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ORIGINAL ARTICLE

The Effects of the Pegword Method on the Multiplication Skills of Students with Math Difficulties

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Abstract This single-case study assessed the effectiveness of a mnemonic pegword strategy designed to enhance the multiplication fact fluency of three 6th-grade students who demonstrated persistent learning difficulties in mathematics. A nonconcurrent multiple baseline across subjects design was utilized, incorporating 3–5 baseline sessions followed by 10–12 intervention sessions. The results indicated a noticeable, gradual improvement in the learners' ability to recall multiplication facts involving two-digit numbers quickly and accurately. Interviews conducted with the participants to assess the social validity of this approach revealed agreement and enthusiasm for the continued use of the strategy. Although acknowledging certain limitations inherent in this research, these results support the continued use of this intervention to aid students who struggle with basic multiplication. Further investigations are warranted to determine the generalizability of these findings and to address the study's inherent limitations.

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Mathematical competence is crucial for all young people. It underpins a wide range of activities and problem-solving situations they will encounter throughout their lives. In school, it facilitates academic success, enhances logical thinking, and supports analytical skills across various subjects. In everyday life, basic math is essential for managing personal finances, shopping, and cooking. Careers in various fields require strong mathematical foundations for tasks ranging from budgeting and financial analysis to data interpretation, inventory management, project scheduling, and quality control (Kaur et al., 2022; Robinson et al., 2023).

When acquiring mathematical competencies, it is essential to understand the underlying concepts behind the relevant procedures. However, a solid grasp of these principles alone is insufficient for practical daily life applications, where tasks often need to be performed quickly. Sometimes, it is necessary to retrieve results automatically, because extended deliberation can be impractical and exhausting. Therefore, fluency in basic math operations must be considered indispensable. Korn (2011) defines this skill as the ability to quickly and accurately perform arithmetic problems from memory, such as 3 x 4 = 12. In addition, it entails performing tasks appropriately, flexibly, and efficiently

(Baroody, 2011; Kilpatrick et al., 2001). Mastery of fundamental mathematical operations is essential for skill retention, maintenance, and subsequent application to other academic pursuits (Gliksman et al., 2022).

Multiplication is crucial in this regard. Compared to other basic arithmetic procedures, it is significant because it is extensively used in advanced concepts such as algebra, calculus, and geometry (Fullerton, 2020; Karnes et al., 2021; Ma, 2010). Mastery of multiplication facts enables individuals to perform complex calculations more efficiently and confidently, supporting their overall mathematical proficiency and success (Krominga & Codding, 2024; Nam & Spruill, 2005).

Declining Math and Multiplication Proficiency

A significant number of students not only acquire a sufficient understanding of the principles behind basic arithmetic but also develop adequate math fact fluency by the end of their elementary education. However, an increasing percentage of children have encountered challenges in mastering this essential competency. This difficulty is reflected in the performance of fourth-grade students in the United States on the 2022 National Assessment of Educational Progress (NAEP), informally known as "The Nation's Report Card," which was lower in mathematics compared to 2019. Overall, this decline was larger for lower-performing students than for higher-performing ones. NAEP outlines learner proficiency levels as standards that indicate what they should know and be able to do at a given age. Results are reported as percentages of students reaching or exceeding three NAEP achievement levels: NAEP Basic, NAEP Proficient, and NAEP Advanced. Learners performing at or above the NAEP Proficient level on NAEP assessments demonstrate solid academic performance and competency over challenging subject matter. In 2022, 64% of fourth-grade students failed to achieve proficient scores in mathematics (National Center for Education Statistics, 2022).

Enhancing Multiplication Fluency: The Role of Mnemonic Strategies

Nevertheless, evidence-based intervention methods are available to assist learners in building math fluency. As Boon et al. (2019) explain in their comprehensive review, many of the most beneficial approaches use mnemonics to help students achieve arithmetic skills, especially in multiplication. These memory-enhancing techniques utilize associations, patterns, or imagery to facilitate information recall. Mnemonic strategies are systematic procedures for improving memory, providing effective cues for recall as a "cognitive cuing structure," such as word, sentence, or picture devices. Through these methods, students can develop better ways to encode new information for easier retrieval. Mnemonic strategies build upon familiarity or meaningfulness (Bellezza, 1981). Higbee (1976) concluded that mnemonic systems contribute significantly to recollection ability, warranting mastery of and continued research into these techniques. Early studies have found that mnemonic strategies benefit delayed recall (Carney & Levin, 2011), improve memory in the elderly (Wood & Pratt, 1987), and aid adult learners (Pressley & Ahmad, 1986).

In the field of special education, the work of Mastropieri and Scruggs served as a vanguard in the applied use of mnemonic strategies for students with learning and behavioral difficulties (Mastropieri et al., 1997; Scruggs & Mastropieri, 2000; Scruggs et al., 2010; i.e., Mastropieri & Scruggs, 1991). However, research concerning the use of mnemonic strategies for the improvement of basic multiplication fact recall has been sparse. Early works by Willot (1982), Greene (1999), and Wood and Frank (2000) addressed the utility of mnemonics in relation to multiplication facts, identifying this arithmetic operation as the most difficult for students with learning difficulties to acquire. Nonetheless, substantial research on this topic did not emerge at the time.

In their aforementioned review on the effectiveness of math interventions with struggling students, Boon et al. (2019) documented that mnemonic strategies can be highly advantageous for acquiring various mathematical skills, particularly fact fluency. They analyzed 11 relevant studies on this topic, 2 of which explored the effectiveness of a particular mnemonic technique related to the acquisition of multiplication fact fluency, known as the pegword method. This approach involves associating a number with a rhyming word (e.g., 1 = bun, 2 = shoe) and linking that word to the information being learned (Mastropieri & Scruggs, 1991). In the case of building multiplication fluency, a visually representable and rhyming sentence is found for a multiplication problem (e.g., “Two times 3 equals 6” becomes “Tiny ants march, carrying sticks”). Likewise, for “Six times 7 equals 42,” the mnemonic “Funny clowns laugh, under skies so blue” can be used.

The two pegword mnemonic studies featured in Boon et al.’s (2019) review were conducted by Irish (2002) and Zisimopoulos (2010). Both works investigated the effectiveness of this method in improving multiplication fact proficiency. They employed single-subject designs and focused on individuals experiencing specific difficulties in remembering basic multiplication operations. Irish’s work utilized a computer-based instructional approach (specifically Memory Math) to teach a pegword mnemonic strategy to six students aged 9–11 years who were identified with learning disabilities. The study reported the intervention’s effectiveness in improving the accuracy of basic multiplication skills, demonstrating the potential of computer-assisted pegword training in supporting children. In the second experiment, Zisimopoulos (2010) examined an instructional package that incorporated adapted pegword mnemonics and a picture-fading technique for two students aged 11 and 12 years, with moderate intellectual disabilities. The study found improvements in the participants’ ability to recall multiplication facts accurately, as well as the sustained application and transfer of acquired skills across various contexts. These findings emphasize the relevance of pegword mnemonics in enhancing fundamental arithmetic skills in students struggling with math, facilitating their access to the general curriculum.

The Current Study

The present research aimed to generalize and extend previous findings by assessing the effectiveness of the pegword technique across three distinct areas. First, the research was conducted in a large urban school in Germany, with the intervention implemented in German (the two aforementioned experiments were conducted in the United States). Second, the study focused on students who experienced persistent difficulties in mathematics, particularly in multiplication proficiency, regardless of a formal disability diagnosis, at an age when these foundational skills should have already been acquired (beginning of their secondary education). Third, the participants were either recent migrants to Germany or children of migrants, from households where German was not the primary spoken language. This situation has become increasingly common in Germany, and it is important to focus more research on this group of students, as little is known about how specific approaches work with them given their unique needs.

Our objective was to examine whether a relatively brief and easily implemented pegword intervention could substantially enhance two-digit multiplication proficiency among these participants. We expected continuous improvement over the course of the process. The ability to quickly recall multiplication facts requires practice, so we did not anticipate a sudden increase in performance. In addition to the observable improvements in this mathematical skill, we also aimed to understand how the intervention was received by the students.

Method

Setting and Participants

The study was conducted in a sixth-grade classroom at a diverse comprehensive school on the outskirts of a large metropolitan area in western Germany. It should be noted that the school’s socioeconomic status, as indicated by the typical occupational status of the students’ families, was low. Participants were selected based on recommendations from their teacher due to their poor performance in mathematics. To identify those eligible for the study, all children in the class were initially administered a worksheet containing 60 randomly selected basic multiplication facts (from the 1s to the 10s) to be completed within 10 min. Students who exhibited significant difficulties (i.e., those who failed to correctly solve at least 25 problems in at least three multiplication tables) were considered for inclusion. To qualify, individuals had to be able to solve at least one- and two-digit additions and have a fundamental grasp of multiplication concepts. This ability was determined by having them complete school-specific addition diagnostic worksheets and demonstrate their understanding of the principles of multiplication through the visual representation of various multiplication tasks using counting objects. The classroom teacher conducted the assessment of these skills. Because our focus was explicitly on students with a migrant background, we ensured that this criterion was met. However, it was already the case that all the children eligible for the study, based on their competency levels in mathematics, were not of German descent.

Three students met these criteria and were selected to participate in the project: Amir, Bella, and Christos (names changed to maintain anonymity). All the children and their parents (or guardians) provided informed consent and indicated interest and willingness to be involved in the project. We clarified that all necessary approvals for our study were obtained in accordance with local regulations, which are fully comparable to Institutional Review Board standards in the United States. Based on the results of the aforementioned assessment with the multiplication worksheets, all of the students experienced significant difficulties with the 6s, 7s, 8s, and 9s tables. The participants are described below.

Amir

Amir was a 12-year-old boy from a Kurdish family, and had moved to Germany from Turkey at the age of 3. The predominantly spoken language at his home was Kurdish, and Amir's German skills were of below-average proficiency. However, although he faced challenges in both German and Kurdish, he had not received an official diagnosis of a learning or language disability. Despite his difficulties, Amir was motivated and willingly participated in the study.

Bella

Bella was a 13-year-old girl who was born in Armenia and moved to Germany at a young age. Although her parents did not speak German fluently, Bella had acquired basic German language skills. She had received a learning disability diagnosis in her elementary years but shown subsequent academic progress. However, Bella faced persistent challenges in mastering multiplication tables. She voluntarily participated in the study based on her teacher's recommendation.

Christos

Christos was a 13-year-old boy of Greek descent who grew up in Germany, but German was not the primary language spoken in his household. According to his teacher, Christos received inconsistent support at home and often displayed a lack of interest when presented with mathematics tasks during class. Like Amir and Bella, he encountered difficulties with multiplication tables. Despite these challenges, Christos had not been evaluated for a learning disability. Following a recommendation from his teacher, he willingly chose to participate in the research project.

It should be noted that among the three participants, only Bella had been identified as having a learning disability. However, based on their background information, all of them experienced challenges that would likely qualify them for diagnostic, academic, and cognitive evaluations. The fact that only Bella had been previously diagnosed with a learning disability could have been due to many factors, including: (1) the school district's reluctance to identify specific learners as having a disability, for fear of stigmatizing them; (2) the school's incapability to provide special education services for eligible students; and (3) the school's inability to separate difference from disability, that is, to identify any potential academic effects of being a multilingual learner. Although these students undeniably needed support, this necessity had never been formally documented with an eligibility determination. This reflects the reality of the current German school system.

The intervention was conducted by the second author, a fourth-semester master's student pursuing a degree in education with a focus on special education. She worked with the children in a 1:1 setting in a resource room of the school. Through various prior internships, she acquired experience in supporting children with academic and behavioral difficulties.

Measurement and Experimental Design

The dependent variable was the count of correctly solved multiplication problems in worksheets containing 15 items each. These questions were randomly drawn from a pool that included all tasks from the 6s, 7s, 8s, and 9s multiplication tables (except for those involving multiplying by 1 or 10). Students were allotted 3 min to finish the test, and each worksheet was used only once per child. These problems were to be solved independently and without any aid. The interventionist determined the number of correctly solved problems and recorded them. To ensure reliability, she cross-verified each evaluation at the end of the intervention period, with no discrepancies found between the initial count and the cross-verification.

We employed a nonconcurrent multiple baseline design to assess the efficacy of the intervention. This method was chosen to demonstrate basic methodologic rigor; it must be able to show that (1) a change in behavior has occurred; (2) the change is likely a result of the intervention; and (3) the change is statistically and practically significant (Hawkins et al., 2007).

This procedure permitted the evaluation of the intervention's impact across different individuals, where establishing a causal relationship between the treatment and the observed changes while accounting for various factors is essential (Horner & Odom, 2014). We planned 15 daily probes, encompassing measurement points from both the baseline and intervention phases. The start of the intervention sessions was randomized within the predetermined limits, determining which students would begin after the third, fourth, or fifth baseline probe. Amir began training after the third session (with 12 pegword lessons), Bella after the fourth (with 11 pegword lessons), and Christos after the fifth (with 10 pegword lessons). This staggered introduction of the treatment among participants effectively mitigated potential threats to internal validity (Morley, 2017).

Procedure

During the baseline phase, students engaged in a 30-min session playing the popular card game "UNO," where they matched cards by color or number while aiming to be the first to discard all their cards. Following play, they were administered a test comprising 15 multiplication problems drawn from the task pool, as previously described. Completed worksheets were collected without any commentary or feedback.

In the intervention phase, in contrast to the baseline phase, students were taught through the pegword method in an approach that closely followed the one outlined by Zisimopoulos (2010). The instructional sequence adhered to a structured pattern, as proposed by Stein et al. (2017)—it began with the 9s table, followed by the 7s table, then the 8s table, and finally the 6s table. Each session lasted 20 min, with additional time allocated for performance assessment.

During the initial session, the focus was on introducing the 9s table. The interventionist explained to the students that the method she was about to teach would aid in mastering multiplication facts and lead to significant improvements in performance. To accomplish this goal, a flashcard was presented for each task, containing not just the equation (e.g., 7 x 9 = 63) but also an accompanying image and rhyme. An example in English for (4 x 8 = 32) might feature a simple drawing of a dog fetching a dirty shoe. This image would be paired with the multiplication problem and its solution, along with the phrase "A dog is fetching a dirty shoe" (rhyming with "4 times 8 is 32"). A German instance for another equation (although one that does not rhyme in English) could depict a horse, accompanied by the rhyme "Sieben mal neun ist dreiundsechzig—dieses Pferd ist ganz schön mächtig" ("Seven times 9 is 63, this horse is quite powerful"). Other examples used in our study included "Neun mal drei ist siebenundzwanzig, der Käse ist schon etwas ranzig" ("Nine times 3 is 27, the cheese is a bit rancid"); "Neun mal fünf ist fünfundvierzig, die Pommes schmecken gut und würzig" ("Nine times 5 is 45, the fries taste good and spicy"); and "Vier mal neun ist sechsundreißig, die Kinder rechnen heute fleißig" ("Four times 9 is 36, the children are doing their math diligently today").

The individual tasks within the 9s table were presented sequentially, with students encouraged to repeat them along with the associated rhyme provided by the interventionist. As students gained confidence in this process, a modified set of flashcards was introduced. They omitted the result and the rhyme (e.g., after the = sign, there was no longer a number but a question mark). The images were also less distinct. When a student could correctly recall the rhyme and solution under these conditions, a different set of flashcards was introduced, where the image was even less discernible. In the fourth and final version of the cards, only the task was presented (e.g., 7 x 9 = ?). All four flashcards were introduced within one session, and the choice of cards used depended on each child's progress. It should be noted that by the conclusion of the initial lesson, all participants were able to work through at least one version without images.

The second session began with a review of the 9s table, followed by the introduction of the 7s table, mirroring the structure of the first lesson. In the third lesson, the 9s and 7s tables were reviewed before presenting the 8s table. Likewise, the fourth session, following a review of the 9s, 7s, and 8s tables, centered on the introduction of the 6s table. Throughout this period, students consistently received praise for accurate responses and were encouraged to persist in their efforts.

Subsequent sessions comprised a thorough review of all tasks, with the use of flashcards without accompanying images. In addition, worksheets were integrated into the intervention—those completed on the previous day were presented to the children at the outset, and the individual tasks were collaboratively worked through. If a child provided an incorrect or no answer, the corresponding flashcard was presented to reestablish the association between the images and rhymes with the mathematical facts on the worksheet. The questions also included problems using the commutative property of multiplication to ensure comprehensive understanding.

Procedural Fidelity

To adhere to the established methodological criteria, a nine-item checklist was developed, listing all the necessary components and steps to be followed during the treatment sessions (available from the authors upon request). This inventory was implemented by the interventionist during each lesson to ensure consistency and fidelity to the treatment protocol. Furthermore, to enhance the rigor of the study, an external observer, a teacher, reviewed the checklist in a random selection of sessions. In line with Horner et al.'s (2005) standards, which stipulate that observing and recording treatment fidelity in at least 20% of all lessons is sufficient for ensuring the reliability and validity of the intervention, 3 out of 15 sessions per child (20%) were observed. The specific lessons monitored, regardless of whether they were baseline or intervention, were randomly determined in advance. The teacher followed the sessions from a background position, primarily focusing on adherence to the predefined standards. The presence of this external observer also served to verify whether the students performed consistently under varying environmental conditions. As a result, procedural fidelity was maintained at 100%, following the guidelines by Morris et al. (2024).

Social Validity

Our study also considered the social validity of the intervention. After the conclusion of the final lesson, all three participants were invited to fill out a short questionnaire to provide their perspectives on several aspects (available from the authors upon request), including (1) whether they enjoyed the process; (2) whether they would recommend it to their classmates; (3) whether they felt their mathematical skills and self-confidence had improved; and (4) whether they would be interested in continuing with the program. An independent teacher distributed and analyzed these questionnaires.

Data Analysis

Each student's data underwent visual analysis to assess the impact of the independent variable on the outcome variable, specifically whether employing the pegword strategy influenced multiplication fact fluency. This examination was done following a common procedure outlined by Ledford and Gast (2024), entailing plotting data points on a graph to visually inspect the level, trend, and variability of the data across different phases of the study.

Effect sizes for the dependent variable were also calculated using the "percentage of data exceeding the median trend" (PEM-T) and Tau-U (Alresheed et al., 2013). PEM-T proves particularly valuable when anticipating gradual, incremental performance improvements rather than sudden leaps. It offers a continuous gauge of change, making it suitable for situations where performance develops slowly, such as during a progressive learning curve or skill acquisition (Wolery et al., 2010). The Tau-U analysis was employed to examine group treatment effects, comparing the baseline phase to the intervention phase, because it considers both the slope and magnitude of change. Tau-U suits the small datasets typically used in single-case designs and provides p-values for assessing statistical significance (Parker et al., 2011). Individual Tau-U contrasts were calculated using the online calculator available at https://ktarlow.com/stats/tau/.

Finally, we conducted a hierarchical piecewise linear regression using the SCAN package for R by Wilbert and Lüke (2022) across all cases. This comprehensive analysis facilitates the identification of overarching trends and intervention effectiveness patterns among participants.

The responses from the social validity questionnaire were reviewed and compiled by the aforementioned independent teacher to gain insights into the students' perceptions of the intervention. This analysis helped determine the overall effectiveness and acceptability of the program based on the participants' feedback.

Results

The intervention led to marked improvements in multiplication fluency in all three students (see Fig. 1). Each participant demonstrated substantial advancement in their performance, consistently achieving higher scores during the treatment phase compared to their baseline measurements.

Amir's baseline data indicated a lack of multiplication fluency skills, with every point at zero. Upon the start of the intervention, he consistently demonstrated improvement, ultimately achieving a perfect result of 15 in the last four measurements. The average score in the intervention phase was 11.00 (*SD* = 4.25). For Amir, the PEM-T reached a perfect score of 100,

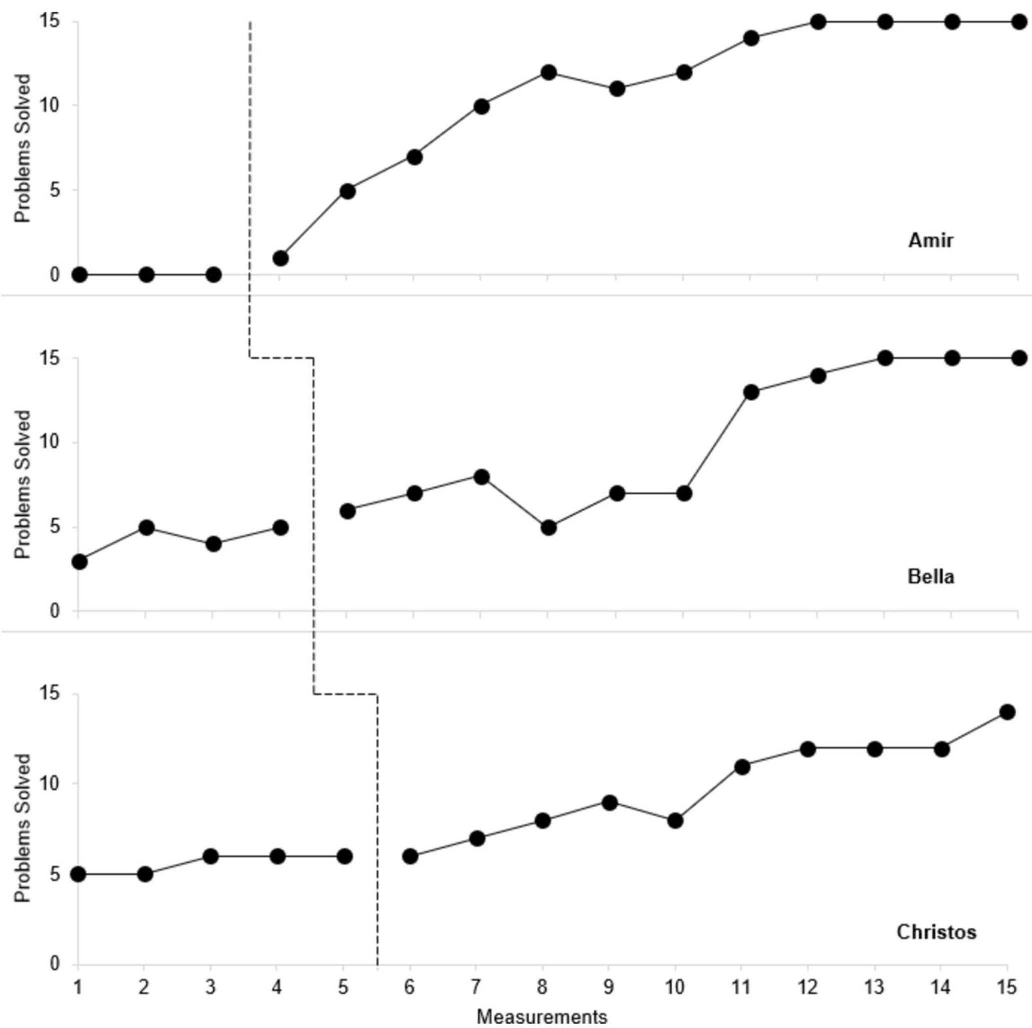

Fig. 1 Multiplication Problems Solved for Each Participant in Each Treatment Condition

signifying a highly positive response to the program. The Tau-U of 0.62 ($p < .01$) fell within the "moderate to strong effect" range, indicating a substantial impact of the intervention on the studied outcome.

Bella's baseline performance averaged 4.00 (*SD* = 0.93) and remained relatively stable, showing no significant trend. Upon commencing training, she exhibited continuous improvement for three sessions and experienced a decline during three measurements before ultimately achieving high scores of 15 during the final three probes. Her mean performance during the intervention phase was 9.75 (*SD* = 3.94). The PEM-T was 72.73, indicating that 72.73% of the data points in the intervention phase exceeded the median trend established during the baseline phase, reflecting a substantial performance improvement. Moreover, the Tau-U reached 0.65 ($p < .01$), indicating a considerable treatment effect.

Christos's baseline performance remained stable, with a mean score of 5.33 (*SD* = 0.54). Like Amir and Bella, his competence showed enhancement following the implementation of the intervention, averaging 9.25 (*SD* = 2.64). However, unlike Amir and Bella, he only achieved a score of 14 at the end of the training. His PEM-T was 90.00, underscoring the remarkable impact of the program on his multiplication fact fluency. The Tau-U was 0.67 ($p < .01$), indicating a strong effect size, consistent with the cases of Amir and Bella.

Hierarchical piecewise linear regression analysis across the three students was also applied and results are provided in Table 1. This method enables the simultaneous assessment of multiple individual trajectories, capturing both individual and collective-level effects of the treatment. It allows researchers to examine differences in benefits among participants, providing a comprehensive understanding of the variability and consistency of effects across diverse individuals (Wilbert & Lüke, 2022).

Table 1 Hierarchical Piecewise Linear Regression Analysis across All Participants

	B	SE	*t*	*p*
Intercept	3.16	0.71	4.47	<.01
Trend	0.38	0.29	1.29	.21
Level	0.33	1.09	0.31	.76
Slope	0.70	0.30	2.35	<.05

The analysis revealed that the intercept was statistically significant ($B = 3.16$, $SE = 0.71$, $t = 4.47$, $p < .01$), suggesting that the performance level of the participants was above zero at the start of the treatment. Although the level change was not statistically significant ($B = 0.33$, $SE = 1.09$, $t = 0.31$, $p = .76$), the differences in slope were ($B = 0.70$, $SE = 0.30$, $t = 2.35$, $p < .05$). The *B* value of 0.70 implies that, on average, the outcome variable is anticipated to increase by 0.70 units for each student in each intervention session. This finding aligns with our initial expectation of achieving gradual performance improvement rather than a sudden leap.

According to the interview data, all the participants (100%) enjoyed the training, believed it helped them to improve their multiplication skills, and would recommend it to their classmates.

Discussion

Main Findings

The objective of this research was to investigate the impact of the pegword technique on the multiplication fact proficiency of three 6th-grade students with an immigrant background who were facing substantial challenges in mathematics. Our findings illustrate the noteworthy influence of the treatment on the participants' ability to recall solutions for problems related to the 6s, 7s, 8s, and 9s tables. The pegword training was vital in enabling students to promptly and consistently retrieve relevant mathematical facts. All participants exhibited effect sizes in either the high moderate or large range on the PEM-T and Tau-U assessments. As anticipated, the children's results displayed a significant increase from baseline to intervention, which was supported by a hierarchical piecewise linear regression analysis across all subjects. Furthermore, all participants expressed their contentment with the intervention, as indicated by their favorable responses to a social validity questionnaire.

Limitations

Like all empirical studies, this research has shortcomings. First, in the domain of single-case design research, our conclusions are derived from a series of replication studies rather than a singular, large-scale investigation (Walker & Carr, 2021). As a result, our experiment can only be seen as a contributing element to the growing body of evidence regarding the impact of the pegword method on the multiplication fact fluency of students. The outcomes of this research cannot be generalized to a broader population. Nevertheless, only two publications have evaluated the pegword method in the context of improving multiplication fact fluency, and both were conducted in the United States. Thus, our German experiment represents a small but significant contribution to the foundation of this approach.

Another shortcoming is that although we were able to meet the minimum requirements outlined in the standards for single-case research by Horner et al. (2005), more than three baseline sessions would have strengthened the validity of our findings by providing a more stable and reliable baseline against which to measure the effects of the intervention (see Kratochwill et al., 2023). However, conducting a single-case study in a school setting requires negotiation with teachers to determine feasibility. In our case, practical constraints within the school environment made it necessary to settle for the standards of Horner et al. (2005).

An additional noteworthy constraint to our study is the omission of a maintenance phase in our multiple baseline design. Its inclusion would have enabled us to evaluate the endurance of the observed effects over an extended time frame. However, due to an upcoming school vacation, we were unable to incorporate a maintenance phase into our study.

Last, the potential for experimenter bias cannot be entirely ruled out, because the interventionist conducted all the sessions and administered all the measurements.

Practical Implications

Despite the aforementioned limitations, this study highlights the pegword method's efficacy in enhancing multiplication fact fluency. Competence in mathematics plays a pivotal role in one's daily life, either explicitly or implicitly, and is a robust predictor of overall academic achievement (Gurganus, 2021). Hence, it becomes imperative to deploy effective teaching and support strategies for struggling students (Kromminga & Codding, 2024). By alleviating the cognitive burden on working memory and facilitating the recall of derived facts, the pegword method enhances mathematical skill acquisition (Fuchs et al., 2005; Viesel-Nordmeyer et al., 2022).

Although effective math interventions aimed at enhancing students' mathematical fluency are abundant, research indicates that they are often underutilized in schools due to their impracticality. Many effective programs are simply too cumbersome to implement, leaving educators with no feasible means to incorporate them into their teaching practices. This underperformance, coupled with the limited implementation of effective practices, underscores the necessity of providing educators with interventions that are both effective and efficient while being resource-friendly to support students' math achievement. The pegword method is easily deployable with minimal effort and yields remarkable results within a short period of time.

It should be noted that our method was shown to be effective for children with an immigrant background from a diverse school with a low socioeconomic status. Although it may not be immediately obvious why such an intervention would work differently for learners with an immigrant background compared to native ones, past experiences have shown that various factors can influence outcomes (Abdulrahim & Orosco, 2020; Turner et al., 2024). Therefore, it was important to address this issue and demonstrate that the intervention was helpful for three children from different cultural backgrounds.

Although it may have been challenging in the past to generate the rhymes required for the pegword method for relevant multiplication tasks, this issue is insignificant in the age of generative artificial intelligence (AI). Today, it is possible to use AI to create an unlimited supply of solutions immediately. Although our study was conducted in a 1:1 setting, it should not be particularly difficult to apply the method to peer tutoring, small groups, or even whole classes.

Future Research and Conclusion

Additional empirical research is needed to analyze the impact of the pegword method on students' multiplication fact fluency. Such investigations should build upon the earlier works conducted by Irish (2002) and Zisimopoulos (2010), as well as the current study, to expand the research foundation. Relying solely on three single-case studies involving a total of eleven 9–13-year-olds is insufficient for establishing a robust evidence base. Furthermore, it would be valuable to explore the modification of specific factors, including the participants' age, implementation within a classroom setting rather than one-on-one scenarios, and the assessment of retained factual knowledge after a certain period.

Researchers should continue to explore effective ways of utilizing the pegword method with the aim to implement it more broadly in school settings. Considering students' reducing mathematical expertise as they transition to secondary education, this intervention seems more necessary than ever.

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Data Availability Data availability is not applicable to this article as it is based on a single-case study. All relevant quantitative data are fully presented within the article and can be extracted from the provided line graph.

Declarations

Conflicts of Interest We confirm that there are no known conflicts of interest associated with this article and there has been no significant financial support for this work that could have influenced its outcome.

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