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# Strategy-Based Math Instruction for Secondary Students with Learning Difficulties: A Replication Study

Matthias Grünke[1], Jennifer Karnes[1], Anne Barwasser[1] & Mack Burke[2]

[1] Department of Special Education and Rehabilitation, University of Cologne, Cologne, Germany

[2] School of Education, Baylor University, Waco, USA

Correspondence: Matthias Grünke, Department of Special Education and Rehabilitation, University of Cologne, Klosterstr. 79b, 53909 Cologne, Germany.

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**Abstract**

This paper presents a replication study investigating the effectiveness of a strategy to assist students with learning difficulties in adding fractions. Drawing on the research conducted by Grünke et al. (2023), this single-case analysis extends the application of the Look, Ask, Pick (LAP) mnemonic technique initially introduced by Test and Ellis (2005) to struggling sixth-grade students. Employing a multiple-baseline design, we implemented the LAP strategy with four participants in a time lagged fashion. Significant improvements were observed in their fraction performance, demonstrating the intervention's potential to enhance understanding and proficiency. The students highly appreciated the strategy, deeming it of great importance. In conclusion, we address the limitations of our study, propose directions for future research, and delve into the implications for teachers. This research contributes to the understanding of fraction interventions and offers valuable insights into facilitating the mathematical progress of students facing challenges.

**Keywords:** fractions, strategy instruction, learning problems, single-case research

## 1. Introduction

Proficiency in fractions is a fundamental component of mathematical literacy, serving as a crucial stepping stone toward mastering more advanced numerical concepts and skills. Whether pursuing further education, vocational training, or entering the workforce, a solid foundation in fractions is essential for success in various domains (Booth & Newton, 2012; Geary et al., 2012; National Mathematics Advisory Panel, 2008). The ability to comprehend and compute fractions enables individuals to engage with data analysis, probability, measurement, geometry, ratios, and algebra, forming the bedrock of mathematical competence (Bailey et al., 2014; Cirino et al., 2022; Moses & Cobb, 2001).

Regrettably, not all students acquire proficiency in fractions by the time they start secondary education, particularly those with identified disabilities. Despite most of them learning how to perform basic operations with fractions during elementary education, a significant proportion continues to struggle, requiring additional support to prevent falling behind their peers (Vukovic et al., 2014; McMullen & Van Hoof, 2020). This disparity is concerning, given that fraction skills are not only pivotal for subsequent mathematical learning but also necessary for everyday tasks such as adjusting recipe sizes, calculating measurements, or making informed financial decisions (Booth & Newton, 2012; Gabriel et al., 2013; Vukovic et al., 2014).

There are promising methods to assist struggling students in developing adequate fraction skills. Previous research has identified several effective instructional approaches that enhance students' conceptual understanding and procedural fluency in fractions (Barbieri et al., 2020; Bryant, 2015; Crawford et al., 2019; Misquitta, 2011; Shin, Schnepel, & Aunio, 2022). For instance, explicit instruction, strategy instruction, graduated conceptual instruction, and video modeling have shown positive outcomes in improving fraction comprehension (Bouck et al., 2020; Ennis & Losinski, 2019; Hughes, 2019; Misquitta, 2011; Yakubova et al., 2020). The use of visual representations, systematic instruction, and a focus on both conceptual and procedural learning have also been found to enhance students' fraction skills (Lenz et al., 2020; Shin & Bryant, 2015).

One specific method that has demonstrated promise in supporting students with math difficulties is the Look, Ask, Pick (LAP) strategy. LAP employs a fraction-specific mnemonic technique, providing students with three consecutive instructions for solving fraction addition and subtraction problems. The mnemonic guides students to "Look at the sign and denominator," "Ask if the smallest denominator divides into the largest denominator evenly," and "Pick the appropriate fraction type" (Test & Ellis, 2005). Feedback on performance from previous sessions, possibly incorporating visual aids like line graphs, along with a reward system for achieving various interim goals, is often an integral part of strategy instruction, as in the case of the LAP intervention. Such supportive measures can ensure that students engage with the intervention and interact with the presented aids (Reid et al., 2013).

Three studies have investigated the efficacy of the LAP-strategy in teaching fraction addition skills to struggling students: Test and Ellis (2005) focused on 6 eighth-graders, including three with mild intellectual disabilities and three with math learning disabilities. The study demonstrated a functional relationship between implementing LAP Fractions and student acquisition of the strategy, with 5 out of 6 participants mastering the skills. Second, Everett et al. (2014) examined the effects of LAP on three 11-year-old general education sixth graders with fraction skill deficits. Using a concurrent multiple baseline design, the study found consistent improvements in both percent problems correct and digits correct per minute during the LAP intervention. Last, Grünke et al. (2023) used a multiple baseline design with four struggling sixth graders. All participants showed significant improvement and perceived the LAP-strategy as highly useful. Prior to instruction, none of them could correctly solve the problems, but by the end of the treatment, they were able to answer all or almost all of the fraction problems they were presented with.

While these three studies have yielded promising outcomes, it is crucial to extent and replicate previous research. Building an evidence base through single-case analyses entails constructing a program of studies by conducting a series of systematic inquiries. This approach involves exploring a research question multiple times through systematic investigations (Kratochwill et al., 2021). Unfortunately, the field of special education faces a replication crisis (William, 2022). This scarcity hinders the establishment of a robust evidence base. It is regrettable that many journals exhibit reluctance in publishing replications, further exacerbating the problem (Makel et al., 2026).

What is more, we often find that not only are there insufficient single-case studies on the effectiveness of a given method, but the existing ones also frequently fail to capture the acceptability of the intervention in question, particularly from the viewpoint of the participants (Snodgrass et al., 2018, 2023). This aspect was termed "social validity" by Wolf (1978), an early pioneer in single-case methodology. It is important to consider how students in a single case or any other intervention study perceive the procedures and whether they find them helpful. Because even the most apparently effective treatment will not be integrated into everyday classroom education if students reject it and do not find it stimulating.

Hence, the current study sought to contribute to addressing this gap by replicating the findings of Grünke et al. (2023). Our objective was once again to assess the extent to which the implementation of the LAP strategy could be advantageous for sixth-graders who face ongoing challenges in mathematics. Additionally, it aimed to gauge the degree to which the participants found the intervention acceptable, relevant, and enjoyable. Thus, this research sought to answer two specific research questions:

1) What is the impact of the LAP strategy on students' proficiency in adding one-digit fractions?

2) To what extent is the LAP strategy socially valid from the perspective of the participating students?

## 2. Method

### *2.1 Participants and Setting*

The study occurred in a sixth-grade classroom of a secondary school in a large metropolitan city in Germany. Four criteria were established to choose the students for participation. First, they needed to exhibit significant difficulties in adding fractions. To assess these challenges, they were given a worksheet with 15 arithmetic problems featuring one-digit fractions and a three-minute time limit to complete them. Additionally, it was necessary for them to achieve a T-value exceeding 35 in the addition subtest of the "Heidelberg Arithmetic Test" (Haffner et al., 2005). The chosen T-value threshold of 35, although relatively low (1.5 standard deviations below the mean), was set to indicate a minimal competence in basic addition. Furthermore, regular attendance in the past month was mandatory, which was confirmed by consulting the records provided by the classroom teacher. Lastly, the participants' active consent to take part in the study was obtained through direct questioning.

Six students in the respective class were unable to correctly solve any of the fraction addition problems within the allocated three minutes. This aligned with the observations reported by the class teacher, who had noted challenges in fraction arithmetic among these particular learners. However, these students achieved a T-value of at least 35 in the aforementioned subtest. While all of them expressed their willingness to participate in the study, two of them had to be excluded due to excessive absences, preventing their inclusion in the data analysis.

The four selected individuals for the study were given pseudonyms for anonymity. Anissa, a 13-year-old female student, obtained a T-value of 41 in the HRT. Bernice, also a female student, was 12 years old and achieved a T-value of 39 in the HRT. Carolin, another female student, was 12 years old and obtained a T-value of 35 in the HRT. Doruk, a male student, was 12 years old and achieved a T-value of 41 in the HRT.

All of them demonstrated proficiency in German. This includes Aminata, who, despite being relatively new to Germany, quickly achieved a strong command of the language (Aminata's parents migrated to Germany from West Africa when she was eight years old). There were multiple signs pointing to the likelihood of a learning disorder in mathematics as defined by the DSM-V (American Psychiatric Association, 2013) among the participants. These indicators were based on teacher observations, outcomes from initial diagnostic assessments, and insights gained during the intervention process. However, formal diagnoses of learning difficulties, as in this scenario, are often not pursued in Germany, mainly to avoid stigmatization and due to limited resources. It is worth noting that most of the students exhibited limited confidence in their mathematical abilities. Prior to the intervention, they displayed minimal or incorrect solution strategies when faced with fraction arithmetic tasks, as reported by their classroom teacher.

### *2.2 Interventionist*

The interventionist for this study was a female graduate student specializing in special education. Possessing experience in teaching children confronted with severe learning difficulties, her knowledge and expertise were acquired through numerous practicum engagements. Notably, her current pursuit revolved around attaining a master's degree in the field of special education.

### *2.3 Experimental Design*

The present study employed a single-case design with a multiple baseline design to investigate the effects of the LAP intervention (Kazdin, 2021). A total of 15 measurement points were collected. Due to the constraints of the school schedule, the project spanned a period of four weeks. To ensure internal validity, the duration of the baseline phase was randomly assigned to each student. It consisted of three to six measurement points, resulting in intervention periods ranging from twelve to nine measurements. Consequently, the start of the intervention for each student was as follows: Anissa began on the 4th day, Bernice began on the 5th day, Carolin began on the 6th day, and Doruk began on the 7th day.

### *2.4 Dependent Variable*

The dependent variable in this single-case study was the number of correctly solved one digit fraction problems. During both the baseline and intervention phases, the students were asked to complete a sheet consisting of 15 fraction problems at the end of each session. A fixed time limit of three minutes was allocated for this task. The students were made aware of this time constraint and were reminded before each measurement that they should only work on the sheet until the timer expires.

To ensure the integrity of the measurement process, the assignment of problem sheets to each measurement point was randomized. As the difficulty level of the problems was consistent across these sets, a random number generator was used for their assignment. All possible fraction problems were listed in a document and then selected using a random number generator. The only modification made was to prevent the inclusion of the same problem multiple times on a single sheet. In such cases, the generator was rerun, and a different problem was chosen.

The problems were scored as either correct or incorrect, allowing each measurement point to be evaluated on a scale of 0 to 15 points. For data analysis, it was sufficient to count the number of correct problems at each measurement point. These scores were then transferred to line graphs to visualize the data. The SCAN package, developed by Wilbert (2023), was utilized for generating these graphs.

### *2.5 Procedures*

#### 2.5.1 Baseline Phase

The primary aim of the baseline phase was to establish the initial proficiency level of students in fraction operations. To capture this information, a consistent structure was employed across the baseline sessions. Initially, a 20-minute card game (Dobble) was utilized as a warm-up activity, allowing students to engage in a math-related task before transitioning to the main assessment. Subsequently, they were presented with a sheet of 15 fraction problems to solve within a fixed time limit of three minutes. This task aimed to evaluate their accuracy in solving fraction-related mathematical problems. It is important to note that no additional instruction or feedback regarding task performance was provided to the students during this phase. Simultaneously, the participants continued their regular mathematics classes, where the topic of fraction operations, including addition, had already been covered. Therefore, no separate or targeted intervention related to fraction operations was administered to any of them during this phase. This ensured that the baseline measurements solely reflected their current abilities, unaffected by external influences or specific support.

2.5.2 Intervention Phase

The intervention phase followed a well-structured approach to facilitate targeted improvement in the students' fraction-solving skills using the LAP strategy. Each session adhered to a consistent format to maintain consistency and comparability across the treatment.

At the beginning of each intervention session, the students' performance from the previous lesson was reviewed and discussed. The results were recorded on a graph to visually track their progress over time. This graph served as a visual representation of their achievements, motivating the students and reinforcing their sense of accomplishment. Additionally, stickers were given as tangible rewards for their efforts, offering further incentives and positive reinforcement.

Subsequently, the LAP strategy was introduced and practiced using a variety of exercises and examples. It was taught using a progressive approach known as "I do it – We do it – You do it" (McLeskey et al., 2017). Initially, the interventionist demonstrated how to solve problems using the strategy (I phase). This modeling provided a clear illustration of the steps and thought processes involved in solving fraction problems. The interventionist explicitly explained their reasoning and highlighted key decision points throughout the problem-solving process. Establishing a thorough and robust understanding of the LAP method was the primary goal of this approach.

In the subsequent phase (We phase), the students and the interventionist collaboratively solved problems using the strategy. By actively engaging with the students, the interventionist promoted participation and interaction, allowing the students to actively contribute to the problem-solving process. During this collaborative phase, the strategy was verbalized by either the interventionist or the students themselves. Verbalization served as a form of metacognition, encouraging students to articulate their thought processes and approach to problem-solving. It also facilitated peer learning and provided an opportunity for students to learn from each other's perspectives and strategies.

Once the students demonstrated a sufficient level of understanding and proficiency in applying the strategy, they transitioned to the independent phase (You phase). This stage aimed to foster self-reliance and autonomy in problem-solving. Participants were encouraged to independently apply the strategy to solve fraction problems, seeking assistance or guidance only when necessary. The interventionist closely monitored the students' progress during this phase, providing feedback, addressing any errors, and guiding their understanding as needed.

Throughout the intervention, adaptive attribution was an integral component of the sessions (Erten, 2015). Students were encouraged to connect any failures or difficulties to specific errors or misconceptions rather than personal shortcomings. This approach aimed to foster a growth mindset and help students develop a problem-solving mindset that focused on identifying areas for improvement and adjusting their strategies accordingly. Celebrating successes and progress also played a crucial role in maintaining motivation and engagement.

To ensure consistency and avoid bias, the intervention sessions utilized pre-created sets of exercise sheets, which were randomly assigned to each measurement point. They were carefully designed to be equivalent in difficulty, eliminating any potential influence of task variability on the measured outcomes. To prevent repetition of problems within a single sheet, a random generator was employed. If any duplicated problems were identified, the generator was rerun to select alternative problems, ensuring a diverse and unbiased set of exercises for each measurement point.

During the intervention sessions, the students' performance on the progress monitoring measures (see dependent variable) was closely observed by the interventionist. Immediate feedback was provided, and any errors or misconceptions were addressed and clarified. Collaborative error correction took place, allowing the students to actively participate in identifying and rectifying mistakes. This collaborative approach not only supported immediate learning but also promoted a deeper understanding of fraction operations through reflection and analysis.

*2.6 Treatment Fidelity*

To ensure that the intervention was delivered as intended, a checklist containing criteria and procedures for implementing the training was utilized (available from the first author upon request). The assessment form was completed three times per student receiving treatment, distributed over time, by an external observer. A consistent 100 percent adherence to the protocol was achieved for all sessions.

*2.7 Social Validity*

After the final intervention session, the interventionist conducted brief social validity interviews with the students, taking concise handwritten notes on their responses. The purpose of these inquiries was to assess the participants' perception of the treatment's effectiveness, their impression of its impact on their personal development, and their likelihood of recommending it to their classmates. Although these interviews were relatively short, they served as a valuable tool to capture the essence of social validity by eliciting the students' candid feedback regarding their satisfaction with the intervention and its perceived benefits on their academic journey. By exploring their perspectives in this manner, this investigation aimed to gain valuable insights into the treatment's social acceptability and practical significance.

## 3. Results

Table 1 contains all the information pertaining to the raw scores. Figure 1 displays the results of the baseline and intervention conditions. Visual analysis of the line diagrams indicated a clear pattern across all participants.

Table 1. Raw scores for the four students per phase

| Student | | Baseline Phase | Intervention Phase |
|---|---|---|---|
| Anissa | N (Probes) | 3 | 12 |
| | Raw Scores | 0; 0; 0; | 4; 5; 4; 6; 8; 9; 10; 11; 11; 14; 14; 15 |
| Bernice | N (Probes) | 4 | 11 |
| | Raw Scores | 0; 0; 0; 0; | 1; 6; 7; 19; 13; 13; 15; 15; 15; 15; 15 |
| Carolin | N (Probes) | 5 | 10 |
| | Raw Scores | 0; 0; 0; 0; 0; | 5; 6; 9; 11; 11; 13; 15; 15; 15; 15 |
| Doruk | N (Probes) | 6 | 9 |
| | Raw Scores | 0; 0; 0; 0; 0; 0; | 5; 6; 12; 14;15; 15; 15; 15; 15 |

During the baseline phase, Anissa repeatedly displayed a lack of proficiency in adding fractions, with scores consistently at 0 points. However, the intervention phase witnessed a notable upward trend in her performance. Starting from a score of 4, Anissa's scores showed a steady upward trajectory, culminating in a score of 15 by the end of the intervention phase. This progress indicates that the LAP Strategy had a profound and positive impact on Anissa's ability to add fractions.

Similar to Anissa, Bernice struggled with adding fractions as reflected in her consistent baseline scores of 0 points. Nonetheless, the introduction of the intervention phase brought about a substantial improvement in her performance. Starting with an initial performance level of 1, Bernice's scores displayed a consistent and steady ascent, reaching a peak of 15 by the conclusion of the intervention phase. This progress underscores the effectiveness of the LAP Strategy in enhancing Bernice's aptitude for adding fractions, empowering her with newfound skills.

Carolin's baseline scores mirrored those of the previous participants, remaining consistently at 0 points, indicating a challenge in adding fractions. However, upon the implementation of the intervention phase, her scores exhibited a gradual and consistent improvement. Commencing with a score of 5, Carolin's performance witnessed a positive trajectory, reaching a pinnacle of 15 at the culmination of the intervention phase. This consistent upward trend vividly illustrates the positive effects of the LAP Strategy on Carolin's ability to add fractions.

Doruk consistently scored 0 points in adding fractions during the baseline phase. However, upon the initiation of the intervention phase, his results showed a significant and notable increase. Starting from a score of 5, Doruk's performance exhibited a steady and impressive improvement, ultimately reaching a maximum score of 15.

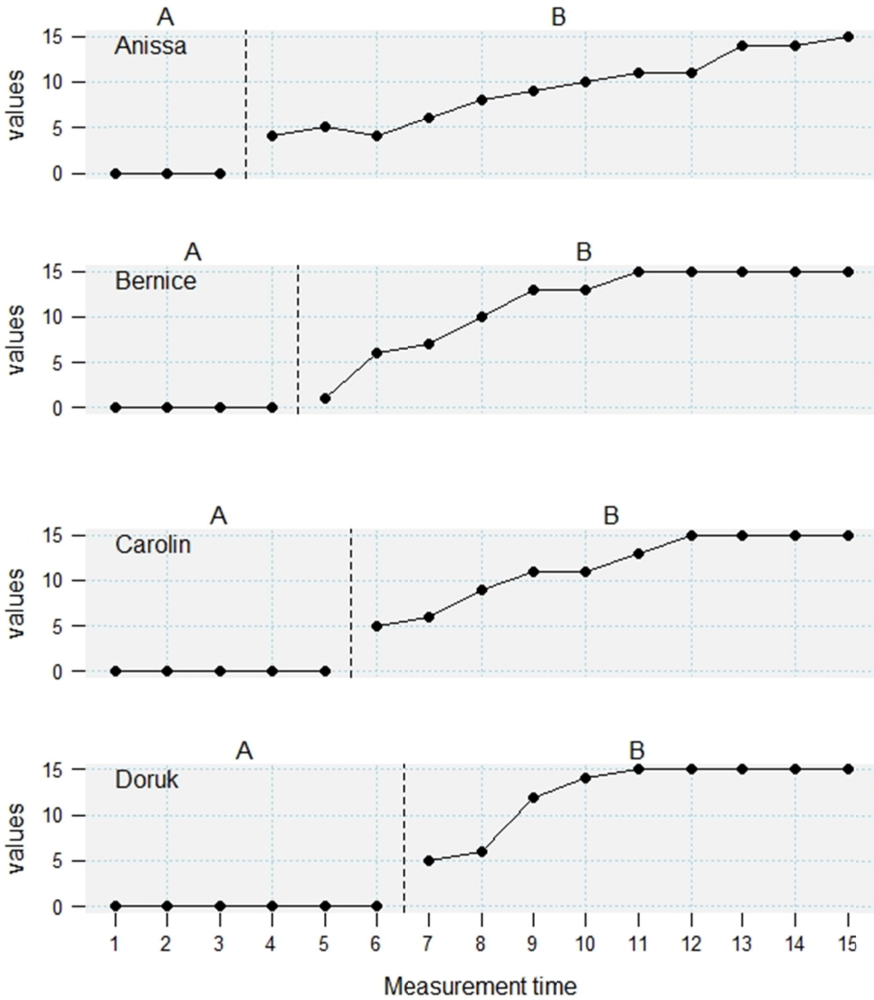


Figure 1. Number of correctly solved fraction addition problems for the four students

In summary, the evaluation findings indicate effectiveness in improving scores compared to the baseline conditions at the onset of the LAP strategy. Without exception, all participants consistently achieved higher scores during the intervention phase compared to the baseline. Notably, significant improvements were observed only after the implementation of the intervention for each participant. The analysis of various non-overlap indices, including the percentage of non-overlapping data, percentage of all non-overlapping data, percentage of exceeding the median trend, improvement rate difference, and non-overlap of all pairs, demonstrated the maximum attainable value, signifying the substantial benefits of the intervention.

The assessment of social validity was conducted through the aforementioned survey. Feedback from all sixth graders indicated a high level of satisfaction with the treatment, expressing great enjoyment of the lessons. They conveyed appreciation for the support provided and firmly believed that the strategy significantly enhanced their understanding of fraction addition. Importantly, every student highly recommended the LAP strategy to their fellow classmates.

## 4. Discussion

### *4.1 Main Findings*

The aim of this study was to examine the effects of an intervention based on the LAP strategy. Overall, all participants demonstrated a clear increase in the number of correctly solved tasks. Effect sizes were consistently at their peak, and the visual analysis of the data clearly indicated improved performance with the implementation of the intervention. The results of this research align well with a similar experiment conducted by Grünke et al.

(2023), which also investigated the effectiveness of the LAP strategy in improving fraction calculation skills. Both studies found significant improvements in the participants' performance after the intervention, indicating the efficacy of the LAP strategy in enhancing fraction calculation abilities.

During the debriefing sessions with the participants, their feedback indicated a high level of acceptance and motivation towards working with fractions using the LAP strategy. They expressed enjoyment and satisfaction in their own achievements, attributing them to the strategy and the practice sessions with the test facilitator. The visualization of their progress using graphics was particularly motivating for the students.

Last, it is worth noting that the use of stickers and rewards initially served as a significant motivator for the participants but diminished in importance as the project progressed. Their focus shifted towards achieving high scores and surpassing their personal best, indicating intrinsic motivation to succeed.

### *4.2 Limitations*

Despite the positive outcomes, it is important to acknowledge several limitations of this study. First, the sample size was small, comprising a limited number of participants from a specific age group. This makes generalizing the results to a broader population challenging. Considering not only this study but also the three others mentioned in the introduction that investigated the effects of the LAP strategy, it must be acknowledged that this approach has so far been tested only with sixth graders who struggle with fractions. The applicability and effectiveness of this intervention across different grade levels and in diverse student populations, including those with and without learning disabilities, remain uncertain. Future research involving larger and more diverse samples would offer more comprehensive insights into the method's viability.

Second, due to time constraints, no follow-up measurements were conducted to assess the long-term effectiveness of the intervention. Follow-up assessments would provide valuable insights into the sustainability of the observed improvements and whether they persist over time.

Third, the intervention was conducted on a one-on-one basis, which may not fully reflect the everyday classroom environment. In standard educational environments, students often work independently or in small groups, and the presence of a test facilitator may not be feasible. Therefore, future studies could explore the implementation of the LAP strategy in a more naturalistic classroom context to evaluate its effectiveness in real-world educational settings.

### *4.2 Practical Implications and Conclusion*

Notwithstanding these limitations, the findings of this study underscore the efficacy of strategy instruction in assisting struggling students in achieving proficiency in fraction addition. In just a few sessions, our participants swiftly grasped the process and demonstrated aptitude in accurately solving the majority of the presented problems.

Educators in classroom settings require access to socially meaningful and efficient targeted interventions for young learners who struggle to attain math proficiency through general instruction alongside their peers (Prater, 2017). Without receiving focused and intensive strategic support, akin to the intervention showcased in this study, these students face the peril of further academic lag. In the current landscape, educators encounter heightened challenges in enhancing the academic performance of students with and without disabilities, particularly as many learners continue to grapple with the lingering effects of remote or hybrid learning, quarantines, and reduced in-person interaction with peers and teachers. Incorporating the LAP strategy into classroom instruction, such as through peer-tutoring, assistance from school escorts, or small group work, can undeniably facilitate this endeavor.

Taken together, the affirmative responses from the participants validate the social effectiveness of the LAP strategy as an engaging and efficacious approach to enhancing fraction calculation skills.

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**Authors' contributions**

Prof. Dr. Matthias Grünke was responsible for the study's planning, overseeing its execution, data collection, data analysis, and drafting the manuscript. Dr. Jennifer Karnes provided consultancy related to the study and contributed to the manuscript revision. Dr. Anne Barwasser also offered consultancy regarding the study and assisted in revising the manuscript. Prof. Dr. Mack Burke was responsible for the final content and linguistic editing of the manuscript. All authors have read and approved the final manuscript.

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

**Data sharing statement**

No additional data are available.

**References**

American Psychiatric Association. (2013). *DSM-V*. American Psychiatric Publishing.

American Psychological Association. (1972). *Ethical standards of psychologists*. Washington, DC: American Psychological Association.

Bailey, D. H., Zhou, X., Zhang, Y., Cui, J., Fuchs, L. S., Jordan, N. C., … Siegler, R. S. (2015). Development of fraction concepts and procedures in U.S. and Chinese children. *Journal of Experimental Child Psychology*, *129*(1), 68–83. https://doi.org/10.1016/j.jecp.2014.08.006

Barbieri, C. A., Rodrigues, J., Dyson, N., & Jordan, N. C. (2020). Improving fraction understanding in sixth graders with mathematics difficulties: Effects of a number line approach combined with cognitive learning strategies. *Journal of Educational Psychology*, *112*(3), 628–648. https://doi.org/10.1037/edu0000384

Booth, J. L., & Newton, K. J. (2012). Fractions: Could they really be the gatekeeper’s doorman? *Contemporary Educational Psychology*, *37*(4), 247–253. https://doi.org/10.1016/j.cedpsych.2012.07.001

Bouck, E. C., Maher, C., Park, J., & Whorley, A. (2020). Learning fractions with a virtual manipulative based graduated instructional sequence. *Education & Training in Autism & Developmental Disabilities*, *55*(1), 45–59.

Cirino, P. T., Tolar, T. D., & Fuchs, L. S. (2022). Domain general and specific contributions to algebra: A sequenced longitudinal path model. *Contemporary Educational Psychology*, *68*(1), 1–14. https://doi.org/10.1016/j.cedpsych.2021.102026

Crawford, L., Freeman, B., Huscroft-D’Angelo, J., Quebec-Fuentes, S., Higgins, K. N., & Smolkowski, K. (2019). Implementation fidelity and the design of a fractions intervention. *Learning Disability Quarterly*, *42*(4), 217–230. https://doi.org/10.1177/0731948719840774

Ennis, R. P., & Losinski, M. (2019). Interventions to improve fraction skills for students with disabilities: A meta-analysis. *Exceptional Children*, *85*(3), 367–386. https://doi.org/10.1177/0014402918817504

Erten, I. H. (2015). Attribution retraining in L2 classes: Prospects for exploratory classroom practice. In K. Dikilitaş, R. Smith & W. Trotman (Eds.), *Teacher-researchers in actio*n (pp. 357–367). Iarefl.

Everett, G. E., Harsy, J. D., Hupp, S. D. A., & Jewell, J. D. (2014). An investigation of the look-ask-pick mnemonic to improve fraction skills. *Education & Treatment of Children*, *37*(3), 371–391. https://doi.org/10.1353/etc.2014.0025

Gabriel, F., Coché, F., Szucs, D., Carette, V., Rey, B., & Content, A. (2013). A componential view of children’s difficulties in learning fractions. *Frontiers in Psychology*, *4*, 715. https://doi.org/10.3389/fpsyg.2013.00715

Geary, D. C., Hoard, M. K., Nugent, L., & Bailey, D. H. (2012). Mathematical cognition deficits in children with learning disabilities and persistent low achievement: A five-year prospective study. *Journal of Educational Psychology*, *104*(1), 206–223. https://doi.org/10.1037/a0025398

Grünke, M., Bell, L., Wasko, L., Barwasser, A., & Connelly, V. (2023). The effects of the Look-Ask-Pick (LAP) Strategy on struggling grade 6 learners' ability to add fractions. *Learning Disabilities: A Contemporary Journal*, *21*(1), 55–68.

Haffner, J., Baro, K., Parzer, P., & Resch, F. (2005). *Heidelberg Arithmetic Test for 1st- to 4th-Graders*. Hogrefe.

Hughes, E. M. (2019). Point of view video modeling to teach simplifying fractions to middle school students with mathematical learning disabilities. *Learning Disabilities: A Contemporary Journal*, *17*(1), 41–57.

Kazdin, A. E. (2021). Single - case experimental designs: Characteristics, changes, and challenges. *Journal of the Experimental Analysis of Behavior*, *115*(1), 56–85. https://doi.org/10.1002/jeab.638

Kratochwill, T. R., Horner, R. H., Levin, J. R., Machalicek, W., Ferron, J., & Johnson, A. (2021). Single-case design standards: An update and proposed upgrades. *Journal of School Psychology*, *89*(1), 91–105. https://doi.org/10.1016/j.jsp.2021.10.006.

Lenz, K., Dreher, A., Holzäpfel, L., & Wittmann, G. (2020). Are conceptual knowledge and procedural knowledge empirically separable? The case of fractions. *British Journal of Educational Psychology*, *90*(3), 809–829. https://doi.org/10.1111/bjep.12333

Makel, M. C., Plucker, J. A., Freeman, J., Lombardi, A., Simonsen, B., & Coyne, M. (2016). Replication of special education research: Necessary but far too rare. *Remedial and Special Education*, *37*(4), 205–212. https://doi.org/10.1177/0741932516646083

McLeskey, J., Barringer, M.-D., Billingsley, B., Brownell, M., & Jackson, D. (2017). *High-leverage practices in special education*. Council for Exceptional Children.

McMullen, J., & Van Hoof, J. (2020). The role of rational number density knowledge in mathematical development. *Learning and Instruction*, *65*, 101228. https://doi.org/10.1016/j.learninstruc.2019.101228

Misquitta, R. (2011). A review of the literature: Fraction instruction for struggling learners in mathematics. *Learning Disabilities Research & Practice*, *26*(2), 109–119. https://doi.org/10.1111/j.1540-5826.2011.00330.x

Moses, R., & Cobb, C. E. (2002). *Radical equations: Civil rights from Mississippi to the Algebra Project*. Beacon Press.

National Mathematics Advisory Panel. (2008). *Foundations for success: The final report of the National Mathematics advisory panel*. U.S. Department of Education.

Prater, M. A. (2017). *Teaching students with high-incidence disabilities*. Sage.

Reid, R., Lienemann, T. O., & Hagaman, J. L. (2013). *Strategy instruction for students with learning disabilities*. Guilford.

Schnepel, S., & Aunio, P. (2022). A systematic review of mathematics interventions for primary school students with intellectual disabilities. *European Journal of Special Needs Education*, *37*(4), 663–678. https://doi.org/10.1080/08856257.2021.1943268

Shin, M., & Bryant, D. P. (2015). Fraction interventions for students struggling to learn mathematics: A research synthesis. *Remedial and Special Education*, *36*(6), 374–387. https://doi.org/10.1177/0741932515572910

Snodgrass, M. R., Chung, M. Y., Meadan, H., & Halle, J. W. (2018). Social validity in single-case research: A systematic literature review of prevalence and application. *Research in Developmental Disabilities*, *74*(1), 160–173. https://doi.org/10.1016/j.ridd.2018.01.007

Snodgrass, M. R., Cook, B. G., & Cook, L. (2023). Considering social validity in special education research. *Learning Disabilities Research & Practice*, *38*(4), 311–319. https://doi.org/10.1111/ldrp.12326

Test, D. W., & Ellis, M. F. (2005). The effects of LAP fractions on addition and subtraction of fractions with students with mild disabilities. *Education & Treatment of Children*, *28*(1), 11–24.

Vukovic, R. K., Fuchs L. S., Geary, D. C., Jordan, N. C., Gersten, R., & Siegler, R. S. (2014). Sources of individual differences in children's understanding of fractions. *Child Development*, *85*(4), 1461–1476. https://doi.org/10.1111/cdev.12218

Wilbert, J. (2023). *Single-case data analyses for single and multiple baseline designs*. Retrieved from https://cran.r-project.org/web/packages/scan/scan.pdf

William, D. (2022). How should educational research respond to the replication "crisis" in the social sciences? *Educational Research and Evaluation*, *27*(1–2), 208–214. https://doi.org/10.1080/13803611.2021.2022309

Wolf, M. (1978). Social validity: The case for subjective measurement, or how applied bevahior analysis is finding its heart. *Journal of Applied Behavior Analysis*, *11*(2), 203–214. https://doi.org/10.1901/jaba.1978.11-203

Yakubova, G., Hughes, E. M., & Chen, B. B. (2020). Teaching students with ASD to solve fraction computations using a video modeling instructional package. *Research in Developmental Disabilities*, *101*, 103637. https://doi.org/10.1016/j.ridd.2020.103637

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