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THE EFFECTIVENESS OF CONCEPT MAPS ON SCIENCE LEARNING IN MIDDLE SCHOOL: A REVIEW OF LITERATURE

By

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B.Ed., University of Buea, 2015

A Research Paper
Submitted in Partial Fulfillment of the Requirements for the
Master of Science in Education

Department of Counselling, Quantitative Methods, and Special Education
in the Graduate School
Southern Illinois University Carbondale

August 2019

RESEARCH PAPER APPROVAL

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By

Clare Nangsin Wirngo

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Fulfillment of the Requirements

for the Degree of

Master of Science in Education

in the field of Special Education

Approved by:

Dr. Dimitris Anastasiou

Graduate School
Southern Illinois University Carbondale
August 2019

AN ABSTRACT OF THE RESEARCH PAPER OF

Clare Nangsin Wirngo, for the Master of Science in Education degree in Special Education, presented on May 08, 2019, at Southern Illinois University Carbondale.

TITLE: THE EFFECTIVENESS OF CONCEPT MAPS ON SCIENCE LEARNING IN MIDDLE SCHOOL: A REVIEW OF LITERATURE

MAJOR PROFESSOR: Dr. Dimitris Anastasiou

Concept mapping is both teaching and learning strategy that involves the use of graphics and text to enhance science vocabulary development and reading comprehension. It is a type of graphic organizer that structures information in hierarchical order, connected by links. This study is a systematic review of the literature on the effectiveness of concept maps on science learning among middle school students. Little research has focused on concept mapping at the middle school level with no systematic review of concept maps in the middle school setting for students with and without learning disabilities (LD). A systematic search located 1080 studies about concept maps published in English and in peer-reviewed journals between 1990 and 2018. Eight studies published between 2000 and 2017 met the inclusion criteria in this review. These studies provided some evidence that concept maps can be an effective tool to improve the performance of middle school students in general education science classrooms. Seven studies included low-achieving students without providing information whether students with LD were included. However, only one single-subject design study focused on students with LD and none with evidence-based practices. More empirical studies on the effectiveness of concept maps are needed to advance our knowledge about research-based practices for middle school students with and without LD.

Keywords: concept map, vocabulary development, reading comprehension, low achieving, learning disabilities, middle school.

ACKNOWLEDGMENTS

I cannot claim the monopoly of coming up with this piece. It was the collaboration, guidance, and assistance from the Special Education Program that I made it. I really want to appreciate everyone who supported me directly and indirectly. First, my immense gratitude goes to my advisor, Dr. Anastasiou who did not leave any stone unturned to see me go through this work. He has shown me by example, what a good researcher and special educator should be.

I am grateful to all of those with whom I have had the pleasure to work with during my study. Each of the members of my Committee has been very instrumental. Professor John McIntyre provided me extensive personal and professional guidance. I would especially like to thank Professor Deborah Bruns. She taught me a great deal about both scientific research and life in general. As a teacher and mentor, she has taught me more than I could ever give her credit for here.

Without any reservations, my sincere thanks go to my family and friends. I will always remain indebted to you for words cannot explain. Above all, I thank God for always watching over me at every step I make.

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CHAPTER 1

INTRODUCTION

Educators in schools may experience challenges meeting the unique needs of students with learning disabilities (LD). The challenges become critical when a student has a reading disability. The hurdles students with LD face may be the outcome of inadequate word recognition, language comprehension, memory retention, retrieval analysis and/or production of spoken words (Lo, Anderson, & Bunch-Crump, 2017). Ineffective word learning, and limited instances of independent reading may negatively impact vocabulary learning and reading comprehension for students with LD (Jitendra, Edwards, Sacks, & Jacobson, 2004). Students with disabilities may have a greater likelihood to struggle to retrieve new information in content area classes due to the demands of note taking, active participation, and possibly memory issues (Miller, 2016).

Concept maps are a type of graphic organizers whose aim is to facilitate learning among diverse learners. More specifically, concept maps can be cognitive maps, semantic networks or visual graphic organizers that make use of figures, lines, arrows, and spatial configurations to illustrate or manipulate a complex set of relationships in a diagram (Davies, 2010; Guastello, Beasley, & Sinatra, 2000). Concept maps demonstrate how content and ideas are related and are an instructional strategy used to classify information into a graphic form, to create a visual representation of the text structure and associated personal knowledge (Kwon & Cifuentes 2007; Sturm & Rankin-Erickson, 2002). In other words, concept mapping is a concise knowledge representation tool for learners to connect their previous knowledge to new information (Marzetta, Mason, & Wee, 2018).

Novak and Cañas (2008) explain that concept maps are a specific kind of graphic organizers characterized by prepositional structures (semantic units), hierarchically arranged and connected by lines or links. Specifically, concepts are often represented in nodes or boxes with a specific label, while the relationship between two concepts is shown with a connecting line. The line can have linking words, phrases, or prepositions (Mok, Whitehill, & Dodd, 2013; Novak & Cañas, 2006; Yin, Vanides, Ruiz-Primo, Ayala, & Shavelson, 2005). The concepts in a concept map are organized in a hierarchical order with the main concept at the center or at the top of the map depending on the content of information that need to be displayed (Novak & Cañas, 2006, 2008). Then, more specific concepts follow below or surrounds the main concept. Relationship between concepts is shown by cross-links between different segments of the concept map (Novak & Cañas, 2008; see Figure 1).

Concept maps can be hand-drawn or computer-generated. Both serve as a promising method to promote learning science vocabulary development and reading comprehension among middle school students with and without LD (Flanagan & Bouck, 2015; Morfidi, Mikropoulos, & Rogdaki, 2017). Computer generated concept maps are viewed as more time efficient and can increase content acquisition for students with and without LD (Ciullo, Falcomata, Pfannenstiel, & Billingsley, 2015). Moreover, Sturm and Rankin-Erickson (2002) suggested using hand-drawn and computer-generated concept mapping for middle school students as prewriting technique can improve several aspects of their writing such as narrating and providing details that may support claims in writing.

It has been theorized that creating or developing concept mapping activities can be beneficial for students. Students are more likely to understand and remember relationships through the mapping process and analysis of their components (Karpicke & Blunt, 2011; Novak

& Cañas 2008; Rewey, Dansereau, Skaggs, Hall, & Pitre, 1989). Concept maps can provide diverse learners different outlets to express their previous knowledge to new information they meet; for example, students can develop their vocabulary and comprehension skills by actively identifying key ideas in new content and relating it to specific details (Carnine & Carnine, 2004; Marzetta, Mason, & Wee, 2018).

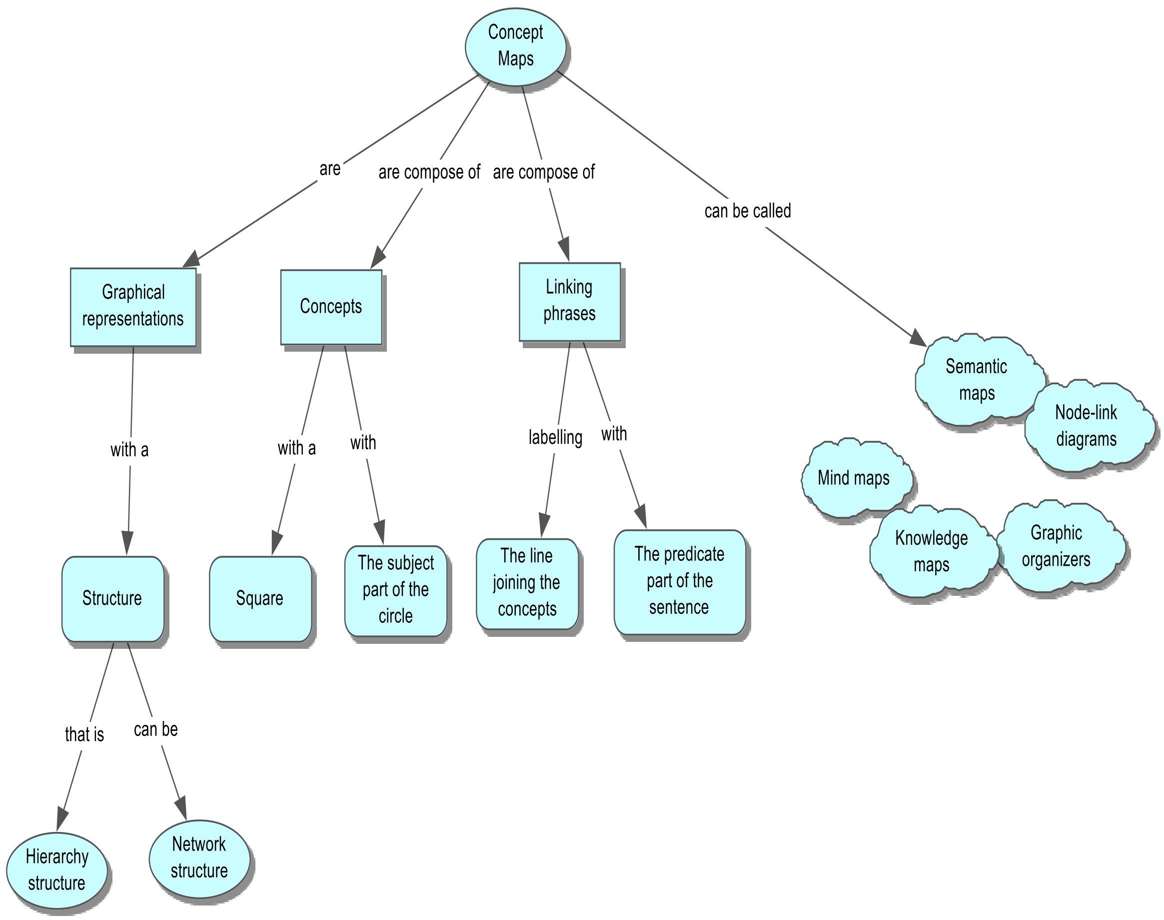

Figure 1. A Concept Map of Concept Map Definition

Moreover, Kinchin, Hay, and Adams (2000) emphasized concepts maps are meta-cognitive tools that can harmonize new material within students' existing cognitive structures. Thus, concept maps can be used to involve learners in a set of mental activities or cognitive processes that can assist them to manipulate and transform new information into knowledge by using their previous knowledge and experiences. For instance, in teaching text on soil formation, the student may have knowledge that soil is formed from decomposition of death plants and animals. Incorporating new information like soil is formed from weathering of rocks will require learners to think elaborately and relate the information to their previous knowledge about soils (Elorriaga, Arruarte, Calvo, Larranaga, Rueda, & Herran, 2013).

Wei and Yue (2017) proposed that concept maps are an easy to learn tool, to construct, and represent knowledge. Concept maps are useful in gaining skills to relate, organize, and structure concepts (Marzetta et al., 2018). Pictures and diagrams are believed to be easier to comprehend than connecting text and as such they can help in illustrating complex ideas for students with LD (Miller, 2016). Most important information can be represented by linking words or phrases that define their relationship and comprehension structures (Carifio and Perla (2009). Thus, students can manipulate a complex set of relationships through plain diagrams rather than connecting text to augment their understanding of content (Davis, 2010). This, in turn encourages reading, which is a fundamental skill throughout a student's education (Riahi & Pourdana, 2017). Finally, concept mapping provides organizational cues for retrieving information and concepts from memory by providing a visual depiction of the interrelationships between concepts (Kwon & Cifuentes, 2007).

Small group, peer-assisted learning, and several forms of classroom setting like a co-taught class, special education class, or resource room can enhance the development and utilization of concept maps (Mason & Hedi, 2011). Teachers can use concept maps to increase vocabulary and facilitate text comprehension in content areas, which are critical skills for students with LD (Alturki, 2017; Davis, 2010). Teachers are advised to consider the need for explicit and systematic reading instruction because students with LD, even when they have similar background knowledge with their peers without LD, they fail to instinctively use the information when reading passages for the purpose of comprehension (Ferreira & Zygouris-Coe, 2013).

The adaptive and diverse nature of concept maps supports a variety of learners with diverse learning needs. Concept mapping can be an instructional strategy to advance vocabulary and comprehension in middle school science settings (Asan, 2007; Ferreira & Zygouris-Coe, 2013). When concept maps are shared in class through interactive wall words, students can identify related items, understanding their connections and become more self-sufficient during classroom activities rather than asking the teacher (Jackson, 2013). This can enhance meaningful learning for students with LD.

Meaningful learning occurs when new knowledge is created or assimilated into the existing interconnected knowledge structure through cognitive elaboration; that is, the desire to recognize and understand, to master information, to articulate and address challenges in the context of learning (Schroeder, Nesbit, Anguiano, & Adesope, 2018).

Concept mapping has been linked to cognitive theory of *meaningful learning*; a theory formulated by David P. Ausubel (1968). Ausubel differentiated between *meaningful learning*, that is, learning by relating new knowledge to what is already known, and *rote learning*. He explained that if the learner's intention is to memorize concepts, words, or phrases, the learning process and outcome may be meaningless or rote. When the learner's intention is meaningful learning, it is fundamentally related to his or her cognitive structures (Ausubel, 1968). Specifically, Ausubel (1968) considered that the essence of meaningful learning is to symbolically express ideas related in a nonarbitrary and substantive fashion to what a student already knows (cognitive structure), and it should be relevant and related to the new idea. A cognitive structure is a human mechanism for acquiring and storing huge quantity of ideas and information represented in any field of knowledge like middle school science. That is, how learners existing knowledge in content is organized. Middle school students with and without disabilities learning science have cognitive capacities such as symbolic representation, abstraction, categorization, and generalization (Ausubel 1968).

Meaningful learning can be acquired through concept mapping (Hu & Wu, 2012). Novak (2010), following Ausubel's theory, maintained that knowledge is retained over time when it is acquired meaningfully, and it serves as a base for future learning that can be used in reflective thinking and addressing new problems. Middle school science students may benefit from implementing and practicing these skills through concept mapping which enhances later acquisition of more detailed, relatable information and ideas represented in a hierarchical and graphical structure (Ausubel 1968).

Cognitive load theory has also been used to explain the functioning of concept mapping. According to cognitive load theory (CLT), there is limited working memory which interacts with an unlimited long-term memory. The limitations of working memory can be circumvented by coding multiple elements of information in organized cognitive schemata that help in reducing cognitive load, which is especially useful for students with learning difficulties (Kirschner, 2002; Sweller, 1994). Schema is a cognitive structure that organizes elements of information in a manner with which a student can handle. The use of concept mapping can lead to low cognitive load for students in science classrooms (Amadieu et al., 2009; Rivet & Krajcik, 2007). This is because the hierarchical, organized and student-friendly format of concept maps facilitate students to develop and use their schemas in science information content. Hierarchical concept maps provide a high degree of structure and may facilitate students' orientation in organizing material, which may facilitate navigation and reducing cognitive load associated with reading through text (Amadieu et al., 2009).

Concept maps effectiveness has been exploited in areas like reading, writing, social studies, science, math, and arts at various educational levels (high school, college, and university) (Davis, 2010; Hu & Wu, 2012). On the contrary, more is left to be done regarding the effectiveness of concept maps at middle school science for students with and without LD. There are no systematic reviews, syntheses or meta-analyses studies on concept maps for this educational level that address science content for middle school students with and without LD. Those found were more general and did not focus on middle school science.

Concept mapping may be an essential strategy to improve the science learning of middle school students. As a result, this study will examine the impact and implications concept maps can make on science instruction for vocabulary development and reading comprehension texts of middle school students. Although there is no evidence-based practice research on the effectiveness of concept maps on science learning, this literature will summarize findings of concept mapping effects for science content in middle school. The next chapter gives a detailed description of the methodology.

Research questions:

(1) To what extent do concept maps affect science learning of students with and without LD in the middle school?

(2) What are the characteristics of concept mapping methods that enhance science learning?

CHAPTER 2

METHODOLOGY

Literature Search Procedure

The search approach followed by Schlosser, Balandin, Hemsley, Iacono, Probst, and von Tetzchner (2014) was used to select relevant studies. The aim was to include individual studies with a single-subject design, quantitative, or mixed methods design, systematic reviews, and meta-analysis relating directly to concept maps effects and published in English peer-reviewed literature, based on electronic database search, ancestry search, and individual journals.

The database search was based on identifying literature on the use of concept maps to improve science vocabulary and reading comprehension of middle school students with and without LD. This included databases in *Morris Library ONESEARCH*: EBSCO, ERIC, PsychInfo, Academic Search Complete, JSTOR and Science Direct.

The primary search term was "concept map*", secondary term was "vocabulary or reading comp*", tertiary search term was "science", and quaternary search term was "middle school." This strategy resulted into the identification of materials that included these phrases in the title abstract, or text regardless of how a database choose to index the entry, published between 1990 and 2018 (Schlosser, Wendt, Angermeier, & Shetty, 2005). The search yielded 1,080 studies published in a variety of journals, after 608 duplicates were removed.

In the selection phase, I read the title and abstract of the 1,080 studies found in the search. If the abstract did not provide adequate information that could exclude the study from the selection criteria, I skimmed the methods, procedures, and data collection parts of the article. Selection criteria, according to the inclusion checklist of Schlosser et al. (2014), were applied.

Studies identified as not meeting the selection criteria (see p. 10) were eliminated. This yielded 117 studies.

The second step of the selection phase included meeting three additional criteria: empirical studies that focus on science, concept maps effectiveness and are peer reviewed. A total of 28 articles were identified published in the following journals: *Journal of Special Education, Journal of Learning Disability, Journal of Educational Technology and Society, Exceptional Children, Focus on Exceptional Children, Intervention in School and Clinic, Learning Disability Research and Practice, Remedial and Special Education, Reading and Writing Quarterly, Journal of Education and Information Technologies, Learning Disability Research and Practice, Behavior Modification Journal, Linguistic Journal, Preventing School Failure, Contemporary Educational Psychology, Behavioral Disorders Journal, and School Science and Mathematics*. Of the 28 articles, seven (7) investigated the impact of concept maps on science vocabulary development in middle school students with and without LD. The remaining studies failed to meet one or more of the selection criteria.

Next, an ancestry search was completed. The reference list of the identified articles was reviewed for additional studies relevant to the search. One study was found from the ancestry search. Thus, increasing the number of studies to eight (8). Figure 2 depicts the search and screening process.

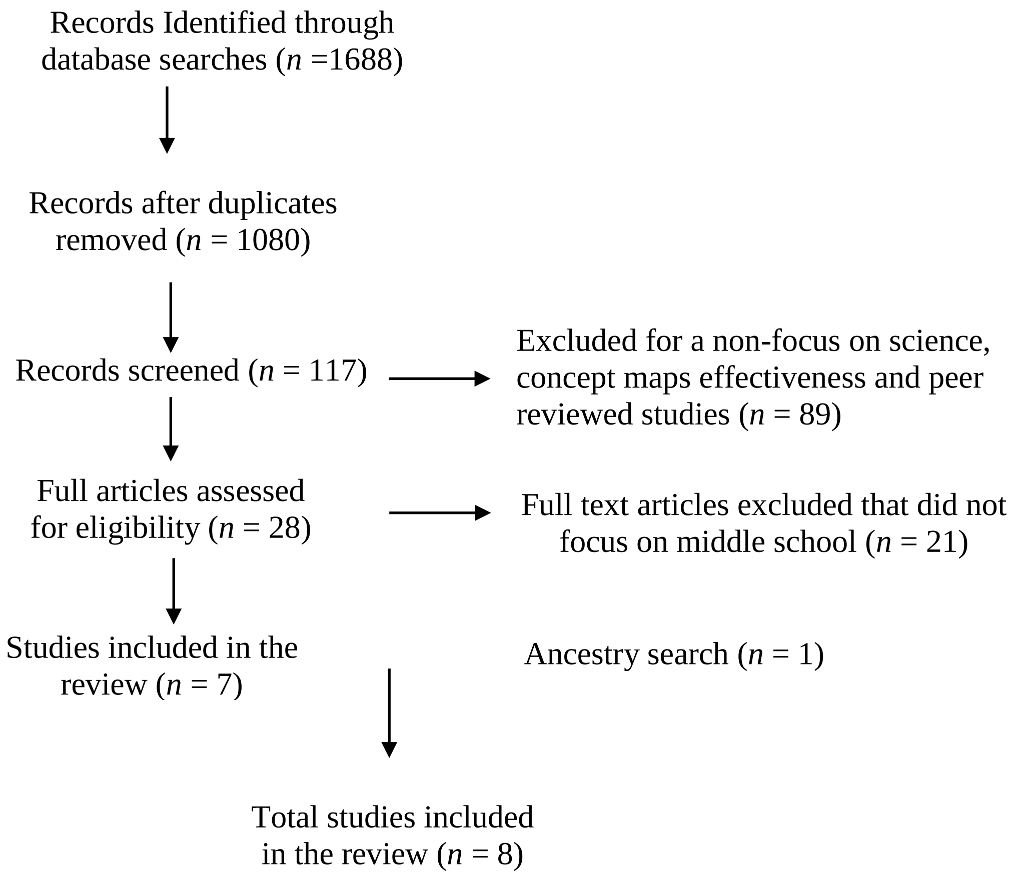

Figure 2. Flowchart of included studies.

Selecting studies and criteria for inclusion

To determine the appropriateness of an article, studies located in the aforementioned scientific databases were evaluated. In the first step of the selection process and/or determining the appropriateness, I applied the inclusion checklist of Schlosser et al. (2014). A paper was excluded if:

1. It is not related to the terms concept map/concept mapping, vocabulary, science, reading or reading comprehension.
2. If it was not peer-reviewed
3. It was not in English

4. If the participants were not in middle school (5th to 8th grade).
5. If the study was not published between 1990 to 2018.

In the second step of the selection process, I examined whether (a) the study explicitly addressed concept maps effectiveness, and (b) was peer reviewed. All articles that met the criteria above were analyzed, according to their methods of evaluating the effects of concept maps.

Level one papers contained experimental and quasi-experimental studies with low-achieving students with and without LD. Pretest and post testing were used to empirically establish the effects of concepts maps on students' science vocabulary development and reading comprehension.

Level two papers contained experimental and quasi-experimental studies in the general education classroom, without giving information whether including low-achieving students or students with LD.

Level three papers contained single-subject design studies, including students with LD.

Coding criteria

Studies were coded based on participants' characteristics of grade level, performance level science content area, geographical region, research design, and outcomes related to science vocabulary development and comprehension of science text. The reviewed studies emphasized middle school students (from grade 5 to grade 8) with and without LD and those identified as low achieving students. Also, the review focused on concept maps as a strategy to enhance science content area in middle schools.

CHAPTER 3

LITERATURE REVIEW

Eight studies met the criteria to be included in the current literature review. The studies were seven group-subject designs (experimental design and quasi-experimental design) and one study with single-subject design. The meta-analyses found did not focus on the effects of concept maps on science and middle school students.

Table 1. Level One Studies: Experimental and Quasi Experimental Studies with Low-Achieving Middle School Students

Author Name/Date	Participants/ Country	Grade level	Type of study	Intervention Description/Duration	Findings
1. Guastello et al. (2000)	124 - Experimental: *n* = 62 - Control: *n* = 62 - *Low Achieving Students*: Participants scored below grade level on the Comprehensive Assessment Program (CAP) and criterion-referenced tests State/Country: New York, USA	7th	Experimental (experimental and control group)	• Participants were taught the circulatory system in randomly assigned groups, a) experimental group (mapping), and b) control group (traditional read and discuss) • Both groups were given introductory lessons and a test that measured reading, and basic skills before the experiment. Intervention period: four (4) 50 mins sessions per week for 8 school days.	• Both groups scored similar at the pretest scores on science achievement test. Control group had a mean score of 5.83 and the experimental group had mean score of 5.86. • At posttest the scores were significantly correlated to posttest. An analysis of covariance (ANCOVA) was carried with pretest science comprehension scores as a covariate, F (1, 121) = 1,261.56, p <.0001 in favor of the experimental group. Concept map treatment **effect size was 5.98** indicating an improvement in science comprehension scores.
2. Morfidi et al. (2017)	30 - Experimental 1 (digital text-based concept maps): *n* = 10 - Experimental 2 multimedia concept maps: *n* = 10 - Control: *n* = 10	5th	Experimental (pre- and post- test design)	• Two experimental groups were taught with the use of (a) digital text-based concept maps and (b) multimedia concept maps. • The study included a control group that received a traditional teaching method.	• Both concept mapping approaches produced statistically significant changes in the children's scores compared to the traditional teaching method both before and after instruction design. • No significant differences found between the two concept map methods. • The highest effect size of the traditional method was r^2 = 0.24. Total r^2 = 0.11. • The effect sizes of *digital text-based concept mapping* were r^2 = 0.83 (for

	- Poor Readers: Participants scored below average in reading comprehension and cloze reading task; the three groups were matched on age gender and reading ability. Country: Greece			• Intervention period: Three sessions of 45 min. each.	Rain), r^2 = 0.75 (for Earthquakes) and r^2 = 0.87 (for Solar Radiation). **Total r^2 = 0.86.** • The effect sizes of *multimedia concept mapping* were r^2 = 0.68, 0.70 0.74 respectively. **Total r^2 = 0.82.**

Table 2. Level Two Studies: Experimental and Quasi Experimental Studies with Students in the General Education Classroom

Author Name/Date	Participants/ Country	Grade level	Type of study	Intervention Description/Duration	Findings
3. Hsieh and Cifuetes (2006)	92 - Experimental 1 Vis-paper: $n = 30$ - Experimental 2 Vis-computer: $n = 34$ - Control: $n = 28$ - Students in the General Education Class: Participants were eight grade science students at a regular public junior high school. State/Country: Texas, USA	8th	Mixed method (Focused on quantitative strand here)	• Two experimental groups and one control group were compared to visualization/paper group, and visualization/computer group at posttest. • Groups studied essays on a) Energy b) Cells, c) Homeostasis d) Coordination, and e) Transport in plants and animals. • Intervention period: 25mins instruction	• Visualization/computer group mean score was $M = 51.68$, visualization/paper group scored $M = 54.95$, and the control had a mean score of $M = 39.38$. • Visualization/paper group (**effect size *d* = 1.51**) and visualization/computer (***d* = 1.20**) group scored higher on comprehension posttest than the control group. • There were no statistically significant differences between the scores of the treatment groups.

				a day for four days with the respective groups.	
4. Abi-El-Mona & Adb-El-Khalick (2008)	62 - Experimental: *n*= 31 - Control: *n* = 31 - Students in the General Education Class: Participants were 8 grade science students in four intact sections. Country: private American School in a Middle Eastern country Language of Instruction: English	8th	Experimental: participants were randomly chosen and assigned to experimental and comparison group.	• Two groups: the experimental group was trained to use mind mapping and the comparison group was trained to use note summarization. ▪ Control: four weeks, given 10 minutes at the end of each session to note summarization ▪ Intervention period: Experimental: four weeks, while working on a unit on hereditary traits, students were given 10 minutes at the end of each session to build mind maps.	• The experimental group (M_E) made significant gains on all target categories, that is conceptual understanding and practical reasoning levels of achievement than the comparison group (M_C): ▪ Conceptual understanding (M_{exp} = 72.90, M_{comp} =57.53, $p < .001$); ▪ Practical reasoning (M_{exp} = 76.31, M_{comp} = 61.00, $p < .001$).

5. Asan (2007)	23 - Experimental: *n*= 13 - Control: *n* = 10 - Students in the General Education Class Country: Turkey	5th	Quasi-experimental: pre and posttest design	• The experimental and control group had the same instruction unit on heat and temperature. • Control group had traditional oral review of material while experimental group used inspiration concept mapping tool. • Intervention period: 90 mins each day for five days of class period.	• The two groups did not statistically differ in their pre-test scores on a multiple-choice test of concepts of heat and temperature (M = 65.00 for both groups) • The experimental group performed statistically significant higher at posttest (M = 83.08) compared their pretest scores (t = -5.598, p < 0.001). • The control group did not perform statistically significant higher at posttest (M = 67.00, p = .522). • The correlation between maps scores and map related multiple choice items were generally high indicating that concept map scores signals is an evident of student's knowledge of content acquired during instruction.
6. Ferreira and Zygouris-Coe (2013)	28 - Experimental: *n* = 12 -Control: *n* =16 - Students in the General Education Science Class State/Country: Florida, USA	7th 12 years old	Quasi-experiment design	• Treatment group and control group received pretest from a science related vocabulary book (chapter 20: Natural resources) and randomly nominated in one of the two groups. • Treatment group received concept mapping instructions for 3 weeks before taking the post test.	• The posttest content was about fossil fuel from the science text book. • Using ANCOVA statistical analysis, the mean score of the posttest for the experimental group was M = 51.33; for the control group was M = 38.43. • The experimental group scored marginally significantly higher (p = 0.067) than the control group.

				• Intervention period: 3 weeks	
7. Merchie and Keer (2016)	644 students - Experimental 1 (RPMM): *N* = 212 - Experimental 2: *N* = 219 - Control: 213 - Students in the General Education Science Class from 17 schools (implemented by 14 teachers) Country: Flemish-speaking part of Belgium	5^{th} and 6^{th}	Quasi-experimental, Pre-test and posttest design, schools' randomization	• Two experimental groups compared with a control group receiving traditional classroom curriculum. • Researcher-generated mind maps (RPMM) versus student-generated mind maps (SGMM) compared for students' independent cognitive and metacognitive text strategy. • The intervention was implemented by teachers with an average teaching experience of 13.7 years • Intervention period:10 successive weeks with 10 lessons of 50 min. each.	• Effects on paraphrasing, re-reading, summarizing and schematizing subscales, measured by a self-reported strategy. • Two post phases: - posttest P1 = phase 1; - retention test P2 = phase 2 • Treatment fidelity was measured. • During Phase 1, the experimental groups reported less significant paraphrasing activities ($\chi^2_{RPMM} = 15.03$, $df = 1$, $p <.001$; $\chi^2_{SGMM} = 19.82$, $df = 1$, $p <.001$). The control group reported significant use of paraphrasing activities. ($\chi^2 = 8.55$, $df = 1$, $p =.003$). • Control group scored significantly more on summarizing and schematizing activities ($\chi^2 = 11.30$, $df = 1$, $p <.001$), though significantly less in relating previous knowledge to the topic. • At phase two, control group subscale scores significantly declined ($\chi^2 = 4.63$, $df = 1$, $p =.034$). Even though the control group was significantly engaged in scratch paper use at posttest, both experimental groups engage significantly more in active knowledge transformation from posttest to retention test ($\chi^2_{RPMM} = 4.303$, $df = 1$, $p <.038$; $\chi^2_{SGMM} = 13.094$, $df = 1$, $p <.001$).

Table 3. Level Three Studies: Single-Subject Studies with Students with LD

Author Name/Date	**Participants/ Country**	**Grade level**	**Type of study**	**Intervention Description/Duration**	**Findings**
8. Ciullo et al. (2015)	4 **- Students with LD:** Learning Disability (*n* = 3). Intellectual Disability (*n* = 1) Country: Texas, USA	4th and 5th	Single-subject design (multiple baseline across subjects)	• Concept map instruction was compared with a traditional instruction at baseline for its efficacy at improving learning informational text for four students with learning disability. • special educator's resource room. • Each student received identical instruction at the baseline and intervention phases. • Duration: Baseline was three days a week consisting of 40 mins lesson followed by a quiz. And same for the intervention across participants.	• Students scored lower at baseline where they received traditional instruction. • With the introduction of an intervention (concept mapping), students observed consistent increase from baseline to intervention. All participants preferred the concept map to traditional instructions. Computer-based concept mapping was effective at increasing content acquisition in four individuals with disabilities. • Baseline (M) Post-Intervention (M) Salvado 36.7% 68.3% Diego 60% 88.3% Mateo 15% 68.9% Julio 36.3% 91.3%

Studies included in this review examined ways of using concept maps to enhance the understanding of materials and content specific information in science disciplines. The studies focused on the impact of concept mapping on science vocabulary development and reading comprehension of middle school students with and without LD. Of the eight studies included in this review, seven involved experimental or quasi-experimental design in which treatment was compared with a control group and one study with a single-subject design. Three studies (two studies with low-achieving students and one study with students in the general education classroom) examined effect sizes, which were found to be large. In the following sections of the chapter, I will describe the findings in greater detail.

The Effectiveness on Concept Maps on Science Learning

Guastello et al. (2000) used concept mapping to teach low-achieving middle school students about the human circulatory system to represent patterns to form schemata of how to organize information graphically displaying relationships with each other. Low-achieving students showed improvement in their science vocabulary development and reading comprehension skills with an effect size of 5.98. Morfidi et al. (2017) used digital text-based concept maps and multimedia concept maps to teach expository text to poor readers, that is, students having difficulties understanding new material. Students in the treatment group recorded significant improvement in their scores with high average effect size ($r^2 = 0.83$). Guastello et al. (2000) and Morfidi et al. (2017) are two of the three studies in this review with effect sizes and focused on low-achieving students at the middle school level. Findings from both studies reported a significant improvement in the performance of students in treatment groups, that is, students that used concept mapping.

In a post-test-only- group control design, Hsieh and Cifuetes (2006) trained a group of students (*n* = 30) in a general education classroom to generate a concept map using science comprehension essay through visualization on paper and another (*n* = 34) on a computer. Two classes were randomly assigned to be the control group and other two classes served as the treatment group. It was not clarified whether some students had IEPs or not. At posttest, the treatment groups (visualization/paper and visualization/computer) performed significantly better than the control group, with large effect sizes (d = 1.51 for the visualization/paper approach and d =1.20 for the visualization/computer approach). It is noted here that an effect size $\geq$ 0.8 is considered large. Thus, results indicated that students in both treatment groups outperformed students in the control condition.

In Merchie and Keer's (2016) study, 212 students in a general education science class formed the experimental groups. These students were trained using concept maps to spontaneously develop a deep level text-based knowledge acquisition of overt information. Ensuring understanding and mastery of concepts at any level of instruction or content area with the aid of concept maps. Students in the control group improved their performance on the paraphrasing, summarizing, and schematizing skills compared to 219 students in the control group. This was also the only study that *treatment fidelity* was measured which indicates some traits of validity.

In Asan's (2007) study, concept mapping was shown to improve vocabulary knowledge middle school students in a general education class including low-achieving students and produced statistically significant improvements when learning novel science vocabulary words. Both studies used a quasi-experimental design to generate their findings from students in general education science classrooms (Asan, 2007; Merchie & Keer, 2016).

Two additional studies reiterated the potential benefits of concept maps. Abi-El-Mona and Adb-El-Khalick (2008) assessed the impact of concept maps as a learning tool on 8^{th} grade students' science achievement. Students in the general education classroom including low-achieving students who used mind maps scored significantly higher than the control group. The authors claimed that mind mapping can encourage learning as manifested by growth across all target categories of students and their performance. Similarly, in a quasi-experimental study, Ferreira and Zygouris-Coe (2013) used a pre- and post-test comparison to identify changes in the performance of the experimental group, comparing the effectiveness of concept maps to a traditional approach of learning natural science vocabulary. Although not defined, it can be inferred that the traditional approach here was based on memorizing material rather than drawing a relationship between new material and what students already know. They found that using concept maps increased vocabulary acquisition for middle school students in a general education science classroom. Participants were randomly assigned to the treatment groups and control groups. Although only Ferreira and Zygouris-Coe used a pre and posttest, findings from these two studies suggest that concept maps account for improvement in performance of treatment groups. Thus, concept maps may support and promote science vocabulary development and reading comprehension skills of students in general education classrooms including low-achieving students.

Of the studies reviewed, only Ciullo et al. (2015) focused on students with LD. In a single-subject design study, the authors compared two instructional methods for improving learning of informational text for students with LD and found that concept maps activities were effective in improving science content acquisition (healthy foods) for four students with Individualized Education Plan (IEP) for reading comprehension. One if the student had an intellectual disability and the rest had LD in reading. Their findings suggest, similar to other studies reviewed here, that concept maps may be a beneficial teaching strategy to improve science vocabulary development and reading comprehension of middle school students receiving special education.

These studies highlighted the positive impact of concept maps on science vocabulary development and reading comprehension of students across science disciplines. For instance, studying of vocabulary words in natural science, providing details of the processes in plant transport as well as coordination in human circulatory system. However, all studies except one did not clearly state if participants included learners with LD but refer to participants as "low achieving (Guastello et al., 2000), poor readers (Morfidi et al., 2017), and science students (Ferreira and Zygouris-Coe, 2013; Merchie & Keer ,2016). Overall, concept maps seem to be a promising tool in developing science vocabulary and text comprehension that if exploited and implemented in middle school science classrooms, students with and without LD may benefit more from the method. Although only three studies with low achieving students and one with LD were identified, the consistently positive findings in this review show that concept maps may be an effective tool for a diverse group of students with varying learning needs. Further analysis and evaluation are required to examine ways that concept maps can be adapted to suit the needs of learners with LD.

Characteristics of Concept Mapping that Enhance Science Learning

Morfidi et al. (2017) indicated that concept maps, whether hand-drawn or computer generated, can improve vocabulary and reading comprehension skills of middle school students. That is, computer generated concept maps were found to be effective at improving the performance of low-achieving students (Morfidi et al., 2017). Studies have found that many students prefer computer generated concept map activities to hand-drawn mapping (Ciulo et al., 2015). Some authors describe how students with and without LD created a visual representation of concepts by using *Inspiration software* to connect concepts (Asan, 2007; Ciullo et al., 2014). Concept map activities that contain attractive picture illustration has the potential to capture the attention of students and keep them on task. Thus, it may increase their vocabulary building and reading comprehension skills.

Merchie and Keer (2016) as well as Morfidi et al. (2017) found that students who construct concept maps tended to perform better than those who studied constructed maps. When students create concept maps, they are engaged in cognitive activities that boost their memory. In the process of deciding how to spatially distribute the nodes and links, higher levels of processing are involved. On the contrary, when students study concept maps, they observe a series of noun-verb-noun relationship without contextual details.

Quite often students may not link content to their past experiences. Students engaged in constructing knowledge maps are likely to explicitly identify concepts and their relationships and not become passive learners (Merchie & Keer, 2016; Morfidi et al., 2017). Providing students with an opportunity to freely express their thoughts in an organizational structure can enhance meaningful learning. Summarily, it is essential for students to use concept maps as a model of presenting text for easy comprehension (Asan, 2007; Merchie & Keer, 2016).

CHAPTER 4

DISCUSSION

Peer reviewed studies addressing the effectiveness and the utilization of concept maps as a tool to improve science vocabulary development and reading comprehension of students with and without LD in the middle school across several countries (e.g., the USA, Belgium, Greece, and Turkey) were examined. This review focused on effectiveness of concept maps science learning in middle schools. I identified studies published between 2000 and 2017. In each study, concept mapping was used as a learning tool on science vocabulary development and reading comprehension. Eight studies met the inclusion criteria for this review and were analyzed. These included seven studies with experimental and quasi-experimental designs, and one single subject design study with multiple baselines across subjects.

Studies suggested that concept mapping may contribute positively to learning and may be used to improve the science vocabulary development and reading comprehension of students in the middle school. The subject matter that unifies the reviewed studies is the results they provide maintaining that concept mapping is a promising teaching strategy to enhance learning (Guastello et al., 2000; Morfidi et al., 2017).

Ferreira and Zygouris-Coe (2013), as well as Abi-El-Mona and Adb-El-Khalick (2008), found that concept maps are effective when applied to science vocabulary. Teachers' illustration of concept maps can help student to construct graphic representation of the text and read independently especially low-achieving students (Guastello et al., 2000). Perhaps, middle school low-achieving students benefit from content-area vocabulary words when concept maps are used as a learning tool (Fore, Boon, & Lowrie, 2007; Tzeng, 2010).

It has also been speculated that concept maps can improve reading comprehension of students, especially those with LD (Boyle, 1996). Morfidi et al. (2017) suggested that the hierarchical and graphical representation of text using nodes and links to illustrate relationships among concepts can harmonize science-related vocabulary and reading comprehension skills to improve performance of students. However, empirical research falls short. This review of studies suggests concept maps as a potential strategy to increase science vocabulary and reading comprehension skills of middle school students with and without LD (Schroeder et al., 2018).

Some theoretical explanations for the way concepts maps impact student learning have been suggested. First, concept map can stimulate students' independent text-based learning as a meta-cognitive strategy to assist students to plan, organize, and understand information from the text they read (Guastello et al., 2000; Merchie & Keer 2016). Explicit concept map instruction can help students think critically about relationships between concepts. Asan (2007) explained that concept maps are a metacognitive tool that helps students learn how to learn by supporting note taking and summarizing key concepts that helps middle school students with and without disabilities to store and retain new knowledge in science.

Second, middle school students can improve their performance if they were first taught a specific technique to organize, elaborate, and encode information from text by using concept mapping. Abi-El-Mona and Adb-El-Khalick (2008), Ferreira and Zygouris-Coe (2013) and Merchie and Keer (2016) suggest that expository text content is often unfamiliar to less-experienced readers. Knowledge structures and organizational frameworks like concept maps can guide reading comprehension. For example, Merchie and Keer (2016) established that concept maps can equip students to independently relate previous knowledge, learn new facts, and recall information that enhances vocabulary development and reading comprehension. When students are given the opportunity to present their knowledge structurally, they can do it independently and in correct order (Abi-El-Mona & Adb-El-Khalic, 2008). Morfidi et al. (2017) agrees that concept maps are a strategy promotes meaningful mastery of concepts that augments vocabulary development and reading comprehension skills. Ciullo et al. (2015) stated that using computer-based software like *Inspiration* to develop concept maps can increase meaningful content acquisition for students with LD. Concept mapping may provide science teachers with the skills for meaningful teaching. When using the mapping strategy, focus may shift from presenting information to creating meaning which supports meaningful and transformative cognitive operations. Concept mapping can assist teaching by facilitating the process of visual integration with related cognitive operations. Thus, concept maps can promote meaningful learning as suggested by Asan (2007) and Ferreira & Zygouris-Coe 2013).

Third, students can develop schemas by organizing, storing and retrieving information and reducing their cognitive load. Several authors highlight how concept maps are illustrative, structured, and graphically organized to help students to construct a cognitive structure or schema of text (Asan, 2007; Guastello et al., 2000; Merchie & Keer 2016; Palmer et al., 2014). Merchie and Keer (2016) used concept maps to facilitate paraphrasing, re-reading, summarizing and schematizing as a means for students with and without disabilities to establish a relationship between prior knowledge and a new vocabulary. Morfidi et al. (2017) suggested that the use of pictorial and verbal representation for building mental connections may assist a student with a LD from his/her current level of vocabulary development to an attainable level using mediating tools like concept maps. Asan (2007) theorized that concept maps can foster long term change in thinking and contribute to students' learning strategies as they construct knowledge with their peers. Students may benefit because text is broken down and illustrated in a form that facilitates science learning by reducing the complexity of information to be stored for future learning.

(Asan, 2007).

In general, authors suggest that middle school students studying science can improve their vocabulary and comprehension skills when concept maps are used as a tool for instruction but, at present, there is an inadequate number of studies to fully support this claim. Similarly, the assertion that concept maps are a student-friendly model that incorporates previous knowledge to new concepts specifically for students with LD needs further investigation.

Despite the advantages, Oliver (2019) pointed out shortcomings such as using concept map as a singular strategy to improve reading comprehension without exploiting other techniques (e.g., partner retelling and dictionary approach could be more effective in some circumstances). In other words, some authors suggest concept mapping could be used with other teaching methods to be fully effective. In addition, Nesbit and Adesope (2006) suggested that concept maps may reduce reading and writing text.

Overall, based on this review, concept maps have the potential for positive impact on learners, apart from some non-favorite theoretical speculations. Authors are optimistic regarding the potential impact concept maps may make on science vocabulary development and reading comprehension skills of students in middle school.

Implications for Practice

Studies in this review have reported some features of concept maps that make them an effective teaching strategy to improve science vocabulary development and comprehension among middle school students, especially those with LD. Concept maps can help students construct, store, and retrieve knowledge when the need to use arises. Concept maps can help struggling students to organize and generate knowledge that is linked to past knowledge and experiences (Flanagan & Bouck, 2015; Sturm & Rankin-Erickson 2002). Teachers can examine the prerequisite skills of students with LD and consider aligning concept maps with instructions and other strategies such as peer teaching, activity-oriented approach, and group projects to be completed per month. Such a combination can empower students with LD to improve their science vocabulary and reading comprehension skills.

When selecting the type of concept map to be used, teachers should consider what keeps an individual student with LD on task. For instance, Sturm and Rankin-Erickson (2002), who focused on writing with middle schoolers, reported the effects of hand-drawn and computer-generated concept maps. Students with LD improved significantly on their writing tasks and demonstrated preference for computer-generated maps. When students are intrinsically motivated and tasks are designed to their preferences, they can focus and improve on their science vocabulary and reading comprehension skills (Gardill, & Jitendra, 1999; Sturm et al., 2002).

Teachers should design concept maps with varying degrees of scaffolding support for students with LD. The diverse backgrounds and experiences students bring is a base for concept mapping. Teachers can help learners organize and connect their previous ideas to new ones as well as encourage metacognitive processes. Using various hierarchical structures to organize students' thoughts with regards to novel information through concept maps can increase their vocabulary and reading comprehension skills in science (Ferreira & Zygouris-Coe, 2013)

To improve reading comprehension in science, studies have revealed that many students desire collaboration with at least one person either a peer or a teacher when using or developing concept maps (Hsieh & Cifuete, 2006; Oliver, 2009). The interaction between peers may lead to meaningful learning and cognitive development of schemas that enhance mastery of new knowledge.

Concept maps by themselves may not necessarily address or improve the learning outcome of every student. If tailored to the learning needs and the abilities of each student, it may be effective. Therefore, teachers should consider using concept map with flexibility in mind to adapt it to suit the needs of each student, especially those with LD. Once there are no EBPs to determine the effectiveness of concept maps at improving science vocabulary development and reading comprehension skills of middle school students, further research is needed to examine whether these tools are effective for students with LD.

CHAPTER 5

CONCLUSION

Across countries, settings and learning levels, the eight studies have suggested concept maps may be beneficial at retaining science information. Using concept maps may help students to develop and maintain knowledge of providing details which are needed skills in vocabulary development and reading comprehension.

Cook and Cook (2013, p. 75) have established criteria for research-based practices. Research-based practices are based on evidence from supporting studies in which the quality indicators of studies (e.g., treatment fidelity) is not systematically evaluated, or they might be supported by a single study. Evidence-based practices (EBPs) should fulfill higher criteria. The supporting studies of EBPs must have addressed rigorous indicators of methodological quality, or EBPs must be supported by greater than one study of acceptable quality and design (Cook and Cook, 2013, pp. 73-75). According to the above criteria for EBPs, I suggest that concept maps is a *research-based study* for low-achieving students in developing science vocabulary and reading comprehension, but not yet an evidence-based practice. Little is known about the implementation of the concept map model for students with LD. More reliable research is required to examine concept maps as tools in developing vocabulary and reading comprehension skills in science for middle school students with and without LD. In general, it seems that middle school students may improve their vocabulary development and reading comprehension skills when concept mapping is an objective in instructional planning.

Overall, concept maps may help students to be active in the learning process. One of the possible benefits of concept map is teaching students to learn how to learn, that is, developing meta-cognitive skills. Concept mapping could assist in creating schemas in students’ memory, store and retain knowledge based on their relationship with other concepts and previous encounters with information.

Limitations

This study is prone to several limitations. The methodology employed to carry out this was by itself sets a constraint. The search terms may have excluded potential studies that could add valid information and support to the current study regarding the effectiveness of concept mapping. I located only a small number of studies that met the identified criteria (n = 8). Treatment fidelity was only measured in one study (Merchie & Keer 2016). Similarly, most of the samples chosen for these studies were small. These studies cannot adequately be generalized as they had only a small number of participants. In the systematic review, only one study with a single subject design concerned students with LD, and other two studies included low-achieving students. Finally, Gaustelo et al. (2000) generalized their findings to science content for low achieving Hispanic students without considering other cultural groups. More research is required to examine the use of concept maps in the middle school, particularly for students with LD.

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Research Paper Title:
The Effectiveness Of Concept Maps On Science Learning In Middle School: A Review Of Literature

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