of their students. The National Center for Educational Statistics reports that approximately 41% of content teachers are responsible for teaching English language learners, while only thirteen percent have had eight or more hours of professional development to learn how to teach English language learners. (Bowers and Keisler, 2012, p. 5) As the diversity of the classroom increases, traditional supports of pullout time or resource time are no longer effective in meeting the needs of English language learners.

A student’s background knowledge, also known as schema, is important and has a major impact on whether or not they will be able to comprehend text. “Reading instruction at the primary level focuses on decoding and reading fluency” (Tovani, 2000, p. 20), at the middle school level teachers expect students

to have mastered the skill of reading for meaning, and by the time students reach high school they are masters at faking reading. “The two types of struggling readers most often encountered in secondary schools are resistive readers and word callers. Resistive readers can read but choose not to participate for an array of reasons. Word callers can decode the words but don’t understand or remember what they’ve read” (Tovani, 2000, p. 14). Text does not carry meaning itself but rather provides hints to allow readers and listeners to create meaning from prior knowledge. By providing students with the necessary background knowledge to help build schema, they will be able to reach every reader’s goal which is to become independent readers.

As teachers we need to recognize that all students bring a degree of literacy knowledge related to their own experiences to the classroom. Therefore, it is imperative that we grab our students’ attention with their own language, experiences, and stories before presenting academic language. As stated by Rajagopal (2011) “student centered vocabulary and language are keys to hooking students’ attention and ensuring that they will be receptive enough to learning the curriculum and textbook vocabulary” (p. 28). Educators must consider prior literacy experiences that might affect the reader’s outcomes. As most students are not considered to be effective readers, most bring to the educational classroom negative attitudes and perceptions of reading. These perceptions and attitudes hinder their literacy abilities so we must find what appeals to most of our students. Typically, students who read at home and outside of school develop positive attitudes towards reading activities, but if the student’s experience is

negative this influence will deeply affect their attitude and limit their outcomes. These negative behaviors have to be combated by teachers to increase literacy inside the classroom. Educators, and school staff in general, need to act as role models and help excite curiosity in the students' minds that can only be quenched by research, therefore leading to an increased use of literary skills. (Kagan-Keskin, 2013)

Rote Memorization

Historically, rote memorization has been used as the main vocabulary teaching strategy in a secondary science classroom. Students are given a list of new vocabulary words at the beginning of a unit with a corresponding definition to practice until it is memorized. This practice of rote memorization often leaves students feeling overwhelmed and discouraged. It is said that students will encounter more new vocabulary during a year-long study of Biology, than they would learning a new foreign language. During a typical semester of Freshman Biology, new vocabulary words are incorporated into every aspect of instruction. New words are used during lecture, while taking notes, participating in laboratory activities, completing homework, and during typical informal knowledge checks by the educator. "Vocabulary knowledge is critical to the long-term literacy development of all students, and high-quality vocabulary instruction should be a priority for teachers across all grades" (Graves et al., 2014, p. 342).

Without an understanding of the associated vocabulary, students have trouble reading and interpreting the associated texts. This lack of understanding

vocabulary compounds on the fact that students are required to read at levels beyond their capabilities. Sadly, research indicates that “in some schools, it is common to have significant numbers of classes in which 75-80% of the students cannot successfully read textbooks” (Carrine and Carrine, 2004, p. 206). Most science textbooks that are currently in use in many classrooms are too difficult for the average student to use and comprehend. Unfortunately, these books provide students with necessary content specific information. Lecture can supplement this lack of understanding, but, again, without the working vocabulary it is nearly impossible for the student to comprehend. The situation worsens when the teacher overlooks science vocabulary as a necessity to establish prior knowledge. It is essential for the student to have a clear understanding of the scientific vocabulary to successfully read the text and obtain a working knowledge of the content.

Understanding science vocabulary affects student success beyond the science classroom. It can significantly affect scores when participating in standardized tests that are administered during the fourth, eighth, and tenth grades. Without a working knowledge and understanding of science vocabulary, students cannot decipher the questions being asked on the test. Vocabulary is an essential part of standardized testing, allowing for the creation of the test and an easier scoring process, and will be a requirement that is not likely to change anytime soon (Nilsen and Nilsen, 2003). A true understanding of scientific vocabulary is a clear indication of student comprehension of the academic material. With the No Child Left Behind Act which provides money for extra

educational assistance for poor children in return for improvements in their academic progress, and the Common Core initiative that details what K–12 students throughout the United States should know in English language arts, student successes on these standardized tests are now directly linked to the success of the school further highlighting the importance of scientific vocabulary and literacy.

Scientific literacy has become an important issue in our society as the US employment needs are shifting from industrial to technological. Scientifically literate citizens are needed in our technologically advanced society. A scientifically literate citizen can determine if science is truly being conducted and whether the results are accurate and useful. They can then apply their research to everyday problems and solve future issues that may face our country. Seeing this societal shift, the National Science Education Standards (NSES) have been changed to reflect the need for a scientifically literate high school graduate. Science students should be able to use science related information and thought processes to make informed decisions about their lives, their communities, and to manage current and future natural resources. These standards create the framework that all science teachers use to guide their precollege instruction. The NSES outlined a clear goal that scientific literacy should be the primary and exclusive goal of precollege scientific education (National Research Council, 1996). The National Science Teachers Association has used these standards to encourage new science teaching talent to use them as guiding goals when developing new instruction (National Research Council, 1996). An

understanding of vocabulary is the key to ensuring scientific literacy is achieved by our high school graduates.

Science is constantly shifting and evolving with time. Just as science changes, so does the associated vocabulary. As science develops, meanings of words change depending on the context in which they are used. As we continue to develop new scientific techniques, new meanings and vocabulary are developed along with these processes. When students only use rote memorization, they are not making meaningful connections with the words, therefore not truly gaining meaning. This lack of meaning does not allow students to begin to understand the scientific processes associated with the words and the information becomes random, lacking any usable information.

In order to ensure our students are achieving success, teachers must give them the tools necessary to decode and develop a working knowledge of scientific vocabulary. Teachers can develop this vocabulary by activating prior knowledge and connecting the new information to the students' past experiences. "We have to learn large quantities of words, and we have to learn to connect them to the objects, events, actions, and qualities that they represent. In other words, we have to learn a meaningful language" (Joyce, Weil, & Calhoun, 2004, p.137). By linking new vocabulary to an associated idea the student builds meaning and can begin to understand scientific processes and new ideas.

Vocabulary Strategies

Mnemonic

Recall of facts is a fundamental skill required for success in content subject areas. It is very important to not limit students to using only rote memorization techniques or to assume students understand the vocabulary being presented. Prior knowledge must be established for each student. It becomes even more pressing for the teacher to use additional strategies when working with diverse populations of students to ensure meaningful connections are being made by the student. Students with learning disabilities may often process information differently than their peers, therefore mnemonic strategies can create cognitive links necessary for student success while leading to mastery of the content. A meta-analysis of twenty different studies performed by Wolgemuth, Brian Cobb, and Alwell (2008) shows that,

“compared to direct instruction, free study, and other control conditions, students in mnemonic conditions had better immediate recall across several academic areas including English, social studies, mathematics, and science. The keyword, keyword–pegword, and reconstructive elaboration mnemonic strategies were all effective and worked for students with learning disabilities and other disabilities. These findings are also consistent with the conceptual literature that argues that mnemonic instruction is effective across disabilities” (p. 9)

A mnemonic is an instructional strategy that is designed to help students improve their memory of important information. It helps with a student’s ability to store and retrieve content information. This technique connects new learning to prior knowledge through the use of key words, peg words, rhyming words, or

acronyms. Mnemonics has also been shown to develop a sense of intellectual power, essentially building self-esteem, self-reliance, and independence (Joyce, Weil, & Calhoun, 2004) in students with special needs. Mnemonics within all populations has led to improved student success over more traditional approaches.

Research shows that various mnemonic strategies such as linguistic mnemonics (key word and peg word), or visual mnemonics which make use of pictures or visualization can effectively link prior knowledge with new information. Essentially, these strategies allow students to connect two ideas together, which results in a myriad of connections for the student. The picture that the student develops cognitively will help to represent the word, idea, or phrase needing to be learned and increase retention. For example, a student may substitute a familiar word that sounds like a new vocabulary word being introduced; this may spark a mental picture that is easily remembered by the student. Rather than just creating a visual, mnemonics can also be created by using the first letter in a list of ordered terms or sequence of information.

A mnemonic acronym used in science is CRIME NERDS, which helps students remember the names of the 10 major body systems: (circulatory, respiratory, integumentary, muscular, endocrine, nervous, excretory, reproductive, digestive, and skeletal). Another mnemonic is “Dear King Phillip Came Over For Great Spaghetti” which is used to help students remember the biological classification system: (domain, kingdom, phylum, class, order, family genus, species). These various strategies can improve the students working vocabulary and content knowledge. There is a preponderance of evidence that demonstrates

“mnemonic instruction is effective in increasing recall and retention of science facts with students with learning problems. Science teachers may use these techniques to help students retain difficult-to-remember concepts. Across studies, students reported enjoying the use of mnemonic strategies and, in many cases, stated that they would use the technique again. Generating students’ interest in mnemonics may help students use mnemonic strategies and thus retain scientific facts” (Lubin and Polloway, 2016, p. 218).

Mnemonics may not be the memorization strategy to solve critical thinking problems, but it does get students involved and engaged in the content increasing their motivation to learn. A review of literature by Bakken and Simpson (2011) indicates that “Mnemonic strategies have been proven to help individuals remember information by making it easier to remember and more concrete. These strategies work with all kinds of students and it can be applied to any type of content” (p. 85). Teaching vocabulary is critical to a student’s ability to understand the content being taught. Struggling readers tend to avoid reading, resulting in limited word encounters and inadequate vocabulary growth.

Reading Strategies

Annotating

Annotation can be a successful practice when reading informational rich text, scientific articles, or analyzing data in a science classroom. Annotation is an approach that allows students to mark text to identify various components such as; main ideas, evidence, connections, questions, or new vocabulary. Students will begin to identify what information should receive focus and what information is

not of importance. Annotation lends well to scientific content as Herman and Wardrip (2012) state, you can annotate “difficult or new science vocabulary words and in text definitions; difficult non-science vocabulary words; main ideas or arguments and related supporting ideas or evidence; heading, transitional words, other sign posts; inferences; and conclusions.” (p. 49)

The process of annotation gives students a task to accomplish while they are able to reflect, understand, and gather questions on the reading. Post annotation discussions can further a student’s understanding of the topic by helping to eliminate any confusion due to vocabulary.

Prefix/Suffix/Root Words

Students with limited vocabularies are very likely to struggle to understand grade-level text. Decoding difficult words encountered in academic text is a strategy that can be used to increase reading comprehension and word acquisition. Morphemic analysis instruction of vocabulary terms can help a student to figure out the meaning of a word and help them to predict the meaning of new words that contain the same root word, prefix, or suffix. A study performed by Harris, Schumaker, & Deshler (2011) tested the effects of morphemic instruction on high school students with and without learning disabilities. The analysis of testing data revealed a significant difference for students with and without learning disabilities between the pretest and posttest scores when morphemic instruction was employed. “This is important, because students must learn large numbers of words each year to keep pace in academic core classes. In addition, if students are able to earn a score of 50% on a word

analysis test, their scores on college entrance tests and state tests may be enhanced, and their overall reading comprehension may be improved” (Harris et al., 2011, p. 31).

Although there is no clear cut solution to increase vocabulary acquisition for high school students, Ebbers and Denton (2008) identified instructional approaches that have proven effective. One instructional approach included teaching independent word learning strategies that use a combination of contextual and morphemic analyses. Morphemic analysis refers to the process of parsing word parts to infer meanings of unknown words. A review of vocabulary studies conducted across differing reading levels showed that increased amounts of time spent on vocabulary lessons correlated to an increase in reading comprehension amongst students with reading difficulties (Ebbers and Denton, 2008). Not all words are of equal importance therefore teachers must determine which words are most valuable. “Where possible, in addition to teaching words necessary for understanding the text, teachers are advised to select academic words that appear across the curriculum and that belong to morphological families. Morphological families include words that share the same root or base, such as logic, logical, logically, illogically, and so on” (Ebbers and Denton, 2008, p. 92). The ability to predict word meaning through their morphemes could have the potential to increase reading skills and new word acquisition.

Graphic Organizers/Concept Maps

Graphic organizers are visual ways to link meaning to text and organize ideas in an easy to interpret way. Graphic organizers include such practices as

cognitive maps, story maps, advanced organizers, visual and spatial displays, and Venn diagrams. Dexter et al. (2013) defines graphic organizers as “visual displays that make relationships appear more between related facts and concepts.” These visuals can make abstract concepts more understood and can connect new information with prior knowledge. Hall et al. (2013) further sheds insight into how the graphic organizer can allow students to connect text to content through “effective compare and contrast, linking of causes and effects, and differentiation between main ideas and details” (p. 48). Graphic organizers are very effective tools in making text have significant meaning. Dexter et al. (2011) states,

“The researchers attribute the effects, in part, to how graphic organizers spatially group and connect concepts so readers are more likely to perceive them as being interrelated and to draw perceptual inferences about relationships. The way concepts are grouped and connected on the graphic organizers helps minimize the stress on working memory and allows better access to prior knowledge.” (p. 204)

Research also indicates that graphic organizers can deeply impact the factual comprehension and vocabulary knowledge for students with learning disabilities. A meta-analysis performed by Dexter et al. (2011) indicates that “graphic organizers improve the factual comprehension and vocabulary knowledge of intermediate and secondary students with learning disabilities in science. Furthermore, the findings from this analysis also indicate that graphic

organizers help to facilitate maintenance of learned science material for students with learning disabilities” (p. 211). Increasing comprehension and vocabulary knowledge can significantly impact the understanding of a student with learning disabilities in a science classroom. Dexter’s research further indicates that graphic organizers give students a way to manage learned information, as well as written text. (Dexter, et al., 2011)

Concept maps are a visual image of text and therefore information tends to be more easily remembered by students. As stated by Safdar et al. (2012) “concept maps can be used for; (1) knowledge construction: how students construct their knowledge (2) learning (3) evaluation (to evaluate how students organize their knowledge) (4) assessment: used as a pre-post assessment of what students have learned (5) record of understanding (6) problem solving (7) application (8) integration (9) and Instruction” (p. 58). Concept maps can assist students in organizing prior knowledge, reflecting on key concepts and vocabulary, and organization of what they learned from reading the text. As a result of using the organizers, students can display connections between ideas and concepts, thus improving text comprehension.

Chapter Summary

This chapter reviewed qualitative and quantitative studies about differentiated instruction related to literacy, vocabulary, and reading comprehension. Although these topics are well researched in the educational community, no known research familiar to the author of this study has been found demonstrating their cumulative effectiveness in a high school Biology classroom.

All the techniques researched have limitations and faults, but the research indicates that their positive impact outweighs any negative implications.

Chapter 3

Methodology

Purpose of Study

The purpose of this study was to investigate if the consistent use of specific differentiated instructional techniques, focused on vocabulary and reading comprehension would help to increase the following student academic abilities: understanding of science concepts, improving retention and skill acquisition, and improved biology academic achievement on the same common assessment that did not use these differentiated techniques. The study was conducted in an urban public high school in Southeastern Wisconsin.

Research Questions

1. Do specific differentiated instructional strategies focused on comprehension with regard to vocabulary retention, and reading with comprehension, impact student performance?
2. Is there a significant difference between pre-treatment test scores and post-treatment test scores for students overall?
3. Is there a significant difference between pre-treatment test scores and post-treatment test scores for students in the area of vocabulary retention?
4. Is there a significant difference between pre-treatment test scores and post-treatment test scores for students in the area of literacy?
5. Is there a significant difference between pre-treatment test scores and post-treatment test scores for students in the area of analysis of scientific data?

Study Design

This study employed an historical review and data analysis of in-class common summative assessment testing data to observe the impact of specific instructional techniques focused on comprehension with regard to vocabulary, and reading with comprehension to simplify science concepts used in the 2015-16, 2016-17 post-treatment groups versus the 2014-15 pre-treatment group. The researcher analyzed data of Biology common assessments to observe this impact of retention and skill acquisition on the final common assessment.

Students

The study was conducted with high school freshman students from a southeastern urban community located in Wisconsin. All freshman students enrolled in 9th grade Biology participated in this study. Three years of data were used from 2014-15 (pre-treatment) and 2015-16, 2016-17 (post-treatment).

During the time of the study 2014-2017, the school had an average population of 1,581 students. The high school was very diverse and incorporated all socioeconomic and cultural groups as indicated in Table 1. The demographic data obtained for this study came from the Wisconsin Information System for Education Data Dashboard (WISEdash), which is on the Wisconsin Department of Public Instruction (DPI) website.

Table 1: Summary of demographic data from WISEdash database.

	2014-15	2015-16	2016-17
Total Population	1553	1645	1546
Students with Disability	14.6%	14.4%	15.3%
Students without Disability	85.4%	85.6%	84.7%
Not Economically Disadvantaged	46.6%	46%	46.1%
Economically Disadvantaged	53.4%	54%	53.9%
English Proficiency	92%	92.8%	93%
English Language Learner/Limited English Proficiency	8%	7.2%	7%
Ethnicity			
Amer/Indian	.4%	.4%	.2%
Asian	1%	.5%	.6%
Black	19.8%	21.4%	20.6%
Hispanic	24.7%	27.1%	29.6%
White	52.3%	48.6%	46.6%
Two or More	1.8%	2.1%	2.3%
Pacific Isle	----	----	.1%

Historical reviews show a total of 1046 freshman Biology students were used in this study; 328 students in 2014-15, 370 students in 2015-16, and 348 students in 2016-17. Three groups of students were compared in this study, a pre-treatment group (2014-15) and two post-treatment groups (2015-16, 2016-17). The Biology classes consisted of students from the general population of entering freshman who were randomly assigned to each class. Class average size was 30 students. All groups mentioned above are represented in the sample

including special education and ELL students. The entire group was subjected to the same content standards, instructional techniques, assignments, and assessments.

Instruments

Students were given a common final assessment covering the required content per the Next Generation Science Standards and district pacing guide at the end of the first semester. See Appendix A for a copy of the common assessment given in 2014-15, 2015-16, and 2016-17. The common assessment was created by a group of six biology teachers, two from each of the three comprehensive high schools in the district, and consisted of 59 multiple choice questions. Next Generation Science Standards (NGSS) were used as a guide to develop unit learning target sheets and identify required vocabulary including prefixes, suffixes, and root words.

Each question was linked to one of the NGS Standards aligned with the student learning targets and required vocabulary. The questions were later evaluated to determine if they were an assessment of literacy, vocabulary, or analysis of scientific data. Three of the six team members that wrote the summative final exam independently categorized the test questions into one of three categories (literacy, vocabulary, or analysis) with 100% agreement as seen in Table 2.

Table 2: Categorization of test questions on the common summative exam.

Literacy Questions	Analysis of Scientific Data Questions	Vocabulary Questions
1, 2, 3, 4, 5, 6, *7, *8, *9	*7, * 8, *9, 33, 34, 35, 54, 55, 56, ^57	10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, ^57, 58, 59

* Question was identified as involving both literacy and vocabulary.

^ Question was identified as involving both vocabulary and analysis of scientific data.

All students were given the common assessment at the end of the first semester. The common assessment was machine graded and one point was given for each correct answer. The machine graded printout was used in this study rather than individual scores. The item analysis included the following information: total number of students taking the exam, unidentifiable scores, and each question identified the number of students who had the incorrect answer.

Procedure

The following steps and procedures were followed in this study:

1. Carthage IRB approval
2. Obtained approval from the school district to use semester 1 common assessment data from 2014-15 through 2016-17
3. The researcher did a proportional analysis to statistically analyze the data. A comparison of pre-treatment and post-treatment data was performed to look for patterns of improved retention and skill acquisition on the common assessment. The confidence level was set at $p = .05$.
4. Two groups of students were compared in this study, a pre-treatment group and post-treatment group. The students were divided into two

groups; the pre-treatment group in 2014-15 and the post-treatment groups from 2015-16 and 2016-17. All students were exposed to the same information from lecture, labs, homework, and assessments, but the post treatment groups received the additional treatment.

Pre-treatment Group:

During 2014-15, the pre-treatment group did not receive any additional differentiation. These students were given very traditional direct instruction. Individual student needs and likes were not taken into account by the educator and no modifications to instruction were made. Direct instruction and lecture were the primary source of instruction. Students were lectured and given assignments and homework that matched the content. Students' assignments and homework were graded and returned to the students without further review or discussion. Reading was assigned, but no additional reading strategies were taught. Vocabulary strategies were not modeled or used as part of teacher direct instruction. These students were given a list of vocabulary words and were required to create vocabulary cards, which included word and definition, to use as a study aid and no additional mnemonic or morphemic strategies were introduced. Students were not consistently assessed on acquisition or understanding of the vocabulary words. Students used rote memorization to learn the required vocabulary.

Post-treatment Group:

The post-treatment groups received treatment of an intensive differentiated program consisting of differentiated vocabulary and reading strategies to simplify

science concepts. The educator adapted to the needs of individual students and made in class modifications to further instruction and student interest. The educator still provided direct instruction, but would add any of the mentioned differentiated strategies when a topic provided an opportunity to further the students' understanding. As stated, differentiation is a free flowing model, so these were completed on an as needed basis. The following were not a set prescription, but rather a tool box that the educator was able to use to improve instruction and retention. Not all students were subjected to identical instructional models, but were provided with the best model for the dynamic of the class. All classes did include at least one component of vocabulary and reading strategies to simplify science concepts as stated in the procedure.

Students in the post treatment group were given a list of vocabulary words and were required to create vocabulary cards prior to starting a new unit. The vocabulary cards included a word and definition, but the student was also required to include a visual representation of the vocabulary word. After modeling and initial prompting throughout the semester, most students were successful at creating a pictorial mnemonic from their own idea or one prompted from the class. The students would underline key words while making associations to prior knowledge. These key underlined words and pictures were used to help the students in their memorization of very difficult scientific vocabulary by using associations. Students were quizzed twice per unit on the given vocabulary words. Students were also encouraged to use educator lead and subject invented mnemonics for long term retention. To further an interest in creating analogies

and mnemonics, the educator created an analogy jar that students were rewarded for creating a mnemonic tool for the class.

Reading strategies were also used by the educator in the post-treatment group. The researcher used graphic organizers and concept maps such as Venn diagrams and T-charts to help simplify complex information. See appendix B for an example of a Venn diagram and graphic organizer. The educator also conducted two minute reads every Monday at the start of class. Students were required to annotate key ideas, evidence, or difficult vocabulary. After the two minutes passed, the educator would help define any words not understood by the subjects by breaking down the word into their respective prefix, suffix, and root words. Discussion of the topic was encouraged amongst the students by the educator. Post the discussion, students were timed and given one minute to summarize the main idea of the article they had read. This helped to foster reading and writing in the content while increasing scientific vocabulary.

Data Analysis

The data analysis in this study was quantitative, the students' test scores were analyzed using a proportional analysis to compare whether the differentiated treatment had any influence on the test results of both pre (2014-15) and post-treatment (2015-16 and 2016-17) groups overall. The post-treatment students were also separated into 2015-16 and 2016-17 groups and their test scores were subjected to statistical analysis using a two tailed "t-test" to further look for any differences between those groups' test scores verses the 2014-15 pre-treatment group.

The students' test scores were further analyzed using a proportional analysis to compare if the treatment had any influence on the test results as it relates to vocabulary retention, literacy, and analysis of data of both pre (2014-15) and post-treatment (2015-16 and 2016-17) groups. The post-treatment students were also separated into 2015-16 and 2016-17 groups and their test scores were subjected to statistical analysis using a two tailed "t-test" to determine whether there were any differences between those groups' test scores verses the 2014-15 pre-treatment group.

Confidentiality and Consent

As this was an historical review of data, all of the records reviewed did not have identifiable students as the records are class data and not individual records. All personal information, such as name, was not available to the reviewer on the item analysis form; therefore, a completely anonymous review of the class data was conducted. Due to this anonymity, no consent was needed from the participants and confidentiality was maintained. The samples were not numbered in any way to reveal the identity of the students. No identifiable responses were generated in the testing process or used for the means of this data review. This research was approved by the Institutional Review Board at Carthage College.

Summary

A common assessment developed by biology teachers in a Southeastern Wisconsin school district was used by the educator to assess the effectiveness of including differentiated instructional techniques in the classroom. The

techniques focused on comprehension with regard to vocabulary, literacy, and analysis of scientific data. Students were taught using differentiated techniques between 2015-16 and 2016-17 while students in 2014-15 received no treatment. The data was put under a historical review analysis and no student identifiable information was used in the study. The researcher analyzed records via proportional analysis to create analyzable results.

Chapter 4

Results

Purpose of the Study

The purpose of this study was to investigate if consistent use of differentiated instruction including differentiated vocabulary and reading strategies and data to inform and modify instruction would help to increase the following student abilities: improving retention of scientific vocabulary, understanding of science concepts when reading scientific information, and analysis of scientific data.

Data Analysis

The data analysis in this study was quantitative. The subjects' test scores were analyzed using proportional analysis to compare if the treatment had any influence on the test results of both pre (2014-15) and post-treatment (2015-16 and 2016-17) groups as a whole. The researcher performed an analysis of variance (ANOVA) and two tailed t-test to determine if there was a difference among group means between pre-treatment (2014-15) and post-treatment group (2015-16 and 2016-17) test results for biology students on a common summative assessment who attended an urban public high school in southeastern Wisconsin. The results were further analyzed to compare pre and post-treatment years and determine if the treatment had any influence on test results as it related to vocabulary retention, literacy, and analysis of scientific data.

Table 3: Summary of ANOVA analysis comparing pre-treatment and post-treatment groups.

Year	f-value	p-value
2014-15 vs 2015-16 vs 2016-17 (Overall Comparison)	4.62	0.0111
2014-15 vs 2015-16 vs 2016-17 (Vocabulary)	5.03	0.0079
2014-15 vs 2015-16 vs 2016-17 (Literacy)	1.07	0.3582
2014-15 vs 2015-16 vs 2016-17 (Analysis of Scientific Data)	0.49	0.6210

The average percentage of problems answered incorrectly on the common summative assessment overall, and for questions related to vocabulary retention, significantly decreased after students received the differentiated instruction (overall comparison: $f = 4.62$, $p = 0.0111$) (vocabulary: $f = 5.03$, $p = 0.0079$), therefore null hypothesis one and two are rejected. The average percentage of problems answered incorrectly on the common summative assessment did not decrease and the scores were at most what they were before the differentiated instruction for literacy and analysis of scientific data questions after students received the differentiated instruction (literacy: $f = 1.07$, $p = 0.3582$) (analysis of scientific data: $f = 0.49$, $p = 0.6210$), therefore null hypothesis three and four are accepted.

Table 4: Summary of proportional analysis for pre-treatment and post-treatment groups by year.

Year	t-value (two tailed)	p-value
2014-15 vs 2015-16 (Overall Comparison)	1.99	0.0489
2014-15 vs 2016-17 (Overall Comparison)	0.86	0.051
2014-15 vs 2015-16 (Vocabulary)	2.72	0.008
2014-15 vs 2016-17 (Vocabulary)	2.44	0.0167
2014-15 vs 2015-16 (Literacy)	0.15	0.8822
2014-15 vs 2016-17 (Literacy)	1.23	0.2364
2014-15 vs 2015-16 (Analysis of Scientific Data)	-0.09	0.9301
2014-15 vs 2016-17 (Analysis of Scientific Data)	0.77	0.4591

The average percentage of problems answered incorrectly on the common summative assessment overall when comparing the pre-treatment (2014-15) and post treatment group from 2015-16 decreased after students received the differentiated instruction (overall comparison: $t = 1.99$, $p = 0.0489$) but the scores remained the same as before for the post-treatment group from 2016-17 (overall comparison: $t = 0.86$, $p = 0.051$).

The average percentage of problems answered incorrectly on the common summative assessment with regards to vocabulary when comparing the pre-treatment (2014-15) and post treatment group from 2015-16 and 2016-17 decreased significantly after students received the differentiated instruction.

The average percentage of problems answered incorrectly on the common summative assessment did not decrease when comparing the pre and post-

treatment groups and the scores were at most what they were before the differentiated instruction for literacy and analysis of scientific data after students received the differentiated instruction.

Chapter Summary

The results of this study showed that consistent use of differentiated instructional strategies focused on comprehension with regard to vocabulary and reading comprehension was effective in increasing student performance on the common summative assessment. The results show that a statistically significant increase in student performance was found when pre-treatment (2014-15) and post-treatment (2015-16 and 2016-17) groups were compared overall. In addition, a statistically significant increase in student performance was found in the area of vocabulary, but not in the area of literacy or analysis of scientific data. Furthermore, both post-treatment groups (2015-16 and 2016-17) separately saw a statistically significant increase in student performance overall. This shows that the desired effect happened in multiple years, with multiple group subjects, increasing the validity of the outcome as this outcome was repeatable.

Chapter 5

Discussion, Strengths/Limitations, and Recommendations

Overview

The purpose of this study was to answer the five primary questions listed below to determine if consistent use of differentiated instruction including differentiated vocabulary and reading strategies and data to inform and modify instruction would help to increase the following student abilities: understanding of science concepts when reading scientific information, improving retention of scientific vocabulary, and analysis of scientific data.

1. Do specific differentiated instructional strategies focused on comprehension with regard to vocabulary retention, and reading with comprehension, impact student performance?
2. Is there a significant difference between pre-treatment test scores and post-treatment test scores for students overall?
3. Is there a significant difference between pre-treatment test scores and post-treatment test scores for students in the area of vocabulary retention?
4. Is there a significant difference between pre-treatment test scores and post-treatment test scores for students in the area of literacy?
5. Is there a significant difference between pre-treatment test scores and post-treatment test scores for students in the area of analysis of scientific data?

Discussion

The researcher's findings are discussed below and information is based upon the results of the data analysis for the five hypotheses studied in this investigation.

In regards to hypothesis set one:

H₀: The combined use of differentiated instructional strategies focused on comprehension with regard to vocabulary, and reading with comprehension will result in scores that will not exceed what they were before on overall student performance in both the 2015-16 and 2016-17 school years compared to the 2014-15 school year on the same common assessment.

H₁: The combined use of differentiated instructional strategies focused on comprehension with regard to vocabulary, and reading with comprehension will result in higher scores on overall student performance in both the 2015-16 and 2016-17 school years compared to the 2014-15 school year on the same common assessment.

$$H_0: X_{\text{Overall15-16 and 16-17}} \leq X_{14-15} \quad H_1: X_{\text{Overall15-16 and 16-17}} > X_{14-15}$$

The data analysis indicated that the number of questions answered incorrectly decreased significantly for overall student performance on the common summative exam. Therefore, null hypothesis one was rejected.

In regards to hypothesis set two:

H₀: The combined use of differentiated instructional strategies focused on comprehension with regard to vocabulary, and reading with comprehension will result in scores that will not exceed what they were

before with regard to vocabulary retention in the 2015-16 and 2016-17 school year compared to the 2014-15 school year on the same common assessment.

H₁: The combined use of differentiated instructional strategies focused on comprehension with regard to vocabulary, and reading with comprehension will result in higher scores on student performance with regard to vocabulary retention in the 2015-16 and 2016-17 school year compared to the 2014-15 school year on the same common assessment.

H₀: $X_{\text{Vocabulary15-16 and 16-17}} \leq X_{14-15}$ H₁: $X_{\text{Vocabulary15-16 and 16-17}} > X_{14-15}$

The data analysis indicated that the number of questions answered incorrectly decreased significantly on the common summative exam for vocabulary retention when comparing the pre-treatment (2014-15) group to the combined post-treatment groups (2015-16 and 2016-17), and when the pre-treatment group (2014-15) was compared to the post-treatment group from (2015-16). Therefore, null hypothesis two was rejected.

In regards to hypothesis set three:

H₀: The combined use of differentiated instructional strategies focused on comprehension with regard to vocabulary, and reading with comprehension will result in scores that will not exceed what they were before with regard to literacy in the 2015-16 and 2016-17 school year compared to the 2014-15 school year on the same common assessment.

H₁: The combined use of differentiated instructional strategies focused on comprehension with regard to vocabulary, and reading with

comprehension will result in higher scores on student performance with regard to literacy in the 2015-16 and 2016-17 school year compared to the 2014-15 school year on the same common assessment.

$$H_0: X_{\text{Literacy15-16 and 16-17}} \leq X_{14-15} \quad H_1: X_{\text{Literacy15-16 and 16-17}} > X_{14-15}$$

The data analysis indicated that the number of questions answered did not decrease and the scores were at most what they were before the differentiated instruction on the common summative exam for literacy.

Therefore, null hypothesis three was accepted.

In regards to hypothesis set four:

H_0 : The combined use of differentiated instructional strategies focused on comprehension with regard to vocabulary, and reading with comprehension will result in scores that will not exceed what they were before with regard to analysis of scientific information in the 2015-16 and 2016-17 school year compared to the 2014-15 school year on the same common assessment.

H_1 : The combined use of differentiated instructional strategies focused on comprehension with regard to vocabulary, and reading with comprehension will result in higher scores on student performance with regard to analysis of scientific data in the 2015-16 and 2016-17 school year compared to the 2014-15 school year on the same common assessment.

$$H_0: X_{\text{Analysis15-16 and 16-17}} \leq X_{14-15} \quad H_1: X_{\text{Analysis15-16 and 16-17}} > X_{14-15}$$

The data analysis indicated that the number of questions answered did not decrease and the scores were at most what they were before the differentiated instruction on the common summative exam for analysis of scientific data. Therefore, null hypothesis four was accepted.

Strengths and Limitations

The sample size of high school freshman students (1046) and diversity of the students in the data set was a strength of this study. By conducting a historical review of data some limitations for the researcher were discovered. The major limitation was that the pre-treatment and post-treatment groups were new classes of students over three years. This added an additional variable to the study. This variable was alleviated by looking at three years of data, therefore increasing the population to observe the trend. This limitation also became the researcher's biggest strength as the researcher was able to reproduce the same statistically significant results in both of the post-treatment groups for overall performance on the common summative exam, showing the impact was far reaching into diverse student populations and would create the desired effect regardless of population.

Also, it would not be ethical to not give treatment to all populations involved in the study, therefore the historical review of data limited students from receiving poor teaching practices intentionally. All students regardless of ethnicity, socioeconomic status, ELL, or students with disabilities received differentiated instruction tailored to meet the individual needs of students in each classroom.

The use of historical data did not allow the researcher to disaggregate data based on ethnicity, socioeconomic status, ELL, or students with disabilities. Disaggregating data would have provided information on whether certain differentiated instructional techniques were more or less beneficial for certain populations of students tested.

During the 2015-16 school year the high school modified the daily schedule to include a 35 minute intervention/enrichment period three times per week. Struggling students who were not in good academic standing were requested by teachers for small group instruction on standards being taught. There was no way for the researcher to track or determine if the students who received additional intervention time were the same students that showed an improvement on the common summative assessment.

The common summative assessment included a total of 59 questions, nine of those questions were identified as being literacy based questions. The number of questions may not have been significant enough to determine if the differentiated instructional techniques were effective. While the researcher could not find a source related to this need, the potential limit is provided.

Suggestions for Further Study

The researcher suggests future studies include identification of subject demographics (English Language Learners (ELLs), Special Education, Gifted and Talented, economically advantaged or disadvantaged, and various ethnicity groups) so disaggregation and analysis of data can be performed to determine if the differentiated instructional techniques have a greater or lesser impact on the

various student groups. In addition, it would be interesting to conduct future similar studies that involve other scientific disciplines such as chemistry or physics. Further, what statistical impact might a co-taught class including a special education or ELL instructor, have on the academic achievement of underserved students versus individually taught courses. The present study provides a framework of understanding that could have significant implications for future studies aimed at increasing the academic performance of all students.

References

- Bakken, J. P., Simpson, C. (2011). Mnemonic Strategies: Success for the Young-Adult Learner. *The Journal of Human Resource and Adult Learning* Vol. 7, No. 2, 79-85.
- Bowers, E., & Keisler, L. (2012). Building academic language through content-area text. Huntington Beach, CA: Shell Education.
- Carnine, L., & Carnine, D. (2004). The Interaction Of Reading Skills And Science Content Knowledge When Teaching Struggling Secondary Students. *Reading & Writing Quarterly*, 20(2), 203-218. doi: 10.1080/10573560490264134
- Carolan, J., & Guinn, A. (2007). Differentiation: Lessons from master teachers. *Educational Leadership*, 64(5), 44-47.
- Childre, A., Sands, J., & Tanner Pope, S. (May/June 2009) Backward Design. *Teaching Exceptional Children*, Vol. 41, No. 5, 6-14.
- Dexter, D. D., Park, Y. J., & Hughes, C. A. (2011). A Meta-Analytic Review of Graphic Organizers and Science Instruction for Adolescents with Learning Disabilities: Implications for the Intermediate and Secondary Science Classroom. *Learning Disabilities Research & Practice (Wiley-Blackwell)*, 26(4), 204-213. doi:10.1111/j.1540-5826.2011.00341.x
- Ebbers, S. M., Denton, C. (2008). A root awakening: vocabulary instruction for older students with reading difficulties. *Learning Disabilities Research & Practice*, Vol. 23(2), 90–102.

- Graves, M. F., Baumann, J. F., Blachowicz, C. L. Z., Manyak, P., Bates, A., Cieply, C., Davis, J. R., & Von Gunten, H. (2014). Words, words everywhere, but which ones do we teach? *The Reading Teacher*, Vol. 67 (5), 333–346. DOI:10.1002/TRTR.1228
- Guastello, E., Beasley, T., & Sinatra, R. (2000). Concept mapping effects on science content comprehension of low-achieving inner-city seventh graders. *Remedial & Special Education*, Vol. 21 (6), 356-365.
- Hall, C., Kent, S. C., McCulley, L., Davis, A., & Wanzek, J. (2013). A New Look at Mnemonics and Graphic Organizers in the Secondary Social Studies Classroom. *Teaching Exceptional Children*, 46(1), 47-55.
- Harris, M. L., Schumaker, J., Deshler, D. (2011). The effects of strategic morphological analysis instruction on the vocabulary performance of secondary students with and without disabilities. *Learning Disability Quarterly*, Vol. 34(1), 17-33.
- Hedrick, K. A. (2012). Differentiation. *School Administrator*, 69(5), 26-30.
- Joyce, B., Weil, M., & Calhoun, E. (2004). *Models of teaching* (7th ed.). Pearson Education, Inc.
- Kagan Keskin, H. (2013). Impacts of Reading Metacognitive Strategies and Reading Attitudes On School Success. *International Journal Of Academic Research*, 5(5), 312-317. doi:10.7813/2075-4124.2013/5-5/B.48

- Lubin, J., & Polloway, E. (2016). Mnemonic Instruction in Science and Social Studies for Students with Learning Problems: A Review. *Learning Disabilities: A Contemporary Journal*, Vol. 14(2), 207-224.
- Martins-Shannon, J., & White, M. (2012). Culturally responsive teaching!. *Kappa Delta Pi Record*, 48: 4–6. DOI: 10.1080/00228958.2012.654718
- Mette, I. M., Nieuwenhuizen, L., & Hvidston D. J (2016). *Teachers' Perceptions of Culturally Responsive Pedagogy and the Impact on Leadership Preparation: Lessons for Future Reform Efforts*. NCPEA International Journal of Educational Leadership Preparation, Vol. 11, No. 1– May, 2016
ISSN: 2155-9635
- Moss, C.M., & Brookhart, S. (2012). *Learning Targets-Helping Students Aim for Understanding in Today's Lesson*. Alexandria, VA: ASCD. National Center for Educational Statistics. (2001-2007).
- National assessment of educational progress: The nation's report card (NCES 2007496).
- National Research Council. (1996). National science education standards. Washington, DC: National Academy Press.
- Nilsen, A.P., & Nilsen, D.L.F. (2003. January). Revitalizing grammar. *The English Journal*, 92 (3), 31-37.
- Rajagopal, K. (2011). Create success!: unlocking the potential of urban students. Alexandria, VA: ASCD.

- Safdar, M., Hussain, A., Shah, I., Rifat, Q. (2012). Concept maps: An instructional tool to facilitate meaningful learning. *European Journal of Educational Research*, Vol. 1, No. 1, 55-64.
- Strahan, D., Kronenberg, J., Burgner, R., Doherty, J., & Hedt, M. (2012). Differentiation in action: Developing a logic model for responsive teaching in an urban middle school. *Research In Middle Level Education Online*, 35(8), 1-17.
- Tomlinson, C. A. (2003). Fulfilling the promise of the differentiated classroom. Alexandria, VA: Association for Supervision and Curriculum Development.
- Tomlinson, C., Brighton, C., Hertberg, H., Callahan, C., Moon, T., Brimijoin, K., Reynolds, T., (2003) Differentiating instruction in response to student readiness, interest, and learning profile in academically diverse classrooms: A review of literature. *Journal for the Education of the Gifted*, vol. 27, no 2-3, 2003, pp. 119-145.
doi:10.1177/016235320302700203.
- Tomlinson, C. A., Brimijoin, K., & Narvaez, L. (2008). *The Differentiated School: Making Revolutionary changes in Teaching and Learning* Alexandria, VA Assoc. for Supervision and Curriculum Development

- Tomlinson, C. A., Gould, H., Schroth, S., & Jarvis, J. (2006). *Multiple case studies of teachers and classrooms successful in supporting academic success of high potential low economic students of color* (Research Monograph No. 06220). Storrs: The National Research Center on the Gifted and Talented, University of Connecticut.
- Tomlinson, C. A., & Jarvis, J. M. (2014). Case studies of success: Supporting academic success for students with high potential from ethnic minority and economically disadvantaged backgrounds. *Journal for the Education of the Gifted*, Vol. 37(3), 191-219. DOI: 10.1177/0162353214540826
- Tovani, C. (2000). *I Read It, But I Don't Get It Comprehension Strategies for Adolescent Readers*. Portland, Maine: Stenhouse Publishers
- Wolgemuth, J. R., Brian Cobb, R., & Alwell, M. (2008). The effects of mnemonic interventions on academic outcomes for youth with disabilities: A systematic review. *Learning Disabilities Research & Practice*, Vol. 23(1), 1–10.
- Wu, E. H. (2013). The path leading to differentiation: An interview with Carol Tomlinson. *Journal of Advanced Academics*, 24(2), 125-133.
doi: 10.1177/1932202X134834

Appendix A

MULTIPLE CHOICE

Read the following passage and answer the questions based on the information in the passage.

History of Life on Earth

The history of the life on Earth began about 3.8 billion years ago, initially with single-celled prokaryotic cells, such as bacteria. Multicellular life evolved over a billion years later and it's only in the last 570 million years that the kind of life forms we are familiar with began to evolve, starting with arthropods, followed by fish 530 million years ago (As), land plants 475 Ma and forests 385 Ma. Mammals didn't evolve until 200 Ma and our own species, Homo sapiens, only 200,000 years ago. So humans have been around for a mere 0.004% of the earth's history.

1. What were the first living things on Earth?
 - a. arthropods
 - b. single-celled prokaryotes
 - c. fish
 - d. land plants

2. How long ago did arthropods begin to evolve on Earth?
 - a. 3.8 billion years ago
 - b. 570 million years ago
 - c. 530 million years ago
 - d. 385 million years ago

3. How long have people been on Earth?
 - a. 1,000,000 years
 - b. 750,000 years
 - c. 400,000 years
 - d. 200,000 years

Read the following passage and answer the questions based on the information in the passage.

Asteroid-Impact Theory

The dinosaurs disappeared at the end of the Mesozoic era, about 65 million years ago. The disappearance took place over a very short period of time and was, according to some scientists, triggered by Earth colliding with a large asteroid.

Today, evidence of this collision can be found in the rock record. Geologists have discovered a thin layer of clay containing a high concentration of the element iridium between 2 particular rock layers. This boundary marks the end of the Mesozoic and the beginning of the Cenozoic era. This iridium-rich layer has been identified at the Mesozoic-Cenozoic boundary at many different locations around the world. Iridium, while rare on Earth, is a common substance in meteorites and asteroids.

The asteroid not only supplied the iridium, but its white-hot rock fragments also started fires that engulfed entire continents. The soot from these fires, combined with asteroid and crustal particles that were propelled into the atmosphere, blocked out the Sun's energy. The lack of sunlight halted photosynthesis and caused a decrease in global temperatures. Much of the plant and animal life, including the dinosaurs, could not adapt to the temperature change and dies.

Gradual-Extinction Theory

Some scientists disagree with the asteroid-impact theory. They point to evidence that the dinosaurs died out gradually because of a long-term climatic change.

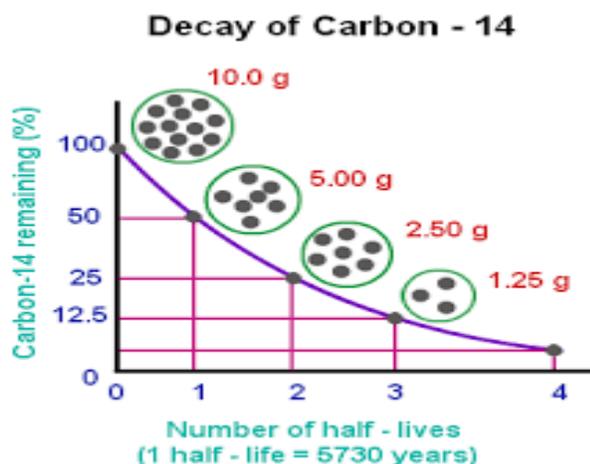
Earth experienced increased volcanic activity 65 million years ago. Not only could Earth's volcanism have produced the iridium, but more important, volcanoes did produce tremendous amounts of carbon dioxide. The increased levels of carbon dioxide in the atmosphere prevented Earth from radiating excess heat back into space, and thus caused a worldwide warming.

The warming of Earth is what caused the dinosaurs' disappearance. After examining dinosaur egg fossils, paleontologists discovered that the eggshells became thinner in at least one species. This was thought to be the result of heat adversely affecting the dinosaurs' metabolism. These thin-shelled eggs, which were easily broken, lowered the survival rate among the offspring and contributed to the eventual extinction of the dinosaurs.

4. A geologist examines a sedimentary rock layer from the Mesozoic-Cenozoic boundary. According to the asteroid-impact theory, the geologist should not expect to find_____.
- a high concentration of iridium.
 - a high concentration of soot particles.
 - evidence of great volcanic activity.
 - fossilized plant remains.
5. What do supporters of the asteroid-impact theory assume about the fires started by the white-hot asteroid fragments?
- they spread quickly and were wide ranging.
 - they removed carbon dioxide from the atmosphere, causing a global cooling.
 - they burned the vegetation, limiting the food supply.
 - they produced high levels of carbon dioxide, causing a global warming.
6. Both theories presented in the passage cite which of the following factors as contributing directly to the dinosaurs' extinction?
- high levels of soot and volcanic ash
 - high concentrations of iridium
 - global temperature change
 - increased amount of carbon dioxide introduced into the atmosphere

Use this information and the diagram to answer questions 7-9.

Scientists often use carbon-14 dating to determine the age of an object that contains organic material that was once part of a living organism. Here's how carbon-14 dating works. Carbon occurs in two forms in our environment. The one that is most common is carbon-12 and the other is a naturally occurring radioactive isotope called carbon-14. Plants and animals naturally have both forms of carbon in their systems and as long as the organism is alive, the ratio of carbon-12 to carbon-14 stays about the same. As soon as the plant or animals dies, the amount of carbon-14 begins to decrease in a predictable way as it undergoes radioactive decay, but the amount of non-radioactive carbon-12 stays the same. Scientists can determine the ratio of carbon-12 to carbon-14 and figure out how much carbon-14 has decayed. They know that it takes about 5730 years for half of the original carbon-14 to decay. This is called the half-life of carbon-14. The graph below illustrates the findings of a scientist who examined a sample of organic material and determined that the amount of carbon-14 was 10 grams when the organism was alive.



7. How much carbon-14 was left after two half-lives?
- 10.0 g
 - 5.0 g
 - 2.5 g
 - 1.25 g
8. How many half-lives have passed if 1.25 grams remain?
- 1
 - 2
 - 3
 - 4
9. If 5 grams of carbon-14 remain in the sample, how old is it?
- 5 years
 - 50 years
 - 5730 years
 - 11,460 years
10. Which of the following chemical equations represents photosynthesis?
- Glucose + Water + Light Energy \longrightarrow Oxygen + Carbon Dioxide
 - Oxygen + Water + Light Energy \longrightarrow Glucose + Carbon Dioxide
 - Carbon Dioxide + Water \longrightarrow Light Energy + Glucose + Oxygen
 - Water + Carbon Dioxide + Light Energy \longrightarrow Glucose + Oxygen
11. Which of the following chemical equations represent cellular respiration?
- Glucose + Carbon Dioxide \longrightarrow Oxygen + Water + ATP Energy
 - Glucose + Oxygen \longrightarrow Water + Carbon Dioxide + ATP Energy
 - Carbon Dioxide + Oxygen + Water \longrightarrow Glucose + ATP Energy
 - Carbon Dioxide + Water \longrightarrow Oxygen + Glucose + ATP Energy

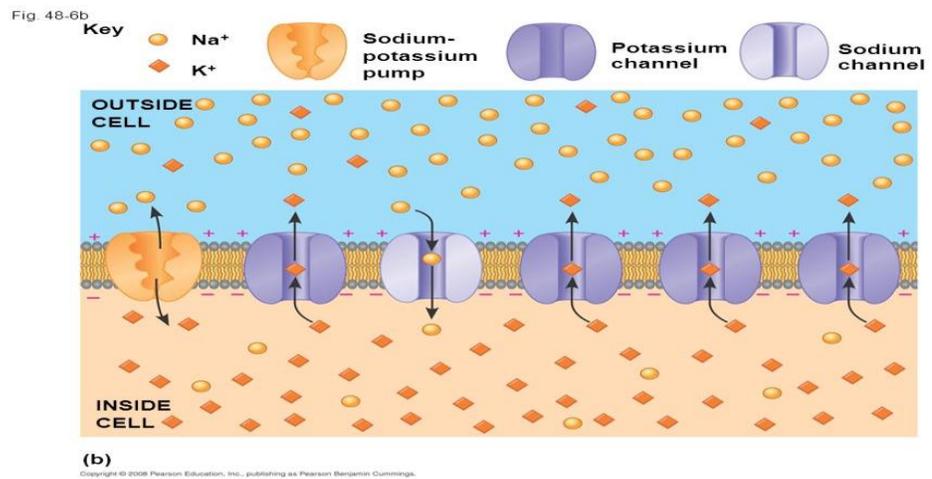
12. Animals cannot get energy directly from the sun, so how do they get their chemical energy?
- drinking water
 - eating plants and other animals
 - through osmosis
 - photosynthesis
13. The process of photosynthesis takes place inside which of the following organelles?
- central vacuole
 - mitochondria
 - nucleus
 - chloroplast
14. The process of cellular respiration takes place inside which of the following organelles?
- central vacuole
 - mitochondrion
 - nucleus
 - chloroplast
15. What hypothesis states that the continents were once joined to form a single supercontinent?
- plate tectonics
 - seafloor spreading
 - continental drift
 - paleomagnetism
16. What is Pangaea?
- Earth's inner core
 - the largest fault found on Earth
 - the large landmass that all continents are currently forming.
 - the large landmass in which all continents once were connected.
17. The theory that continents are slowly moving over Earth's surface is called
- the theory of Pangaea
 - the theory of continental drift
 - the theory of plate boundaries
 - the theory of plate tectonics

18. Which type of molecule is assembled inside cells and is made up of amino acids?
- carbohydrate
 - lipids
 - nucleic acid
 - protein
19. Which type of molecule is a main source of energy and includes sugars and starches?
- carbohydrate
 - lipids
 - nucleic acid
 - protein
20. Which type of molecule is a long chain of nucleotides and carries an organism's genetic information?
- carbohydrate
 - lipids
 - nucleic acid
 - protein
21. Which type of molecule is the main source for storing energy and includes fat, steroids, and waxes?
- carbohydrate
 - lipids
 - nucleic acid
 - protein
22. Aerobic respiration involves all of the following except
- ATP
 - chloroplast
 - mitochondria
 - oxygen
23. Which element forms the backbone of the macromolecules of living organisms?
- iron
 - lead
 - sodium
 - carbon
24. All of the following are true about anaerobic respiration except
- does not use oxygen
 - occurs in bacteria
 - is more efficient than aerobic respiration
 - makes energy

25. Which is not in both prokaryotic and eukaryotic cells?
- cell membrane
 - membrane bound organelles
 - cytoplasm
 - DNA
26. What is the name of the outer portion of the cell that controls the movement of materials in and out of the cell?
- cell membrane
 - membrane bound organelles
 - cytoplasm
 - DNA
27. What is the smallest unit of life in all living things?
- cell
 - membrane bound organelles
 - cytoplasm
 - DNA
28. The movement of a substance across a cell's membrane which **requires energy** is _____.
- active transport
 - equilibrium
 - osmosis
 - passive transport
29. The movement of a substance across a cell's membrane which **does not** require energy is _____.
- active transport
 - equilibrium
 - exocytosis
 - passive transport
30. The process of moving **molecules** from an area of **high to low** concentration is _____.
- active transport
 - diffusion
 - equilibrium
 - osmosis
31. The process of moving **water** through a selectively permeable membrane is _____.
- active transport
 - diffusion
 - equilibrium
 - osmosis

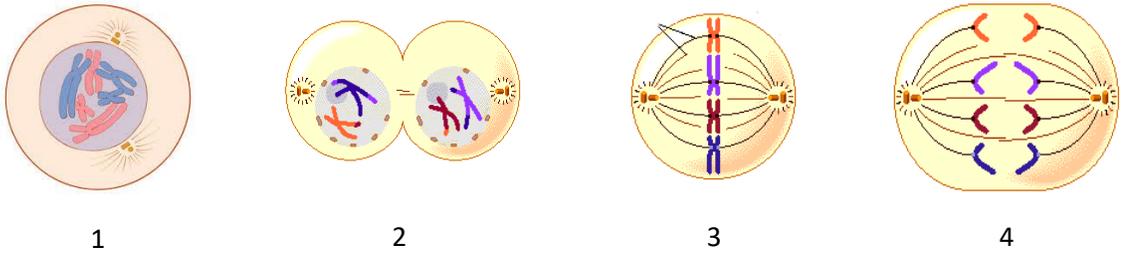
32. What is the function of the cell membrane?
- regulating temperature
 - controlling what comes in and out of the cell
 - making proteins
 - making DNA

Use this diagram to answer questions 33-34.



33. In the diagram above, which of the following protein channels is moving molecules from an area of low concentration to high concentration?
- the sodium/potassium pump
 - the potassium channel
 - the sodium channel
 - all of the above
34. Why wouldn't Ca⁺ ions move across the cell membrane shown in the previous diagram?
- because ions cannot cross a cell membrane
 - because the cell membrane does not have a Ca⁺ ion channel
 - because Ca⁺ can only pass through the lipid bilayer
 - because Ca⁺ is not needed by the cell

Use the diagram to answer question 35.



35. In the picture above, which of the following correctly indicates the order in which these events occur?

- a. 1, 2, 3, 4
- b. 3, 2, 1, 4
- c. 1, 3, 4, 2
- d. 2, 1, 4, 3

36. What is the name of the process that starts with diploid cells (paired chromosomes)?

- a. mitosis
- b. meiosis
- c. Both mitosis and meiosis start with diploid cells.
- d. Neither mitosis nor meiosis start with diploid cells.

37. What is the name of the process that goes through 2 cycles of cell division?

- a. mitosis
- b. meiosis
- c. Both mitosis and meiosis start with diploid cells.
- d. Neither mitosis nor meiosis start with diploid cells.

38. This process goes through 1 cycle of cell division.

- a. mitosis only
- b. meiosis only
- c. both mitosis and meiosis
- d. neither mitosis or meiosis

39. This process produces two new identical cells.

- a. mitosis only
- b. meiosis only
- c. both mitosis and meiosis
- d. neither mitosis or meiosis

40. This process produces four new cells.
- mitosis only
 - meiosis only
 - both mitosis and meiosis
 - neither mitosis or meiosis
41. This process produces new cells with slightly different DNA than the original parent cell.
- mitosis only
 - meiosis only
 - both mitosis and meiosis
 - neither mitosis or meiosis
42. When genetic material is randomly distributed to give each cell a unique single (haploid) set of chromosomes this is called?
- crossing over
 - homologous chromosomes
 - meiosis
 - independent assortment
43. What do we call the exchange of genetic material between homologous chromosomes during meiosis?
- crossing over
 - homologous chromosomes
 - meiosis
 - independent assortment
44. What is it called when cells grow and divide at an abnormally high rate?
- diabetes
 - cancer
 - cytokinesis
 - mitosis
45. A small segment of DNA that codes for a specific trait is called?
- diploid
 - haploid
 - gene
 - life cycle
46. Which of the following is not found in RNA?
- T (thymine)
 - C (cytosine)
 - U (uracil)
 - G (guanine)

47. A sugar, phosphate, and a nitrogen base make-up what structure?
- amino acid
 - protein
 - nucleotide
 - carbohydrate
48. What type of RNA carries the amino acid?
- cRNA
 - mRNA
 - rRNA
 - tRNA
49. Which type of RNA copies the DNA and leaves the nucleus through the nuclear pore?
- cRNA
 - mRNA
 - rRNA
 - tRNA
50. Which type of RNA physically moves along the mRNA and reads it?
- cRNA
 - mRNA
 - rRNA
 - tRNA
51. Which of the following terms is used when a nitrogen base is incorrectly paired in the new strand during DNA replication?
- mutation
 - transcription
 - cloning
 - translation
52. Mutations that can be inherited arise in
- liver cells
 - heart cells
 - germ cells
 - skin cells
53. Tallness (T) is dominant to shortness (t) in pea plants. Which of the following represents a genotype of a pea plant that is heterozygous for tallness?
- T
 - TT
 - Tt
 - tt

Use this information to answer questions 54-57.

In human trait inheritance, having freckles is dominant over not having freckles. The inheritance of these traits can be studied using a Punnett square similar to the one shown below.

F stands for “having freckles”
f stands for “not having freckles”

	F	f
F	1	2
f	3	4

54. The child represented in box 1 in the Punnett square would be which of the following?
- homozygous dominant for freckles
 - homozygous recessive for freckles
 - heterozygous and have freckles
 - heterozygous and not have freckles
55. Refer to the Punnett square above. What percentage of the children will have freckles:
- 25%
 - 50%
 - 75%
 - 100%
56. Refer to the Punnett square above. Which box represents a child who does not have freckles?
- box 1
 - box 2
 - box 3
 - box 4

57. Refer to the Punnett square above. The child in box 3 has which of the following genotypes?

- a. FF
- b. Ff
- c. freckles
- d. no freckles

58. An organism who has the trait of brown hair would be an example of which of the following terms?

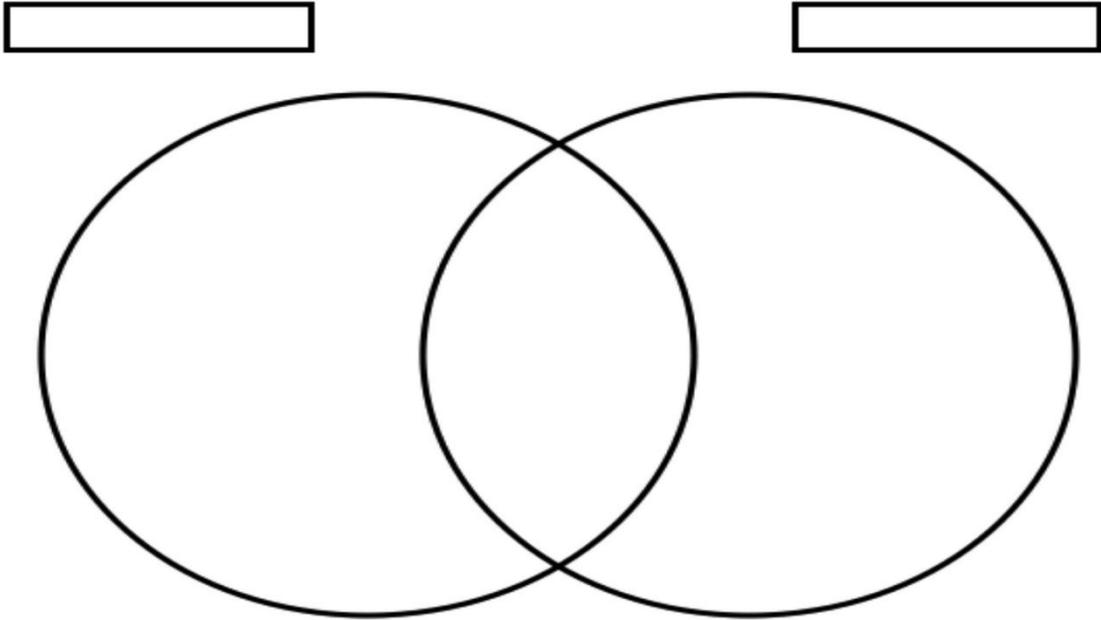
- a. genotype
- b. phenotype
- c. genotypic ratio
- d. phenotypic ratio

59. In a heterozygous pair of alleles such as Aa the capital A represents which of the following terms?

- a. dominant
- b. phenotypic
- c. recessive
- d. superior

Appendix B

Venn Diagram



T-Chart