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Video Self-Explanation as a Compensation Strategy for Mathematical Procedural Memory Deficits in Absence Seizures: A Neuroeducational Case Study

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ABSTRACT

Students with absence seizures may experience loss of mathematical procedural memory despite adequate performance in other subjects. This case study examined Video Self-Explanation (VSE) as a compensatory strategy for a 16-year-old student with absence seizures and mathematical procedural amnesia. Conducted in a real-world tutoring context, this single-student case study spanned 12 weeks. The participant recorded narrated solution videos as homework, explaining the rationale for each procedural step. After each submission, the tutor-researcher provided feedback on procedural errors and prompted reflection and correction in subsequent videos. Quantitative analysis showed marked improvements in delayed retention, formula retrieval, and procedural accuracy. Delayed retention increased from below 10 percent at baseline to over 60 percent during the intervention, while procedural accuracy improved from about 40 percent to 85 percent. Qualitative analysis indicated growth in metacognitive activities, including self-monitoring, error detection, and justification of solution steps. VSE also appeared to reduce cognitive fragmentation associated with seizures, supporting a more continuous problem-solving process. The findings suggest that VSE is a practical, low-cost neuroeducational strategy to support procedural learning and retention in students with seizure disorders, particularly in low-resource educational settings.

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INTRODUCTION

Absence seizures, that is, short episodes of impaired awareness lasting for 30 seconds to 2 minutes, involve 10–17% of children with epilepsy (Glauser et al., 2010). This type of seizure leads to impaired attentional control during or after the seizure, which then leads to a reduced ability to perform in math (Cheng et al., 2017; Reilly et al., 2014). While Cheng et al. (2017) proposed that impaired attention is a primary mechanism in the reduced mathematical performance after absence seizures, Taylor et al. (2017) and Poole et al. (2021) both described that impaired working memory negatively affects subsequent academic performance. Together, these findings emphasize that, compared to other subjects, mathematics is uniquely vulnerable to cognitive disruption during seizure episodes that can be sustained (Smith, 2023).

Mathematics is particularly vulnerable to these interactive cognitive perturbations. To successfully solve arithmetic problems, a person must sustain a continuous sequence of procedures, be willing to persistently engage working memory resources, and maintain attention throughout (Geary, 2011). With clear theoretical implications, few studies have directly assessed how absence seizures may impact long-term procedural retention in mathematics, and there are few studies on related issues (Poole et al., 2024). We define these difficulties as epilepsy-associated procedural amnesia (EAPA), a seizure-induced deficit characterized by the fragmentation of mathematical procedural memory traces, wherein learners comprehend steps during instruction but cannot retain or independently reconstruct them post-seizure. Previous research addressing students with absence epilepsy has exclusively addressed pharmacotherapy and more generalized cognitive training, such as mnemonics, spaced retrieval, or computerized working memory games. (Rodas et al., 2024; Taylor et al., 2017). These strategies have some potential for wider cognitive support, but typically do not target content areas specifically and do not consider the cognitive demands of procedural mathematics learning.

In contrast to these previous approaches, video self-explanation (VSE) is a metacognitive, subject-specific scaffold that externalizes cognitive steps and provides students with a permanent, revisitable artifact of their learning. This approach aligns with the generative learning theory (Fiorella, 2023), which posits that self-explanation forces learners to reorganize information and integrate it with prior knowledge, transforming passive recall into active schema construction. Critically, VSE leverages the neurobiological process of memory reconsolidation (Nader et al., 2000): each time a procedural memory is retrieved (as occurs during self-explanation), it becomes temporarily malleable and open to being updated. For learners with absence seizures, who may form fragmented or erroneous procedural traces, VSE provides a structured opportunity to retrieve the procedure, detect and correct errors within the explanation, and re-encode a strengthened and accurate memory trace. This positions the self-generated video artifact as both an assessment tool and a 'reconsolidation scaffold.' No empirical studies have examined self-generated video artifacts as compensatory mechanisms for procedural memory deficits in students with epilepsy-related issues.

LITERATURE REVIEW

This case study investigated whether student-created video self-explanations (VSE), a process that allows for metacognition, verbal rehearsal and retrieval practice, can improve procedural retention in a Grade 10 student with reported absence seizures. Empirical evidence of seizure-related impairments in procedural memory has been shown in those with epilepsy, as repeated seizure activity prevents the automation of performance and retention of task steps (Schalkwijk et al., 2021). Video self-explanation (VSE) prompted the student to verbalize each step in the problem-solving process and to record his verbalization. The process of verbalization allowed the student to compare his cognition with his actions, an important factor in improving the cognitive fragmentation caused by seizure activity. The use of video self-explanation (VSE) also supports the learning of durable mathematics content.

For learners with epilepsy who commonly experience frequent absence seizures, working memory and executive functioning can be significantly impacted, so that learners are unable to hold, process, and impact information through multi-step mathematical procedures (Taylor et al., 2017). A recent cross-sectional study conducted by Sayed et al. (2023) showed that generalized epilepsy, in particular, affects executive functions, attention, and visual spatial skills, which are known to be important for procedural mathematics. In such instances, these modes of instruction may not be adequate because they operate under the initial assumption that internal cognitive control is continuous. The new fields of educational neuroscience and special education are beginning to demonstrate that externalized executive functioning (tools and strategies) can be used to help students organize their cognitive processes outside their brains (Rodas et al., 2024). In this case, student-generated video explanations serve as a "cognitive prosthesis": because the student is externalizing the steps taken to solve the problem, sequencing the calculations, and explaining the reasoning through the video, the cognitive load was lighter and also served as memory aids once the students watched them again to assist with reflection, accuracy, and retention. This can be viewed as a scaffolding process for learners to remove disrupted internal executive functioning processes by taking advantage of structured, repeatable formats to help support the work of learning.

The instructional approach in this study is based on the generative learning theory, which suggests that students perform meaningful learning by making sense of information, mentally reorganizing information, and connecting it with their prior knowledge (Fiorella, 2023). This is consistent with the findings of Beege and Ploetzner (2025), who showed that interactive video formats with self-explanation prompts significantly increased conceptual retention and decreased cognitive load during mathematics learning. When students explain each step of a mathematical procedure, as in video self-explanation, they do not just memorize steps; they build and connect schemas or mental frameworks for deeper understanding and transferring mathematical ideas. This is particularly important for students who experience working memory disruption, such as absence seizures, because developing schemas reduces cognitive load and supports long-term retention (Sweller, 1988). By using generative activities, such as teaching through explaining, students externalize their thoughts and increase metacognitive monitoring, both of which are crucial for procedural learning in mathematics.

A compelling explanation from neurocognitive theory for the efficacy of the VSE strategy, as introduced earlier, is in the way memories are reconsolidated. Not all memory systems respond equally to the effects of epilepsy. Phillips et al. (2024) found that procedural and episodic memory have different profiles of vulnerability depending on the seizure type and brain region. Nader et al. (2000) reported that each time a memory is pulled from storage, the memory is vulnerable to change or enhancement before it is stored again in the brain. This process of making memories vulnerable to change and then restoring them is called reconsolidation. With respect to mathematics learning, students suffering from absence seizures may create impaired memory traces or incomplete memory regarding the forms and processes learners need to implement to explain solutions to problems correctly. If a student has the ability to experience error-managed reconsolidation of their videos, they can potentially view the steps they took, articulate the steps to control the previous incorrect traces, and create new or strengthened procedural memory, where the videos serve as a reference for effective explanations to increase retention over time. Neurocognitive theory, which supports self-generated video self-explanation, may have additional implications as a diagnostic and prescriptive function for learning. Building on these neurocognitive foundations, we applied the VSE protocol to a real-world tutoring context involving a student with absence seizures and severe procedural memory difficulties in mathematics.

This case study details a case with absence seizures of and significant deficits in procedural memory, specifically in mathematics, despite having normal verbal intelligence. Following six months of unsuccessful treatment options (mnemonics, spaced repetition), we designed a new Video Self-Explanation (VSE) protocol that had her video-record herself solving the problems while verbally justifying every step of her thinking process. Importantly, the videos were created independently after tutoring (to be used for assessments and reconsolidation strategies).

Research Questions

This study aimed to explore the following:

RQ1: Does Video Self-Explanation (VSE) support immediate/delayed retention of mathematical procedures in a student with absence seizures?

RQ2: What metacognitive processes (e.g., error self-correction, articulation of steps) occur in VSE artifacts?

RQ3: How does the VSE mediate the relationship between seizure events and procedural memory consolidation?

Significance & Roadmap

Establishing Video Self-Explanation (VSE) as a neuroeducational compensation strategy, this study makes three contributions.

1. A neuroeducational model for addressing epilepsy associated procedural amnesia (EAPA)

2. Evidence of externalized metacognition as a tool for seizure resilience

3. Practical protocols for tutors in low-resource settings, such as those lacking access to specialized educational software, neuropsychological services, or clinical support.

METHODOLOGY

Participant Profile

The participant in the study was a female student in Grade 10 in a General Certificate of Education program, who was 16 years old. She was diagnosed with childhood absence epilepsy at the age of 11 years and the neurologist confirmed that she exhibited 6–8 absence seizures per day. The participant's verbal abilities were in the normal range, and she demonstrated average (65% – 75%) in all specific subjects except mathematics.

Before receiving tutoring help, the student received below 40% in mathematics for all of year during 9^{th} grade. The participant's parents indicated that her math performance at the beginning of primary school (before the seizures started) was acceptable, scoring around 60% on average. The participant had been receiving one-on-one tutoring support for six months and continued to struggle severely with retaining mathematical procedures, especially in algebra, mensuration, and trigonometry. While the participant could understand new mathematical concepts when they were explained, she always forgot the formulas and procedures after a short period.

In her baseline teaching duration, even after repeated attempts and a multitude of methods such as visual mnemonics and mental imagery, the student had difficulty remembering formulas. Of the 20 mensuration formulas expected, she only managed to consolidate eight, and of the 10 basic trigonometric identities, only three were retained over a 6-month period. These formulas seemed to stay in memory for a maximum of two weeks before requiring full re-teaching. The student also struggled with visual-spatial reasoning, including differentiating left from right, up from down, and recognizing positive and negative values or exponents (e.g., would mistake a square for a cube).

The student also struggled with visual and spatial reasoning. Despite multisensory support (e.g., clay models for 3D geometry), the student exhibited persistent difficulties with spatial reasoning tasks, including identifying geometric properties and interpreting angles in diagrams. While her immediate retention after instruction was acceptable (80%–90%), retention dropped off drastically upon delayed recall; <10% after 1 day, and <5% after 1 week. Homework performance revealed a similar pattern. Although she was assigned practice that she completed on a fairly regular basis (15–20 questions per session), approximately 90% of her answers were incorrect or incomplete. Occasionally, she provided the correct final answer but had copied it from the book, or she changed her answer, but not the flawed method. She seldom noticed or corrected her errors and solved problems more mechanically than meaningfully.

She often worked too quickly when reasoning through problems, often matching a keyword or type of problem from memory long before reading the entire question and understanding what was being asked. Of note, when asked to solve a new problem, she rarely attempted to draw or articulate the question prior to employing whatever algorithm popped into her head; she applied the algorithm without regard for whether it made sense for the problem at hand. She had a habit of providing incorrect reasoning (e.g., she thought a triangle was right because it "looked right"), and when asked to reflect upon or justify why she made a choice, she struggled. Even when the instructor reminded her that she had used the correct process in similar problems, she often said, "I don't know."

Although, she struggled with some areas, she caught on to new topics rather quickly when engaged with live instruction. However, her procedural knowledge decreased significantly after 24 hours, and her broken reasoning links hindered her problem-solving accuracy. Even with ample practice and regular feedback, the student continued to make careless and repetitive errors, such as ignoring visuals, misreading numbers, or utilizing the wrong units, while treating these errors as typical or absent-minded.

Importantly, in each of the one-hour sessions, the tutor reported that 2-3 absence seizure episodes of 5–30 seconds manifested, especially during complex problem-solving activities that required prolonged attention and reasoning. In each of the sessions, although the student resumed the task after each seizure episode from where she had left off, she was not aware of the seizure break in her thinking process; therefore, she was completing problems incorrectly without awareness that gaps in her reasoning were omitted. Although her logical gaps were evident, she was generally confident in her ability to solve the problems and rarely reread or re-examined the question after an episode.

These patterns of superficial engagement, problems with procedure, and unawareness of error (and later, cognitive fragmentation due to seizures) informed the development of a new intervention video self-explanation (VSE). The deliberate goal of the intervention, in part, was to allow the student to externalize her thinking, support her employment of the procedure, and enhance long-term retention through repeated independent reasoning and recall.

Ethical Considerations

The research in this case was done following the ethical guidelines used in research. The parent of the participant gave written consent for their child's participation and the child also agreed to participate. All data collected for this study were kept confidential and stored securely.

Research Design

This study used a single-subject case study design under the action research format, given the individualized nature of the intervention and the clinical specificity of the participant's learning hurdles. The case study was designed not to be generalizable across populations, but rather to gain insight and improve an individual learner's experience of mathematical retention under the conditions of absent epilepsy. Given these boundaries, we believe that a case-based qualitative methodology is the most appropriate.

The case study was conducted within a real-life tutoring context, which allowed for ongoing observations, opportunities for individualized feedback, and naturalistic engagement over time. Additionally, the action research aspect allowed the tutor/researcher to continually experiment and modify the instruction in response to the students' cognitive profiles and learning outcomes. The opportunity to experiment and adapt was crucial because the participant presented with significant seizure activity, variable attention span, and variable retention rates.

Data were gathered during a 6-month baseline period (i.e., traditional instruction without intervention), followed by a 3-month VSE phase. Nature of the VSE intervention: During the VSE phase, the independent variable was implemented as a post-class video self-explanation to support students' procedural retention via metacognition and retrieval practice. The design enabled within-subject comparisons, both pre- and post-intervention performance using matched tasks, and qualitative analysis of the procedural explanations contained in video artifacts.

This design is congruous with neuroeducational research's call for ecologically valid, contextually sensitive, and learner-specific approaches, particularly relevant when working with neurodivergent populations such as students with epilepsy (Reilly et al., 2014), and bridges the gap between theory and practice by allowing the researcher to think and document in the moment response to students' acute neurological disruptions.

Intervention Protocol: Video Self-Explanation (VSE)

After observing poor retention for procedural learning during the baseline period, despite many attempts to explain the processes, reminders through homework, and hands-on support, I implemented a specific instructional strategy to promote long-term retention. The approach I chose was video self-explaining (VSE), which was implemented over 12 weeks as a structured, independent post-class activity. The primary goal of the intervention was to promote deep processing, metacognitive monitoring, and retrieval-based reconsolidation of procedural math skills through the student verbalizing and recording her own steps in her own words.

Structure and Process

The student had three one-hour tutoring sessions each week (on alternate days). At the end of each tutoring session, the student was assigned two to three

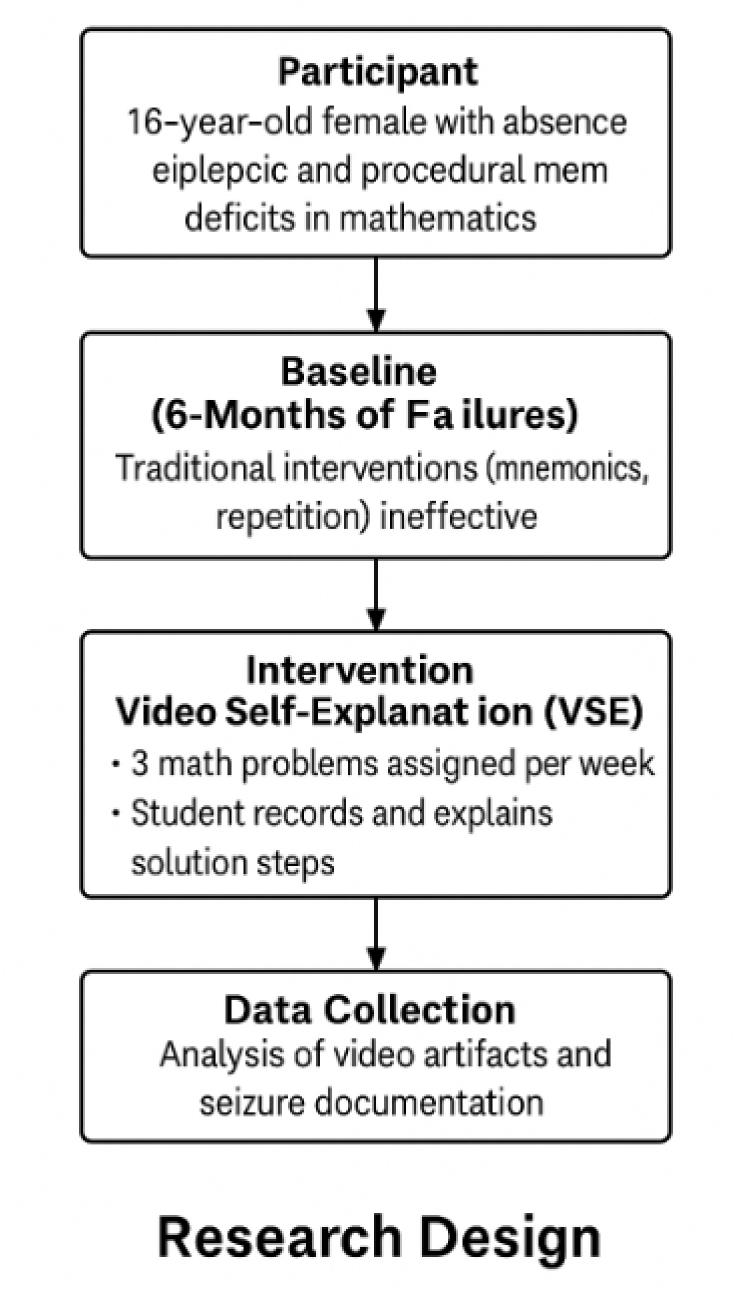

Figure 1: *Research Design Timeline (Baseline: 6 months; VSE Intervention: 12 weeks).*

practice problems that represented the procedures discussed in class. Instead of a traditional written assignment, the student was asked to:

1. She solved each problem assigned to her without looking at her class notes.

2. She recorded herself explaining aloud exactly what she was doing at each step as she solved the problem.

3. The recorded videos were sent to the tutor before the next tutoring session. The recorded videos were sent to the tutor via WhatsApp message before the next tutoring session. All videos were shared via WhatsApp's end-to-end encrypted platform with parental consent.

The student was specifically instructed to explain each step and the reasoning underlying every formula or operation used, to refer explicitly to diagrams and given data when appropriate and articulate the rationale for selecting particular values or units, and to avoid reading from memorized scripts by engaging instead in spontaneous verbalization that reflected active cognitive processing.

After the video submissions, the tutor reviewed each recording prior to the subsequent session. When a procedural or conceptual error was identified, the tutor provided corrective feedback by explaining the nature of the error and, when necessary, demonstrating the correct procedure. The student was then asked to re-record the same problem, verbally explaining the steps involved, explicitly identifying the error made in the previous attempt and describing how it was corrected in the new recording

Thus, the student went through a cycle of revision for each video, with error reflection and modification as part of the process. In a fair number of cases, the student submitted multiple attempts at the same problem (generally 2-4 attempts) until she reached a correct, fully articulated solution. In each new version, she clearly identified and corrected her previous mistakes, allowing for metacognitive repair, error awareness, and long-term retention.

For example, in one of the corrected submissions, the student wrote:

"In my last video, I used the wrong value for the radius; I forgot to square it. Therefore, my answer was incorrect. Now, I'll do it again, hopefully remembering to square the radius when I apply the area formula for the circle."

Over time, the preface included fewer frequent phrases, as there was evidence of self-monitoring development and deeper procedural understanding where none existed before.

Independence and Timing

Videos were made outside of tutoring hours for the purpose of the study, and the analysis of a week of problems was conducted to develop delayed usability, requiring the student to retrieve the knowledge from the earlier tutoring session without support. This provided an environment for the videos to serve both as:

Assessment artifacts. Demonstrating what the student remembered and how she solved and reasoned through the instances.

Instructional scaffolds. Presented as an external artifact that the student could look back at before future problem sets or revision activities.

Feedback Loop

The researcher viewed each video prior to the subsequent session and made specific notes regarding the correctness of the procedure and final answer, evidence of metacognitive behaviors such as self-correction, checking, and step-by-step articulation, as well as recurring patterns of common mistakes or misconceived ideas

In the next live session, feedback was provided on the videos, and the tutor often played parts of the video as a way of prompting thinking and self-monitoring. As a result, the tutor was able to emphasize accurate reasoning and bridge gaps in procedural learning in a real-time, individualized, and relevant manner.

Purpose and Rationale

The intervention was based on three interconnected theoretical constructs:

Generative learning. Prompting schema construction with self-explanation (Fiorella & Mayer, 2016).

Externalized executive functioning . Video self-explanation acts as a form of externalized executive function by offloading working memory demands and supporting procedural retention, particularly for learners with seizure-related fragmentation (Fiorella & Mayer, 2016; Sweller, 1994)."

Error-controlled reconsolidation. Memory reconsolidation is a process in which retrieved memories can be modified before being stored again (Nader et al., 2000).

This method was particularly effective for the participant's profile in that it diverted the learning focus from in-the-moment constructions to long-term retrieval and consolidation, which was identified as her primary difficulty.

Data Collection Methods

The researcher collected data using a variety of qualitative artifacts, quantitative performance records and field notes to assess the efficacy of the video self-explanation (VSE) intervention and to investigate its potential consequences for procedural retention and metacognitive behavior. The multimodal method provided triangulation of the findings and allowed for a more holistic consideration of the participant's learning process cognitively, behaviorally, and neurologically.

Video Artifacts

A total of 36 original problems were assigned during the intervention, resulting in over 90 video submissions, including revisions, produced by the student as part of her VSE homework. These videos focused on the student's verbal explanations of math problems and the student's procedural work on the problems that were explained in the classroom. When the student was directed to modify her work, subsequently, all the versions of the problem (original and corrected recordings) were collected and analyzed. The collected pieces allowed comparisons between original misconceptions and later procedural modifications, and offered a window into the process of metacognitive awareness.

Each video lasted between 2 and 8 minutes and was analyzed for the accuracy of the final answer, the correctness of the procedural work, and the clarity of the verbal explanation. In addition, the analysis examined evidence of metacognitive behavior, including self-corrections, rechecking of values, articulation of the rationale for choices, and recognition of errors.

The videos were transcribed, and then coded thematically for both cognitive processes and learning behaviors.

Retention Assessments

In the process of measuring retention, the student took the following assessments:

Immediate assessments. Provided orally and in writing at the end of each class period.

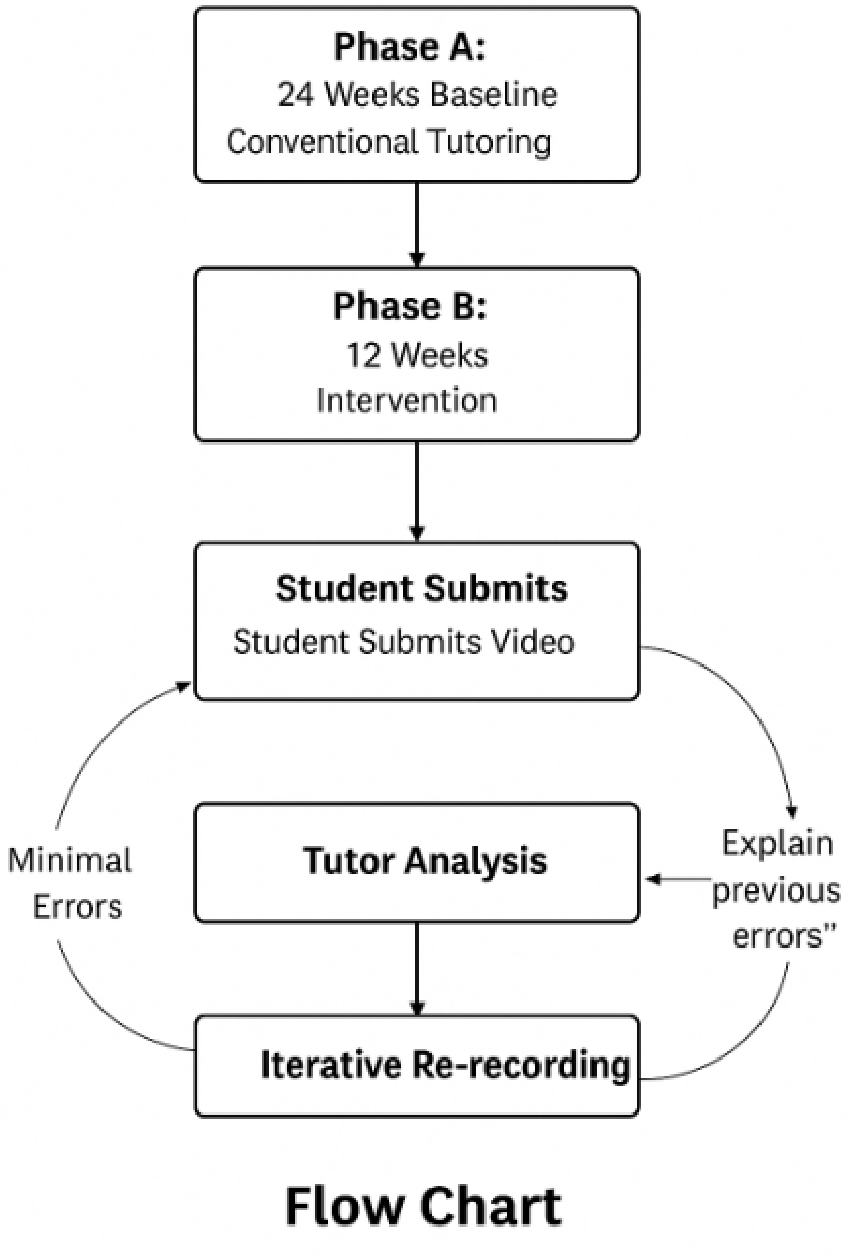

Figure 2: *Participant's VSE workflow diagram (12-week intervention cycle)*

Delayed assessments. Provided 3–5 days later on similar problems (no questions or notes).

Retention was measured through:

1. The accuracy percent (%) the student got right for each problem set
2. Retention drop-off (%) between immediate and delayed performance
3. Consistency in errors over time (e.g., incorrectly repeating the same procedural error).

The student collected this data on a weekly basis to track the student's progress and assess trends in short- and long-term retention.

Tutor Observations

During the intervention, the tutor maintained a structured observation log after each tutoring session. The field notes documented the frequency and timing of observed absence seizure episodes, interruptions in reasoning or task completion, patterns of behavior such as rushing, skipping reading directions, or overconfidence, and the student's responses to error correction and feedback.

The tutor paid special attention to behavior following the absences, e.g., did the student return to the incorrect logical point to continue problem-solving, or were they aware of the deviation?

Baseline Performance Records

Data from the student's academic progress during the previous six months (Grade 9 and early Grade 10) were used as the baseline, drawing on school mathematics test results and performance in other subjects, homework performance records, and the tutor's notes from the initial instructional sessions.

This baseline would provide comparative values for the retention work using VSE, particularly with retention, error ratio, and strategy.

Data Analysis Procedures

The data analysis focused on developing key indicators aligned with the three research questions addressing procedural retention, the metacognitive processes for pre- and post-mechanical or procedural processes, as well as the cognition of absence seizures. The data analysis involved a mixed-methods approach that incorporated quantitative information about retention rates and errors and qualitative data about the video artifacts and observational findings, which were coded in the observables.

Quantitative Analysis: Retention and Error Tracking

To assess changes in procedural retention over time in a post-VSE intervention period will calculate the following performance metrics:

The immediate accuracy rate. Percentage of problems correctly solved immediately after instruction (baseline vs. VSE).

The delayed accuracy rate. Percentage of problems correctly solved in a delayed manner, 3–5 days after instruction, without any scaffolding.

Retention rate. The delayed accurate response rate in relation to the immediate accurate response rate.

Error patterns. The frequency and consistency of certain procedural errors (e.g., confusion with formulas, sign errors, diagram misreadings).

Together, these measures represent change in short- and long-term retention, as well as increased time awareness on the subsequent correction of specific errors.

Qualitative Analysis: Video Coding and Thematic Review

Each one of the 90 submitted video recordings was transcribed and analyzed from codes in a thematic fashion. The thematic coding analysis was based on a predetermined coding scheme (Table 1) grounded in the metacognitive and cognitive learning literatures.

All 90 videos were coded by the tutor–researcher, and patterns were documented across the course of their 12-week intervention, to keep track of the later development (or non-development) of metacognitive behaviors over time. When there were multiple recordings related to an identical problem, the analysis focused mainly on the trajectory of correction, the errors that were caught, and how explanations changed throughout multiple iterations. Coding focused on self-reflective statements, corrected reasoning, and the ability to explain past errors was utilized.

Table 1.
Metacognitive and Cognitive Coding Scheme for Video Data

Code Category	Examples of Evidence
Step articulation	Clearly expressing every mathematical step one by one.
Self-correction	Correcting a previously stated incorrect answer without cues from others
Self-monitoring	Stopping to check for mistakes or a lack of certainty
Error detection	Noticing an incorrect value, formula, or step during one's explanation
Justification	Explaining the reason a step or formula was chosen
Surface-level mimicry	Repeating the pattern blindly rather than being able to use it in a contextualized way
Impulsivity	Solving rapidly without careful reading, skipping explanation, or making assumptions

Note. This coding scheme was adapted from models of metacognitive learning (Fiorella & Mayer, 2016; Rittle-Johnson et al., 2017), cognitive load theory (Sweller, 1988), and observed learning behaviors in mathematics contexts (Geary, 2011; Kay & Kletskin, 2012).

Observational Data Review

Observational logs maintained by the tutor were reviewed on a weekly basis to examine the timing and behavioral effects of absence seizure events, whether seizure episodes interrupted procedural flow or resulted in misplaced confidence, and behavioral shifts observed before and after the implementation of VSE, including changes in motivation, error sensitivity, and independence.

These field notes were triangulated with video artifacts and performance data to examine seizures' cognitive and behavioral effects on memory consolidation and the interceptive impact of the VSE protocol.

Baseline Comparison

Findings all related to the intervention stage were compared against the baseline period (pre-intervention) to determine qualitative and quantitative shifts in procedural retention, error amounts & types and engagement with metacognitive strategies.

The videos that we transcribed were then coded thematically based on a pre-determined metacognitive-cognitive framework adapted from research done previously. The videos were examined for behaviors regarding self-correction, justification, and impulsivity. The framework shown in Table 1 was used to track behaviors related to metacognition. Definitions for each category in the framework are provided, along with examples. The quantitative results are reported as comparative measures and behavior frequency (see Tables 1, 2, 3 and 4), while qualitative trends were obtained using thematic coding of the videos using the framework shown in Table 1.

RESULTS

The results of the intervention are provided in this section and follow the three research questions. Quantitative trends, qualitative notes, and behavioral changes were triangulated to investigate the impact of a video self-explanation (VSE) strategy on a student's mathematical learning with absence epilepsy.

Comparison of Retention Metrics in Baseline and VSE Period (RQ1)

ummarizesthe student's baseline performance and her performance during the Video Self-Explanation (VSE) intervention period. The data suggests substantial gains across the measured dimensions of retention, procedure performance, and error reduction.

Table 2.
Comparison of baseline and VSE performance

Metric	Baseline Period	VSE Period	Change (%)
Step Accuracy (%)	40%	85%	45%
Immediate Average Accuracy (%)	90%	95%	5%
24-hour Delayed Average Accuracy (%)	10%	>60%	> +50%
1-Week Average Retention (%)	<5%	>40%	> +35%
Formula Recall Rate (Out of 10)	4/10	8/10	+40%
Mistakes in Homework (Average)	3.6/problem	1.2/problem	–66.67%
Identification of Question's Subject Area	65–75%	85–95%	+20%

Note. Baseline performance metrics were derived from observations and assessment records collected during the six months of traditional tutoring prior to the introduction of the VSE protocol.

The improvements in long-term memory retention are the most important part of this study. The student showed a high accuracy of around 90% at the beginning, but after participating in the program, she increased her accuracy by over 50% on her 24-hour delayed retention test, and by over 35% on her 1-week delayed retention test. These results show that this program focused on helping students develop the memory consolidation skills needed to remember what they learned.

The student's ability to recall information from a written note also doubled. This shows that by encouraging students to verbalize and repeat information, it is possible for them to encode information more deeply.

It is important to note that mistakes made on homework assignments decreased by 66% compared to pre-program levels. This shows that this student moved away from using ”trial and error” or ”trial and error” methods in solving problems, and began using more accurate and deliberate ways to solve problems. Additionally, the student made significant progress in learning how to identify the mathematical domain of problems, which is a very important skill for students to possess as it supports their ability to transfer their knowledge and to generalize their knowledge to other situations.

These results strongly support the conclusion that the VSE program is an effective way to help students both reinforce learning and develop the cognitive ability to avoid the memory difficulties caused by seizures, as well as encourage their ability to monitor their own thinking as they learn.

Metacognitive Behaviors in VSE Period (RQ2)

To assess the presence and richness of metacognitive activity across the intervention, the next phase of analysis involved coding 90 videos created by students for seven reported behaviors. As noted in Table 3, the most frequently used behavior was step articulation, present in 88.9% of the videos, which indicates that the student became increasingly more at ease with verbalizing and organizing the procedural steps.

Table 3.
Frequency of coded behaviors across 90 videos

Behavior	Frequency	% of Videos	Example Quote
Step Articulation	80	88.9%	“I am drawing a rough diagram before finding the equation of the perpendicular bisector…”
Self-Correction	41	45.6%	“I have not taken the square in the above step. Let me correct it… ”
Self-Monitoring	59	65.6%	“Let me check if I have copied the values correctly…”
Error Detection	43	47.8%	“It’s not going the right way, I think I have made some mistake…”
Justification	66	73.3%	“I have used the cosine law to find the angle because all three sides were given…”
Surface-Level Mimicry	21	23.3%	“I am using curly brackets because sir always uses this bracket before simplification…”
Impulsivity	32	35.5%	“It’s very simple, just put formula…”

Compared to her initial level of learning, there was a significant increase in retention and error reduction due to the VSE intervention. Also evident were changes in metacognitive behavior in relation to self-monitoring, error detection, and justification of procedural steps, as shown in Table 2. This suggests that she is becoming more aware of her own thought processes (i.e., becoming less impulsive when dealing with an error). In addition to their prevalence in the videos, step articulation (89%) was the most common form of metacognitive behavior exhibited by this student, followed by justification (73.3%) and self-monitoring (65.6%). Students regularly verbalized the steps they took during problem solving, suggesting an increased awareness of their overall process for solving problems. Error detection and self-correction behaviors appeared in roughly half of the recordings; however, they were observed much later in the intervention timeline. Although the percentage of times students exhibited behaviors of surface-level imitation (23.3%) and impulsivity (35.5%) still exist, they were not as prominent as before, indicating an improvement from this type of thought process. Overall, the type of metacognitive behaviours exhibited by the student changed to those consistent with self-regulated learning.

Reduction in Types of Mistakes (RQ1, RQ2)

hows the frequency and type of mistakes made during the baseline and VSE intervention phases. The findings show a wide-ranging and substantial decrease across all seven categories of procedural and reasoning errors.

Table 4.
Comparison of mistakes between the baseline and VSE period

Type of Mistake	Baseline Period (%)	VSE Period (%)	Example Mistake
Use of Formula	80%	10%	Used the volume of a prism formula, V=base area × height, for the volume of a pyramid
Sign/power Mistake	60%	20%	Used volume of sphere formula as $V=4/3\pi r^2$ instead of $V=4/3\pi r^3$
Diagram Misreadings	50%	10%	Identified a scalene triangle as an isosceles triangle because two sides seemed equal
Incomplete Procedures	70%	10%	Found the value of 'x' but failed to use it to calculate the car's average speed as required.
Misreading the Question	90%	30%	Ignored time units and used without conversion (e.g., minutes to hours)
Faulty reasoning	60%	10%	Misapplied Pythagoras' theorem based on the previous question context
Transcription error	50%	10%	Copied incorrect values from previous steps

Misreading the question (90%), usually either ignoring units or the interpretation of the problem statement, was the most common baseline error. This decreased to 30% during the VSE phase, partially due to the requirement to reread the problem and verbalize as part of the process.

Misuse of formula and flawed reasoning errors, which typically indicate greater misconceptions about procedures, dropped from 80% and 60% respectively, to 10% each. This suggests that the VSE helped the student remember the correct procedures, but also seemed to internalize conceptual distinctions between similar-looking problems.

Notably, transcription errors, which indicate a lapse in attention or working memory, reduced from 50% to 10%. This is potentially an indirect consequence of video making as forced organization and verbalization of information probably increased attentional control and self-monitoring in the student.

In total, we see the reduction of all these types of errors demonstrates how the intervention was designed to target not just surface-level lapses in attention, but more global and persistent cognitive heuristics leading to more accurate, systematic, and contextually sensitive problem-solving.

Seizure Impact & VSE Mediation (RQ3)

rovides a summary comparison of the student'sproblem-solving during absence seizures from baseline and the VSE intervention. While the average number of seizures remained constant (2–3 per hour), the evidence clearly demonstrates a marked improvement in student's cognitive recovery and continuity of task engagement across baseline and VSE conditions.

Although the frequency of seizures remained unchanged, the unawareness of cognitive lapses/residual disruption/incompleteness after the seizure decreased dramatically (from 100% to 45.6%), which indicated that the student was beginning to make connections that she was previously unable to detect in her reasoning chain. This effect was also accompanied by an increase in rereading rate, which was almost never in the baseline but became more frequent as the VSE habit set in. In summary, these changes represent an increase in metacognitive regulation during and after the period of seizure recovery.

The level of error experienced by participants after seizures decreased to 83.3%, indicating that participants improved their ability to identify errors as a result of VSE procedures. The greatest change for participants was a reduction in using a false-assumption method (i.e. 'If I had conviction about my correctness, it means I am correct') to judge errors, which suggests that through the VSE process they were able to further develop or acknowledge their capacity to self-identify

Table 5.
Comparison of seizure impact between baseline and VSE period

Observation	Baseline Period	VSE Period	Key Change
Avg. Seizures/Session	2–3	2–3	No significant change
Error Rate	~100%	~83.3%	–16.7%
Unawareness of Gaps	100% of episodes	45.6%	–54.4%
Confident yet Incorrect	High	Low	Improved self-monitoring
Rereading Rate	Rare	High	Improved metacognition
Procedural breakdowns	Frequent	Occa-sional	Improved connectivity
The mean time to resume the task	45-60 sec	30-45 sec	Faster recovery and better metacognition.
Rigidity in Thinking	Very High	Moder-ate	~30% improvement in cognitive flexibility

cognitive gaps.

In addition, the frequency of procedural breakdowns that occurred as a result of seizure activity experienced by participants moved from frequently (i.e. regularly missed elements of the problem-solving process) to occasionally during VSE treatment; thus confirming the role that VSE can have in supporting participants with the maintenance and relevance to the original problem solved during the problem-solving process.

An example of baseline rigidity of thinking and the inability of the student to be flexible in her thoughts would be the fact that when attempting to determine whether or not something was a reflective transformation, she continued to state it was a reflection and then continue to identify a coordinate change associated with the correct rotation. The inability of participants to change their assumptions improved significantly during the VSE phase. Video-based self-explanation encouraged post-hoc reflection and correction, reducing rigidity and increasing openness to alternative problem-solving approaches by approximately 30%.

Together, these findings suggest that despite continued cognitive seizure activity, the cognitive effects were offset through externally available working memory scaffolds offered by the VSE intervention. The developed structure of explaining each step offered an anchor point for cognition to latch on to, which assisted in recovery after episodes of altered consciousness.

DISCUSSION

This research examined Video Self-Explanation (VSE) as a 'metacognitive' strategy to substitute for the impairments to the student's procedural memory caused by absence seizures (i.e., EAPA) and their mathematics-specific learning difficulties. The intervention provided substantial improvements in immediate and delayed retention, decreased the number of errors, and a significant increase in metacognitive behaviors. The following discussion relates these results to research questions and the theoretical models.

Enhancement of Retention and Procedural Accuracy

The most significant outcome was the improvement of more than 50% in delayed retention of mathematical procedures (Table 1) and a marked decline in types of procedural errors, such as the misuse of formulas, misreading diagrams, and sign / power errors (Table 3). These results indicate that the VSE intervention assisted the student in moving from rote rehearsal to more durable and meaningful encoding of procedures. The improvement in formula view rate and retention after 1 week lends credence to the thinking that repeated articulation and reflection through VSE serve as generative learning, as described in the research by Fiorella and Mayer (2016).

Development of Metacognitive Behaviors

The video analysis showed that the student was engaging in significant metacognitive regulation during the intervention. The student exhibited more step articulation, self-monitoring, justification of steps, and self-correction in the 90 videos throughout the intervention (Table 2). These behaviors indicated a process of externalized metacognition since the act of teaching or explaining the self-led to a better assembly of schemata and procedural fluency. With nearly half the videos exhibiting self-corrective behavior, compared to none of the videos during the baseline writing task, we see an indicator of increased cognitive control and reflective capacity. This trend is mirrored in studies examining the value of learning-by-teaching and self-explanation on the experience of making in mathematical problem-solving (Rittle-Johnson et al., 2017).

Reduction in Seizure-Related Disruptions

An original contribution of this case is to document a way in which VSE may mitigate cognitive fragmentation due to seizures; the number of seizures per session remained stable, but the student demonstrated increased awareness of cognitive gaps (Table 4), an increase in rereading behavior, a decrease in impulsive behavior, and the number of procedure breakdowns. This indicates that VSE may serve as a ”cognitive prosthesis,” addressing working memory and possibly allowing cognitive error recovery following periods of transitory unconsciousness, something consistent with the neuroeducational idea of compensatory executive supports (Poole et al., 2024).

Conceptual vs. Surface-Level Improvement

Although gains were observed across multiple domains, residual mimicry and impulsive problem-solving were still present (Table 3). It appears that even though the student moved from surface-level thinking to a deeper level of understanding (via generative learning), he or she has retained certain habits of thinking heuristically. This supports generative learning theory (Fiorella & Mayer, 2016), which says that putting your thoughts into words helps you internally develop a more comprehensive understanding, but your first experiences are likely to show only partial integration into the overall framework. In addition, video-based reflection helped the student reconsolidate their understanding of errors by allowing him/her to see and then ”rewrite” any misleading procedural memory. Future uses of video-based self-evaluations might be improved by including explicit indications of the difference between merely imitating a procedure/rule and justifying it conceptually based on a particular principle or theoretical foundation.

Neurocognitive Mechanisms

How this improvement occurred is likely through neurocognitive processes that are related to memory reconsolidation and externalized executive function. Repeatedly articulating, recording, and reflecting upon his problem-solving steps through VSE were likely ways in which VSE acted as a cognitive prosthesis by offloading demands upon working memory and reinforcing procedural sequencing that were otherwise disrupted due to absence seizures. This finding reinforces the notion that memory traces can be ”edited” through structured retrieval and correction (Nader et al., 2000). Moreover, articulating the steps verbally is consistent with generative learning theory (Fiorella & Mayer, 2016) as it supports deeper cognitive encoding and schema refinement. The aforementioned processes may explain how VSE counteracts the fragmentation of procedural memory that generally results from seizure events and helped solidify more stable procedural memories.

Practical Implications

These results offer an opportunity to influence how math tutors, those that work with special education and neuroeducational environments, deliver instructional support. When students' ability to remember the steps needed to solve math problems fails to function, rote repetition and practice alone aren't sufficient for those students' learning. The (VSE) provides a low-cost, broad-based method of providing students the ability to externalize their thoughts about what they think occurred incorrectly, as well as the means to develop a presence of procedural resilience. Therefore, the use of VSE for learners who attend schools with limited resources or do not have easy access to highly specialized software, assessments or other forms of clinical or technical support appears promising, based on these findings. However, while the low cost and simplicity of VSE may be considered a significant benefit for tutors operating in low-resource settings, it's also important to keep in mind there are barriers that could impede the effective implementation of VSE; for example, sufficient devices for digital recording, mobile access to data or tools for learners, as well as the learners' level of verbal fluency or confidence when speaking aloud. Students with expressive language difficulties and those with technological constraints may also need further scaffolding or different formats (i.e. paper-based articulation or peer explanation) to bridge the gap caused by their challenges.

Limitations and Future Directions

Although this study provides meaningful insight, there are some limitations. As a single-case design, the results cannot be considered statistically generalizable; still, exploratory designs like this one are needed to uncover mechanisms in poorly investigated neuroeducational populations. This proof of concept suggests VSE has potential for addressing the memory gaps related to seizures by scaffolding error detection, error correction, and re-consolidation of the procedure.

Additionally, the study did not include a control condition, and while the participant was her own control in baseline versus intervention comparisons, future research should explore VSE against other interventions (e.g., note taking, audio-only self-explanation, and tutor-guided learning review) with matched samples of students with epilepsy or procedural memory deficits. These comparisons would support isolating the contribution of both the visual-verbal integration and the externalized metacognitive demands of video-based learning.

The video-based format, while effective in this case, may not generalize well to students with expressive language challenges, limited access to digital recording devices, or discomfort with self-recording. These practical and accessibility related barriers should be considered when scaling the intervention. Longitudinal follow-ups and larger participant samples are also needed to examine the durability and transferability of VSE-related gains, especially in a more naturalistic classroom context.

Finally, the tutor-researcher's dual role in both implementing the intervention and analyzing the data may have introduced unintentional observer bias. While this provided consistent and in-depth observation, it limits objectivity. Future studies should consider involving independent or blinded raters to enhance validity.

CONCLUSION

Based on our case study findings, it appears that Video Self-Explanation (VSE) could be an effective means of supporting students with epilepsy-related procedural amnesia (EAPA) while they learn mathematical procedures. The participant in this study was a learner who experienced frequent absence seizures as well as significant impairments in her ability to recall mathematical procedures.

Through the use of VSE, the learner achieved marked improvements in the long-term retention of and ability to accurately recall mathematical formulas and the correct sequence of steps to arrive at answers. In addition to the objective increases noted above, the implementation of VSE yielded an increase in the use of metacognitive strategies such as providing justification for each step taken, revising prior steps when making an error, and monitoring her comprehension of the mathematics procedure being performed.

These results suggest that by allowing the learner to use VSE, she was able to utilize scaffolding to compensate for the problems created by an absence seizure episode; specifically, video self-explanation allowed her to recognize gaps in her reasoning and provided her with a support system and motivation to reduce her disorganized thinking, impulsivity, and tendency to make frequent mistakes when solving problems.

Although restricted to one context, the findings provide hopeful evidence that reflective, student-generated explanations might help mitigate neurological influences on student learning. The findings describe the potential to further scale the use of video-based generative methods as part of one-to-one learning in other settings–specifically for student learners with working memory challenges. Future investigations should replicate this study with varied learners with epilepsy, include appropriate controls, and research how long students can retain the learning from the intervention.

VSE offers a novel model for building mathematical resilience and independent problem-solving skills in students at risk of academic vulnerability in educational environments, particularly in settings with both neurological and instructional constraints. This study underscores the value of neurocognitively informed pedagogy for learners with neurological vulnerabilities and demonstrates that simple, low-tech interventions like video self-explanation can yield meaningful cognitive and academic gains.

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