RAIS RESEARCH ASSOCIATION for INTERDISCIPLINARY STUDIES
MARCH 2021

DOI: 10.5281/zenodo.4640927

A Strategy for Teaching Carrying in the Mathematical Operation of Addition to Students Who Are Deaf or Hard of Hearing

Mohammed Alajlan

Department of Special Education, College of Education, Qassim University, Buraydah, Saudi Arabia
msajan@qu.edu.sa

ABSTRACT: This study investigated the effectiveness of using manipulative items for teaching the process of carrying in the mathematical operation of addition with a third-grade student with hearing loss. A single subject reversal design protocol was used. The subject student had low achievement in addition of two-digit numbers with regrouping. When visual aids, concrete materials, and practice were implemented with the student, he was eventually able to achieve a top score of 90% on a 10-item quiz. The strategy was found to be very effective in this setting. Further research is needed to investigate whether the student would be able to implement this strategy successfully with three-digit numbers. The use of the intervention should also be explored with more than a single student and with younger students who are deaf or hard of hearing.

KEYWORDS: single subject design, deaf and hard of hearing students, ASL, math strategies, carrying numbers

Introduction

Students who are deaf or hard of hearing (D/HH) have been found to struggle in academic achievement in comparison with their hearing peers (Antia et al. 2009). While traditionally these deficits are observed most often in language-based subjects, there is evidence that these students may also experience challenges in task achievement in mathematics (Antia et al. 2009). This paper focuses on factors that cause low achievement in mathematics for students who are deaf or hard of hearing. By presenting additional visual and tactile props to assist in mathematical operations, it is asserted that these students can make greater gains in achievement in quantitative skill performance (Freese, 2008). Even though using different strategies for teaching this group of students have been shown to be effective, it is rare to find a study that is based on introducing manipulative items – visual, non-language-based tools to support learning – at different stages to help these students overcome mathematical difficulties that they may encounter.

The subject of this study, Ali (a pseudonym), is a third-grade student experiencing difficulty in employing carrying in addition problems. Ali attends a public school where he receives instruction as an ESL student. He has also been identified as requiring special education services for mathematics and so receives math instruction in a non-inclusive classroom. Like many D/HH students, Ali experiences difficulties with computational math. This study was designed to investigate the effectiveness of using manipulative items for teaching the process of carrying in addition to an elementary school student who is D/HH.

Literature review

Students with special needs often face academic challenges. Those who are deaf/hard of hearing tend to exhibit lower mathematical achievement than their hearing peers. In their study, Swanwick et al. (2005) analyzed a sample of 73 completed National Curriculum Test papers in mathematics completed by students who are D/HH in England in June of 2002. (This is an exam administered to all students at 14 years of age). They found these students have more language difficulties in math than hearing students (Swanwick et al. 2005). The results underline the importance of modifying the general education mathematics curricula, because the language used in some textbooks is not accessible to many D/HH students. Furthermore, it exposed the need for teachers of mathematics to utilize more effective instructional strategies to explain mathematical procedures to these students. Concepts should be explained step-by-step. If instructors follow these practices, students who are deaf or hard of hearing may more readily understand mathematics (Swanwick et al. 2005).

Nunes and Moreno (2002) also confirmed that deaf and hard of hearing students differ from hearing students in math achievement. They observed these students tend to have lower achievement scores in math than their hearing peers. However, they stated that it was not their hearing impairment that was the direct cause of their difficulties in mathematics (Nunes & Moreno, 2002). Instead they asserted the achievement lag is linked to having fewer opportunities for incidental learning, even before starting school, and the difficulty children who are D/HH tend to have related to completing tasks that require them to "process a sequence of events over time, keeping in mind a gap for an unknown element in the sequence" (Nunes & Moreno 2002, 2).

Such students can clearly develop their knowledge and skills in mathematics, eventually; however, they need visual, tactile, and kinesthetic interventions to promote achievement. The incorporation of drawings, diagrams, and concrete materials can help children who are deaf or hard of hearing understand addition and subtraction. Classroom observations have established that this method of teaching helps these students understand addition and subtraction problems (Nunes & Moreno 2002).

Swanwick et al. (2005) stated that "consistent evidence from research studies between 1980 and 2000 indicates that deaf children lag behind hearing peers (by 2 to 3.5 years) in mathematics" (p. 2). Freese (2008) speculated that students who are D/HH encounter difficulties in mathematics related to delayed language development. Additionally, Freese asserted that the gap in mathematics achievement between students who are D/HH and their hearing peers can be overcome by educating teachers on the barriers these students face and determining how to present the curriculum in the most effective way to support their success. Freese (2008) argued that four factors impact math achievement. These are "(1) the amount of exposure to pre math concepts, (2) auditory memory, (3) delayed language, (4) the development of logical reasoning, and (5) the reading style/technique practiced by students" (Freese, 2008, p. 8). One of the most important factors here is the lack of exposure to verbal references to math concepts from an early age, which puts individuals who are deaf or hard of hearing at a disadvantage when they begin school.

To support the importance of these four factors, Freese (2008) analyzed textbooks used in the elementary math curriculum in Missouri and focused on certain factors: (a) the degree of simplicity of the language used, (b) the amount of relevant visual content used to teach concepts, (c) the amount of practice work available in the instructor's manual to support the introduction of a new concept, and (d) the amount of resources, not part of the textbook, that the publisher makes available to support instruction and be used alongside the textbook (e.g., websites).

Using visual techniques and concrete materials with students who are D/HH to teach mathematics produces positive results in performance. Moreover, these students also benefit when more, rather than fewer, practice opportunities are provided (Freese 2008). These techniques were found to successfully support improved achievement in these children (Freese 2008). After analysis of each textbook and comparison of the texts with the factors determined to be most supportive in D/HH mathematics instruction, Freese determined that the *Houghton Mifflin Math* (2005) textbook was the most appropriate text for use in a specialized mathematics curriculum for these students. It contains simpler and more concise language, has more appropriate and relevant illustrations, and provides more practice problems in the teacher's manual. These factors can be kept in mind for any mathematics curriculum at any grade level, regardless of the textbook, to support the learning of students who are deaf or hard of hearing.

Van de Walle et al. (2013) examined mathematics education from the perspective of a student-centered approach to learning. While their concepts are designed to be implemented with all students, they are particularly useful to educating students who experience challenges. For example, these authors note that a key aspect of teaching addition to all students is explaining the concept of carrying numbers. In particular, it is critical for students to understand the concept of place value. In basic math where two-digit numbers are being added, this means that the student must understand the difference between the ones place and the tens place. One of the better methods for demonstrating this is to use cubes with different colors for ones and for tens, such as using a green color to represent the ones and a red color to represent the tens (Ali 2011). Using concrete objects and materials in instruction is useful for all children, particularly in the pre-K and early elementary years. Specifically, using visual representations to teach mathematical concepts is extremely effective for D/HH individuals, due to the language delays they are often found to experience (Nunes & Moreno 2002). Therefore, using such cubes to demonstrate the concept of ones and tens to support the learning of addition can improve the performance of students who are deaf or hard of hearing.

Another effective strategy for teaching addition visually, and reducing the reliance on language, is a practice where the teacher writes the addition problem on the right side of the board and presents a visual representation of it on the left side, where red sticks represent the tens and green cubes represent the ones (Van de Walle et al. 2013). Drawing a line dividing the ones and tens in addition problems of two-digit numbers that involve carrying numbers and drawing a small box above the tens is another strategy for reminding students to write carry numbers in their correct place (i.e., in the box). When students demonstrate that they understand the concept, the instructor can then employ the same strategy without using the small box above the tens column. Students then remember the concept of carrying the number over from the ones to the tens. This strategy has been found to be very useful in both demonstrating how carrying works in addition problems with two-digit numbers, and also how to teach a mathematical concept to students visually in a way that they can better understand and retain (Qaryouti et al. 2009).

Methodology

This study was designed to investigate the effectiveness of introducing manipulative items at different stages for teaching the process of carrying in the mathematical operation of addition to a student with hearing loss. It is rare to find a study implementing a single subject reversal design protocol that employs visual aids, concrete materials, and practice for helping a student who is D/HH overcome difficulties they encounter in math. The aim was that combining this protocol with the implementation of manipulative items would foster the process of learning math and help the student acquire the target skill in a more natural way.

Subject

While the researcher was conducting an experiment at a public school, the math teacher contacted him seeking help in teaching a student, who was a third-grader at an urban school in a U.S. city in the southeastern part of the country who was 9 years old. The student was born in a Central American country where the primary language is Spanish. Ali, a pseudonym, is not a native English-speaker and neither are his parents. In addition, Ali's father does not speak English very well and his mother does not speak English at all. For first and second grade, Ali attended school in his native country where the language of instruction was, of course, Spanish; this was his first year of school in the United States. Ali is considered "hard of hearing" and wears hearing aids. He had been placed in the ESL program at his school; he had not been diagnosed with any other learning disabilities.

Ali's teacher indicated that he exhibits several challenges in math learning. The one this study focuses on is his issue with comprehending how the concept of carrying works in addition. For example, when Ali is given an addition problem with two-digit addends, he tends to write all the resulting sums on the results line without carrying any numbers over from the ones to the tens.

A specific instance of this would be that when Ali adds [34 + 88], he sums the ones column and writes the total on the results line, then sums the tens column and writes that total on the results line as well. As in:

```
  34
+ 88
1112
```

Prior to Ali receiving the intervention in this study, Ali's teacher had relied on traditional methods of addition instruction to work with him regarding this issue.

Design

The researcher employed an A-B-A reversal design. This design type begins with a baseline phase (A), which is followed by a treatment phase (B), and then concludes with a withdrawal phase (A). This design was chosen because it enables the researcher to note any changes the subject exhibits as the intervention progresses. It also shows the results of the treatment in an effective way when there are a small number of subjects. The baseline phase helps the researcher observe and document the student's performance level without treatment (Engel & Schutt 2008). This allows the investigator to then apply the treatment and observe any changes that may occur during the process. Thus, the A-B-A design provides researchers with clear information about the treatment/intervention strategy and its impact on the subject.

Procedure

Once Ali had been identified by his math teacher as a good candidate for the research, his parents were contacted and asked to provide written consent for him to participate in the study. They were also asked to release their son's academic records to support the process. After these permissions had been received, the researcher was provided with background information on the subject, which included Ali's academic records and biographical background on him and his family. These data were acquired on February 12, 2018, from a number of sources.

His teacher also provided background on Ali's progress across subjects during the first semester of the school year, which was his first year in a U.S. elementary school. After this background data was acquired and reviewed, the process of implementing the intervention began. The course of the study was 8 weeks. The first of these was the baseline phase, which involved two observations that took place on 2 different days. Next, the treatment phase occurred, which involved seven sessions on 7 different days over a span of 6 weeks. The last phase was the withdrawal of the strategy, which included documenting Ali's achievement on three 10-item quizzes on 3 different days, after the intervention had ended.

Results

Baseline phase

The observation or baseline phase started on February 17, 2019, in a session that lasted 35 minutes. The researcher observed as Ali's math teacher gave Ali 10 addition problems after presenting a 20-minute lesson on addition from the textbook. The 10-carrying item quiz is considered the experimental probe and it was used to obtain data for all three phases of the study. During the first observation, Ali did not get any correct answers (0%) on the five addition problems that involved carrying numbers. However, he answered all of the five addition problems that did not require carrying correctly (e.g., 18 + 11 = 29), for a score of 50%. The second observation took place on February 19. During this class, Ali was given 15 minutes to complete the 10-carrying item quiz and answered just one problem (10%) correctly. This demonstrated sufficiently that Ali needed intervention to develop his skill in carrying numbers in addition problems.

Treatment Phase

The intervention plan was based on strategies identified by the literature review, including: (a) using colorful cubes and sticks; (b) drawing a line between ones and tens, placing a small box above the tens, then removing the small box; and (c) using cubes. The treatment phase was initiated on February 24. The researcher's practice was to present material for about 15 minutes at the start of each class. The intervention was conducted during the remaining 35 minutes of the class. On February 24, the difference between the ones place and the tens place was explained to Ali, using green cubes to represent the ones and red cubes to represent the tens. The explanation took about 20 minutes. Next, he was given 10 addition problems, all of which involved carrying, and a box of cubes. On this occasion, Ali was able to answer two of the problems (20%) correctly.

The second intervention was then implemented on March 3, this time it employed a standard algorithm for addition strategy. This strategy seemed to be more effective in helping Ali understand carrying numbers. After this presentation, he was able to answer three (30%) of the addition problems correctly. Since giving students more opportunities to practice a strategy has been found to support better outcomes, this intervention was again delivered on March 10. On this occasion, Ali was able to answer six (60%) items correctly.

On March 19, the third intervention was presented. This involved demonstrating how to separate the ones and tens with a line and putting a small box above the tens column. Ali answered four problems (40%) correctly on this date. When the intervention was reintroduced on March 26, he answered six problems (60%) correctly. Continuing the weekly practice, the fourth intervention was implemented on April 1 and used the same strategy but without including the box above the tens column. Ali answered five (50%) of the addition problems correctly on this date. When this practice was repeated on April 8, Ali answered eight (80%) addition problems correctly.

It also has been found that positive reinforcement is beneficial in encouraging a student to work with teachers and/or researchers on an intervention. In this study, the subject received reinforcement twice during every lesson: (a) when he focused with the researcher during the lesson, and (b) when he showed improvement. Because he likes treats (e.g., chocolate, cookies, cake, and chips), these were presented in a basket and Ali could choose an item when any of the two situations was satisfied. Ali was very enthusiastic throughout the intervention and tried to do his best both during instruction and on the quizzes.

Withdrawal Phase

After using these strategies, Ali was found to be capable of solving almost any addition problem with two-digit addends. On April 14, the withdrawal phase (return to baseline conditions) was initiated, where Ali received instruction with his classmates and then took the same quiz that they were all administered. Ali answered eight (80%) of the addition problems correctly. Two days later, he achieved a 70% on the quiz. On April 20, he was able to solve nine (90%) addition problems correctly on the quiz. The following figure shows the progress Ali displayed, beginning from the baseline phase (A), followed by the treatment phase (B), and then during the withdrawal phase (A; see Figure 1).

Figure 1. Probe Data of Subject

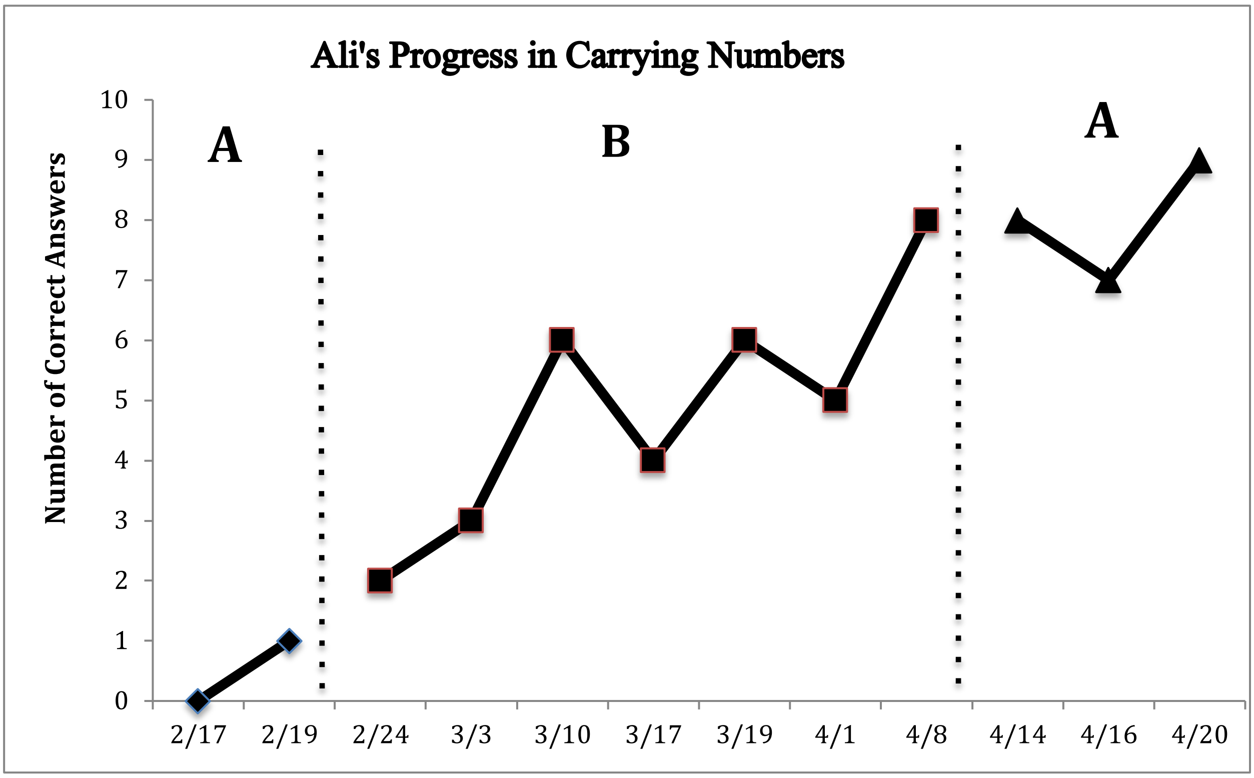

Figure 1 presents the results of Ali's testing, using 10-item quizzes, over the period of the study. Ali showed progress in his performance when manipulative items were introduced. He demonstrated that, through these practices, he obtained enough information to improve his understanding of the process of carrying in addition problems that involve two-digit numbers. Initially during the baseline phase, Ali's scores were very low, where he could only answer at most one question correctly on a 10-item quiz. This demonstrates that his performance level was very low prior to the study and that he needed support. During the intervention, Ali showed progress gradually. After the first intervention, he was able to answer 20% of the 10 items correctly. His performance then improved to where he could answer 80% of the items correctly. His achievement increased from an average of 5% (zero items or only one item answered correctly) during the baseline phase to 80% at the end of the intervention. As is typical with academic improvement in a specific skill, there is no real return to baseline scores since once a concept is mastered, it is not usually forgotten. Therefore, it was not surprising that Ali continued to show increased performance on probes during the withdrawal phase. Notably, he was able to answer nine (90%) problems correctly by the end of the withdrawal phase.

Discussion

The goal of this study was to demonstrate that the introduction of manipulative items – visual, non-language-based tools to support learning – results in improved outcomes for students who are deaf or hard of hearing. This study achieved its objective. Ali, a third-grader with hearing loss, was able to master the process of carrying in addition problems successfully, after undergoing various interventions that included manipulative items and positive reinforcement. The need for intervention was confirmed through observation during the baseline phase. Although Ali showed improvement during the intervention phase, his performance was not consistent. He would show some progress and then his scores would decrease. This may be attributed to changes in the strategy employed.

Whenever the strategy was modified, Ali's performance decreased. However, Ali's overall performance was progressively better from the baseline. The positive reinforcement that was introduced also greatly affected his enthusiasm and by extension, his performance.

Conclusion

Research has found that different factors affect the ability of students who are deaf or hard of hearing to master mathematics skills. This study examined one student, third-grader Ali, who is hard of hearing and 9 years old. Ali had been identified as having difficulty in successfully answering addition problems where it was necessary to carry over from the ones column to the tens column. This study utilized an A-B-A design with three phases: baseline, treatment, and withdrawal. Multiple interventions were used during the treatment (B) phase. After each lesson, Ali was presented with a 10-item quiz (a probe) consisting of addition problems that included carrying to evaluate his level of progress. Ali's difficulty was clearly documented in the baseline phase. During the treatment phase, his performance developed over multiple applications of the interventions. The intervention strategies employed led to success and strong achievement for this student. In the final phase, Ali was able to maintain that improvement and achieve excellent results on probes post-intervention.

Strengths and Limitations

The structure of this study allowed the researcher to obtain in-depth data on the benefits of implementing different interventions to support a student who is hard of hearing in obtaining improvement in his addition computational achievement. Since the researcher was able to implement the intervention over time, it was possible to examine and document the student's progress very closely. The primary limitation of this research is obvious in that it was a single-subject case study focusing on only one individual. Furthermore, the first language of the student is Spanish; English is his second language, and this was his first year of schooling where the primary language of instruction was English. Finally, the student was a third-grader. Therefore, it is not clear that the process of the intervention would achieve the same results with younger or older students who are deaf or hard of hearing.

Recommendations for Future Research

In the future, it would be beneficial to investigate whether the intervention would be as effective with students who are younger than Ali, because early intervention has been shown to be key to supporting the educational success of students with disabilities throughout their education. It would also be useful to conduct a study utilizing these strategies that investigated the student's ability to successfully learn carrying with three-digit numbers. Future research could examine whether the intervention might be employed to support other aspects of mathematic achievement in students who are deaf or hard of hearing. Such research should also evaluate the effectiveness of this study design with deaf students, versus students who are hard of hearing, to see whether there is any difference in the response to the strategy.

References

Ali, S. 2011. "Mathematical skills in the early grades." http://aghandoura.com/thirdyears.htm.

Antia, S. D., Jones, P. B., Reed, S., & Kreimeyer, K. H. 2009. "Academic status and progress of deaf and hard-of-hearing students in general education classrooms." *Journal of Deaf Studies and Deaf Education 14*(3): 293-311. https://doi.org/10.1093/deafed/enp009.

Engel, R. J., & Schutt, R. K. 2008. *The practice of research in social work* (2nd ed.). Thousand Oaks: Sage.

Freese, M. R. 2008. *Recommendations for a mathematical curriculum to be used in conjunction with an oral deaf education program* [Master's thesis, Washington University School of Medicine in St. Louis]. Digital Commons at the Bernard Becker Medical Library. https://digitalcommons.wustl.edu/pacs_capstones/421/.

Nunes, T., & Moreno, C. 2002. "An intervention program for promoting deaf pupils' achievement in mathematics." *Journal of Deaf Studies and Deaf Education* 7(2): 120-133. https://doi.org/10.1093/deafed/7.2.120.

Qaryouti, Y., Sartawi, A., & Smadi, J. 2009. *Teaching mathematics*. Dar al-Qalam.

Swanwick, R., Oddy, A., & Roper, T. 2005. "Mathematics and deaf children: An exploration of barriers to success." *Deafness & Education International* 7(1): 1-21. https://doi.org/10.1179/146431505790560446.

Van de Walle, J. A., Karp, K. S., & Bay-Williams, J. M. 2013. *Elementary and middle school mathematics: Teaching developmentally* (8th ed.). Pearson.