Changing How We Think, Changing How We Learn: Scaffolding Executive Function Processes for Students With Learning Disabilities

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Students with learning disabilities have been reported to have difficulty in a number of different executive function processes that affect their academic performance (Singer & Bashir, 1999). Executive function difficulties for students with learning disabilities have been implicated as the reason why these students struggle with complex academic tasks such as reading, writing, and note-taking (Denckla, 2007). This mixed-methods study explored the extent to which a strategic note-taking intervention encouraged more efficient employment of executive function in middle school students with learning disabilities. This paper draws on interviews, students' notes, and pre- and postintervention assessments to present case studies of three student participants. Results indicate that the strategic note-taking intervention served as a scaffold, opening up new pathways for struggling students to access executive functions and flexibly deploy cognitive strategies. Importantly, *how* each student did so and *what* each student learned about her/himself as a learner in the process were dependent on the specific challenges presented by her/his learning disability. These cases shed light on the potential for cognitive scaffolding to help students actively improve their own executive functioning in complex tasks such as note-taking.

Keywords: *learning disabilities, executive functions, scaffolding*

Introduction

Note-taking during lectures is a cognitively demanding task that involves listening, processing, organizing, and writing skills synchronously, while also contending with the temporal demands of the lecture. Unlike other academic tasks that allow students to periodically pause to process their thoughts, such as reading a book or composing an essay, the temporal nature of recording notes during lectures prohibits students from slowing down because when they do, they risk missing subsequent lecture points spoken by the teacher (Piolat, Olive, & Kellogg, 2005). To compound matters, students with mild disabilities (e.g., learning disabilities, ADHD) are often characterized as having executive function difficulties that interfere with complex writing and planning tasks such as note-taking (Meltzer, 2010, Semrud-Clikeman, 2005). For students with disabilities, the temporal demands combined with executive function deficits result in poor note-taking skills (Meltzer, 2007). These students miss important lecture information, resulting in incomplete or illegible notes and, ultimately, poor performance on measures requiring lecture comprehension (Boyle 2010b; Hughes & Suritisky, 1994).

In order to assist students who have disabilities with recording notes during lectures, these authors taught them how to use a strategic note-taking intervention, and, in turn, examined its use from an executive function perspective. In this paper, we ask, "Were students able to use strategic note-taking to mitigate the cognitive challenges associated with their learning disabilities?" and "How did this note-taking strategy alter their thinking and learning?"

Literature Review

Executive Function Processes During Academic Tasks

Executive function (EF) is viewed by some as an all-encompassing construct that describes cognitive and metacognitive processes used by students in the classroom (Anderson, 2002). Alternatively, McCloskey, Perkins, and Van Divner (2009) view EF as a collection of cognitive capacities that act in a coordinated manner to direct students' actions in an organized, strategic, and goal-directed process. EF's main role is to orchestrate various cognitive processing during complex problem-solving tasks (Neisser, 1967). Moreover, there is general agreement within the literature that executive functioning is comprised of these multiple cognitive processes or skills that allow students to "initiate and sustain behavior, inhibit competing actions or stimuli, select relevant task goals, plan and organize problem-solving strategies, shift strategies flexibly when necessary, and monitor and

evaluate one's own behavior" (Gioia, Isquith, Kenworthy, & Barton, 2002, p. 122). EFs are not the actions themselves (e.g., to perceive, think, and act), but instead issue the commands or cues that direct perception, thoughts, and actions. In conjunction with working memory, executive functions also help students retain active information so that it can be sorted, discarded, practiced, processed, or retained.

Students with learning disabilities have difficulty in a number of different executive function processes that affect their academic performance in the classroom (Singer & Bashir, 1999). Executive function difficulties for students with learning disabilities cause these students to struggle with complex academic tasks such as reading, writing, and note-taking (Denckla, 2007). Among students with learning disabilities, Meltzer and Krishnan (2007) found that executive function difficulties hindered students' ability to use efficient strategies and prevented them from using strategies in a flexible manner during problem-solving tasks. Further, they claim that these difficulties explain why students struggled with self-regulation and monitoring of strategies during complex learning tasks. In addition to these problems, Anderson (2002) reported that students also had difficulty in the areas of impulse control, reasoning ability, responding to feedback, and retaining information in working memory.

Students with learning disabilities have been characterized in the literature as "inefficient" or "passive" learners, whereby they have difficulty naturally deploying strategies, they struggle to use strategies flexibly, they fail to monitor their strategy use, or they do not utilize a new strategy when their strategy is ineffective (Ellis & Lenz, 1996; Evers & Spencer, 2007, Meltzer, Katzir, Miller, Reddy, & Roditi, 2004; Yang, 2011). These struggles, then, involve both selecting and employing an effective strategy and using a strategy in a fluent and flexible manner while completing learning tasks (Gunstone, 1994). Students who use efficient strategies are able to integrate new learning with prior content (Yang, 2011). Flexible use of strategies enables the student to shift to a new strategy or devise an alternative strategy when the current one is failing, as well as learn from mistakes and understand a given strategy's role in the mistake (Anderson, 2002). This shifting reflects students' use of inhibition during problem-solving activities. During complex problem-solving activities, students must inhibit inadequate strategies and task-irrelevant information and choose more appropriate strategies in an attempt to successfully complete the task (Toll, Van der Ven, Kroesbergen, & Van Luit, 2011).

Role of Executive Function During Academic Tasks

According to Meltzer and Krishnan (2007), the core executive functions that are used by students during academic tasks include planning and goal setting, organizing, prioritizing, memorizing, shifting flexibly, and self-monitoring/checking. These core functions are used in a variety of written language tasks from writing essays to note-taking. Planning and goal setting enable students to examine the task demands in order to plan which strategies to use and set goals for the task itself. These two executive functions play a principal role in the initial stages of writing as students brainstorm ideas and plan out ideas for the writing task (Taft & Mason, 2011) and are also used in note-taking, for instance, when students use an advance organizer to plan out how they will record notes during a lecture. Unfortunately, students with disabilities have difficulty planning, organizing, prioritizing, and elaborating during writing tasks, including note-taking (Boyle, Rosen, & Forchelli, 2014; Harris & Graham, 1999).

Organizing is an ongoing process that begins during the planning process and continues well after the task is completed. During complex tasks, students organize and coordinate multiple cognitive activities simultaneously (Meltzer & Krishnan, 2007). Organizing before or during a task involves visual planning and understanding the bigger picture prior to beginning the task so that information can be organized, processed, and stored. Moreover, organization of verbal information is an essential component of learning and may create difficulties for students with learning disabilities during complex activities involving the storage and processing of information, such as note-taking (Craik & Lockhart, 1972; Polychroni, Economou, Printezi, & Koutlidi, 2011). Organization also involves sorting and classifying information, particularly as students move between their understanding of the task as a whole and their engagement with task details (Krishnan & Feller, 2010).

Throughout an academic task, students must also prioritize information, which involves identifying and attending to the most important information in the task (Meltzer, 2010). Frequently, students must decide with which parts of a task to begin and on which parts to spend the most time (e.g., major projects and tests), determine which lecture points are important to record and which to ignore, and choose how much time to spend on different aspects of writing a research paper (e.g., how much time to spend reading versus writing the paper) (Meltzer, 2010).

In addition to planning, organizing, and prioritizing, other executive functions are used by students during memorizing of information, shifting strategies to solve problems/tasks, and self-monitoring/checking of task success/completion/progress. Students must manipulate information mentally and direct attention to various aspects of the task to memorize. For example, using

effective study strategies can help students make more connections between important new concepts and create fresh connections with previously learned concepts (Meltzer, 2010). Kincaid and Trautmen's (2010) work on memorization identified four common approaches: attending to details, repetition/rehearsal/review, attaching meaning, and chunking information. Many of these approaches are used during note-taking, and they increase recall and memory of information (Swanson & Hoskyn, 1998).

The deployment of appropriate strategies enables students to perform efficiently on learning tasks. This cognitive flexibility is a critical element during learning, yet it can be difficult for students with disabilities to master (Meltzer & Krishnan, 2007; Meltzer, Cohen, Miller, & Roditi, 2001). On tasks such as note-taking and studying, shifting back and forth between topics/subtopics and using strategies flexibly (i.e., using certain parts of a strategy more extensively than other parts of the strategy) are important executive functions that are used to learn content information efficiently (Meltzer & Begnato, 2010). Finally, self-regulation of behaviors is important for students to use as they work to complete complex tasks. For example, during writing tasks (e.g., note-taking), students must monitor their writing continuously to insure that it is organized in a logical order and makes sense.

Executive functions play an important role as students successfully complete school tasks. During complex learning tasks, these executive functions are called on for planning and goal setting, prioritizing, and organizing information. Likewise, as students are working on tasks and activities in the classroom, memorization, shifting, and self-regulation components help students learn content efficiently and make corrections in the face of errors or difficulties. It is the skillful coordination of these components that ensure successful learning in academic tasks.

Using Executive Functions During Note-Taking

Writing notes during a class lecture is a cognitively demanding task that many students encounter daily. Piolat, Olive, and Kellog (2005) found that recording notes during a lecture requires a degree of cognitive effort that is comparable to a chess expert deciding her next move during a match. As students listen to lecture information, they must prioritize which ideas are important and temporarily hold a lecture point in memory while processing (e.g., paraphrasing) it or linking it with prior knowledge, subsequently recording it in their notes before the teacher delivers the next lecture point. The temporal nature of notes also adds to their complexity. If students do not record a lecture point in their notes (or electronically record the information via a digital recorder), the information may be lost forever.

Skilled note-takers use planning and goal setting in the initial step of the writing process to create frameworks for essays. In note-taking, this process manifests in students' preparation for the lecture, when the teacher reviews what students already know about the lecture topic. Organizing when writing or note-taking involves recording ideas or lecture points in a cluster, with one main idea representing the topic of the cluster and details or related information representing component information of the main idea. Prioritizing is important for students as they decide which lecture points are important to paraphrase or record in notes and which are merely supporting details that may not be worthwhile to record. Due to the temporal nature of note-taking during lectures, self-regulation plays a major role as students must monitor both the quality and quantity of notes recorded, as well as make judgments about whether or not to ask questions to clarify confusing content. When students find that they have difficulty recording notes quickly enough to keep up with the teacher, they must shift to other strategies or approaches (e.g., using abbreviations, pausing and listening, or looking at a classmate's notes to see what they missed) to help them capture the lecture content. Likewise, students can shift their focus to certain aspects of the content to better understand those parts or decide which parts of their note-taking procedure/strategy to apply more extensively.

Though most students are fluent and successful at using executive functions, students with disabilities often have difficulties using their executive control functioning and thus do not perform well on note-taking tasks. For example, in a study that examined the note-taking skills of students with and without learning disabilities, students with learning disabilities performed significantly worse than their nondisabled peers in their ability to record notes from a lecture (Boyle, 2010). This particular study found that when compared to their peers, students with learning disabilities recorded fewer important lecture points (18% for students with learning disabilities versus 42% for students without learning disabilities), fewer total lecture points (e.g., 13% versus 24%), and fewer words overall in notes (57 versus 131 words). In addition, students with learning disabilities scored about 20% lower on a measure of lecture comprehension than peers without disabilities. Other studies have found similar results (Hughes & Suritsky, 2004), further confirming the cognitive demands placed on students with disabilities during note-taking.

To assist students with disabilities to manage the cognitive demands of content learning, teachers typically supply students with cognitive support (e.g., guided notes, graphic organizer) or teach students how to use

a strategy (Boyle & Rivera, 2012). These supports can be understood as scaffolds for learning. The purpose of these interventions is to teach students to monitor or self-regulate their behavior during lectures or, in the case of guided notes, to reduce the cognitive demands by having students record notes on a guide that already contains content (see Butler, 1998, for a more detailed description of this model of strategic learning). In our study, the strategic note-taking strategy provides a framework for using note-taking with the strategic note-taking paper to help students self-regulate their behavior.

Methods

This mixed-methods study was conducted in two suburban middle schools in the Northeastern United States. The research team introduced a strategic note-taking intervention to learning disabled students and their non-learning disabled peers in four 7th grade science classes and used both qualitative and quantitative measures to better understand the effect of this intervention on the cognitive processes of the students with learning disabilities. Quantitative measures included a scored note-taking task and pre- and postlecture quizzes. These measures were administered to students with and without learning disabilities. Qualitative measures included semi-structured interviews with all participants with learning disabilities and analysis of these students' notes. The analysis presented here draws on both the qualitative and the quantitative data, with a stronger emphasis on the findings from our qualitative interviews. The interview data provided insights into *how* change was occurring for these participants. We were only able to identify one study that examined how students use strategies to mediate executive function difficulties. In that particular study, Singer and Bashir (1999) examined the use of self-talk by a student with language learning disorders to regulate his communication difficulties. Therefore, this study represents an extension of the research on how students can use interventions to improve their success on an academic task, in this case note-taking.

Participants

With the goal of understanding how students with learning disabilities used our strategic note-taking intervention, purposive sampling, or the selection of individuals who meet a particular set of criteria (Creswell, 2007), was used to identify potential study participants. The goal was to include all students with learning disabilities in the classes that were implementing the intervention. Teachers of 7th grade science were recruited and received a monetary stipend for their participation. Consent forms were sent to the homes of all 7th grade students of these teachers and a gift card lottery was used as an incentive for returning forms. Of the 36 students with learning disabilities who consented to participate in the note-taking intervention, 22 were White, 7 were African American, 3 were Latino and 1 was Asian American. The group included 20 boys and 16 girls. After examining our quantitative data and finding that most of the students demonstrated improvements in their note-taking, we became interested in understanding how and why that improvement was happening for students with learning disabilities. For this analysis, then, we used the pre- and postintervention quantitative measures to identify three cases to examine in depth. These students were all chosen because they had improved significantly in their noting of vocabulary and important points and their recall of information.

Strategic Note-Taking Intervention

Pre-/postintervention note-taking task. Baseline was determined by administering a mock lecture during which they would listen and record notes using traditional note-taking. The mock lecture was comprised of a 15-minute video lecture on Electro-Plasma Rockets. Following the video, notes were collected and students were administered an immediate free recall (IFR) test, during which they were given a blank paper and asked to write down as many facts, ideas, and vocabulary from the lecture as they could within three minutes. The IFR was collected and students were administered a 10-question multiple-choice quiz. This same procedure was used as a posttreatment measure with the only difference being that students used the strategic note-taking intervention to record notes. Scoring of the measures occurred by undergraduate and graduate level students scoring the notes and IFR on three criteria: Cued Lecture Points, Total Lecture Points, and Vocabulary. The quiz was scored using an answer key.

CUES+ strategy and SN paper. The strategic note-taking intervention, adapted from Boyle (2010b; 2012), Boyle and colleague (2001), and Lee and colleagues (2008), is comprised of two parts, the mnemonic CUES+ (i.e., "C"-Cluster, "U"-Use, "E"-Enter, "S"-Summarize, + - abbreviations, symbols, or pictures) strategy and the strategic note-taking (SN) paper:

- ***CUES+ strategy.*** In the CUES strategy, each step prompts the student to perform an action using lecture information and the SN paper. In the Cluster step, students are asked to cluster lecture information into manageable units of three to six related ideas and record the chunked ideas on the SN paper. The Use step prompts students to pay attention and listen for teacher cues (i.e., number cues and importance

cues) during the lecture and, when they hear these cues, record the lecture points that are associated with them. In the next step, Enter, students are asked to listen for vocabulary words and record any vocabulary words from the lecture in the appropriate area on the SN paper. In the Summarize step, students are asked to write a word or words that would categorize the three to six lecture points they have already listed (i.e., clustered together) on the SN paper. In the + step, students were told to use abbreviations, symbols, or pictures as they recorded notes.

- ***Strategic note-taking paper (SN paper).*** The SN paper placed boxes with guidelines for types of information students should record. At the top of the paper, students recorded the topic and include any background knowledge they may have on the topic. Students then group together three to six main points from the lecture with details. At the end, students were prompted to summarize the lecture ideas. There was also a separate section for key or new vocabulary words to be listed and defined.

Modules. To ensure uniformity of information across classrooms, participating teachers developed scripted lectures and vocabulary for each lesson, or module,. Half of the modules were recorded and presented to students in video format, and the other half were presented in vivo. These scripts included cued and noncued lecture points. Two types of cues are used to alert students to important information: emphasis cues and organizational cues. Emphasis cues were those that emphasized the importance of the statement (e.g., "Please write this in your notes: A plasma engine uses only one tenth of the fuel that a chemical rocket engine would use.). To help students organize chunks of related information, organizational cues were used ("There are three kinds of plasma engine rockets: ion drive, Hall thruster, and MPD thruster."). Noncued lecture points were pieces of information that did not have a prompt or cue before their presentation.

Data Collection

Participants' baseline note-taking ability was assessed using the Preintervention Note-taking Ability Task. Students then participated in two SN training sessions. During the first 50-minute training session, the principal investigator followed a scripted lesson and trained students how to use the SN strategy with the SN paper that included a brief description of SN and modeling of the technique. During this time, he also guided students through practice portions of a videotaped lecture. During the second session, students used the same videotape, but with new SN paper and were acclimated to the pace of a typical lecture.

Upon completion of the training, teachers presented the prescripted modules during the students' 7th grade science class. One or two modules were presented each week, for a total of twenty modules over the course of a semester. In each session, students were provided with the premodule test at the beginning of each class period, the scripted module, and the postmodule test at the conclusion of the lesson. Though the topics varied from module to module (e.g., mutualism, symbiosis), the same pretest was used as the posttest in the module (e.g., Module 17 contained the same pre- and posttest on symbiosis; Module 18 contained the same pre- and posttest on Mutualism). Each pretest (and posttest) consisted of a ten-point multiple-choice quiz that was administered before and after a module with the goal of determining learning gains. Students did not necessarily have time to study their notes after the lecture; therefore, the postmodule tests were merely a measure of the effects of taking notes and not necessarily studying their notes.

In addition, after each session, trained research assistants conducted 5- to 10-minute interviews with all participants who had learning disabilities. They used a semi-structured interview protocol that focused on the students' experiences using the note-taking strategy, as well as how they believed their note-taking was changing over time. The number of interviews each student completed over the course of the intervention varied depending on attendance and ranged from one to seventeen. After the last module was presented, the Postintervention Note-taking Ability Task was given to the students.

Data Analysis

Students completed the note-taking task before and after the intervention implementation as a pre- and postmeasure. Independent raters scored all the notes using a key created by the principal investigator. The raters counted the number of Cued-Lecture Points (CLP), Total Lecture Points (TLP), and Vocabulary Instances for each set of notes. We examined students' pre- and postintervention scores in all of these areas, both looking at the students as a group and analyzing their individual scores.

All interview transcripts were input into *Atlas.ti.* In a first cycle of coding (Saldaña, 2013), we used a process of open coding to analyze the transcripts in chronological order and identify both etic themes, which reflected the aims of the intervention and our guiding conceptual frameworks, and emic themes, which emerged in participants' experiences with the CUES strategy (Hammersley & Atkinson, 2007). In our second cycle of coding (Saldaña, 2013), we sought to identify several cases that would allow us to explore in more depth how students were using the CUES strategy to develop their

note-taking skills. To this end, we used the quantitative findings to isolate a handful of participants who had shown improvement between their pre- and postintervention assessments. We then narrowed down these choices to three cases to analyze in more depth by identifying evidence of change in participants' approaches to note-taking over time. This approach helped us triangulate our analysis. Juxtaposed with our quantitative data, we found that the interviews had tremendous explanatory power as we sought to understand how successful students used the CUES intervention to become better note-takers.

Limitations

As a relatively short-term study, this project aimed to examine students' engagement with our strategic note-taking intervention solely during the intervention period. As such, the long-term impact of this scaffolding approach is unknown. Further, the study focused specifically on note-taking in science classes and does not provide insight into how students might have transferred these skills to better employ executive functions in other subjects or in other academic tasks. Therefore, the findings presented here reflect the goal of understanding what kinds of cognitive shifts occurred for the students in our study as they used the strategic note-taking intervention.

Findings

Using the quantitative measure of change in cued lecture points (CLP) between the pretest and the posttest (i.e., pretreatment versus posttreatment), we identified three students who demonstrated significant increases in CLP and examined, first, how they used the CUES strategy and, second, how it altered their thinking and improved their learning. In this section, we talk about these cases in terms of the metacognitive approaches the students used as they learned a new note-taking strategy in their science classes. Though there were marked differences in how these students employed the CUES strategy, as demonstrate in Table 1, each of their approaches was ultimately successful in helping them improve their note-taking.

Noah

Noah was a poor note-taker prior to the strategic note-taking intervention. He scored 0 out of a possible 15 CLP in the initial assessment; however, he increased to 10 CLP out of a possible 15 by the end of the intervention. As is evident in Figure 1, he also showed significant increases in TLP and the number of key vocabulary used in notes. In his interviews, Noah reported to us that the CUES strategy helped him to write faster, understand information from the lectures, and use his memory more effectively.

Table 1

Percentage of Total Points Note-taking Task Scores Pre and Post Intervention

Note-taking Task Score	Ben		Sandra		Noah		Group Average	
	Pre	Post	Pre	Pre	Pre	Post	Pre	Post
Cued Lecture Points (CLP)	20%	40%	26.6%	80%	0%	66.7%	34.9%	42.2%
Total Lecture Points (TLP)	6.4%	14%	5%	25.6%	2.6%	20.2%	20.3%	15.2%
Vocabulary Instances (VI)	4.4%	27.5%	1.1%	19.8%	2.2%	14.3%	13.9%	16.7%

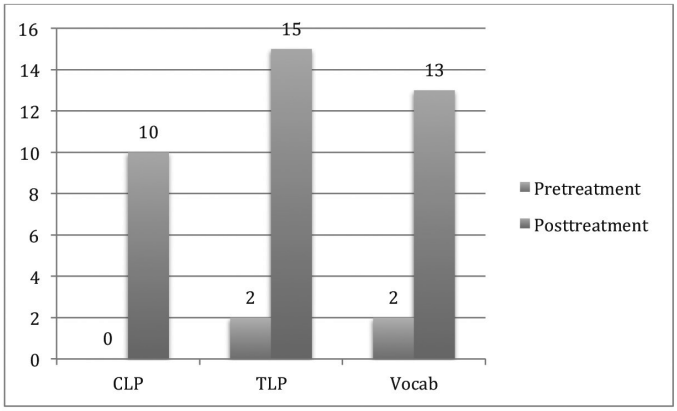

Figure 1. Noah's Pretreatment and Posttreatment Measures. Values of Cued Lecture Points (CLP) out of 15, Total Lecutre Points (TLP) out of 78, and vocabulary instances (Vocab) out of 91. Noah displayed large gains in all three categories.

For Noah, writing fewer words enabled him to write faster. Following CUES strategy training, he used abbreviations and left out smaller words such as the articles "the" and "an." Often, the abbreviations in his notes were ones that he made up himself, as in the instance when he wrote "les" instead of "less." Near the end of the study, he explained, "I could write more, and I could write it in less time, 'cause I would write bigger sentences smaller." An examination of Noah's notes and a review of his final assessment score confirmed this point. By the end of the intervention, he was able to include significantly more distinct lecture points in his notes than prior to the intervention.

Though it was important for Noah to be able to write down as much information as possible, he also benefitted greatly by learning to identify which lecture points were the most important and distinguishing between more

important and less important points. Several times over the course of our interviews with him, Noah identified teacher cues as the pivotal clues that drew his attention to key points. Even when he missed a teacher cue, he recognized the value of deciphering the most important part of each lecture topic. As he learned to identify significant points, he also came to understand that writing down information helped him to better comprehend the lecture content. In one interview, he explained, "I understood what they were saying by writing it down 'cause [by writing it down] I thought about it." For Noah, then, being able to include more of the "important" lecture points in his notes meant that he was able to grasp more of the lecture content.

Noah also used the prelecture quizzes to gauge what content was important. In effect, the content from the quizzes served to scaffold the lecture for him by giving him a sense of what to look for in the lecture before it began. When he was able to incorporate quiz content into the "3-6 Main Points" section of his SN paper, he gained a better understanding of that content and could apply fundamental scientific principles to the problems posed in the postlecture quiz:

> **Interviewer:** Can you show me an example of why you did better [on the postlecture quiz], you think?
>
> **Noah:** I was, for this same sentence [points to "Name 3-6 main points" question in CUES notes]. And then [the quiz] asked if a bowling ball would stay in motion if nothing hit and there was no friction. Last time I wrote no, but this time I wrote yes because I remembered.

Noah's interviews revealed that his active engagement with the lecture content through note-taking allowed him to use working memory to understand important points that he would later store in his long-term memory. He remarked on this difference in how he retained and processed information from his science lectures, saying, "When I write down stuff, I think about it when I'm writing it down, and then I remember it if they ask something that I wrote down. Then I'll know the answer." Thus, in giving him the tools to include more of the important lecture points in his notes, the CUES strategy allowed Noah to understand and remember more of what was important in his science lectures.

Sandra

Like Noah, Sandra was a relatively poor note-taker prior to the strategic note-taking intervention. Sandra scored 4 out of a possible 15 CLP in the initial assessment and improved a great deal by the final assessment, when she had brought her score up to 12 out of a possible 15 CLP, an improvement that was also echoed in her TLP and vocabulary scores (see Figure 2). The structured CUES notes helped her capture lecture points faster, focus on less content, and more efficiently make decisions about the lecture content.

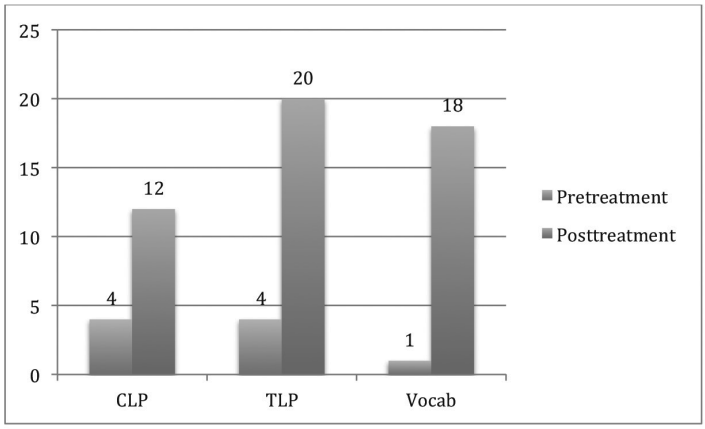

Figure 2. Sandra's Pretreatment and Posttreatment Measures. Values of Cued Lecture Points (CLP) out of 15, Total Lecutre Points (TLP) out of 78, and vocabulary instances (Vocab) out of 91. Sandra displayed large gains in all three categories.

At the beginning of the intervention, Sandra repeatedly expressed concern that the lectures moved too fast. Because she could not record information as fast as she was hearing it, she easily got lost and missed large chunks of the lectures. Over the course of the intervention, she learned to use teacher cues to help her identify 3-6 main points from each lecture:

> **Interviewer:** Imagine I was inside your mind when the teacher gave you some important information to write down. What thinking process would I see? So what goes through your head when the teacher is saying these points?
>
> **Sandra:** To get the 3-6 main points and try to find some definitions.
>
> **Interviewer:** In what ways have you changed as a note-taker since the beginning of this project?
>
> **Sandra:** I think I do better now because now I don't have to write down everything that I don't really need.

Further, Sandra explained that the CUES note-taking paper "separates everything," which made it easier for her to focus on capturing the most salient information from the lectures. The structured strategic note-taking format

provided her with concrete categories that directed her attention toward main points and vocabulary and include important points "without writing all the extra," and it was by using this more focused approach that she learned to write faster and keep up with the lecture pace.

Sandra used the CUES strategy as a way to avoid feeling overwhelmed by the relatively dense science lectures. The note-taking format provided a context for her to break up note-taking into discrete tasks and then focus on one task at a time. For instance, during one lecture she reported focusing on definitions, whereas in a previous lecture she had focused on capturing main points. In this way, she learned to write less by wading through content-heavy lectures to identify the most significant lecture points, allowing her to keep up with the lectures' fast pace. Like Noah, she used the pretests to scaffold her focus as she took notes, stating, "On the pretest, I saw things that I didn't really know, but then once I took the lecture I saw what I needed to know." Together, these factors gave Sandra the tools to make quick decisions about whether or not new information was important, how to interpret it, and what to do with it.

As a result, Sandra came away from each lecture with a set of notes that was more succinct and easier for her to understand than her non-CUES notes. After Module 10, she said enthusiastically that her CUES notes helped her better remember the lecture content because "with regular notes I have to write down everything and then I read through it. And some of the stuff I can't remember, 'cause it's too much... [My CUES notes are] shorter and more understandable than the regular notes I used to take."

Ben

When he was first introduced to the CUES strategy, Ben was roughly on par with Sandra. By the end of the intervention, he had improved considerably, raising his CLP from 3 to 6 (i.e., out of a possible 15 CLP), his TLP from 5 to 11, and his vocabulary from 4 to 25 (see Figure 3). Though Ben said several times that the CUES strategy made no difference in his note-taking, he often contradicted these statements by pointing out clear ways in which he was using the strategy to think differently about the lecture content. Central to how Ben talked about his note-taking experience was the way CUES helped him to write faster, write more, and learn content as he recorded it in his notes.

As would be expected for a student with earning disabilities, at the beginning of the intervention, Ben struggled a great deal with writing fast enough and keeping up with the lecture as he took notes. He pointed out that he paid careful attention to what was being said and was conscientious about recording lecture content in his notes.

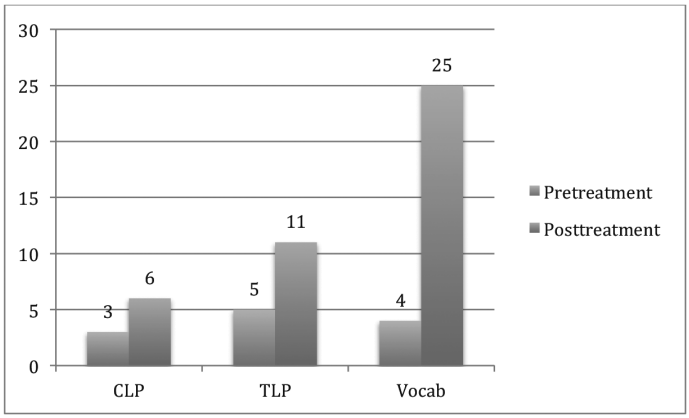

Figure 3. Ben's Pretreatment and Posttreatment Measures. Values of Cued Lecture Points (CLP) out of 15, Total Lecture Points (TLP) out of 78, and vocabulary instances (Vocab) out of 91. Brian displayed gains in all three categories.

Even so, he struggled to keep up with the fast pace of both the video lectures and the in-person lectures.

Throughout his interviews, Ben spoke repeatedly about how vital it was to work hard and write down as many points as possible. Ben viewed "main points" as information that he needed to know after the class ended, either to pass a test or for some other purpose. From Ben's perspective, then, including more points in his notes meant having access to more important information:

> I decided to work as fast as I can and write the words down that I wanted because, like I said, the more work the better. And you learn a lot more when you do more work so you can study off of it… Forget about three to six [main points], but put more than you're supposed to do… So main points means facts. So I want to write more to learn off of.

In general, Ben focused on the three to six main points and the vocabulary as the defining features of his CUES notes, and each time he listened to a lecture he put his energy toward filling out these sections of the strategic note-taking packet. He was able to increase his speed by using abbreviations, which helped him to record more lecture points. Successfully constructing a set of notes that included many main points, vocabulary words, and definitions improved Ben's self-concept. In one interview, he said, "When you write a lot of notes down, you feel good about yourself."

As Ben learned to make his notes more comprehensive, he acknowledged that writing his notes helped him remember what he was hearing and served as a way of studying the lecture content. Near the end of the intervention, he had a revelation:

> When you do the… strategic note-taking, it's a lot easier because you remember what you're doing while you're listening to the [lecture] video. Because I actually just understand that now it's a lot easier because you study while doing your strategic note-taking. You remember everything on the paper, which is basically the problems on the test, and if you learn in the video you still remember stuff from there too.

He specified that writing things in his notes helped him remember information because it gave him phrases to picture in his head. As a result, he felt more able to apply information from his notes to the postlecture quizzes. The quizzes played an important role in how Ben used his CUES notes. Like Noah, Ben used the prelecture quizzes as a guide to recognize the gaps in his prior knowledge of the lecture topics. These gaps became evident as he listened to the lectures and noticed what he had gotten wrong on the initial quiz.

Discussion

Noah, Sandra, and Ben all began the strategic note-taking intervention with different struggles—weaknesses in the area of note taking. Indeed, students with learning disabilities each cope with their own unique constellations of what Meltzer and Krishnan (2007) call "executive function dysfunction," or the inability to use executive functions efficiently. This dysfunction includes trouble with planning and goal setting, organizing, prioritizing, memorizing, shifting flexibly, and self-monitoring/checking. Our findings revealed that each of our focal participants faced unique challenges in these areas of executive function dysfunction, and their adaptation of the CUES strategy made it possible for them to successfully confront and overcome those challenges. Accordingly, although the CUES note-taking strategy led to positive outcomes for all three of these students, there was great variety in *how* it scaffolded their learning: Noah learned to organize and prioritize information, Sandra used CUES to focus her attention on the most salient lecture content, and Ben employed the SN paper to support goal-setting and planning.

Planning, Organizing, Prioritizing, and Memorizing

Our findings demonstrate that CUES offered students a means of focusing their attention and, thus, better organizing information. Prior to using CUES, Sandra struggled to identify what was important enough to include in her notes and, like many students with learning disabilities, she felt overwhelmed by all the information in the lecture (Sermud-Clikeman, 2005). However, over the course of the intervention she learned to take more concise notes that helped her remember information. Consistent with this trajectory, in the postintervention assessment, Sandra's cued lecture points score increased even as her total lecture points decreased. Juxtaposed with her interview responses, this finding can be understood as evidence of the way she used the CUES strategy to build schema around specific science topics.

Choosing which pieces of information are important enough to include in one's notes and which information can be excluded is a complex process that involves the use of working memory to temporarily store this incoming information, consider how it relates to one's existing knowledge, and make a split-second decision about its relative importance (Piolat et al., 2005). Consequently, it is not surprising that being equipped with a more systematic, purposeful approach to listening and recording lectures gave Noah the sense that he understood the material better as he took his notes. The CUES strategy scaffolded Noah's cognitive processes, both with the structured sequencing of note-taking tasks and with the pre-lecture quizzes, which gave him the tools with which to organize and prioritize what can feel to a student with learning disabilities like a great deal of information all at once (Meltzer & Krishnan, 2007).

Ben followed through on his goal-setting by employing the cognitive skills of planning and organizing. His search for main points and important vocabulary structured how he approached each lecture, guiding him as he made conceptual connections between the bigger task of learning about science topics and the detailed task of creating a set of science notes that would capture the most important aspects of one specific topic (Krishnan & Feller, 2010). Thus, he increased his speed by learning to listen for specific types of information, which eliminated the need to constantly interpret and evaluate everything he was hearing. The SN paper supported Ben's planning by offering him what Kincaid and Trautman (2010) call "a visual-spatial sketchpad" (p. 113) in which to organize the information from the lectures and hold it in working memory before he committed it to his long-term memory. His flexible deployment of visualization and other cognitive strategies and his increasing self-awareness as a learner helped Ben to use note-taking as a learning experience. As Ben acknowledged in his interviews, recording important information on the SN paper allowed him to commit that information to memory and internalize the lessons from the science lectures.

Shifting Flexibly

Over the course of the intervention, Noah learned how to use strategies more flexibly. Meltzer and Krishman (2007) assert, "effective cognitive strategies help students

bridge the gap between their weak executive function skills and the academic demands they face" (p. 88). Noah's flexible use of abbreviations in his CUES notes and his choice to write less overall was an example of how he employed this approach as a replacement for his previously inefficient strategy of attempting to write down exactly what he heard using the rules of written Standard English. Noah's new orientation to note-taking involved organizing and prioritizing information prior to writing it down (Meltzer & Krishnan, 2007).

As she practiced using the CUES strategy, Sandra also learned to include in her notes only the information she would need for later. In doing so, she was developing the ability to efficiently organize and prioritize information, effectively silencing the cognitive static of a content-heavy lecture. She adapted the CUES strategy to help her focus on one aspect of the lecture at a time, using CUES as a tool to help her respond flexibly to complex cognitive demands. For Sandra, each lecture offered her a new learning experience with a new set of knowledge and a unique assumption about what she should already know. By attending to how CUES could help her identify key facts and concepts, she was both adapting the CUES strategy and using it to adapt to new learning situations (Meltzer and Bagnato, 2010).

Self-Monitoring/Checking

Ben's case illustrates the relationship between goal-setting, planning, organizing, and memorizing. Beginning with the concept of identifying three to six main points (from the SN paper), he envisioned the idea of recording more important information as a central goal of his note-taking. By setting specific goals for what initially felt like a vague task, Ben engaged in self-monitoring to become more aware of his own needs as a learner. In order to meet his goal of "put[ting] more than you're supposed to do," he had to be able to see how this task fit into his broader goals for his science class, and he had to value the task of note-taking. Ultimately, meeting his goal helped Ben adopt a positive self-conception in science class, as is common when students use executive functions effectively (Krishnan, Feller, & Orkin, 2010). Noah, too, used the quizzes as an opportunity to self-monitor and to accurately gauge the degree of importance of different lecture points.

Conclusion

Noah, Sandra, and Ben all adapted the CUES strategy in unique ways. Far from limiting or constraining the way these students engaged with their science lectures, CUES opened up new pathways for struggling students to access executive functions and flexibly deploy cognitive strategies. However, *how* each student did so and *what* s/he learned about her/himself as a learner in the process was dependent on the specific challenges presented by her/his learning disability. These cases indicate the potential for cognitive scaffolding to help students actively improve their own executive functioning in complex tasks such as note-taking.

For teachers and other educators, implementing a strategy during complex note taking tasks assists students who have EF difficulties to plan, organize, and prioritize information, particularly written information. Strategies provide these students with the structure to attack these learning tasks in a *planful* and organized manner: something that occurs intuitively in students without such difficulties. As was the case with the CUES strategic notetaking paper, visual organizers (e.g., note-taking formats) serve as an external scaffold to help students more easily integrate new strategies while learning content (Patsenko & Altmann, 2010). In a sense, the note-taking paper serves as an *idea scaffold* (e.g., lecture ideas) to help manage ideas or content, while the strategy serves as a *task scaffold* to assist students in successful task completion. Likewise, in a parallel task such as composing a story, brainstorming ideas on paper serves to scaffold or manage ideas, while an actual strategy serves to manage writing task demands.

As students begin to master efficient strategy use with the learning tasks, teachers should begin to teach students to use the strategy in a flexible manner so that when they encounter new or different learning tasks they can modify or shift different parts of the strategy as the task demands change. For note-taking, this might mean adjusting strategy use when the teacher presents illustrations to recognize that these should recorded in notes as important lecture information. Likewise, when approaching a new note-taking task, such as recording notes from a textbook, students should recognize that the cued information in textbooks might include bolded or italicized words, headings or subheadings, questions embedded in the text, or numbered information (e.g., three types of fungi are…). Finally, students should also be taught self-regulation strategies such as periodically stopping to check for gaps in notes, watching to see if other students are recording notes, and asking oneself if the information makes sense (e.g., self-questioning). These components could help keep students actively engaged during learning and should lead to larger gains in knowledge as students record better notes and process content more efficiently.

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