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Teaching High School Students Scientific Concepts Using Graphic Organizers

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By

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Abstract

In the current study, the effect of using graphic organizers as a teaching method in a special education classroom was compared to the effectiveness of lecture style teaching in a regular education classroom. It was hypothesized that the use of graphic organizers in a special education classroom would result in a greater difference between the pre-and post-test measures than the group that was taught using lecture style instruction. Each classroom was given the same pre-test, followed by four weeks of instruction, then the same post-test. A paired samples *t*-test indicated that there was a significant difference observed in both groups, but the difference in the group of students that were taught using graphic organizers was greater, indicating that this teaching style was more effective for students in the special education setting.

Keywords: graphic organizers, lecture style instruction, special education, teaching methods

Chapter 1: Introduction

Introduction

The current teaching methods that teachers commonly use in classrooms includes traditional lecture style instruction and expository text (Gajria, Jitendra, Sood, & Sacks, 2007; Minskoff & Allsopp, 2003). Although this practice is commonly used by both special education and general education teachers, it may not be the most effective method to teach those who have special needs. This may be true because these students typically have problems with comprehending scientific textbooks due to how they are written (Fang, 2004); problems building on previously acquired knowledge, and difficulty ignoring unnecessary details (Kim, Vaughn, Wanzek, & Wei, 2004). For these reasons, special education teachers in particular should consider revising teaching methods so that students with disabilities are taught using effective instructional strategies. Although there are many possible modifications and revisions that teachers could make, perhaps the best choice would be to implement the use of graphic organizers.

Graphic organizers are visual and spatial displays that provide students with a meaningful framework for relating their prior knowledge to newly learned information (Kim, Vaughn, Wanzek, & Wei, 2004). Graphic organizers can be used more effectively with students who have low verbal ability or little prior knowledge about a subject (Dexter & Hughes, 2011). Using them prior to, during, and after a lesson is taught allows the student to initially be introduced to the information, then to discuss and understand the concepts, and finally to connect it to previously acquired knowledge. By doing this, students are exposed to the information in a concrete manner which enables them to better understand the concepts and to have the ability to apply them. This will prepare students to use this knowledge in real-world situations.

This study connects effective teaching methods, in the form of graphic organizers, and student understanding of scientific information. By looking at the relationship between the use of graphic organizers as a teaching method and student understanding as measured by pre-and post-test assessments, it can possibly be determined whether it would be beneficial for special education teachers to implement the use of graphic organizers throughout the curriculum to increase student understanding of not only science, but also math, English, and history.

Statement of the Problem

In today's society, special education students are an underrepresented group in the labor force as it pertains to science (Melber & Brown, 2008). With this being said, there is an obvious decrease in the number of job opportunities available for students that have no technical training; therefore it is of utmost importance that students graduate high school with the scientific knowledge necessary to enter the work force and be successful. There are a number of commonly cited reasons that individuals with disabilities are underrepresented in scientific careers. These include lack of early exposure (Melber & Brown, 2008) and problems with comprehending scientific textbooks due to how they are written. This comprehension difficulty lies within the grammar that is used, the density of the information, the use of abstract concepts, the technicality of the writing, and finally the authoritative nature of the writing (Fang, 2004). Only 6 percent of learning disabled (LD) students in the twelfth grade are proficient in science and 70 percent of LD students perform below the basic level. When compared to their peers who are not labeled as LD, these numbers are 24 and 37 percent, respectively (Dexter, Park, Hughes, 2011). These numbers will need to increase if we expect these students to contribute to the labor force and society as a whole.

It will be up to teachers, both special and general education, to teach students important scientific information. Some things that should be considered when teaching special education students is the use of concrete examples (Slough & McTigue, 2010), hands-on instructional techniques (Melber & Brown, 2008), and a "stress free" environment where the students feel comfortable asking questions and discussing concepts without the possibility of negative feedback from teachers or peers (Melber & Brown, 2008) . A teaching method that facilitates the use of these techniques is graphic organizers. Graphic organizers can be used in conjunction with hands-on learning to allow students to work collaboratively so that new information can be discussed openly without the possibility of negative feedback. This will also provide concrete examples that assist students in understanding the information. The concrete examples that are used in graphic organizers can be placed around the classroom to provide students with a reference point so that they can review previously learned material and build upon it.

Purpose of the Study

This study investigates the effectiveness of using graphic organizers as a teaching method, as opposed to lecture style teaching, on student's scientific knowledge as measured by pre-and post-test assessments. These assessments, which will measure student learning of scientific information, will be conducted over the course of four weeks. Initially, students in both the control and experimental groups will be given a pre-test to establish baseline knowledge. Four weeks of either lecture style instruction or instruction incorporating graphic organizers will follow the pre-test, and then the students will be given the post-test to determine the amount of knowledge gained over the four weeks. Student performance on these assessments will be compared to determine which teaching method is more effective. The study will be conducted in a small, rural high school in Wyoming County, West Virginia. The sample will consist of 5-10 special education students, comprised of Learning Disabled, Mentally Impaired, and Other Health Impairment exceptionalities.

Rationale for the Study

Using teaching methods that are proven to be effective for special education students will increase the likelihood that these students will grasp the concepts and be able to apply them to real-life scenarios. This will also increase the chance that these students can become more equally represented in the labor force as it pertains to science. If using a graphic organizer to teach students with disabilities predicts a gain in knowledge and understanding and subsequently allows them to be successful upon graduation from college, then also using graphic organizers to teach special education students math, English, and history may be a beneficial revision to the teaching methods that special educators are currently implementing in classrooms. The purpose of this study is to demonstrate the effectiveness of using graphic organizers throughout the special education curriculum for increasing student knowledge base and understanding so that these students can become successful adults considering the number of jobs that now require some scientific experience.

Research Question

Will special education students who are taught scientific concepts using graphic organizers have a larger score increase between pre-and post-tests than students who are taught using a lecture-style instructional method?

Chapter 2: Review of Literature

Among twelfth grade students, approximately 6 percent that are classified as learning disabled (LD) are proficient in science and 70 percent of students with learning disabilities are performing below the basic level. When compared to students who are not labeled at LD, these numbers are 24 and 37 percent, respectively (Dexter, Park, & Hughes, 2011). The most common methods that are used include traditional lecture style instruction and the used of expository text (Gajria, Jitendra, Sood, & Sacks, 2007; Minskoff & Allsopp, 2003). Students who are intellectually disabled have problems with these teaching methods due to their lack of early exposure (Melber & Brown, 2008), and problems comprehending expository text, due to how it is written (Fang, 2004). It is the responsibility of today's educators to find an effective method to allow special education students to be able to read and understand scientific text. To solve this problem, the use of graphic organizers should be incorporated into the curriculum, because research shows that they are effective methods to teach learning disabled students conceptual knowledge. By using graphic organizers, teachers can remove the aforementioned potential barriers and offer an alternative way to understand expository text (Barton-Arwood, & Little, 2013).

Science and Special Education

In today's society, scientific knowledge has come to be a valued commodity, but it is something that we are lacking in the United States. On a recent Program for International Student Assessment, only 29 percent of students in the U.S. scored at the proficient level in science achievement. This places the U.S. behind 15 other countries (Fleischman, Hopstock, Pelcza, & Shelley, 2010). Also, according to the National Assessment of Education Progress, only one-third of 4^{th}-, 8^{th}-, and 12^{th}-grade students scored at the proficient level in science while students with Learning Disabilities (LD) scoring significantly lower than students without (National Center for Education Statistics, 2011).

Research shows that students with LD may struggle with science due to language disabilities (Parmar, Deluca, & Janczak, 1994; Steele, 2004), and behavioral issues including problems with sustained attention, attitude toward science, and social skills (Steele, 2004). Although this information is both surprising and concerning, the United States does have adequate knowledge on how to improve this, especially for students with LD. The first is that students with LD can be successful in a regular education science inquiry classroom, but this is dependent on whether or not the instruction is structured and teacher directed. Also, special education teachers can enhance this success by using various supplemental programs, including mnemonics and peer tutoring (Therrien, Hughes, & Hand, 2011).

Furthermore, the use of graphic organizers has been associated with the increased vocabulary knowledge and factual comprehension which suggests that graphic organizers may not only be effective at improving vocabulary and factual recall, but also inference and other higher-level thinking skills (Dexter, Park, & Hughes, 2011). Some additional instructional components and modifications that are beneficial for LD students include preteaching, reducing language and literacy demands, providing hands-on experiences, giving formative feedback, providing additional practice, and reviewing key components (Mastropiere & Scruggs, 1992; Mastropieri, Scruggs, Norland, Berkeley, McDuffie, Tornquist, et al., 1998) Also, students with LD profit when teachers focus on overall concepts as opposed to extraneous facts, and allow students to demonstrate understanding in a variety of modalities (Therrien, W.J., Taylor, J.C., Hosp, J.L., Kaldenberg, E.R., & Gorsh, J., 2011).

Current Teaching Methods

As previously discussed, the teaching methods that are currently used in today's science classrooms include traditional lecture style instruction and the use of expository text (Gajria, et al., 2007; Minskoff & Allsopp, 2003). Special education students struggle with this style of teaching because they need more adaptive techniques to be able to comprehend the large number of facts and ideas that are presented in most of the textbooks that are used in school systems (Horton, Lovitt, & Bergerud, 2001).

Reading and learning from scientific text has been noted as the most difficult of all academic tasks form students with Learning Disabilities (Therrien, W.J., Hughes, C., & Hand, B., 2011). Special education students struggle with scientific text due to the way it is written in that important connections and relationships are not made explicit (Armbruster & Anderson, 1988; Beck, McKeown, Hamilton, & Kucan, 1998). This includes the grammar that is used, the density of the information, the use of abstract concepts, and the technicality and authoritative nature of the writing (Fang, 2004). Additionally, LD students are more likely to be passive learners in that they do not possess the skills necessary to process and organize written information (Bos & Vaughn, 1994; Lenz, Alley, & Schumaker, 1987; Torgesen, 1982).

Although many LD students may attempt to take their own notes to better understand the content of the text, the notes usually are not comprehensive because they are in a linear (outline) format; however research states that spatial formats are optimal for encoding new information (Robinson, Beth, Odom, Katayama, Hsieh, Vanderveen, 2006). Incorporating graphic organizers into the classroom would allow students to better understand the concepts that teachers fail to teach when using linear outlines because graphic organizers allow students to take notes in this spatial format which increases understanding and encoding for students with special needs (Horton, Lovitt, &Bergarud, 2001).

Graphic Organizers

Graphic organizers are visual and spatial displays that make relationships between related facts and concepts more apparent (Gajria, et al, 2007; Hughes, Maccini, & Gagnon, 2003; Kim, Vaughn, Wanzek, & Shangjin Wei, 2004) and facilitate learning and teaching by visually representing the organization of key concepts (Darch & Eaves, 1986). It has been suggested that if realistic pictures lie at one end of the information spectrum and words at the other, then it could be said that graphic organizers fall somewhere in the middle (Winn, 1987). Graphic organizers can be designed to represent different patterns of text structure, which is one of their key features (Jitendra & Gajria, 2011).

Additional reasons that graphic organizers are effective at teaching students scientific concepts is due to their concrete nature (Slough & McTigue, 2010), in that the structure of the diagram allows the information to be consolidated into a meaningful whole instead of many unrelated pieces (Horton, et al., 2001). They also allow for the possibility of incorporating hands-on techniques and create a stress-free environment where students feel comfortable discussing concepts and asking questions without running the risk of getting negative feedback from teachers and peers (Melber & Brown, 2008). Additional advantages of graphic organizers are that they can: allow students to develop a holistic understanding that words cannot convey, provide users with tools to make the thought and organization processes visible, clarify complex concepts into a simple, meaningful displays, assist users in processing and restructuring ideas and information, and promote recall and retention of learning through synthesis and analysis (Kang, 2004).

Research has shown that when students are given graphic organizers to study along with the text, they perform better on assessments that measure conceptual knowledge and application (Robinson & Hsu, 2004; Dubois & Staley, 2001). They do this by directing their attention to important text features along with recognizing relationships across concepts (Robinson, et al., 2006). Some examples of graphic organizers include semantic/cognitive maps, semantic feature analysis (Jitendra & Gajria, 2011), hierarchical organizers, comparative organizers, sequential organizers, diagrams (Marchand-Martella, Miller, & MacQueen, 1998), and matrix organizers (Kang, 2004). Hierarchical organizers present main ideas and supporting details (e.g. concept map, network tree, structured overview); comparative organizers depict similarities and differences among key concepts (e.g. Venn diagram); and sequential organizers illustrate a series of steps or events (e.g. chain of events, storyboard) (Marchand-Martella, 1998; Kang, 2004).

Graphic Organizers and Instruction

Although the use of graphic organizers is more effective than simply assigning a student a chapter to read with questions to answer at the end, research does not indicate that just any type of graphic organizer is suitable for any situation (Horton, Lovitt, &Bergarud, 2001). Also, teachers must explicitly teach students how to use graphic organizers for them to be effective (DiCecco & Gleason, 2002). Graphic organizers are more effective for immediate and factual recall when they require teacher instruction so that students can understand conceptual relationships (Dexter & Hughes, 2011). Simpler graphic organizers that require little to no teacher instruction are more effective for maintenance and transfer (Dexter & Hughes, 2011).

There are three major types of graphic organizers; skeletal frameworks (teacher provides concept names and attribute heading), partial (teacher provides approximately half of the information from the complete notes), and complete (teacher provides all of the information from the complete notes) (Katayama & Robinson, 2000). When these three structures were compared, it was found that the partial graphic organizer condition allowed the students to learn the most concept relations and apply that knowledge in novel situations (Kiewra, Dubois, Christian & McShane, 1988; Robinson & Kiewra, 1995). This is because it allows students to become involved in the process of taking notes, without the task being too difficult or eliciting frustration (Robinson, et al., 2006).

Teachers may include graphic organizers in their instruction at various times for various reasons. The first possibility is to use a graphic organizer before instruction (Kang, 2004). When using this technique, the teacher may make instructional plans that are used as an organizational framework to conceptualize course structure. The second option is to use them during instruction so that novel information can be clarified (Kang, 2004). The final option is to use graphic organizers post-instruction (Moore & Readence, 1984). Current research suggests that the third option could be the most effective because it allows the students to practice so that the new information is reinforced and learning can be assessed (Kang, 2004; Moore & Readence, 1984).

Another area of graphic organizers that should be of concern to educators is how they can be differentiated based on students needs. This is especially true in a special education classroom in which student’s disabilities vary. To address this issue, teachers can construct tiered graphic organizers. Based on the needs of the students, the teacher can decide on the number of tiers to create and to ensure that each of the organizers look equally challenging and have an equal workload (McMackin & Witherell, 2005). The cognitive demand is what should be taken into consideration when differentiating which group a student belongs in (McMackin & Witherell, 2005). This method also allows students to work collaboratively, and by doing so students can benefit greatly from helping each other activate prior knowledge (Pearson & Spiro, 1982), construct new meaning, and to value the thinking and learning styles of others (Kaiden, 1998). Overall, graphic organizers can be used to increase student motivation and experience greater satisfaction and success in learning (Egan, 1999).

The current study will implement the use of graphic organizers as a teaching method for students in a special education classroom. The students will be given a pre-test to determine their knowledge of scientific concepts prior to the implementation of graphic organizers as a teaching method. Students will then be given a post-test to assess the amount of conceptual knowledge gained from the graphic organizers.

Conclusion

In general, special education students find abstract scientific concepts difficult to comprehend. To assist students in understanding this material, graphic organizers can be used as an effective instructional method. Graphic organizers present new material in a concrete manner so that students have a visual representation of new material which allows for easier assimilation. The use of graphic organizers in special education science classrooms will allow students with LD, OHI, and MR to access information in a manner that allows them greater understanding and comprehension of the complex scientific concepts being taught to them.

Chapter 3: Methods

Research Design

A 25 question assessment was given to both classes as a pre-and post-test measure to determine whether using graphic organizers as a teaching method as opposed to lecture style instruction resulted in a greater difference between pre- and post-test scores for tenth grade students at Westside High School.

Participants

Two classrooms of tenth-grade students at Westside High School were used to determine whether students acquire more conceptual scientific knowledge when they are taught using graphic organizers. This study consisted of 15 girls and 18 boys ranging in age from 15-17 who were all Caucasian. The students were placed into groups based on whether or not they were in the special education classroom versus the general education classroom. This resulted in one group of 7 students who were in the special education classroom (1 female and 6 males) and served as the experimental group. Another group of 26 students who were in the general education classroom (14 females and 12 males) served as the control group.

Measures

The instruments used to collect data for this study included a self-constructed 25 question assessment that was used to measure baseline knowledge as well as the amount of conceptual knowledge gained. This assessment was composed of 6 matching, 7 multiple choice, 6 fill in the blank, and 6 short answer questions (see Appendix).

Procedure

The study began by administering students in both the control and experimental classrooms the 25 question assessment to determine their baseline conceptual scientific knowledge. For the following four consecutive weeks, the experimental classroom was taught conceptual scientific knowledge using graphic organizers. During these same four weeks, the control group was taught the same conceptual scientific knowledge using lecture style instruction. At the end of this four week session, each group was given the 25 question assessment to determine if the students who were taught using graphic organizers gained more conceptual scientific knowledge than those who were taught using lecture style instruction. The difference in the number of questions correctly answered from pre-to post-test was used to determine the amount of conceptual knowledge learned. These results were then analyzed using a *t*-test to determine if the difference between the pre-and post-test scores in each of the classrooms was significant.

Chapter 4: Results

Results

The purpose of this study was to investigate the effectiveness of using graphic organizers on learning conceptual scientific content. The control group in this study consisted of a tenth grade regular education science classroom, which was taught using lecture style instruction, while the experimental group consisted of a tenth grade special education science classroom, which was taught using graphic organizers. After the pre-test, the students were taught using the lecture style teaching method or graphic organizers for the following four weeks. At the end of these four weeks, each group was given a post-test. To determine if there was a significant difference between the pre-and post-test scores for each group, a *t*-test for paired samples was used. As shown in Table 1, the *t*-test indicated that there was a significant difference between the pre- and post-test measures for the control group, $t(25) = -2.46$, $p < .05$ as well as the experimental group, $t(17) = -13.52$, $p < .05$.

Table 1

Difference in Scores between Pre-Test and Post-Test Measures

	Pre-Test Mean	Post-Test Mean	Difference	*t*-ratio
Control Group	21.8%	31.7%	9.9%	-2.46*
Experimental Group	13.5%	78%	64.5%	-13.52*

Note. *= p<.05

Although the *t*-test found a significant difference for both groups, it should be noted that there is a greater difference between the pre- and post-test scores for the individuals in the experimental group indicating that a teaching style that uses graphic organizers is more effective than lecture style instruction when teaching a special education population.

Chapter 5: Discussion

Discussion

As previously stated, the hypothesis for this study was that the use of graphic organizers in a special education science classroom will allow students with LD, OHI, and MR to access information in a manner that allows them greater understanding and comprehension of the complex scientific concepts being taught to them as opposed to lecture style instruction. The results of this study indicate that there was a significant difference in both the experimental group and control group from pre- to post-test, as measured by a *t*-test for paired samples, but this difference was much more significant in the experimental group which was taught using graphic organizers, indicating that the hypothesis was supported.

The fact that there was a significant difference seen in both groups was anticipated, considering they were both expected to gain some new knowledge during the study. The difference that was seen in the experimental group was a greater difference and indicated that teaching methods using graphic organizers is beneficial for students in a special education classroom who are being taught conceptual scientific knowledge. The process that was used by the teacher to incorporate graphic organizers into each lesson began with the class doing a complete graphic organizer together, followed by a partial one where the students filled in approximately half of the information, and finally, a skeletal framework, where the students were expected to fill the in the majority of the graphic organizer on their own. This method was shown to be beneficial for the students in the experimental group.

Limitations to this study include sample size, considering there were only 7 students in the experimental group and 26 students in the control group. Also, the students were not randomly selected, which could also be considered a confounding factor. Another variable that affected the outcome of this study was the amount of school cancelled due to snow days and extracurricular activities. This decreased the number of instructional days during the time in which the study was taking place by approximately half. This could have affected the amount of knowledge gained and retained by students. Finally, it would be beneficial if pre- and post-test measures that were used in similar studies were available so that reliability and validity of the study could be increased. Considering the relevance and benefit of this study to special education teachers and students, it would be advantageous to replicate this study using a larger and randomly selected sample size, more reliable and valid measures, and a control group that is also a special education population. Also, there is a possibility that the results of this study may generalize to other subjects as well as to general education students which could also be considerations for further research.

Conclusion

Graphic organizers are visual-spatial displays that provide students with a framework so they are better able to relate new knowledge to previously learned information (Kim, Vaughn, Wanzek, & Wei, 2004). This study looked at the effectiveness of using graphic organizers to teach special education students conceptual scientific knowledge and found that there was a significant difference between the pre-and post-test measures, indicating that this method of teaching is beneficial for this population. Although further research needs to be conducted in this area, this study opens up the possibility that using graphic organizers may be the most beneficial way to teach students in special education classrooms.

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Appendix

Name: ________________________ **Class:** ___________________ **Date:** __________ **ID: A**

Pre-Post Test

Multiple Choice
Identify the choice that best completes the statement or answers the question.

1. The smallest units of life in all living things are
   a. cells. **c.** cytoplasm.
   b. mitochondria. **d.** Golgi apparatus.
2. One difference between prokaryotes and eukaryotes is that
   a. nucleic acids are found only in prokaryotes.
   b. mitochondria are found in larger quantities in eukaryotes.
   c. the Golgi apparatus is found only in prokaryotes.
   d. prokaryotes have no nuclear membrane.
3. Which of the following is an example of a prokaryotic cell?
   a. an amoeba **c.** a bacterium
   b. a virus **d.** a liver cell
4. Plasma membranes
   a. are part of only a small number of cells.
   b. contain genes.
   c. are made of DNA.
   d. are thin coverings that surround cells.
5. The structure that regulates what enters and leaves the cell is called the
   a. nucleus. **c.** nuclear membrane.
   b. cell wall. **d.** plasma membrane.
6. The plasma membrane
   a. encloses the contents of a cell.
   b. allows material to enter and leave the cell.
   c. is selectively permeable.
   d. All of the above
7. Plant cells have a large membrane-bound space in which water, waste products, and nutrients are stored. This place is known as a
   a. mitochondrion. **c.** Golgi apparatus.
   b. chloroplast. **d.** central vacuole.

Completion
Complete each statement.

8. Eukaryotic cells are much larger and have more specialized functions than prokaryotic cells because they contain ____________________, which carry out specialized activities.
9. A cell with a well-defined nucleus and cytoplasm surrounded by a plasma membrane is a(n) ____________________ cell.
10. ____________________ molecules have “heads” and “tails” and are found in the plasma membrane.
11. Photosynthesis takes place in the ____________________ of plant cells.

Name: ________________________ **ID: A**

12. Matthias Schleiden worked with ____________________ cells, and Theodor Schwann worked with ____________________ cells.

13. Some plants produce a _________________________ between the plasma membrane and the primary cell wall.

Short Answer

Write the answer in each blank below.

14. What are the three essential parts of the Cell Theory?

15. What is a Prokaryotic cell?

16. What are the three additional structures that are in plant cells?

17. What are the two types of endoplasmic reticulum?

18. What is nucleus?

19. What is the function of the mitochondria?

Name: ______________________ **ID: A**

Matching

Write correct letters in blanks. There may be more than one letter used in each blank; letters can be used more than once.

20. ______________ Plasma Membrane
21. ______________ Chromosomes
22. ______________ Central Vacuoles
23. ______________ Cell Wall
24. ______________ Nuclear Envelope
25. ______________ Nucleolus

A. Animal Cell

B. Plant Cell

C. Made of DNA and protein

D. Acts as a barrier around the cell.

E. Making of ribosomal RNA

F. Fluid filled organelle

G. Double Membrane

H. Rigid layer outside the plasma membrane