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Guided Drawing with Preschool Dual Language Learners in Head Start: Building Science Vocabulary and Content Knowledge

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Abstract: Drawing offers a way for young children to demonstrate what they understand about the world. This study reports on the findings from an eight-week intervention program called guided drawing designed to build vocabulary and content knowledge for dual language learners in Head Start settings. Four researcher-designed assessment measures were used to assess thirteen preschoolers' vocabulary and concept knowledge at the receptive, expressive, and definitional levels in a pre/post-intervention design. Analysis of researcher-designed measures reveals positive changes in all vocabulary and concept knowledge areas targeted by the intervention. Thematic analysis of researcher–child interactions and drawing products indicates the guided drawing intervention provided opportunities and context for every participating child to explore new content and concepts related to science learning; reveal what they know; grow knowledge and vocabulary; reveal misunderstandings; and overhear and adopt new language.

Keywords: vocabulary; language acquisition; drawing; science; dual language learners; preschool; Head Start

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1. Introduction

Head Start, the federally funded early childhood program serving low-income children in the United States, requires the "full and effective" (n.p.) participation of dual language learners (DLLs) [1]. Children are identified as *dual-language learners* if they are learning two or more languages simultaneously or if they are learning a second language while continuing to develop their first [2]. Unlike the term *English learner* (EL), a designation assigned to students identified as having limited English proficiency based on performance on English assessments [3], *dual language learner* is an asset-focused term that signals children's full linguistic potential and the cognitive, social, and cultural benefits of learning multiple languages without privileging English [4].

Language plays a critical role in effective participation [5]. Dual language learners begin preschool with differences in knowledge, language skills, and interests. Although understanding their academic and social needs and providing developmentally appropriate opportunities to learn English is essential, identifying and building on children's linguistic strengths can promote educational success and establish a strong literacy and language foundation [6,7]. This research is part of a series of studies on *guided drawing*—one component of a science intervention with dual language learners in Head Start. The goal of guided drawing is to provide interactive and engaging opportunities to build and extend DLLs' knowledge while inviting them to use their drawing to demonstrate their learning [8].

1.1. What Is Guided Drawing?

Guided drawing is a scaffolded approach to teaching content-related vocabulary and concept knowledge through language-rich explanations in combination with children's drawings. Guided drawing is paired with a directed learning activity, such as examining body

parts of insect replicas or observing sprouted bulbs. Direct learning experiences, often referred to as hands-on learning, are opportunities to see science up close by observing items and phenomena, experimenting, and using new knowledge to ask new, more content-specific questions. During a directed learning activity, the teacher incorporates language-building strategies by introducing, repeating, and explaining the target vocabulary using child-friendly language [9]. The teacher then builds on and extends the foundational knowledge established in the directed learning activity through guided drawing. This offers authentic opportunities to use their developing understandings of content-related vocabulary and deepen their concept knowledge. The teacher models the drawing, invites children to draw, elicits children's use of language, and scaffolds their emerging concept-related talk. Concrete materials such as informational texts, realia, photo cards, and other relevant materials are readily available to reinforce children's developing understandings. Table 1 includes the steps of guided drawing.

Table 1. Teacher-initiated steps to guided drawing.

To initiate guided drawing,	
1.	Invite 1–5 children to participate. Smaller group sizes work well as new content is being introduced, whereas larger sizes are appropriate as the content becomes more familiar.
2.	Explain what children will be drawing and make explicit connections to the directed learning activities.
3.	Model drawing while using and explaining target vocabulary and concepts.
4.	Build and extend children's use of target vocabulary and concepts using language-building strategies such as questioning, labeling, expanding, recasting, and clarifying.
5.	Scaffold concept and drawing-related talk during drawing.
6.	Elicit talk by encouraging children to label parts of their drawing and explain their thinking during drawing.
7.	Clarify misunderstandings and confusions as they arise.
8.	Offer language practice by inviting children to continue to talk about their completed drawings and explain them to others.

Guided drawing interactions are purposeful and intentional. The interaction between a teacher and child through guided drawing, presented in Table 2, demonstrates this intentionality: In this example, 3-year-old Ximena is invited to the science table during choice time. The children have just finished a read-aloud on insects and the song *Head*, *Thorax*, *Abdomen* (to the tune of *Head*, *Shoulders*, *Knees*, *and Toes*). On the table are lifelike, plastic replicas of insects including a bumblebee, ant, and dragonfly, large photo cards of insects, and several books, as well as paper and drawing materials. The teacher's goal for this interaction is to check Ximena's understanding of the parts of the insects.

Ximena's drawing of an ant with a tail created during the guided drawing interaction from Table 2 is presented in Figure 1.

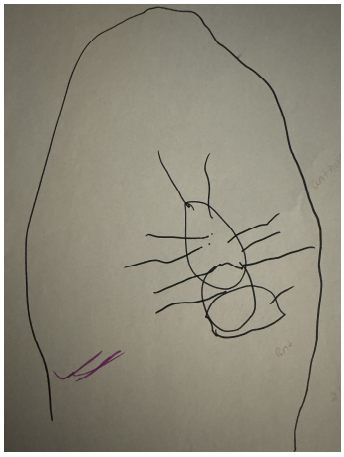

Figure 1. Ximena's drawing of an ant with a tail in an ant hill.

Table 2. Guided drawing interaction with Ximena and her teacher.

Teacher [Step 1]	We have been learning about the names of different insects and their body parts. Will you draw an insect with me so you can show me what you are learning?
Ximena	[nods, reaches for plastic ant] This?
Teacher [Step 2]	That's an ant—we see them on the playground sometimes, don't we? Remember when we tried to look at them with magnifying glasses?
Ximena	Them. . .[holds arms overhead]
Teacher [Steps 3, 4]	Oh! Yes! They were carrying something, weren't they? Remember we learned that even though ants are small, they are very strong. . .[picks up plastic ant]. Hmm. I want to draw an ant. I know ants are insects, so they have three body parts—a head [points], thorax, and abdomen [points]. I'll draw it! First, I draw the head [draws], then the thorax [draws], and then the abdomen [draws]. . .Can you draw the ant's parts—the head, thorax, and abdomen?
Ximena	[draws and sings] Head, thorax, abdomen, abdomen.
Teacher [Step 4, 5]	That's right! That song is a good way to remember the insect body parts. . . An insect also has six legs. Let's put legs on our ants so they can walk. I'll put 6 legs on my ant [draws]. Your ant needs 6 legs too.
Ximena	Yeah [draws]. 1, 2, 3, 4, 5, 6.
Teacher [Step 5]	Great! 6 legs! What else does our ant have? [points to eyes on plastic ant]
Ximena	He has fly?
Teacher [Step 3, 4, 5]	No. This ant doesn't fly. This ant doesn't have wings, see? [points]. He has compound eyes to see all around [draws], and antennas to help feel [draws].
Ximena	[draws more lines] And a tail!
Teacher [Step 7]	A tail? Lots of animals have tails but not ants! Ants don't have tails. They have [points to drawing] a head, thorax, and abdomen, but not tails.
Ximena	He needs home. . .
Teacher	Ants live in ant hills. . .Remember we saw some ant hills on the playground?
Ximena	[draws] Ant home.
Teacher [Step 8]	Yes. This home is an ant hill. . .Tell your abuela about ants and ant hills when you show her this drawing.

1.2. Why Science in Preschool?

As evidenced by the example in Table 2 and Figure 1, guided drawing is intricately connected to science content. According to NASA, "Science consists of observing the world by watching, listening, observing, and recording. Science is curiosity in thoughtful action about the world and how it behaves" (n.p.) [10]. Engagement in science is generally of high interest to young children and carries the additional benefit of being highly useful in the world [11]. Studying science offers engaging opportunities to build on children's strengths and interests while supporting language development in a meaningful and supportive context [12,13]. Young children demonstrate science knowledge even before entering preschool, and intentional learning experiences can support and extend this knowledge [14]. The multiple modalities of engaging with science—through seeing, listening, moving, smelling, touching, and tasting—offer a meaningful context for DLLs to learn English. The way adults talk during science-related activities matters. Research indicates that when adults use science-process talk (i.e., talk related to the hows and whys of science) or explanations, children's use of content-specific language increases [15,16]. Differences in scientific achievements are evident as early as kindergarten, primarily explained by the scientific knowledge that children acquire before formal schooling begins [17].

2. Theoretical Framework

The Vygotskian perspective on the significance of the social context in which learning takes place informed guided drawing interactions in several ways. First, Vygotsky viewed drawing as a significant activity for young children that plays an essential role in both cognitive and social–emotional development [18]. Drawing is a cognitive tool that allows children to make their thinking visible as they create, communicate, and record their understandings and ideas. Encouraging DLLs to talk about their drawings promotes language use and social–emotional skills, particularly in a small group setting, because DLLs can show what they are learning and learn from others even if they do not have the vocabulary or the English proficiency to fully explain their thinking [19]. Furthermore, teachers can focus on building language and content in English because, in an interactive setting, language is continuously modeled and scaffolded [20].

Guided drawing interactions are also aligned with the dynamic nature of the Zone of Proximal Development (ZPD). The ZPD refers to the range of tasks a child cannot yet perform independently but can successfully perform with the guidance of a more knowledgeable other—that is, the zone between what the child can do independently and what can be done with support. Guided drawing supports DLLs within the ZPD because it requires (1) connecting the drawing to a directed learning experience (e.g., planting bulbs in cups); (2) scaffolding the drawing; (3) modeling and scaffolding language with an emphasis on target concepts and vocabulary; and (4) encouraging active participation by eliciting talk about their thinking before, during, and after guided drawing [8].

Through intentional language interactions, DLLs acquire three types, or levels, of vocabulary knowledge: Receptive vocabulary includes the words comprehended when listening—that is, they understand the word but cannot use it when speaking. Expressive vocabulary includes words children produce when speaking. Definitional knowledge requires an understanding of the concepts a word represents. Definitional knowledge develops over time from repeated exposure to, and experience with, words across different contexts. DLLs need a definitional knowledge base on which higher levels of knowledge can be built [21,22]. For example, in early directed learning and guided drawing interactions, receptive and expressive understandings such as “spiders have spinnerets” and “spiders make webs” are targeted. Over time, definitional knowledge is targeted as the instruction focuses on the form (i.e., spiders make sticky webs that are hard to see) and function (i.e., to catch insects flying by) or cause and effect (i.e., when an insect gets stuck in the web, the spider feels the vibrations and knows it is time to eat). Drawings can provide evidence of children’s developing understandings. For example, when asked to draw a scientist at work, children with higher levels of science vocabulary included more content-specific details in their drawings [23].

Lastly, the ongoing scaffolding and individualized support that occur as new vocabulary words and concepts are introduced in the directed learning experiences are reinforced in guided drawing interactions. Guided drawing interactions can support the transition of words and concepts from the Zone of Proximal Development to the Actual Development Level (ADL) for DLLs. Once learned, a DLL’s new word, such as Ximena’s new use of the words thorax and abdomen in Table 2, becomes part of their ADL, representing current vocabulary knowledge.

Guided Drawing: A Promising Practice

A pilot study examined the instructional possibility and viability of guided drawing and served as a model for the present study. The intervention consisted of a content-rich topic (i.e., Insects and Spiders) combined with research-based language strategies and guided drawing. Children engaged in directed learning activities and interacted with multimedia (informational and narrative texts, online videos, etc.) [8]. Guided drawing opportunities designed to reinforce the focal content and target vocabulary followed each directed learning activity. The sessions lasted for 20–40 min twice weekly for four weeks (eight sessions). The target vocabulary (e.g., thorax, abdomen, compound eyes)

and concepts (e.g., insects have three segments and six legs; a spider has two segments and eight legs) included rare words or concepts that children were unlikely to hear in everyday conversation.

The pilot study yielded three important findings: (1) guided drawing provided repeated exposures to focal vocabulary/concepts and opportunities for targeted instruction in a meaningful context for preschoolers; (2) children's misunderstandings were revealed and supported during guided drawing; and (3) drawings provided opportunities to reinforce newly developed concept/vocabulary knowledge. While promising, the pilot study did not test the impact of the instructional approach on targeted outcomes in vocabulary and concept knowledge.

The study reported here sought to better understand how the guided drawing intervention could support DLL preschool participants' developing vocabulary and concept knowledge using the same structure and topic. Two questions were examined:

- How did children's performance on content-specific pre-test and post-test measures demonstrate growth in target vocabulary and concepts?
- In what ways did DLLs use drawing to make their learning "visible" in their conversations, drawing processes, drawing products, verbal explanations, and reflections?

3. Method

To investigate the ways guided drawing supported DLL participants' developing vocabulary and conceptual knowledge, a pre-test/post-test design was used before and after the guided drawing intervention took place. Video/audio recordings were captured of teacher–child interactions before planned guided drawing sessions began and during each of the eight 20–40 minute intervention sessions. Photos were captured of each child's drawings.

3.1. Setting and Participants

The data collected emerged from two separate intervention studies conducted several months apart (i.e., Fall and Spring) at an inner-city Head Start in the Northeast. This study was conducted in two classrooms (Classroom A and Classroom B). Both included a full-time teacher and an assistant. The participants were all dual language learners as indicated on the Head Start Home Language Survey, with all the children except for one being Spanish speakers who had at least one parent who was also a native Spanish speaker. The one exception was a child who spoke Russian. Signed consent forms served as the selection criteria for participation.

Study One included four boys (mean age = 42.3 months; range 40–46 months) from Classroom A in the Fall. Five children (two girls, three boys; mean age = 56.8 months; range 52–62 months) participated from Classroom B. The intervention was conducted with small groups within their respective classrooms. All children were native Spanish speakers. Study Two participants included ten children (six girls, four boys; mean age = 48.3 months; range 37–62 months) from Classroom B the following Spring. In this way, data were collected for 19 children through the guided drawing intervention, but high absenteeism resulted in many incomplete data sets that have been excluded from analyses. Data from thirteen children were examined in the analyses that follow.

3.2. Procedures

Two weeks before the start of the intervention, a trained researcher conducted a pre-test to establish each participating child's baseline understanding of (1) their general receptive vocabulary in English and (2) their vocabulary and concept knowledge that were to be targeted in the intervention. Once pre-tests were completed, the intervention was carried out. The trained researcher then collected post-test data for each child's vocabulary and concept knowledge that were targeted in the intervention.

3.3. Measures, Analyses, and Findings

The *Peabody Picture Vocabulary Test (PPVT-4)* [24] was administered only at the beginning of the intervention to establish each participating child's baseline understanding of receptive vocabulary in English. The *PPVT-4* is an individually administered, norm-referenced receptive vocabulary measure for individuals between the ages of 2 years and 6 months to 90+ years. During testing, the participant indicates, by pointing, which of the four items presented represents the word spoken by the examiner. Two practice items with feedback are provided at the beginning of the assessment. The assessment is given in English to identify the participants' English language performance as compared to same-aged, monolingual English-speaking peers. Based on the nature of the assessment, *PPVT-4* scores were not expected to increase during the four weeks of the intervention. On the receptive vocabulary measure, the mean pre-test vocabulary scores were equivalent to approximately 1.5 standard deviations below the normative average score of 100.

3.4. Content-Specific Measures

A set of researcher-designed, content-specific measures examined the content-specific vocabulary and concept knowledge targeted in the guided drawing intervention (i.e., insects) across multiple levels. The receptive measure asked children, "*Point to grasshopper*" as the examiner pointed to four squares containing four choices (e.g., grasshopper, butterfly, ladybug, bumblebee). Two expressive measures asked children to tell and label, "*What is this?*" [as the examiner pointed to the picture of grasshopper] and "*What is this [insect part] called*?" [as the examiner pointed to an insect part on an enlarged diagram of an insect]. The measure to assess definitional levels of language prompted, "*Tell me about this*" as the examiner pointed to a picture of the life cycle of the butterfly. The receptive measure included five items. The expressive (telling) task contained five items as well, whereas the expressive (labeling) task contained 12 items. The definitional measure included two open-ended response items. Table 3 presents an overview of the measures, the number of items, minimum and maximum scores earned, and the calculated means and standard deviations for each measure. Figures 2–4 are examples of some of the assessment items utilized in this study. These are included to illustrate the format for each measure in the current study.

Table 3. Descriptive statistics for receptive, expressive (telling), and expressive (labeling) vocabulary measures.

	Number Items	Min Score	Max Score	Mean	SD
Pre-test receptive	5	2	5	3.77	1.01
Post-test receptive	5	4	5	4.92	0.28
Pre-test expressive	5	1	4	2.62	1.12
Post-test expressive	5	2	5	3.69	0.85
Pre-test labeling	12	2	6	3.31	1.44
Post-test labeling	12	3	11	6.85	2.34

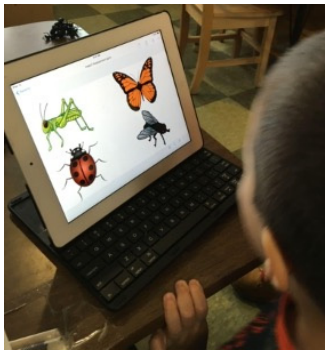

Figure 2. Sample receptive vocabulary item: "*Point to the* ____."

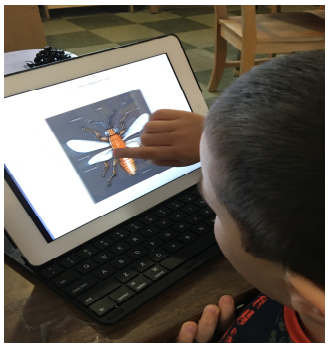

Figure 3. Sample expressive (labeling) vocabulary item: "*What is this [insect part] called*?"

Figure 4. Sample definitional vocabulary measure: "*Tell me about this.*"

Concerning the first research question, how did children's performance on content-specific pre-test and post-test measures demonstrate growth in target vocabulary and concepts, the results of the researcher-designed measures indicated that children made gains in all areas of the assessment with few exceptions.

3.4.1. Receptive Vocabulary

Observed scores on the researcher-designed pre-test measures of receptive vocabulary before the intervention ranged from one to five items correct, of five possible items. Given the small sample size, bar graphs were used to represent the changes from pre-test to post-test. The observed change in scores ranged from one to three more items scored correctly in the post-test than in the pre-test. Scores increased from pre-test to post-test for all children whose scores did not demonstrate ceiling effects (i.e., ceiling effects are defined as those scores that started and remained at five items scored as correct from pre-test to post-test). The 10 children whose scores demonstrated no ceiling effect yielded a mean increase of 1.5 items (SD = 0.71). Figure 5 shows participants' change in topic-related receptive vocabulary scores from the pre-test to the post-test.

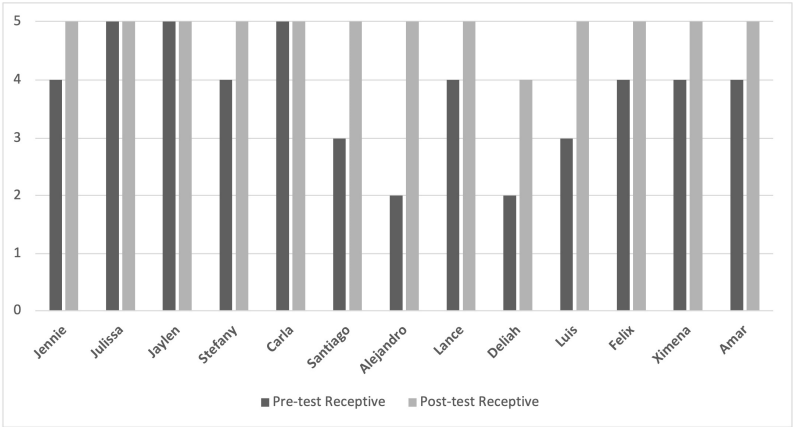

Figure 5. Change in content-specific receptive vocabulary.

3.4.2. Expressive Vocabulary

Observed pre-test and post-test scores on the researcher-created measures of expressive vocabulary for telling generally trended lower than receptive vocabulary. At the pre-test, none of the DLL preschoolers scored at the ceiling. The observed change in scores ranged from zero to three more items scored correctly in the post-test than in the pre-test. The scores of all 13 children yielded a mean increase of 1.08 more items scored correctly at the post-test compared to the pre-test (SD = 0.86) for this measure. Figure 6 shows participants' change in content-specific expressive vocabulary scores from the pre-test to the post-test.

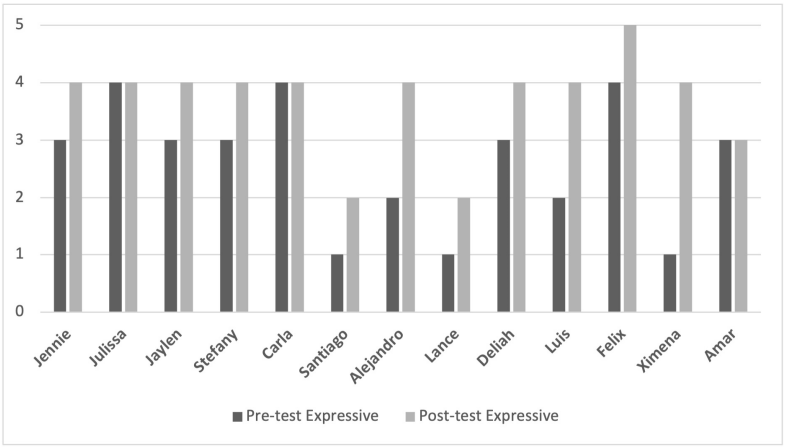

Figure 6. Change in content-specific expressive vocabulary.

3.4.3. Labeling

A comparison of verbal labeling tasks with 12 items was designed to elicit labels of the specific parts of the insects and spiders that were often the focus of guided drawing also indicated growth. The observed change in scores ranged from one to six more items scored correctly in the post-test than in the pre-test. The scores of all 13 children yielded a mean increase of 3.54 more items scored correctly at the post-test compared to the pre-test (SD = 1.45) for this measure. Figure 7 illustrates the participants' change in labeling scores, a content-specific component of expressive vocabulary, from pre- to post-test.

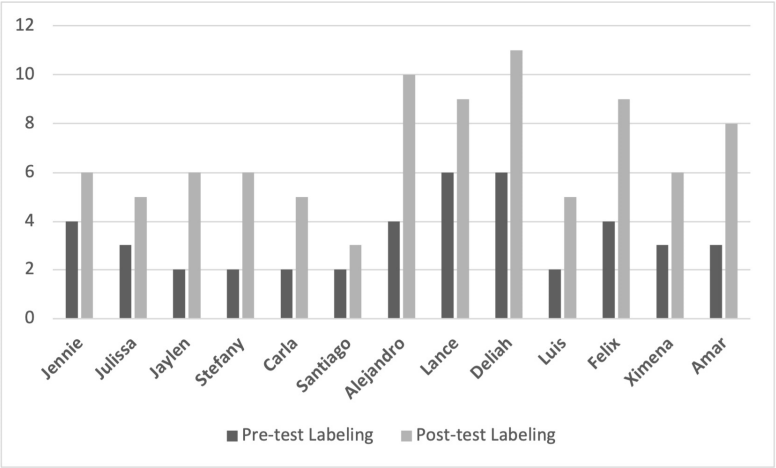

Figure 7. Change in content-specific (labeling) vocabulary from pre-test to post-test.

3.4.4. Definitional Vocabulary

The last researcher-created task examined definitional vocabulary by inviting participants to "tell me about this." Pre-test responses included more incidences of basic knowledge (e.g., "insects fly" or "[spiders] make webs") or physical descriptions (e.g., "bees are yellow" or "[that ant] is black") than utterances containing content-specific knowledge (e.g., "butterflies lay eggs"

or "spiders have eight legs"). Misunderstandings were also evident (e.g., "ants have tails" or "small bugs are babies"). No further analyses of definitional vocabulary were conducted.

3.5. "Visible" Learning

The second research question asked, in what ways did DLLs use drawing to make their learning "visible" in their conversations, drawing processes, drawing products, verbal explanations, and reflections. To address this question the research team—including the authors and a graduate research assistant—examined children's drawings, observational notes, and transcriptions of the guided drawing conversations.

Thematic analysis [25] was used to examine the drawings and digital recordings to identify patterns in the participants' drawings and parallel interactions. Thematic analysis is a qualitative research method used to identify and analyze patterns (themes) among the drawings by categorizing them into four categories. First, the drawings and contextual data (e.g., children's transcribed explanations, observation notes, or video/audio transcriptions) were examined multiple times to document initial impressions and potential themes/categories. These initial themes and categories were discussed with the theoretical frame of ZPD in mind. The research team actively considered the knowledge children already demonstrated through their drawings and conversations, as well as the kinds of knowledge that could be needed to support their developing understandings. Second, meaningful elements of the drawings and parts of the drawings were identified and labeled (e.g., type of insect drawing, body parts, etc.). Recurring features that were targeted during the intervention such as six/eight legs, three body parts, compound eyes, or antennae were labeled and coded. Next, drawing-related talk captured through transcripts of video/audio recordings and observational notes were examined and coded. The codes were then grouped into broader themes that capture significant patterns across the drawings and drawing-related talk. The four themes are described below. After the themes were refined, the drawings were then re-examined to ensure the four themes captured the elements well. Each drawing was then assigned to a theme.

3.5.1. Theme 1—New Knowledge Is Revealed in Children's Drawings

In this theme, children's drawings included evidence that indicated tacit knowledge of key vocabulary and concepts even when these were not included in their verbal productions. In the teacher's language about spiders used across the intervention, this phrase, "one circle and another," was followed by "the head and then the abdomen." Visual emphasis by pointing further supported the connection between each circle and the vocabulary label. For example, Jennie's spider, drawn with a blue marker, was made first on the paper (Figure 8). It included the two parts of the spider's body—a circle representing the head and a second circle for the abdomen. While drawing, Jennie said "One circle and another." This verbal production mirrored the teacher's verbal scaffolding for the drawing process but did not yet present the targeted vocabulary. Compound eyes, legs, and spider webs—other targeted vocabulary words—are also present in Jennie's spider.

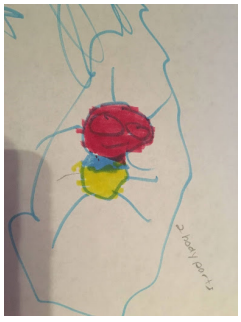

Figure 8. Jennie's drawing of a spider.

Jennie's drawing of an "ant on the wall" (Figure 9) offers validation of the hypothesis that tacit knowledge precedes verbal production. The directed learning activity accompanying

the guided drawing intervention presented children with a song to help them remember the body parts of insects. Jennie hummed the tune of the song but did not say the words as she drew. Yet, the drawing of Jennie's ant includes each of the targeted vocabulary words for the body parts—head, thorax, abdomen—as well as legs, antennae, and compound eyes.

Figure 9. Jennie's drawing of an "ant on the wall."

3.5.2. Theme 2—Emerging Knowledge Is Supported during Guided Drawing Interactions

Drawings and transcriptions from Luis and Carla (Figures 10 and 11) illustrate the ways guided drawing interactions supported emerging knowledge, the second theme emerging from analysis. In both examples, the teacher's repetition of targeted vocabulary and explicit vocabulary/concept instruction during guided drawing provided opportunities to learn new concepts. While Luis was drawing an ant, the researcher and another child, Lance, were engaged in a guided drawing interaction nearby. The researcher was supporting Lance's drawing of an insect after a focal lesson on insect body parts. In that conversation, the researcher reinforced the concept that insects have three body parts. Luis had finished drawing his ant. After hearing the researcher's reminder to Lance, Luis returned to his drawing and added a third segment (i.e., the abdomen). Similarly, upon being reminded, during a guided drawing interaction, that spiders have eight legs, not six legs like insects, Carla counted her legs and added an eighth leg—albeit in the middle of the spider, not on the side of the spider's body with the others (Figure 11).

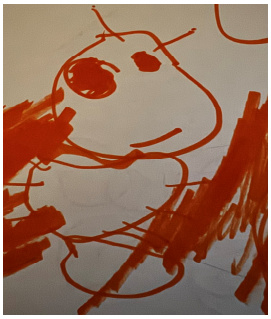

Figure 10. Luis' ant with three body parts.

Figure 11. Carla's spider with eight legs.

3.5.3. Theme 3—Misconceptions Are Revealed in Children's Drawings

The third theme is illustrated through the interactions surrounding Figures 12 and 13. In this theme, children's misconceptions were revealed as the researcher examined children's completed drawings and reflected on the possible sources of their misunderstandings. During a guided drawing session that focused on the life cycle of the butterfly, Stephany proudly declared, "*The caterpillar, she, sitting on them. These are her babies* [points to circles]" (Figure 12). The research team concluded that the babies below the caterpillar suggested the child was likely drawing on her understanding of chickens and eggs rather than information on the life cycle of butterflies. In Figure 10, Amar indicated that he misunderstood the concept of insects having six legs in total (i.e., three on each side). He drew his dragonfly with two sets of six legs (i.e., twelve legs in total).

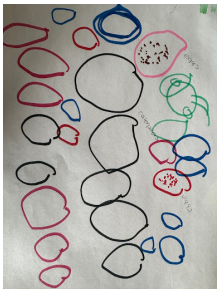

Figure 12. Stephany's caterpillar hatching eggs.

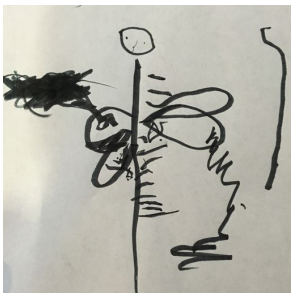

Figure 13. Amar's dragonfly with 12 legs.

3.5.4. Theme 4—Misconceptions Are Revealed through Children's Drawing-Related Talk

In this theme, the research team also noted that participants sometimes revealed misunderstandings through the dialogue provided during and after drawing. For example, in Figure 14, Santiago explained, "*The frog stuck* [in the spider web] *and* [pummels the air with fists] *by the spider.*" Santiago's drawing indicates several possible misunderstandings: (1) spider webs seldom exist underwater where frogs are commonly found; (2) spider webs are not likely to catch a frog due to the frog's size, strength, and mobility; and (3) spiders do not pummel their prey prior to consumption.

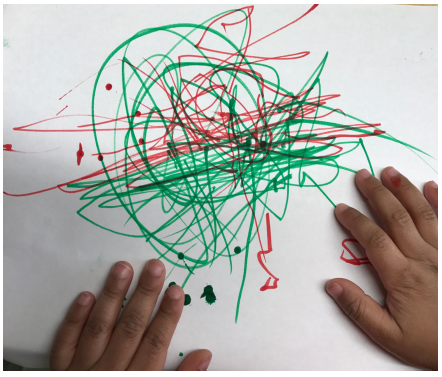

Figure 14. Santiago's spider catching and pummeling a frog.

4. Discussion

The purpose of this study was to examine DLL preschool participants' acquisition of target vocabulary and concepts within a guided drawing context as well as the way they made their thinking visible through their drawings. Consistent with the results of the pilot study, guided drawing provided repeated exposures to focal vocabulary/concepts and opportunities for targeted instruction in a meaningful context for preschoolers. Moreover, guided drawing interactions provided scaffolded opportunities to reinforce newly developed vocabulary and knowledge. Misunderstandings were also revealed in DLLs' drawings and interactions. The results of the pilot study were extended with the addition of the researcher-designed, content-specific assessment that provided additional insight into the impact of guided drawing on targeted outcomes in receptive, expressive, and definitional vocabulary and concept knowledge related to insects.

The results of the standardized measure of receptive vocabulary administered at the onset of this study indicated an average of 1.5 standard deviations below average. These results are consistent with Hammer and colleagues' [26] finding that DLL preschoolers from low-income backgrounds score at least one standard deviation below the norm. It is important to note, however, that the *PPVT-4* [24] was administered in English only. When both languages are assessed, DLLs' vocabulary size is similar to their monolingual peers [27]. One possible explanation is that children acquiring two languages take longer to build their vocabularies in each language than children who are acquiring only one [28].

Taken together, the results from the researcher-designed, content-specific assessment point to the potential power of guided drawing to improve young DLLs' concept/vocabulary knowledge in a science context. Across all measures, there were positive gains in content-specific receptive and expressive vocabulary as well as children's overall use of targeted vocabulary in labeling and definitional tasks. Given the rare nature of many of the words (e.g., abdomen, thorax), it is unlikely the participants learned the words through everyday exposure. It is more likely the positive results are rooted in the research-based practices that ground guided drawing including high levels of language exposure throughout the directed learning activities and science instruction as well as the elicitation of language during and after guided drawing interactions. The role of frequency and quality of child-directed speech (i.e., input) in supporting children's vocabulary acquisition in economically diverse populations is well documented [27,29]. The importance of eliciting talk in developmentally appropriate ways (i.e., output) is often overlooked. In a study of over 700 Spanish-speaking DLLs in preschool and kindergarten, Bowman and colleagues [30] determined that a DLL's language exposure and language usage (i.e., input/output) played a larger role in the participants' English and Spanish acquisition than language exposure alone. They contend, "Using a language (i.e., output) forces the learner to process the language in a way that only hearing it (i.e., input) does not" (p. 339).

Lazaroth and Vlach [23] confirm the role of science vocabulary in science learning. In this study, 3- to 11-year-olds were assessed in receptive and expressive science knowledge, as well as general science knowledge. The results indicated that science vocabulary, particularly expressive vocabulary, was the strongest predictor of general science knowledge beyond receptive vocabulary and demographic variables (i.e., age, gender, SES). This study also included a drawing task in which the participants were asked to draw two pictures of scientists. The results indicated children with larger science-related vocabularies added more scientific-related content in their drawings and explanations.

The thematic analysis of the drawings in this study also provided valuable information about children's science vocabulary and concept knowledge. The analysis identified the power of drawing and drawing-related talk in illuminating children's thinking and learning even when the children may not have the English or scientific vocabulary to fully explain their understandings. During the initial phases of the theme analysis, it became evident that children's thinking was made visible in drawings alone (Themes 1 and 3) or with drawing-related talk *and* the drawings combined (Themes 2 and 4). Themes 1 and 2 are consistent with a longstanding body of research demonstrating how drawing enables even

young children to convey thoughts, feelings, and experiences that they may not yet have the words to express themselves [31].

One finding of interest was the frequency with which children's misunderstandings were evident in their drawing (Theme 3) or drawing-related talk (Theme 4). Schickedanz and Collins [32] note that children's misunderstandings can often result from a misapplication of background knowledge, such as was evident with Stephany's caterpillar sitting on eggs like a chicken (Figure 9). In this case, the misapplication of background knowledge was evident. In other cases, a lack of background knowledge can also contribute to children's misunderstandings, but these can be more difficult to detect. For example, it was unclear if Santiago's drawing (Figure 12) indicated a lack of background knowledge about frogs and/or spiders or a vivid imagination. Schickedanz, Collins, and Marchant [33] contend children's understanding of vocabulary and concepts is "bolstered when teachers provide experiences that go beyond a short discussion at the writing/drawing table" (p. 27). Further, they note directed learning experiences such as the ones that precede guided drawing can help to clarify children's confusion, building and extending their vocabulary and concept knowledge. Lastly, the importance of science in preschool cannot be overstated as differences in knowledge are evident early on and are difficult to ameliorate:

> The strongest contributors to science achievement gaps in the United States are general knowledge gaps that are already present at kindergarten entry. Therefore, interventions designed to address science achievement gaps in the United States may need to be implemented very early in children's development (e.g., by or around school entry if not earlier) to counteract the early onset of general knowledge gaps during the preschool and early elementary years (p. 31) [17].

Put simply, children who start behind are at risk of remaining behind without high-quality instruction and targeted support. Guided drawing provides interesting and engaging ways for DLLs to *do science* in a language-building context.

This study is limited by several factors. The first of these is the fact that the intervention was conducted by a researcher and not the classroom teacher. Second, guided drawing instruction took place during the choice time of the school day (sometimes called centers). Because of this, some children drifted in and out of guided drawing. Some remained for the full 20 min session as was planned, whereas others left to explore something of higher interest elsewhere in the class. Some children who were not targeted for intervention also joined in. This context was not ideal for capturing audio and video that could be easily transcribed. The openness of the guided drawing table and the freedom children were granted to come and go resulted in incomplete data sets for several children. Consequently, specific interactions and children with missing data were excluded from the analysis.

Another limitation of this study is the number and linguistic profiles of the child participants. Additional rounds of intervention were designed to follow the two classrooms presented here in other cities and regions of the United States. This would have afforded opportunities to utilize guided drawing as an intervention with preschoolers speaking myriad languages and exhibiting a wider range of levels of English language acquisition than those presented here. These plans were interrupted by COVID-19 and subsequent changes to visitor policies in Head Start.

5. Conclusions

These results emphasize the importance of the use of elicitation to support and encourage DLLs' productive use of science vocabulary and advance their knowledge from ZPD to APD [18]. In sum, research and policy reports have consistently noted the importance of supporting the acquisition of science vocabulary and concept knowledge in the early years [34]. There remains limited research that satisfies Head Start's [1] call for specific approaches for supporting DLLs' "full and effective" (n.p.) acquisition of content-related vocabulary and concepts. This study provides insights into one way to support and extend children's knowledge in developmentally appropriate ways.

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