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Keywords

science of learning, principles of practice, instructional design, memory retrieval

LEVERAGING THE SCIENCE OF LEARNING TO ENHANCE STUDENT SUCCESS: AN APPLICATION OF SYFR LEARNING'S PRINCIPLES OF PRACTICE

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Abstract
The purpose of the current article is to describe a set of empirically validated principles of practice with the potential to enhance student learning and academic performance. Specifically, we provide an overview of Syfr Learning's principles of practice – a collection of scalable instructional techniques derived from decades of research in the domain of learning science. Further, we provide an illustrative example of the benefits of Syfr Learning's principles of practice when incorporated into existing curricula in a K-12 setting.

Introduction

A review of achievement data suggests that a large number of high school graduates do not develop the skills and knowledge needed for college success during their involvement in the United States educational system. For instance, K-12 learners commonly perform worse than their international peers in key academic domains (Hanushek, 2016; OECD, 2016), fail to reach validated performance benchmarks on standardized assessments that are indicative of collegiate readiness (i.e., ACT Readiness Benchmarks) (ACT, 2018), and are required to complete remedial coursework following their admission to a college program (Radford & Horn, 2012). These issues have contributed to a call for increased accountability and alterations to existing educational practices to enhance student achievement (Callan, 2006; Fuhrman, 1999; Mehta, 2013).

In response to calls for increased accountability, policymakers and educational practitioners have proposed various directives with the explicit goal of improving college readiness. One of the most commonly adopted approaches to enhancing academic quality and student learning involves school finance reform focused on increasing the amount of funding available to educators and support staff to support high-quality teaching (Suter & Camilli, 2019). Logically, it is assumed that increased funding for instruction (e.g., teacher salary, number of teachers, etc.), the purchase of instructional resources, and the establishment of student support services will improve student learning and performance (Odden & Busch, 1998). Unfortunately, data collected over the last 30 years has repeatedly demonstrated that merely providing educators, and school systems, with additional funds devoted to student learning, often fails to translate into meaningful learning gains (Hanushek, 1997; 2006; Lafortune, Rothstein, & Schanzenbach, 2018). We propose that educators and school systems instead emphasize the importance of incorporating general principles and specific instructional techniques found within the science of learning shown to improve short-and long-term academic success into the existing curricula.

The Science of Learning

The science of learning is a data-driven discipline dedicated to investigating the processes that contribute to meaningful learning (Sawyer, 2012). Investigations focused on memory, complex cognition, and cognitive development have demonstrated that learning is a constructive process that follows learners' efforts to integrate to-be-learned content with their existing knowledge base (Mayer, 2008). Additionally, the science of learning has placed considerable emphasis on the development of instructional practices that facilitate learners' efforts to identify important information during learning events, create a coherent mental representation of presented information, and generate novel connections between new and existing knowledge (Roediger & Karpike, 2006; Roediger, Agarwal, McDaniel, & McDermott, 2011; Wittrock, 2010).

Leveraging findings from empirical investigations related to the science of learning, the founders of Syfr Learning, Richard Erdman and Christine Drew, have developed a series of professional development institutes that describe scalable principles of practice (POPs) for use in K–12 and post-secondary settings to improve teaching and student learning. The POPs were engineered to transform instruction design guided by existing scientific knowledge of basic cognitive approaches to learning. Syfr Learning's approach to educator development emphasizes the importance of expanding upon educators' sizable understanding of how learning occurs. By reviewing critical findings related to the science of learning and applying data-driven practice, Syfr Learning emphasizes the acquisition of both meaningful and conceptual learning. During each of Syfr Learning's professional development institutes, teachers are exposed to instructional activities aligned with empirically supported POPs; provided with the knowledge necessary to assess academic growth following from change(s) in practice; are encouraged to discuss challenges and successes related to Syfr Learning's POPs to foster an educational culture emphasizing collaboration and teaching improvement. Teachers accomplish these broad goals through their involvement in an experiential learning process that involves designing and implementing a job-embedded instructional project. Each project is based on Syfr Learning's POPs and the useful measurement of project results through teacher self-assessment and examination of student success indicators.

Principles of Practice

Syfr Learning's institutes introduce teachers to numerous POPs that have been shown to have a positive correlation with academic success. Syfr Learning's training builds the educator's capacity and understanding of how learning occurs cognitively and how the application of science-based instructional strategies takes root in short-term memory. Through memory retrieval, it penetrates long-term memory. The POPs are divided into an overall *Learning Principle* with subsequent *Design Principles*. The POPs presented in this analysis of best practices include:

Learning Principle 1: *Practicing Memory Retrieval*

Through cognitive neuroscience research on memory, scientists have discussed the significance of three processes in learning and memory formation: encoding of new knowledge, storage, and retrieval (Anderson, 1995; Brown, Roediger, & McDaniel, 2014; Craik & Lockhart, 1972; Melton, 1963; Roediger & McDermott, 1995; Wittrock & Carter, 1975). Practicing memory retrieval is essential for profound learning and long-term memory penetration, which can be accomplished through the *Design Principles* of repetition with association and variation, spacing student learning over time, and creating a sense of progress.

Repetition with association and variation. Repetition of practice and memory retrieval significantly contribute to the learning process. Syfr Learning's POPs were heavily influenced by Roediger's research on learning and memory retrieval (Roediger & Karpike, 2006). Empirical investigations into the characteristics that support optimal learning have shown that instructional activities that require learners to engage in repeated memory retrieval enhance new knowledge learning. Repeating the retrieval of memories has been shown to increase the accessibility of existing knowledge stored in the brain, making it easier for students to retrieve this knowledge in the future (i.e., during a testing or evaluative event). Further, it is assumed that repetition aids learning and the formation of long-lasting memories by increasing connectivity and neural communication in brain structures critical to memory formation (Kandel, 2001; 2006).

For over a century, the role of cognitive associations and long-term memory has been a focus of cognitive scientists (Ebbinghaus, 1913). Associative learning is a fundamental component of cognition in which the retrieval of one memory primes the retrieval of another (Thomson, Harrison, Trafton, & Hiatt, 2017). Hebb (1949) discovered a change in the brain's cell structure when an activity is repeatedly experienced, which improves long-term recall of information. When associations occur, neurons in the brain fire together, forming a neural network through strengthening synaptic connections. Information stored in the brain is retrieved through associations such as a song or fragrance evoking a specific memory or remembering you parked your vehicle near the entrance door of the men's suit section of the department store at the mall. Association occurs in the brain instinctively when new learning is related to prior knowledge. These mental connections work to encode new information in the brain, and through memory, retrieval reinforces retention of learning. Utilizing a variety of associations assists in the remembering process. Vlach, Sandhofer, & Kornel (2008) highlight, "when learning occurs in varying contexts, retrieval cues associated with an item increase and therefore the probability of recall increases" (p. 166). Respectively, the number of repetitions and the expanse of time needed to learn is reduced. For example, when new knowledge is connected to emotions, senses such as sight, spatial, or muscle memory, the retrieval of prior memories become fluent.

Best Practice

Repetition serves as a critical function in storing memory in the brain and constructing pathways to long-term learning retention. Variation of the repetitions deepens the understanding of new concepts and aids in preventing mundane repetitions of the same learning activity. Repetition can be varied through the use of multiple senses, emotional hooks, and stories. Using the senses during instructional repetition activities help engage a different memory like motor memory. Motor memory includes learning how to throw a ball in multiple ways, such as underhand/overhand/curveball), riding a bicycle, and composition in dance. Repetition of these tasks improves performance and contributes to long-term memory.

Variation in the learning task assists in expanding the understanding of a concept. Moreover, varying the learning activities works to prevent boredom of a repetitive drill. Variation in learning tasks includes matching the words to the pictures, memory matching games, matching the words to definitions, and matching the picture to the definition. Variation may begin informally with an activity such as matching and then move incrementally faster into an activity with greater rigor such as a word problem or an open-ended writing assignment. Learning should be designed with a mixture of paraphrasing, summarizing, simplifying, or abstracting the knowledge to connect learning, increasing long-term memory recall of vocabulary words.

The association helps connect prior knowledge to new learning and can be accomplished by tying content together through the senses. Activities that include emotional connections, visuals, music, and the physical context of the learning contributes to memory retrieval. Teachers should design learning by linking existing knowledge to new concepts. An example of a learning task might include connecting a word problem to what students have learned in language arts in analyzing the plot of a story. The events within a plot can be tied to solving a math word problem by associating the problem as a short story with characters and the conflict they are working to resolve.

Similarly, instructional activities connecting popular music to learning grammar by using song lyrics can improve recall. Visual association activities such as connecting new vocabulary words to visual images, icons, or drawings. The teacher can utilize graphic organizers, anchor charts, timelines, or imagery to arouse curiosity or a gallery walk. Learners are encouraged to build on existing knowledge and promote critical thinking.

An exemplar of repetition with association and variation activity would begin by introducing targeted vocabulary words to the students using images. The teacher asks open-ended questions and encourages students to inquire about the image's representation, followed by identifying and discussing the word meaning. An incremental and future activity is to have students complete sentence stems with the appropriate word. In a subsequent activity, the teacher can increase the repetition's complexity with association and variation by having students write a personal story or narrative using prior experiences while incorporating the targeted vocabulary words.

Spacing student learning. One of the most robust findings in the science of learning is how the POPs of spacing and association leads to accelerated learning. Early work on the nature of memory demonstrated the importance of distributing learning over a space of time (e.g., distributed practice). Specifically, investigations have demonstrated that learners who engage in distributive practice often exhibit substantial gains in learning. Increases in learning occur following repeated engagement with material spaced over an extended period compared to students who engage with content during a single interaction.

Ebbinghaus (1913), through his research on memory, discovered the importance of spacing (or distributed practice) in memory recall. Cepeda, Pashler, Vul, Wixted, & Rohrer (2008) found that learning sessions' timing impacts long-term recall of studied material. The spacing effect vs. massed practice, a term used in the cognitive science for continuous practice with few or no pauses for rest (Wek & Husak, 1989), has been identified as a method to improve long-term retention learning. Ebbinghaus (1913) affirms, "…with any considerable number of repetitions, a suitable distribution of them over a space of time is decidedly more advantageous than the massing of them at a single time" (p. 89). Vlach, Sandhofer, & Kornel (2008), in their research on spacing and children's memory and category induction, confirm distributed learning or the "spacing effect" enhances memory "when learning events are distributed" (p. 163).

Contemporary research asserts, "retrieving knowledge from memory is more beneficial when practice sessions are spaced out so that some forgetting occurs before you try to retrieve again. The added effort required to recall the information makes learning stronger" (Roediger III, 2014, p. 18). The distribution of practice influences memory due to the human brain's complexity, which is wired to forget. When spacing is completed through deliberate practice and distributed through repetition of content over time, long-term memory recall is strengthened. Kang's (2016) review of research on spaced practice found spaced repetition promotes efficiency and efficacy of learning.

Best Practice

Learning and memory retrieval is greater when spaced over time. The spacing effect can be accomplished by scheduling practice over several days by limiting direct instruction and learning activities to shorter periods ranging from 10-15 minutes. Content is repeated through a variety of activities distributed each day of the same week. Spaced learning's instructional design should include content that incorporates relevant connections and elaborated content that links memories together by connecting new knowledge with prior knowledge. The spacing effect can be executed within the same class period, spread over several days, and likewise distributed over months.

An exemplar in instructional design for vocabulary acquisition includes the distribution of student learning by spreading the repetition of vocabulary words. The teacher might introduce a vocabulary lesson beginning with a 10-minute repetition of practice through variation and then a longer interval of time spaced between learning 60-90 minutes later. Each day, in 10-minute time blocks, activities are implemented to practice the selected vocabulary words. The teacher spaces the time between these activities through the deliberate use of interleaving practice through repetition, using variation in the learning activity. Interleaving involves arranging instruction of two or more learning sets by alternating instruction between the sets (Rohrer, 2012; Bjork, Finley, Linn, Richland, 2005). “Interleaving is a second principle for designing learning contexts in which learning is made more difficult during instruction, but retention and transfer are higher after a delay” (Bjork, Finley, Linn, Richland, 2005, p. 1851). The spacing between the repetitive practice of vocabulary words aids in long-term memory recall. Furthermore, distributing vocabulary practice over time, by its very nature, increases the difficulty of the task. Distributed practice increases the level of processing, creating longer-lasting, and stronger memory retrieval.

They are creating a sense of progress. Research by Amabile and Kramer (2011) served as the stimulus for the POP of creating a sense of progress. The researchers identified factors that influence performance and motivation, such as the positive impact of meaningful work progress. Student's sense of progress, or small wins, serve as catalysts for performance. Performance is increased by embedding a sense of progress and improvement into student learning activities (Amabile and Kramer, 2011; Ericsson & Pool, 2016). Contemporary motivational frameworks suggest that making students aware of self-improvement and growth increases learners’ commitment to educational goals (Fishbach, Eyal, & Finkelstein, 2010; Schunk,1990), increase academic self-efficacy (Bandura, 1991; Schunk & Ertmer, 1999), thereby enhancing subsequent effort and persistence.

Best Practice

Educators can motivate and build learners’ confidence by providing time to reflect and evaluate their sense of progress. To create a sense of progress, the teacher's starting point would begin with a pretest on existing knowledge, followed by activities moving the students towards the endpoint, such as a post-test, unit test, etc. By beginning with the end in mind, learning activities relative to the pretest help students visualize their progress. Syfr Learning suggests providing students with feedback and representations of the individual’s success, such as progress bar graphs or having students chart their individual growth.

Learning Principle 2: *Desirable Difficulty is Required*

According to Bjork (1994), "desirable difficulties," or enhancing the target of instruction by introducing a desirable amount of challenge by varying the learning conditions, increases long-term retention of knowledge. Students must receive the appropriate level of challenge during a task to motivate them to learn. Desirable difficulty can be accomplished through the *Design Principles* of breaking down learning in smaller increments; eliminating ceilings; interleaving practice; and using assessment, including failures, as learning. "The difficulties introduced by variation, spacing, and interleaving, are desirable because responding to those difficulties (successfully) engages the very processes that support learning, comprehension, and remembering" (Bjork & Kroll, 2015, p. 2). Introducing variation in the context of learning of content instead of constant and predictable repetition of the same activity increases information retention. The temporal distribution of practice, or the spacing of learning over multiple sessions rather than learning content in continuous cyclic practice leads to long-term retention (Cepeda et al., 2008; Dempster, 1989). Dunlosky et al. (2013), in an extensive review of effective learning techniques, rated distributed practice as a high utility strategy. Interleaving the learning of different types of practice/problems or topics for practice sequenced leads to greater long-term retention by strengthening memory association through the intentional spacing of practice on a given learning task.

Best Practice

Educators should design learning in order for students to experience a desirable difficulty or challenge to stretch their learning. Activities too easily become dull; tasks too arduous become frustrating (National Research Council, 2000). One method of presenting challenges for students is to increase the rigor of questioning. Another strategy is to break down learning into smaller increments by simplifying the information into key components or chunking by grouping content into meaningful categories. Breaking down rigorous content into manageable parts and related groupings help connect new concepts to existing knowledge (Bjork, 2001; Wickelgren, 1981). Breaking down the task provides opportunities for frequent successes and decreases the impact of failures. Increasing the task's complexity can be accomplished by having students compare and contrast, identify patterns or similarities, elaborate through paraphrasing, or expand/justify why a solution to a problem is correct or incorrect.

Learning Principle 3: *Creativity Comes to the Prepared Mind*

Boden (2004) states, "In the absence of magic or divine inspiration, the mind's creations must be produced by the mind's own resources" (p. 40). Creativity occurs organically by connecting recognized concepts and contrasting ideas in original and unique ways. Kounios et al. (2006), quoting Louis Pasteur, "Chance favors only the prepared mind," asserting "insight occurs when problem solutions arise suddenly and seem obviously correct, and is associated with an "Aha!" experience" (p. 882).

Creativity comes to the prepared mind through the *Design Principles* of synthesizing knowledge in unique ways, transferring knowledge into different contexts, and providing structured, safe free time/play. Through a literature review on creativity, Syfr Learning found that when the learner's mind is prepared in habits, skills, and knowledge, they can convert knowledge in innovative, meaningful, and memorable ways.

Best Practice

A mentally prepared mind provides the stimulus of reinterpreted knowledge that assists in comprehending a joke or metaphor or solution to a problem creating an "aha moment" (Kounios & Beeman, 2014). Providing opportunities for students to transfer skills and knowledge in experiential ways such as play, improvisations in the representation of their knowledge help maximize creativity during the learning experience. Best practices such as designing instruction in which learners synthesize and transfer knowledge through creating a new model, prototype, or developing a riddle, play, narrative, or a new ending to a story.

Effective Information Processing

Researchers within the learning sciences have long advocated for adopting learning frameworks emphasizing the importance of effective information processing strategies to the knowledge construction process (i.e., Cognitivism; Wittrock, 2010). One of the primary assumptions of learning theories in the cognitivist tradition is that learning is enhanced when the learner implements strategies that support the organization of to-be-learned information in a meaningful manner and generation of meaningful associations between existing knowledge and to-be-learned information (Schwamborn, Mayer, Thillmann, Leopold, & Leutner, 2010; Wittrock, 2010; Wittrock & Carter, 1975). Learning techniques that support the organization and integration of new content with existing knowledge supports the development of mental representations, enhances future problem-solving efforts, and serves as the foundation to establish a complex conceptual understanding of information (Fiorella & Mayer, 2016; Van Merrienboer & Sweller, 2005).

Designing Instruction Using the Principles of Practice

Learning Target & Implementation Context

The following is a single case study illustrating the instructional design and implementation of lessons using Syfr Learning's POPs by a third-grade teacher in a K-12 urban school district in a northeastern state with a student population of approximately 26,000. Table 1 and Table 2 provide an overview of student enrollment information disaggregated by ethnicity and student group for the school district. Table 3 and Table 4 provide student enrollment information for the students directly involved in the case study.

Table 1. Percentage of Student Enrollment by Ethnicity

Enrollment by Ethnicity	%
African American or Black Students	56.7%
American Indian or Alaska Native	<.1 %
Asian or Native Hawaiian or Other Pacific Islander	3.67%
Hispanic or Latino	29.2%
White	10%
Multiracial	<.1 %

Table 2. Percentage of Enrollment by Student Groups

Enrollment by Student Groups	%
Economically Disadvantaged	90.6%
Students with Disabilities	21.2%
English Language Learners	15.3%
Migrant	<.1 %
Homeless	4.2%

Table 3. Percentage of Student Enrollment by Ethnicity

Enrollment by Ethnicity	N	%
African American or Black Students	7	41.2%
American Indian or Alaska Native	0	0%
Asian or Native Hawaiian or Other Pacific Islander	0	0%
Hispanic or Latino	5	29.4%
White	3	17.6%
Multiracial	2	11.8 %
Total	17	100%

Table 4. Percentage of Student Enrollment by Student Groups

Enrollment by Student Groups	N	%
Special Education	3	17.6%
English Language Learners	0	0%
Gifted & Talented	0	0%
Economically Disadvantaged	17	100%
Total	17	100%

The teacher chose vocabulary acquisition and oral reading fluency as primary areas of focus to apply the POPs. The specific learning targets for students in this example included vocabulary acquisition, knowledge of linguistic context to determine the meaning of unknown words and reading grade-level text with purpose and understanding. The grade three teacher selected Learning Principle 1: *Practice Memory Retrieval* using repetition with association and variation, spacing learning over time, and creating a sense of progress. She also selected Learning Principle 2: *Desirable Difficulty is Required* by breaking down learning in smaller increments, eliminating ceilings, interleaving practice, and using assessment, including failures as learning. The next POP utilized was Learning Principle 3: *Creativity Comes to the Prepared Mind* by having activities organized to allow students to synthesize knowledge in unique ways and transferring knowledge into different contexts.

Pre-Assessment

To determine a baseline that would be used to determine the effectiveness of Syfr Learning's POPs, students completed a vocabulary matching assessment before each unit. The assessment included words used as a part of the Houghton Mifflin Journeys language arts program (Houghton Mifflin Harcourt, 2019). In addition to vocabulary acquisition data, the teacher collected benchmark data from the previous fall term using Pearson's (2019) aimswebPlus. AimswebPlus is a web-based formative assessment tool used to screen, monitor, and report student progress in reading and math. Pearson's aimswebPlus was used to report student progress on oral reading fluency. Baseline data indicated that approximately 24% of students demonstrated "passing" performance on unit pre-assessments and 22% of students' reading fluency was on grade level.

POPs in Action

The following example demonstrates one week of instructional design using the POPs:

The grade three teacher designed English Language Arts instructional activities for the week to include Learning Principle 1: *Practicing Memory Retrieval* using *repetition with association and variation*. On the first day, students completed a short pretest that required learners to match new vocabulary words to the appropriate definition. Following the first exercise, the teacher presented vocabulary words by displaying images without the interactive whiteboard's associated word. The teacher used an inquiry-based approach in which students were asked to discuss and connect vocabulary words with a related image. When students correctly matched the vocabulary word to the image, the teacher and students discussed the word and then wrote it above the image. When students provided a similar term(s) that matched the vocabulary word, the teacher used this extemporaneous learning opportunity to discuss the related term(s). The teacher also focused on making connections between their vocabulary words and the "real world." This activity aimed to present opportunities for students to connect each vocabulary word with practical uses and contexts. Afterward, students read a story and highlighted the vocabulary words they saw within the text.

On Day 2, the teacher continued using Learning Principle 1: *repetition with association and variation* as an instructional strategy by displaying only a visual representation visual of the word. Students were again asked to identify the vocabulary word that corresponded with each of the images. After students responded with the correct vocabulary word, the word was written above the image. However, this time the teacher expanded the activity to promote meaningful connections to existing knowledge. The teacher used Learning Principle 3: *Creativity Comes to the Prepared Mind* by synthesizing information in unique ways by having them transfer knowledge into different contexts. She designed an activity that required the students to access prior knowledge. Specifically, students were asked to discuss each vocabulary word using "real-world connections." For example, if the vocabulary word was “slope,” students had to respond to a “Think About It” question in the group and partner discussions: “How would riding a bike on a slope be different than riding a bike on flat land?”

Additionally, the teacher designed instructional activities by following Learning Principle 2: *Desirable Difficulty is Required*. She began to space learning by incorporating practice over multiple days while creating distractions to increase the struggle. By breaking down content into smaller increments and spacing the learning over days, she used interleaving practice. Subsequently, spacing practice with interleaving, the learner is required to retrieve memories.

During Day 3, the teacher exposed students to a limited number of vocabulary words. She exposed them repeatedly through reading, writing, questioning, and group work. On Day 4, the teacher repeated the same activities with a set of words different from Day 3. This time the teacher used “Think About It” cards and instructed students to reflect and discuss the vocabulary words with a classmate. On Day 5, the teacher presented five words, displayed visually on the interactive whiteboard technology system, and discussed each detail. The teacher increased the task's complexity by having students create a Four-Square Vocabulary Map on chart paper in groups. The Four-Square Vocabulary Map is a graphic organizer with four squares used to promote vocabulary development. Students were assigned to five groups, with each group being assigned a specific vocabulary word in this activity. Students were provided with instructions detailing how to complete the Four-Square Vocabulary Map effectively. The teacher emphasized the need to identify and define the word, use it in a sentence, draw a picture (a picture different than the images displayed on Days 1 & 2), and write the word out five times.

After completing the vocabulary maps, they were placed around the room. The students participated in a gallery walk to view each group’s map. Students were asked to write, "I notice… and I wonder…" statements during the gallery walk. Having students participate in the gallery walk produced students' opportunity to evaluate their own and others' work by asking "I wonder" statements. This created a sense of progress through assessment. For the final task on Day 4, students completed a fill-in-the-blank activity using the five words. The teacher worked to break down learning by providing multiple and frequent opportunities for success in small learning increments and celebrating growth.

On Day 5, students reviewed all ten words using various SMART Board and Quizlet vocabulary games on the interactive whiteboard. Throughout the week, the words were contextualized using the Houghton Mifflin Harcourt (2019) Journeys literature and informational texts. Journeys is a comprehensive K-6 English language arts program. The curriculum program provides teachers with an instructional system for reading, including literature and informational texts, for acquiring foundational skills, for developing mastery of speaking, listening and writing, and assessments. At the end of the week, a quiz was given to assess students' knowledge of all ten vocabulary words. Evaluations included multiple-choice tests provided as a part of the Journeys program. The assessment required students to use each vocabulary word alone and in an appropriate context.

Outcomes

Evidence of student performance and academic growth was based on assignments and assessments given throughout several units using the POPs in standard vocabulary lessons' instructional design. The teacher expressed that students were making connections with the vocabulary in multiple stories from the Journeys text. Collectively, data indicated that students demonstrated considerable growth in vocabulary acquisition and oral reading fluency following the vocabulary lessons. Specifically, the teacher who was the focus on the current case study noted a sizable increase in students demonstrating satisfactory performance on Houghton Mifflin Harcourt Journeys language assessments. She remarked that the students' retention of the vocabulary had increased, and students could recall words more frequently following the introduction of instructional strategies with the embedded POPs within the activities. Students also increased from a 24% passing rate at pretest to 82% passing at post-test; most notably, oral reading fluency assessments data revealed that 100% of the students involved in the current case study exhibited growth in oral fluency and 71% were reading on grade level after the vocabulary lessons (only 22 % of students were on grade level at the onset of the unit). This case study results reflect similar student learning gains reported by other teachers interviewed in a large study of the POPs (Jones, 2017; Jones, 2018) and have reported 88% - 90% recall rates on weekly vocabulary quizzes after incorporating the POPs into their classroom instruction.

Conclusion

Available data suggest that many students leave high school underprepared for standard college learning environments (Hanushek, 2016; Radford & Horn, 2012; Shapiro et al., 2017). Therefore, this manuscript's primary aim was to demonstrate the viability of a set of empirically validated and easily scalable principles of practice developed by Syfr Learning designed to support student learning and academic success. Specifically, we described a case study in which an educator modified their instructional practice following involvement in a Syfr Learning teacher development seminar to include activities emphasizing principles repetition, variation, association, and spacing when providing vocabulary content to students. Data collected during instruction indicated that students exhibited improvements in vocabulary assessments, oral fluency measures, and reading levels following their exposure to lessons incorporating Syfr Learning's practice principles. We believe the current investigation highlights the importance of the educator's instruction design that considers how learners acquire and process new knowledge. Learning must be constructed to maximize the depth of knowledge stored within the brain and reactivating this information stored in memory to build new knowledge. The instructional methods used affect information processing and directly influenced how well information is preserved and students' ability to transfer their knowledge to related situations. Further, the current investigation provided evidence from a real-world learning situation that demonstrated how incorporating instructional practices derived from the science of learning, such as Syfr Learning's principles of practice, can positively impact student learning and performance.

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