Strategies to Improve Working Memory in the Classroom

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Abstract
Memory has several different parts and abilities. There are several different theories that attempt to explain how memory works, and what outside influences can change memory or how the process works. Exceptionalities are affected in distinctive ways, as a memory problem in a child with a Learning Disability looks very different then lack of recall does in a child with Autism. A review of the literature shows that there are many different ways memory can be affected, and ways working memory can affect performance. Literature also supported a link between hyperactivity/impulsivity and working memory. This research focused on flashcards as a way to improve student’s content vocabulary skills. A study was conducted at a rural high school in Western New York in a freshman algebra class using students of varying exceptionalities. Each of the participants took a pre test and post test, then results were analyzed to see the affect this memory strategy had on students overall, and on different subgroups in particular.

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Strategies to Improve Working Memory in the Classroom

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M.S. Special Education

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Abstract

Memory has several different parts and abilities. There are several different theories that attempt to explain how memory works, and what outside influences can change memory or how the process works. Exceptionalities are affected in distinctive ways, as a memory problem in a child with a Learning Disability looks very different then lack of recall does in a child with Autism. A review of the literature shows that there are many different ways memory can be affected, and ways working memory can affect performance. Literature also supported a link between hyperactivity/impulsivity and working memory. This research focused on flashcards as a way to improve student’s content vocabulary skills. A study was conducted at a rural high school in Western New York in a freshman algebra class using students of varying exceptionalities. Each of the participants took a pre test and post test, then results were analyzed to see the affect this memory strategy had on students overall, and on different subgroups in particular.
Strategies to Improve Working Memory in the Classroom

A teacher is a person that is relatively common in today’s society; almost everyone has encountered a teacher either in his or her own schooling or through a part of a community. A teacher is defined as “one whose occupation is to instruct” (Definition of Teacher, 2010) and though the definition is simple there is more than simply instructing to teach. It is a common scenario for many teachers: finish explaining a particular lesson that seems relatively straightforward, students appear to understand without a problem. Two days later, the students have no recollection of the information that was taught. This is a very common and very frustrating situation for educational professionals.

This lack of recall of information leads to many questions about memory; its methods and what can affect it. To answer these questions a look at education theory involving memory is helpful. There are few different perspectives about the operation of memory, for this, a look at the theory of information processing and short-term memory is necessary. Following the look at information processing is a look at additional perspectives. There are several researchers that believe a lack of recall is directly related to motivation (Graham, 1991); hence this concept will need to be investigated. Next will be a look at how working memory is affected by different disorders such as Autism and Attention Deficit Hyperactive Disorder. Finally, strategies to increase memory will be discussed; including motivational strategies since many different theorists are adamant motivation is linked to problems with recall.

Information Processing

The theory of information processing was created many years ago and focuses on the transformation particularly from input (in the form of stimuli) to output (Feden, 2003). This theory uses a basic flow chart shown below to explain how memory works. The theory here is
that stimuli from the environment the senses gather goes first into the part of the brain known as the sensory register, which makes meaning out of the stimuli. The impulses that register in this area of the brain can only be held for seconds so whether the decision to have the bit of information either to move on, or decay happens almost immediately. If stimuli moves on to working memory the person must have paid attention to the stimuli; without attention stimuli is unable to move on and decays. It is estimated that a bit of information is held in working memory on average fifteen to thirty seconds. The individual can choose to move the information into long-term memory using different methods. Methods to accomplish this include elaboration, relating the new information to prior knowledge, chunking information and other processes that will be discussed more in depth when talking about strategies teachers can use to increase memory. Working memory is vital to this process, as it is the place memory is stored and processed (Alloway, 2009). Without this link, senses and impulses would not transfer from our sensory register to long-term memory. The key element of this model as a whole focuses around attention, essentially how information must be given attention to move it along through the different memories.

Components of working memory

Recent studies have been completed to learn more about working memory. Though in the beginning, working memory was thought of as simply a place where information was temporarily stored having limited space and short retention time, new information and theories have a much different perspective (Baddeley, 2003). Currently, it is believed working memory
is made up of three different parts with four different functions: the phonological loop, the visuospatial sketchpad, and the central executive. Each of these are said to work together to make the working memory highly functional (Baddeley, 2003).

The phonological loop is comprised of two parts, the phonological store, which holds memory traces for a brief time before they are lost, and an articulatory rehearsal process that retrieves the information from the phonological store (Baddeley, 2003). The phonological loop is thought to facilitate the acquisition of language; the capacity of the phonological store is a good predictor of the ability of a person to learn a second language. This is a problem area for children with specific language disabilities, as well as non-verbal learning disabilities, possibly caused by a deficit in the left hemisphere of the brain. Phonological loop handles the language acquisition aspect of working memory; the other components must work to handle all other stimuli (Baddeley, 2003).

The next component of working memory is the visuospatial sketchpad, the part of working memory that allows for the retention and manipulations of visual and spatial information (Baddeley, 2003). Many believe the sketchpad is associated with attaining knowledge about spatial orientation, geographic knowledge (such as maps and directions), understanding complex systems and machinery, as well as the overall appearance of objects and how to use them. This portion of the memory is an indicator of success in the fields of architecture and engineering, a strong visuospatial sketchpad allows for a clear vision before stimuli is clearly presented. It is clear to neurologists and scientists how the phonological loop functions, however more research needs to be completed before proficient knowledge of the visuospatial sketchpad will exist (Baddeley, 2003).
The central executive is considered the most important part of working memory; it is also the least understood (Baddeley, 2003). Central executive is also divided into two parts, though instead of retaining knowledge this part of the working memory is directly related to behavior. The first process, as they are considered, relies on the control of behavior by habits or schemas, guiding behavior by environmental cues, often without awareness of the individual. Examples are through body language and other behaviors so well known they are completed without thought. The second process, the supervisory activating system, has the job of interfering when routine control is insufficient. Many psychologists believe there is a link between working memory and behavior due to the central executive, making more research imperative to discern how working memory and behavior relate, how habits and environmental factors dictate behavior, and what individuals have conscious control over (Baddeley, 2003).

Initially these three were thought to be the only components but this caused several problems given prior knowledge, mainly dealing with long-term memory (Baddeley, 2003). A fourth element of working memory was accepted to help explain many things, such as the use of chunking to help move information directly into long-term memory. Another missing factor was a way for the phonological loop and the visuospatial sketchpad to communicate. Until the prospect of the episodic buffer was introduced, there was no explanation of how the three previous parts of working memory could interact. The episodic buffer has two main functions: it is the storage for the central executive and it allows the working memory to manipulate and create new representations using new input. Previously this was only thought to happen in long-term memory, but with the discovery of the episodic buffer, it becomes clear working memory can not only hold information and connect it to old memories, but create new memories and visual representations as well. Though the idea of the episodic buffer was a new and somewhat
novel concept for many, it was quickly accepted as a reasonable explanation of how the different parts of working memory collaborate. Overall, working memory has been thought of as a simple storage space but in recent studies has been shown to have far more intricacies that scientists expected.

Schema Theory

Schema theory takes the idea behind Information Processing Theory one-step farther to explain how knowledge is stored in long-term memory. In our mind, according to schema theory, are thousands of schematas, or structures of knowledge (Macaulay, 1999). The mental image that comes to mind is a large file cabinet as the brain, with thousands of ‘files,’ or pieces of information. The information in each schema can range from something small like recognizing one’s mother, to something complex such as understanding the theory of relativity.

According to this theory, the best way to ‘place’ information into long-term memory is to connect it to pre-existing schemata (Macaulay, 1999). This idea of relating new information to previous situations already stored in the mind is called generalization; many theorists maintain generalization is the leading process of information retention. Scientists point out that just as important as generalizing, discriminating, or noticing how situations are different, is equally as important. Being able to generalize helps the student see the important information, recognize patterns and apply the information elsewhere, once the student is able to affectively discriminate, they cannot only see the pattern, but see how a different situation calls for an adaptation of that pattern. This becomes significant when teaching concepts that can be used in different situations; if taught perfectly the students should not only relate the new skill or concept to something they already know, they should be able to acknowledge the similarities and difference between the new skill and the previously known. While this is just as difficult as it sounds, once
Working Memory

The theory is understood it becomes easier to use this to teach new concepts and skills in a way that will better transfer them into long-term memory (Macaulay, 1999).

Memory and students with non-verbal learning disorders including Autism Spectrum Disorders

Students who are diagnosed with non-verbal learning disorders are often thought to have a deficit in the area of visuospatial memory as well as social skills (Alloawy, 2009). Some scientists feel this comes from an impairment in the right hemisphere of the brain (Mammarella, 2010), though this theory has not been confirmed by neurologists. There are others who agree, but more specifically state data indicates hippocampal irregularities that can extend from the right hemisphere into the hippocampus and other regions (Boucher, 2008). It becomes difficult to determine the causes of memory problems, as Autism and nonverbal learning disabilities are often co-morbid with other impairments (Boucher, 2008), though a brain abnormality could be a factor in many cases. There have been several studies to determine the effects of memory and brain function in children with nonverbal learning disabilities, as well as children with Low Functioning Autism though none have had a sample size large enough to be statistically significant, though the results are notable.

One such study was conducted with the hypothesis that language impairment in children with low functioning Autism is cause partially by a memory problem; more specifically an impaired ability to create memories for personal experiences (Boucher, 2008). Boucher contends the problem is with episodic memory (memory based on experiences) instead of procedural memory and this is why there is a language impairment. They set out to test this concept using four groups of children. In this particular study four different categories including high functioning Autism, low functioning Autism, typically developing and intellectually disabled
Working memory

Children were utilized. The children in each group had been classified using several different rating scales including the Childhood Autism Rating (CARS), the British picture vocabulary scales (BVPS) and the DSM IV, in addition to being evaluated by experienced psychologists and psychiatrists. Each group was put through similar testing, based on two central themes, pattern recognition and shape recognition, with an emphasis on non-representational shapes. The results of this study were in line with the hypothesis, mainly that recognition is impaired in children with low functioning autism in relation to their peers with both high functioning autism and typically developing children, though they rated comparable to those students with intellectual disabilities. While results were expected, they do not prove the cause for a language impairment is a problem with episodic memory. The ability to process memories was not studied nor personal experiences brought into this analysis though both of these areas could show interesting results when studied further.

Another study conducted by a different group looked to connect nonverbal learning disabilities with visuospatial working memory (Mammarella, 2010). This team of people also felt there is a deficiency in not only visual spatial tasks but tasks requiring motor coordination, as these tasks also rely on the manipulation of spatial information. To assess this hypothesis in children with nonverbal learning disabilities Mammarella, Lucangeli and Cornoldi (2010) studied 21 children with nonverbal learning disabilities as well as studying 21 children in a control group for comparison purposes. All students in this experiment were between the ages of seven and eleven, with their levels of hyperactivity, sociocultural levels and other emotional disabilities assessed to ensure the only difference between the control group and the nonverbal learners was speech. Tests were administered in a quiet room in the children’s school by researchers to ensure continuity. Children were to answer different questions at different
difficulty levels, scored by how many questions they answered at each level. Questions ranged from simple arithmetic questions to identifying shapes or objects, or completing a pattern. Of the three subtests, the spatial–sequential test showed the most drastic results with the nonverbal group’s mean score eleven points behind the control group. There were two other subtests: visual, which had a difference of .8 in the mean scores, and spatial-simultaneous, which had the exact same score for each group. Since two of the three subtests had similar scores, the test with a high difference is worthy of note. Mammarella and her associates (2010) feel this demonstrates that a VSWM [visuospatial working memory] deficit can be found in NLD [nonverbal learning disabled] children in recognition tasks, namely, passive tasks typically less powerful than active tasks in discriminating between groups, but more specific in distinguishing between different VSWM components and in predicting specific learning domain difficulties. (p 463)

While it is difficult to draw this conclusion confidently from one small study there is clearly a need for more widespread investigation in this matter, most likely with a larger sample size and across a wider region. Though if result are consistent as these individuals believe them will be, they will show a direct correlation between nonverbal learning disabilites and a deficit in visiospatial working memory.

Memory and children with Attention Deficit Hyperactivity Disorder

Attention Deficit Hyperactivity Disorder (ADHD) is a condition found in children today, with symptoms such as inattention, hyperactivity and impulsivity. No academic challenges are directly related to ADHD as is the case with Intellectual Disabilities, though ADHD students often achieve at rates lower than their peers (Nyman, 2010). Students with ADHD also show poor attention to directions, have difficulty remembering multistep instructions, and interrupt
frequently with unrelated comments. Students with ADHD typically show significant
deficiencies at each stage of development, coupled with academic underachievement (Alloway, 2009). This lack of achievement if often though ot be a result of the central executive, it must
work at controlling the attention of the student instead of storing information. Much of the research done about this topic shows that students with ADHD perform abnormally low in
complex tasts that require the use of the central executive. There is evidence of the deficit in
children as young as five, showing that this behavior is not learned, but instead a result of a
attention problem (Nyman, 2010). This is just one such study done to link ADHD to a flaw of
the working memory.

Another study was completed to determine whether students with ADHD and those with
working memory problems exhibit similar behaviors in the classroom (Alloway, 2009). The
study was completed using children with ADHD (46 of them), students with low working
memory and typically developing students, these students were taken off any medication they
were taking at least 24 hours before the study began. Participants took a continuous test in which
they had to respond to a specific stimuli, but ignore majority of the presented stimuli. Children
were also rated by their classroom teacher using the Connors Rating scale, and Working Memory
Rating Scale. Connors helps monitor eight different topics, ranging from emotional control to
organization. On the other hand, the Working Memory Rating Scale keeps track of twenty
different characterists children with working memory deficits often display. A secondary aim
was an investigation of ADHD and whether ADHD triggered working memory problems. The
result of the study was clear, children with low working memory have a separate behavior profile
than those with ADHD as they should no characterists associated with hyperactivity or
impulsivity, this was evident in both the continuous test given, and through the teacher’s ratings.
Working memory was found to impact performance in the classroom in the form of multi-step tasks, coping with simultaneous processing and storage demands, and remembering extensive instructions. ADHD students also receive low grades, though it is more likely to be caused by inattentiveness instead of anything else (Alloway, 2009). This study was able to show a distinct separation between characteristics of children with ADHD and students with working memory problems.

On a much smaller scale, an analysis was completed to determine how best to improve working memory in students with attention or hyperactivity problems, but not diagnosed with ADHD. For this particular experiment, nine children who displayed characteristics of hyperactivity were given time to improve their working memory (Mezzacappa, 2010). The children ranged in age from second to fourth grades, and were given 45 minutes each day out of the regular class period to work on a computer to increase their working memory, the time period was rotated so the students did not miss the same class more than once. Exercises included eleven different activities that varied in complexity, but adjusted automatically to ensure the child was challenged continually. Both teacher and parent filled out the Home and School Version of the ADHD Rating Scale IV before and after the study. Researchers found that hyperactiveness and impulsivity decreased in seven of the nine children from start to finish. This suggests training the working memory in school settings may be a way to help students who struggle with hyperactivity or attention problems in the classroom. Researchers realized the limitations of this study, the most significant being the sample size, and the lack of consistency in testing of children (Mezzacappa, 2010). However reliable results are, this area of study should be tested further, especially with the exceptional results; 78% of students improving behaviorally, and therefore academically, is too significant a statistic to ignore.
Memory and math anxiety

One academic discipline that often has different problems and issues than many of the other content areas do is mathematics. Additionally, the longer the operation, the slower the retrieval process becomes. Given the difficulty many students have, there also is an increased anxiety level, as there often is when a person must perform in an area of weakness (Ashcraft, 2007). Mark Ashcraft (2007) performed a study to see if an increased anxiety level affects memory and its functioning. This was completed by having students keep a number, or series of numbers, in their mind while at the same time completing arithmetic. Furthermore participants took the Wide Range Achievement Test and completed a survey measuring their comfort with this subject. Researchers then analyzed the tests results in comparison with the anxiety level of the participant. “The story told by the correlations is sad indeed. The higher one’s math anxiety the lower one’s math learning, mastery and motivation” (Ashcraft, 2007). This proves that as math anxiety increases, learning decreases. While this fact is helpful to know, it does not relate math struggles to deficit of the working memory. Ashcraft (2007) was able to find interesting results with his study though he was unable to prove in most people a lack of performance in math is not related to a memory problem.

Strategies for improving memory

Information processing theory gives several methods to help improve working memory. One method is rehearsal, the practice of re-learning and practicing information several times. This is especially useful with students with disabilities as it often takes these students longer to commit data into long term memory. Another useful strategy is chunking, the process of breaking up information into parts, and remembering small parts (a good example of this is phone numbers, people remember groupings of numbers instead of one long number) (Alloawy,
Another such strategy is used by both memory theories mentioned previously though each claim it as their own. This is the process of connecting new information or facts with information already in memory. The thought is new information this time would not have to have its own portion of memory, it can join information that is already there, allowing much faster acquisition of information (Macaulay, 1999).

One study has spoken of the importance of teaching children about memory, what it is and how to understand such an abstract concept. Zumbo (2006) recommends teaching young children about memory through the use of picture books, she feels it is imperative students can think critically about their memory and learn how to improve it by intentionally using memory strategies. While there was no research done to confirm or reject her theories, the idea of using picture books (or books at all) in education had been a proven method to improve knowledge across the content areas (Zambo, 2006).

One much researched theory to improve students who are low performers is motivation. There are two types of motivation: intrinsic – the motivation of oneself due to the wish to accomplish a task because of its complexity and the challenge it presents and extrinsic - motivation that is shown because the students wants to obtain something tangible (Newby, 1991). Students have shown that motivation can also increase memory, mainly due to the fact that motivation strategies also increase attention and can help build confidence. This is accomplished using sound or noise to get attention, and turning the lights off or using a type of music that signifies work time. Students build confidence, and once successful they are more likely to continue to be successful. With an increase in attention, more stimuli and facts are moved from working memory to long term memory. This increases the capacity of working memory as well (Newby, 1991). Graham and Golan (1991) showed in their research that
students and adults alike were able to remember more when there was a reward or incentive that motivated them to accomplish a task. By providing participants with a highly desirable reward, more learning and retention took place in all participants of their study without exception. This extrinsic motivation is often used by teachers and psychologists when creating behavior plans; it should be broadened to help increase academic performance as well (Graham, 1991).

One strategy to increase the capacity of working memory is through the use of computer programs. This technique is very under researched and for that reason it is difficult to say without question that computers will help increase the memory of all students, though that is what preliminary studies indicate. Computer based programs can work with memory in several different ways, from teaching strategies to the user, such as how to chunk information, or the best way to make and use flashcards (Alloway, 2009). They can also be used to rehearse specific facts or recall information such as online games or school supported websites. This particular area needs to be further examined before any best practices can be supported, though in early stages, it appears the use of technology will benefit the learning process.

Methodology

This study was completed with children in an upstate New York school to find out if content vocabulary recall can be improved using flash cards and memory games involving flash cards. Research in this area shows that using flash cards is an effective way to learn English vocabulary, but it is unclear if the results will be the same for vocabulary in a different content area. Thirty-three students participated, ranging in age from fourteen to eighteen. Of the students who took part, four were classified Other Health Impaired (OHI), fourteen were classified Learning Disabled (LD), eight students were not classified, two students had Speech and Language Impairments, one was Intellectually Disabled, one was Emotionally Disturbed,
and three had 504 plans. All classified students that participated in this study had been classified for over a year, and had been tested recently by a psychologist to ensure the necessity and appropriateness of the classification. For this particular analysis, students were grouped by their classification, with the exception of 504 students, speech and language impaired students, the one emotionally disturbed student and the mentally retarded students; all these students were grouped together as there were not enough students to be statistic significantly on their own.

Students were given a pre-test with four multiple choice questions on it of material they had learned and reviewed once prior to the assessment. After the pretest was administered, students used memory strategies once a week to help reinforce the vocabulary and processes to solve the given equations. The central memory strategy used was flashcards. Students worked in small groups, of eight pupils or less, with an educator to create meaningful definitions for each of the words, then wrote the word on one side of a note card and their definition on the other. Over a period of 8 weeks, students worked with the vocabulary terms when reviewing their note cards (once a week). They also had the opportunity to review terms and definitions through two games played in class. The first was a memory game in which the students had to correctly match the term with the definition, the other games were similar to jeopardy where students were given either the term and had to state the meaning, or vice versa, students were given the meaning and they had to correctly state the word being defined. The only students who did not receive the same amount of instruction were those who were absent frequently, as they did not make up the missing assignments at another time.

After eight weeks of strategies being used for at least twenty minutes weekly, students were given a post test exactly the same as the pre-test. The two assessments were given in
similar settings with the same directions. All students were required to complete the final assessment, regardless of their attendance throughout the trial time.

Results

The first group in this study, students with the classification of Other Health Impaired, had varying results on their pretest, as displayed in the graph below. On the first question, of the pretest, all students answered correctly, while on the post test, only seventy-five percent of students answered correctly. The second question showed an increase in correct answers, with seventy five percent of students getting the correct answer on the post test, when only twenty five percent of students answered correctly initially. The third and fourth questions both had zero correct answers on the initial assessment, and both showed significant growth, fifty percent and twenty five percent respectively as displayed below.

The group of students with Learning Disabilities was the largest, with fourteen students. The pretest data for this class showed a large difference as well. On the initial assessment, students answered seventy one percent of the first question correctly, seven percent of the second question correctly. When compared to the post test, as shown in the graph below, results varied, with fifty five percent of students getting the correct response on question one, seventy three
percent getting the correct answer on question two. Questions three and four had similar responses, with a ten and twenty percent increases in correct responses respectively.

![Test Results in Students with a Learning Disability](image)

General education students continued with the same trends as seen in other subgroups of students. Question one had similar test results, with students doing slightly better on the pretest as they did on the post test. On questions two and three, students did significantly better on the posttest as on the pretest, with no students answering questions correctly on the pretest, and seventy one percent answering correctly on the post test. Question three also showed significant growth, thirteen percent on the initial assessment, verses fifty seven percent on the final assessment. Question four had no growth, with thirty eight percent of students answering correctly originally, and seventeen percent answering correctly at the end of the trial. These discrepancies are shown throughout the subgroups, and will be analyzed in the discussion portion.
The final group is the group of mixed exceptionalities, including students with 504 plans, and speech and language delays. This group had very different results from others; this group scored better on the post test than in the pre test for questions one, two, and three by a margin of thirty-three, thirty-one, and six percents respectively. Question four was a slight anomaly as well, with the pre test outscoring the post test by a margin of nine percent. While these percents are not very large, they do show a trend very different than what appeared in the other subgroups.
Discussion

There are certain consistencies among all groups in this study that should be considered. The first and most noteworthy is the large improvement of all groups on questions two and three. Every group demonstrated improvement, showing that this technique did work to improve the memory of students. This supports the hypothesis that using flashcards and memory games is an effective way to learn content vocabulary. It is important to note two of the four groups did better on the initial assessment than the ending assessment on questions one and four. This lead to the conclusion that while this strategy worked to help improve problem solving based on vocabulary, it did not aid the ability to answer questions when more than a definition was needed. When answering the first and last questions, the students not only had to pick a response that best answered the question, they had to complete a process based on the vocabulary well. Question one asked students to find the complement of a set given a subset, and question four required solving a four step inequality. These require more work than questions based simply on identifying the correct vocabulary term. While two groups did show significant improvement in their scores, it cannot be determined if the memory strategies were the cause, or other factors led to the improvement.

An important factor to consider is the testing situation and attendance on the day of the evaluation. The pre-test used in this situation was a formal midterm examination in which all students were required to attend and complete. There was a staff member assigned by the school to ensure the attendance of the students on the day of the test. On the day of the final assessment, this structure was not in place and as a result, several students were absent or took the exam at a later time. There were thirty three students who took the midterm (pre-assessment), but only twenty nine who completed the final assessment. While some students refused to
complete the test, others were absent on not in attendance the week of the test. If these students had participated, a higher percentage of questions answered correctly would be expected in both the general education group of students and the group of students with assorted abilities. Since the post assessments were not completed by all the students, the scores of these groups were lower than originally expected.

Another area where inconsistencies were noted was in classroom attendance. A number of students who are classified as Learning Disabled, and other students in the category of “assorted abilities,” miss an average of two classes each week. Since strategies were used once a week and not every day an absence during that class period when strategies were practiced would result in the student going at least a week without the using the strategies. In the case of one student, three consecutive weeks of school was missed, which included not only memory strategies but also general instruction and practice. This unpredictable behavior was not something that could be controlled, but most likely had a negative effect on the overall results of both the study and student learning.

It was difficult to judge if increased success on the vocabulary questions was due to the memory strategy used, or if the high success rate was related to increased exposure and rehearsal of material. Information Processing Theory and Schema Theory both maintain that the more attention a stimuli is given, the more likely it is to be moved from working memory to long term memory. In this instance, it was impossible to determine if the information was retained because of the flashcards and memory games used, or if it was simply due to the fact that at least once a week, students were being forced to recall and manipulate the same information. The best way to investigate this would be to have a group that simply had to answer test questions or use a recall method to answered questions about the given vocabulary. That evaluation could be
compare to the results found in this study. Due to the small sample size available, it was necessary to have all the students participate using the described method, to get the most valid results possible.

Small sample size and inconsistent group ratios was another important factor when creating groups based on exceptionalities as well as when looking at results. Group size varied from four students in one, to a group with fourteen students. This size difference can play a significant role in the percentage of questions answered correctly. In a group of four students, if one participant got an answer correct, that would be twenty five percent of the group’s score. On the other hand, if a person in the group of fourteen gets a question correct, it would only be seven percent of the group. For this reason, groups were not compared to each other on the pretest and posted, just themselves. Comparing groups with this size difference would not provide reliable results for comparison. Results for this analysis were considered consistent since the group size remained the same throughout the process, and groups were only looked at in relation to themselves and their own personal growth.

The limitations of this study can be found in many different areas. When considering sample size, group sizes were unequal, as were the makeup of some of the groups. To have more valid results, the overall number of student responses analyzed should have been larger and group size should be more balanced. A second limitation of this study is the level of support each student received. Services for students with exceptionalities range from those receiving no additional support, to those scheduled for resource room (a time to work on IEP goals) and academic support period (similar to a guided study hall). General education students are not able to have this extra time and support. Students who received additional support may have been given extra time working on these topics using different strategies, helping to increase their
success even more than the exposure in class once a week. Finally, being able to look at each group in comparison to each other to compare would have been preferable. This would have provided an idea of how memory problems manifest themselves in students with different exceptionalities. Since this was language based research, having a larger group of students with speech or language impairments would have provided interesting feedback. This type of strategies could be something to consider not only for students with disabilities but for students learning English as a second language as well.

Conclusion

Findings of this process clearly show students improved memory from beginning to end, though the cause is unclear. With this knowledge, teachers of all disciplines should work to increase the content vocabulary strategies throughout the year. It is clear that using some sort of technique to teach memory is successful and through the use of more strategies and methods from the strategies section listed above, students could greatly increase their rate of retention. Teachers should not only use these strategies in class, they should also help students understand how their memory works and what to do it improve it on their own. Many students are unaware of how much work is required to make a lasting memory, and don’t know how to study on their own. By teaching them this metacognitive technique, we are not only teaching them our content, but helping students to teach themselves, and to be more self sufficient. These skills will be a valuable asset as they continue with their education.

There are many areas that need to be explored further, in some ways it seems this research did not explicitly answer any question, instead it raised several more. One area that should be looked into is the correlation between ADHD and working memory. Research on a very small group showed computer based working memory strategies can lessen the impulsivity
of a student in at a young age, this area needs to be greatly explored in the United States to find out if a correlation actually exists, and if an application of this method would be useful in schools. Another field for potential research would be to look at which memory strategy would best help students when dealing not with simple vocabulary but with a process such as solving an inequality or computing an answer that requires more than three steps. The methods used here were inconclusive at best, so further research would be necessary. It is important to remember any strategies or methods, memory or otherwise, should have a positive effect on the learning of students; it should help them to succeed academically and possibly improve classroom behavior as well.
References


