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# Cognitive Processes Used by Graduate Students During Case-Based AAC Assessment and Intervention Think-Aloud Tasks

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## Abstract

Think-alouds are a validated data collection method that have been used across disciplines in the scholarship of teaching and learning. Scholarly teachers in CSD can use think-alouds to uncover the cognitive processes students use when completing case-based learning assignments. The purpose of the study was to identify and describe graduate students' thought processes when planning for AAC assessment and intervention during think-aloud tasks. A total of 19 CSD graduate students were given cases and completed think-alouds in groups while planning for AAC assessment and intervention. Students' think-alouds were recorded, transcribed, and then coded using the revised Bloom's taxonomy. All groups engaged in cognitive processes representing each level of thinking in the taxonomy, but data analysis revealed differences across groups in the complexity of cognitive processes used during the think-alouds. The researchers present considerations for CSD instructors related to incorporating think-alouds in the classroom.



## Keywords

AAC, think-alouds, cognitive processes, graduate students



## Cover Page Footnote

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Despite a continuous increase in augmentative and alternative communication (AAC) course and clinical practica offerings in communication sciences and disorders (CSD) programs in the United States over the last 25 years, Johnson and Prebor (2019) found faculty from only 51% of programs believed half of their students were prepared to support people who use AAC. Thus, although more CSD programs are offering AAC courses, it remains critical to explore teaching methods that can improve preservice education in this area of practice. To advance student learning in AAC courses, faculty and instructors must take a scholarly teaching approach to developing impactful learning opportunities and to examining student learning outcomes throughout the course. McKinney (2004, p. 8) states that scholarly teachers "reflect on their teaching… try new teaching techniques, and read and apply the literature on teaching and learning in their discipline."

Sauerwein and Burris (2021) surveyed 64 faculty and instructors who taught AAC courses, and 60 (93.8%) reported using case-based learning opportunities in the course they teach. Thus, they reported engaging in scholarly teaching. Case-based teaching techniques can provide students opportunities to apply their knowledge, evaluate information, and/or develop a plan (Middendorf & Shopkow, 2018). Case-based instruction can be applied in myriad ways. Half of the AAC instructors who reported using case-based instruction prompted students to create a product, such as a treatment plan or a communication board, based on the case(s) and an additional 20% of participants led in-class discussions about case(s) (Sauerwein & Burris, 2021). Think-alouds can also be used to facilitate case-based learning; they have been discussed only minimally, however, in the CSD literature. By reviewing a case and thinking aloud while planning for assessment or intervention, the participants' thoughts become visible to an observer.

Think-alouds are a validated method for making individuals' thoughts visible that originated in psychological research (Ericcson & Simon, 1993). When engaging in think-aloud tasks, participants verbalize their thoughts throughout a problem-solving task. Thus, they allow the observer to uncover cognitive processes that would otherwise be invisible within the participants' minds (Miller-Young & Yeo, 2015). Think-alouds can serve a variety of purposes, such as uncovering participants' thoughts about product design and utility, monitoring reading and comprehension skills, and facilitating self-analysis and introspection.

The first research studies describing think-alouds were published in the 1940s, and the approach became more widely utilized by the 1980s (van Someren et al., 1994). In CSD, McFadd and Wilkinson (2010) used think-alouds to investigate how speech-language pathologists (SLPs) made decisions about designing AAC page displays. Wineburg (1991) was among the first to apply think-alouds in the scholarship of teaching and learning (SoTL) by prompting students to think-aloud while reading historical texts. Since then, think-alouds have been used in a variety of disciplines, including teacher preparation and nursing (Banning, 2008; Leapard, 2008). Ginsberg and colleagues (2016) were the first in CSD to use think-alouds in SoTL work, by comparing the thoughts and decisions of experts (i.e., experienced SLPs) and novices (i.e., graduate student clinicians). Participants in their study thought aloud while they planned an assessment for two fictional cases that described individuals with communication difficulties. Sauerwein and Wegner (2020a; 2020b) similarly utilized think-alouds with eight AAC specialist SLPs and eight graduate student clinicians. These experts and novices read two fictional cases of children who utilized AAC systems and completed think-aloud tasks while they planned for intervention. In these studies, the researchers uncovered the clinical reasoning cognitive processes that the participants

engaged in during tasks and illustrated the similarities and differences in expert and novice thinking (Ginsberg et al, 2016; Sauerwein & Wegner, 2020a; Sauerwein & Wegner, 2020b). Some of the cognitive processes, such as summarizing, hypothesizing, rationalizing, and comparing, were observed across studies (Ginsberg et al., 2016; Sauerwein & Wegner, 2020a). Other processes, such as a feature matching, were specific to the AAC cases or to intervention planning think-alouds, as was the case for processes like planning activities, selecting or developing materials, selecting targets, and goal setting (Sauerwein & Wegner, 2020b). It is important to note that, in these studies, data were collected for research purposes. No studies in CSD to date have explored the use of think-alouds in the classroom.

Because the use of think-alouds in the classroom has not been described in the CSD literature, it is important to evaluate the utility of think-alouds as a formative (i.e., assessment *for learning*) and/or summative (i.e., assessment *of learning*) tool (Ginsberg et al., 2012). Scholarly teachers recognize that meaningful assessment of student learning is an important part of effective teaching, and design formative and summative assessments to meaningfully measure student learning in their courses (Ginsberg et al., 2012). Further, scholarly teachers seek to understand where students struggle in the learning process. Middendorf and Shopkow (2018) argued instructors should pinpoint breakdowns in learning so they can provide tailored instruction and appropriate learning opportunities. Think-alouds may be more useful than other tools in pinpointing these learning bottlenecks and uncovering "hidden levels of student insight and misunderstanding" (Calder, 2018, p. 111). While prior research studies have identified cognitive processes used by graduate students in CSD during assessment and intervention think-alouds, it is important to evaluate the functions and complexity of cognitive processes uncovered using think-alouds.

Bloom's taxonomy, originally developed in 1984 and later revised in 2001, provides a framework for classifying cognitive processes (Anderson & Krathwohl, 2001; Bloom & Krathwohl, 1984; Middendorf & Shopkow, 2018). It was revised to assist teachers in designing instruction and assessments with a particular focus on student learning outcomes (Anderson & Krathwohl, 2001). Six categories within the cognitive process dimension of the taxonomy (e.g., remember, understand, apply, analyze, evaluate and create) represent cognitive complexity. The categories remember, understand, and apply are assumed to be less cognitively complex as compared to analyze, evaluate, and create (Anderson & Krathwohl, 2001). Table 1 presents the revised Bloom's taxonomy cognitive process categories and their definitions, as provided by Anderson and Krathwohl (2001). The categories are presented from least complex (i.e., remember) to most complex (i.e., create).

Within the taxonomy, specific cognitive processes are proposed in each cognitive process category (Anderson & Krathwohl, 2001). For example, within the understand category, cognitive processes include interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining. It is suggested that readers refer to the complete edition text of the taxonomy for an in-depth description of the framework, process categories, and cognitive processes and how it can be applied to various teaching and learning contexts (Anderson & Krathwohl, 2001).

**Table 1**

*Revised Bloom's Taxonomy Cognitive Process Categories and Definitions*

| Cognitive Process Category | Anderson & Krathwohl (2001) Definition |
|---|---|
| Remember | Retrieve relevant knowledge from long term memory |
| Understand | Construct meaning from instructional messages, including oral, written, and graphic communication |
| Apply | Carry out or use a procedure in a given situation |
| Analyze | Break material into constituent parts and determine how parts relate to one another and to an overall structure or purpose |
| Evaluate | Make judgments based on criteria and standards |
| Create | Put elements together to form a coherent or functional whole; reorganize elements into a new pattern or structure |

Because think-alouds are a validated data collection method that has been proven useful in uncovering cognitive processes for students in CSD, a scholarly teacher might consider applying them to the CSD classroom. Many faculty and instructors who teach AAC courses require assignments in which students generate treatment or assessment plans or reports (Sauerwein & Burris, 2021); these completed assignments, however, present only the student's solution to a given problem, and require the student to articulate their knowledge in formal writing (Calder, 2018). In contrast, think-alouds provide a means to assess learning and clinical reasoning during the problem-solving task itself (McAllister & Rose, 2008). Further, it is a direct measurement of student learning, as opposed to asking students to share their perceptions of their learning using surveys or course evaluations (Calder, 2018). When embracing scholarly teaching, it is helpful to consider the utility of a new approach. The present study will allow readers to evaluate the usefulness of think-alouds for uncovering students' cognitive processes and to consider the benefits and disadvantages of incorporating think-alouds in their own classroom contexts.

## Purpose

The purpose of the study was to identify and describe the cognitive processes graduate students used during case-based AAC assessment and intervention think-aloud tasks. The research questions included the following:

1. Which cognitive processes in the revised Bloom's taxonomy do students demonstrate during AAC assessment and intervention think-aloud tasks?
2. What proportion of the think-aloud transcripts were represented by each cognitive processing category?

## Methods

**Study Design.** A qualitative design was used to address the research questions. The researchers used a descriptive approach to inquiry (Denzin & Lincoln, 2018). This approach allowed the researchers to observe and describe students' behavior while engaging in think-aloud tasks. Data were collected while participants completed think-aloud tasks. The thoughts they spoke aloud were transcribed and analyzed using theoretical coding, because the revised Bloom's taxonomy guided data analysis procedures (Anderson & Krathwohl, 2001; Denzin & Lincoln, 2018). The researchers followed ethics procedures and standards for research involving human subjects and the study was granted institutional review board approval.

**Participants.** Convenience sampling was used to recruit participants enrolled in a graduate AAC course taught by the second author in the Winter 2019 quarter at a university in the Western region of the United States. Students in the course were in their second year of a master's speech-language pathology program. The inclusion criterion was enrollment in the course. There were no exclusion criteria. All 20 students enrolled in the course completed the procedures as educational activities; however, data were only analyzed from 19 students (95%) who consented to participate in the study. Consent forms were not reviewed by the researchers until after grades had been assigned for the quarter to minimize coercion and researcher bias. Although data collection occurred during the Winter 2019 term, data analysis did not begin after the course had concluded. Participants were informed that the study was a scholarship of teaching and learning study; they were blind, however, to the research questions and data analysis procedures.

Of the 19 students who participated, 18 students (94.7%) identified as female and one student (5.3%) identified as male. A total of 18 students reported their race; seventeen of these students (94.4%) identified as white, and one student (5.6%) identified as Asian. Participant ages ranged from 22 to 44 years ($M$ = 27.8, $SD$ = 6.5). Two students (10.5%) had previously completed an AAC course. One student completed this course during their undergraduate education and another student took an AAC course while enrolled in a non-CSD master's program.

A total of 13 students (68.4%) had completed or were currently enrolled in a part-time clinical practicum supporting client(s) who used AAC at the time of participation. Of these participants, two students had supported four or more clients who used AAC, one student supported three clients who used AAC, six students supported two clients who used AAC, and four students supported one client who used AAC. In addition, six students reported having other prior experience(s) with AAC, including supporting individuals who used AAC in early intervention and school contexts. The students had not yet begun clinical externships at the time of participation in the study.

**Data Collection: Assessment Think-Aloud.** During a face-to-face class session in the first half of the quarter, participants completed a think-aloud in small groups (i.e., three students). Each of the six groups was given the choice of an adult or child written case, which described an individual who used or would benefit from an AAC system. The adult case described a 57-year-old female diagnosed with aphasia who had not previously used an AAC system, and the child case described a 10-year-old female with cerebral palsy who had previously used a high tech AAC device and was eligible for a new AAC system. The assessment cases are included in Appendix A. Note that the researchers wrote the assessment and intervention cases so they included the following

information: (a) vision; (b) hearing; (c) language; (d) cognition; (e) gross and fine motor; (f) communication needs and participation; (g) communication partners; and (h) rationale for the evaluation (assessment think-aloud only) or current use of the AAC system (intervention think-aloud only).

It should be noted that the think-aloud tasks were designed to be formative assessments (i.e., *for* student learning; not graded) in the AAC course rather than summative assessment (i.e., *to evaluate* student learning). In order to reduce student anxiety and to help students establish expectations about the first think-aloud, the instructor demonstrated a think-aloud using a different case during the prior class period. The instructor read the following instructions prior to the students beginning the task:

> You will read a case study. Immediately after you finish reading it, start thinking aloud as you develop your plan for assessment as an SLP in private practice. Your assessment plan should include your planning and preparation for the assessment and describing what the assessment session will look like. Thinking-aloud means sharing aloud everything that comes to your mind. Explain each step and your rationale as thoroughly as you can. If there is information you would like that is not included in the case study, think aloud about how you would obtain that information. Remember to explain each step in your decision making and include your rationale.

Each group then read their case study and thought aloud as they planned for an AAC assessment for that individual. Groups were given approximately 30 min to complete the task in separate rooms, so that others were not present when the data were collected. Participants video recorded their group conversation during the think-aloud task. They chose their video recording technology, using recording capabilities of a personal laptop, iPad, or other device. After the task was completed, the researcher transferred videos to a memory stick and uploaded them to a private YouTube channel. Recordings ranged from to 24 min 37 s to 30 min 29 s, with an average length of 28 min 47 s. The verbal data in the videos was later transcribed for analysis.

**Data Collection: Intervention Think-Aloud.** In the latter half of the term, the students participated in a second think-aloud task, in groups of three and during a face-to-face class meeting, using the same procedures described above. Participants again chose an adult or a child written case; this second think-aloud, however, was designed so participants planned for an intervention session. The researchers prioritized student-centered learning by giving students autonomy to choose the adult case or the child case, as well as the peer(s) they wanted to work with. Thus, students were not required to complete the adult intervention case if they had previously selected the adult assessment case. As a result, group membership and case selections were not balanced across the assessment and intervention think aloud tasks. The instructions were the following:

> You will read a case study. Immediately after you finish reading it, start thinking aloud as you develop your plan for intervention as an SLP in private practice. Your intervention plan should include planning for the first intervention session, describing what the first intervention session will look like, and your plan for future intervention sessions. Thinking-aloud means sharing aloud everything that comes to your mind. Explain each step and your rationale as thoroughly as you can. If

> there is information you would like that is not included in the case study, think aloud about how you would obtain that information. Remember to explain each step in your decision making and include your rationale.

Similar to the first think-aloud, participants were read instructions, given approximately 30 min, and video recorded the think-aloud. Recordings ranged from 24 min 18 s to 32 min 26 s with an average length of 27 min 54 s.

The intervention cases are included in Appendix B. The adult case described a 48-year-old male with amyotrophic lateral sclerosis (ALS) who was beginning intervention to support a new AAC system, and the child case described a 4-year-old male diagnosed with autism who was continuing AAC intervention.

**Data Analysis.** Approximately six hours of video recordings (i.e., approximately three hours for the assessment task and approximately three hours for the intervention task) were generated during data collection. Individual participants and student groups were assigned numbers for confidentiality purposes. Research assistants manually transcribed each of the recordings verbatim. The first author then independently checked all transcripts to ensure the transcribed text accurately reflected the audio recordings. They discussed instances where speech was difficult to understand or unintelligible until transcription agreement was reached for 100% of the text in all transcripts. Therefore, the final transcripts had resolved all intelligibility disagreements and were determined to be accurate representations of the audio recordings.

For the research study, the researchers analyzed six assessment think-aloud transcripts and six intervention transcripts, completing four rounds of qualitative coding. In the first round (i.e., initial coding), the authors completed microanalysis, reading transcripts word by word, line by line, and utterance by utterance, and simultaneously used a priori codes (Denzin & Lincoln, 2018) that represented cognitive processes within revised Bloom's taxonomy categories (Anderson & Krathwohl, 2001) or codes from Ginsberg et al. (2016) or Sauerwein and Wegner (2020a). The authors independently applied the codes to a subset of the transcripts to discover the characteristics and dimensions of the codes (Corbin & Strauss, 2015). In the second and third rounds of coding (i.e., focused coding), the researchers developed a codebook that they applied to all transcripts and revised during discussions to build consensus. The codebook defined the codes, provided examples from the transcripts, and was used to "maximize coherence among codes" (Creswell & Creswell, 2018, p. 196). The final codebook is presented in Table 2.

It should also be noted that the researchers focused coding on cognitive processes to isolate thoughts related to solving the problem (e.g., problem solution; Anderson & Krathwohl, 2001) as compared to reading, repeating, or recapping. In other words, the researchers did not code portions of the transcript in which participants read or repeated information from the case study or restated information they or their groupmates had said earlier in the think-aloud. Researchers decided that reading and repeating information from the case study represented efforts to understand the problem (e.g., problem representation; Anderson & Krathwohl, 2001) and recapping or restating previous utterances represented management of group discussion dynamics, rather than cognitive processes.

The researchers independently applied the final codebook (Table 2) to all 12 transcripts in the fourth round of coding. They met virtually to compare their independent application of the codebook and to resolve all discrepancies in each transcript, one at a time, until 100% intercoder agreement was achieved for all codes on all 12 transcripts. After intercoder agreement was reached for all transcripts, the researchers used NVivo software to calculate the percentage of the transcript represented by each revised Bloom's taxonomy category of codes.

**Table 2**

*Final Codes and Codebook Definitions*

| Bloom's Taxonomy Category | Code | Codebook Definition |
|---|---|---|
| Remember | Recall | Mentioning or naming a concept or term from class |
| Understand | Clarify | Seeking clarification about details in the case |
| | Compare | Detecting similarities between two cases or a larger population by age or diagnosis |
| | Explain | Providing additional meaning or explanation of a concept or term |
| | Interpret | Drawing a logical conclusion from presented information |
| Apply | Apply | Applying specific terms or knowledge from class to the case |
| Analyze | Differentiate | Developing criteria (i.e., things to look for) that drive feature matching |
| | Seek outside information | Seeking more or outside information; beyond clarification, perhaps by mentioning a specific person |
| Evaluate | Rationalize | Providing rationale or justification for decision |
| Create | Planning | Describing assessment/intervention processes and procedures, such as materials, activities, and strategies |

Finally, it should be noted that the researchers provided students with feedback to improve their learning in the class prior to conducting the data analyses for the study. The researchers collaboratively reviewed and discussed all of the video recordings. Following this informal evaluation of the data, the instructor used in-class time to debrief with the students and provide feedback on their learning as formative assessment. In all, the think-aloud process required three to four hours of in-class time to prepare, conduct, and debrief as well as approximately eight hours for the researchers to review, synthesize, and discuss the data. To maximize student retention of

the think-aloud activity, the debrief occurred in the following class session, which required the researchers to complete the informal evaluation in a short time frame.

## Results

**Cognitive Processes Demonstrated by Students.** The first research question examined the cognitive processes in the revised Bloom's taxonomy students used during AAC assessment and intervention think-aloud tasks. The following cognitive processes were observed during the think-aloud tasks: (a) recall; (b) clarify; (c) compare; (d) explain; (e) interpret; (f) apply; (g) differentiate; (h) seek outside information; (i) rationalize; and (j) planning. Table 3 presents quotations from individual participants for each cognitive process. Two quotations are provided for each code, with the quotation from assessment think-aloud transcripts presented first and the quotation from intervention think-aloud transcripts presented second.

***Recall.*** As defined in the codebook, recalling occurred when participants mentioned or named a concept or term from class without elaborating or explaining. Participants recalled many terms and important concepts related to AAC and intervention. Some common concepts related to assessment included (a) communication needs; (b) opportunity barriers; (c) practice barriers; (d) access; (e) iconicity; and (f) symbol representation and organization. For example, when a group member peer mentioned the need to assess the child client's participation barriers related to the Participation Model (Beukelman & Mirenda, 2013), Participant 7 simply stated aloud the related term opportunity barriers without defining or elaborating on it. The Participation Model and related terms had previously been discussed in the class. Multiple participants used the following terms related to intervention: (a) aided language; (b) modeling; (c) guided practice; and (d) prompting hierarchy.

***Understand.*** Participants demonstrated their knowledge of AAC assessment or intervention by clarifying and interpreting information provided in the case, making comparisons, and explaining terms. They sought clarification about a variety of details in the case, without specifying how or from whom they would gather that information. For example, some participants wanted to know more about the communicator's strengths and weaknesses, like Participant 13 who said the following about a child with cerebral palsy, "So it says she's ambulatory and can transition independently from one position to another. Does that mean she's walking or she just can like move from sitting to standing? Ambulatory means walking, right?" Other participants were interested in learning more about communication contexts like educational and community settings or the features of the AAC device. For example, Participant 3 asked, "So he's got a speech generating device with thirty-two buttons per page. Does it tell us like how that's designed?" All groups interpreted the case to some degree, by drawing conclusions based on the information provided. For example, in regard to the child intervention case, Participant 14 noted, "We don't know what his MLU is with AAC" and assumed "it's pretty low because he only has thirty-two buttons… so he's probably not making three and four word combinations."

When making comparisons, most compared the case in general terms such as to a larger population (i.e., individuals with autism) or by age. For instance, Child Intervention Group 1 noted the importance of repetition and using Social Stories during intervention with autistic children. However, Child Intervention Group 6 compared the case more specifically to a client one of the group members had previously supported in their clinical internship, and planned to bring visual

aids and to set up the room with different areas to represent work versus play, just as this group member had done in clinical practicum.

**Table 3**

*Sample Quotations by Code*

| Code | Quotations |
|---|---|
| Recall | P04: So that would be more like a syntactic category organization, yeah.<br>P05: Versus like an alphabetical organization.<br>P04: Versus like a schematic one.<br><br>P20: Like aided language?<br>P09: Aided language.<br>P20: Modeling…<br>P09: Focused language stimulation and language modeling. |
| Clarify | P05: I am also curious if the paraeducator is someone that she's familiar with or if this is a new person.<br><br>P15: And have they done anything voice banking? I didn't see anything in there. |
| Compare | P10: But I know like given her age… she's in fourth grade so she… might not be typical… we're considering a person with typical development.<br><br>P10: So considering that he is on the spectrum, I mean engaging in play might be difficult… well yeah it's just difficult for individuals with ASD. |
| Explain | P07: And that Genie [app] would give us an idea of size of symbol, shape of symbol, types of symbols, what kind of organization in terms of semantic categories, syntactic, picture scenes.<br><br>P02: Collaboration is like more direct and consultation is a little bit more indirect. |
| Interpret | P14: She's pointing, she's gesturing, she's writing to communicate. So I guess maybe it is showing that she does have some grapheme-phoneme correspondence… like maybe her literacy skills are more intact.<br><br>P20: He seems to need a lot of support during play so I'm assuming with peers he has a more difficult time because he's typically responding to adults using his device. |
| Apply | P14: Where you just need more of those core words on the cover page and then you can have more of the… fringe words on the other pages that aren't important to her because we want like the core words to be more accessible.<br><br>P15: And according to that I would say that it would be like stage three so he's intelligible, he's somewhat intelligible, but not severely unintelligible. |
| Differentiate | P06: If she's using a switch… how is she activating the switch? How is she maintaining the hold or releasing the switch? So what kind of switch system would we need to use?<br>P11: … Do you need to apply a lot of pressure to it or not a lot of pressure to it? |

| Code | Quotations |
|---|---|
| | P06: Or does she have great head stability and we could do eye gaze? |
| | P14: I'm wondering if he's using this one, this low-tech one with thirty-two buttons pretty well if it should maybe be upgraded to a high-tech device. |
| Seek outside information | P11: If she can do like direct touch like does she have that fine motor movement down? I think that would be like when OT and the PT would come into play to help if she was able to do that. |
| | P03: We know we're going to talk to our teachers, our aides, other SLPs, OTs, anyone he's working with to collect information to… make sure we really understand his strengths. |
| Rationalize | P02: Yeah, because that's gonna impact feedback from her auditory processing or feedback from the device or from other people around her. So we would want know [hearing status]. |
| | P08: I think it will be really important for like his family to… participate in a lot of the session… so they can hear the direct instruction that we're giving and give it at home if needed. |
| Planning | P02: So we'd wanna observe her probably using her current device, operating her wheelchair, playing the computer games. Maybe we would give her some different switches… try some different positioning to see if different ways of stabilizing her trunk helps for that |
| | P07: Data collection would be how much prompting with a hierarchy of prompting is needed… number of trials [and opportunities]… how many times at what level of support. |

Participants also demonstrated their understanding of concepts learned in class by explaining them during the think-aloud tasks. After recalling the term ecological inventory, Participant 2 explained the concept by stating, "You break down that task into all the steps, and then you see like how typically developing peers are able to complete those steps and then what… gaps or discrepancies there might be."

***Apply.*** When applying concepts, participants demonstrated more complex cognitive processes than simply recalling or explaining terms. This level of processing revealed how participants manipulated and made sense of the information that was provided in the case or that they had learned in class. Vision assessment had been discussed in class as an important part of the Participation Model (Beukelman & Mirenda, 2013). Participant 12 applied what they had learned about vision assessment to the child case by recognizing the SLP would need to assess "how many symbols,.. [the client] is able to take in and process within the visual field" as well as the size of the symbols the client could process.

***Analyze.*** When differentiating, or developing criteria to look for during assessment and intervention, the groups mentioned a variety of things to look for, including device set up, organization, and positioning as well as client characteristics like communication skills, mobility,

motor skills, and access methods. Participants planned to seek outside input from a variety of professionals and other stakeholders, including family members, other SLPs, occupational therapists, physical therapists, audiologists, teachers, paraeducators, physicians, vision specialists, social workers, and mental health counselors. Some plans were more general, such as having a conversation to learn more about something, while others planned to get access to specific evaluation or progress reports or other formal documents like Individualized Education Programs. For example, Participant 13 assumed previous assessments had been conducted because the adult described in the assessment case had a diagnosis of severe, non-fluent aphasia. This participant specifically planned to ask the client's SLP for data from that assessment.

***Evaluate and Create.*** As defined in the codebook, planning represented clinical decision making related to materials, activities, and strategies, and rationalizing occurred when participants provided rationales for those clinical decisions. While groups frequently engaged in these complex cognitive processes, they did not move through levels of complexity in a linear fashion. Table 4 presents an excerpt from the Child Intervention Group 3 transcript, which illustrates multiple cognitive processes at play while the participants planned intervention targets, goals, and strategies for the pediatric case. After determining they needed to establish baseline data, this group began discussing targets (i.e., requesting, making choices), but then steered the conversation into strategies they might use to target those goals (i.e., aided language modeling, parallel talk). Note that conversational devices such as confirming or repeating were not coded and the symbols < and > were used to denote overlapping speech among participants.

**Table 4**

*Child Intervention Group 3 Transcript Excerpt*

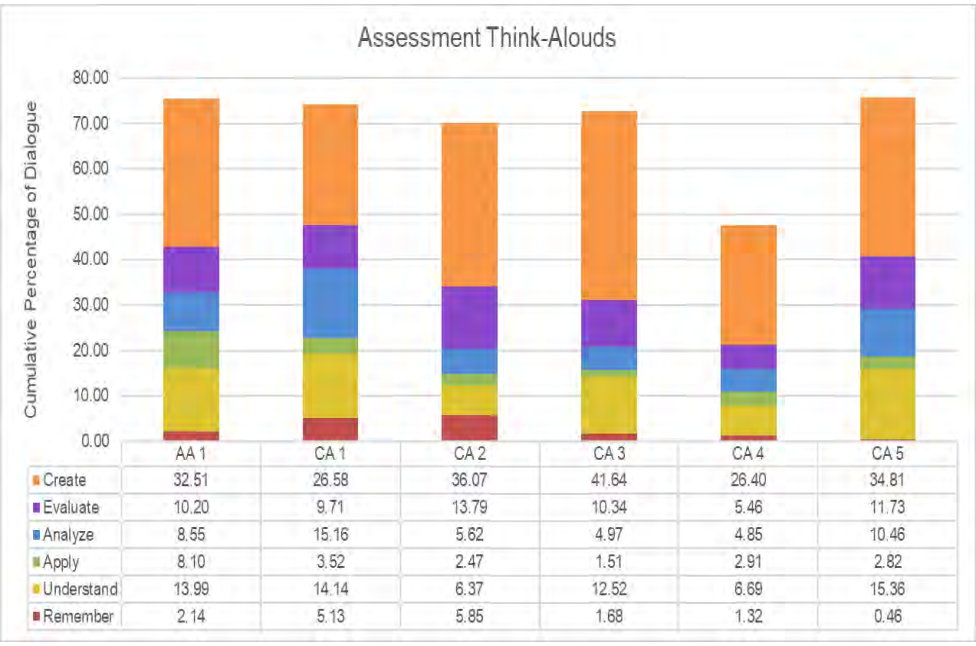
| Code | Transcript Excerpt |
|---|---|
| Planning | P11: And like what would we target? Like making communication temptations and then figuring out like to what extent is he requesting <and>. |
| --- | P02: <Mhm>. |
| Planning | P11: Responding to others? I think we've gotten that taken care of so I guess what would we do? |
| Planning | P02: So our goals are gonna be requesting, maybe making choices <between>. |
| --- | P11: <Mhm>. |
| Planning | P02: Two objects. And for play perhaps commenting on, engaging by commenting on the toys or the activities that we're <doing>. |
| Apply | P11: <Mhm>. Yeah. Maybe like doing the aided language modeling. |
| --- | P02: Yeah. |
| Explain | P11: On the device for him like if he's playing and it's next to him but he's not using it. |
| --- | P02: Mhm. |
| Explain | P11: Like bring it more into focus. |
| Recall | P06: Yeah what do we call that again when you, like parallel talk. |
| --- | P02: <Yeah>. |
| --- | P11: <Mhm>. |
| Apply | P06: Right? So like using parallel talk, whatever he's playing with |
| Rationalize | P06: because he has ASD so he might not be engaging with us. |

All groups described their plans for the assessment or intervention session; however, specific processes and procedures varied across groups. For example, Child Intervention Group 6 thought aloud using the same pediatric case as Child Intervention Group 3, but prioritized literacy and vocabulary goals rather than communication functions like requesting and making choices.

**Proportion of Transcripts Represented by Cognitive Process Categories.** The second research question focused on the proportion of the think-aloud transcripts represented by each cognitive processing category. When coding was complete, the researchers used NVivo software to calculate the percentage of the transcript represented by each code. Figures 1 and 2 present the percentage of each transcript that was coded for cognitive processes in each of the revised Bloom's taxonomy categories: Remember, Understand, Apply, Analyze, Evaluate, and Create (i.e., problem solution). Note that because problem representation data was excluded, the percentages do not add up to 100.00% for each transcript. While one group of participants (i.e., Adult Assessment Group 1) chose the adult assessment case, the remaining five groups chose the child assessment case. Similarly, one group of participants (i.e., Adult Intervention Group 1) used the adult intervention case and five groups used the child intervention case. Several participants chose to work with different classmates for the two think-alouds, and one group thought aloud about the adult case for one task and the child case for the other tasks. Therefore, it cannot be assumed that the participants in Child Assessment Group 1 are directly comparable to the Child Intervention Group 1 in composition, and so forth. Note that in Figures 1 and 2, group names are abbreviated with the adult (A) or child (C) case represented first, then assessment (A) or intervention (I), and the group number. Thus, the group that selected the adult case for the assessment think-aloud task is labeled AA1 in Figure 1.

**Figure 1**

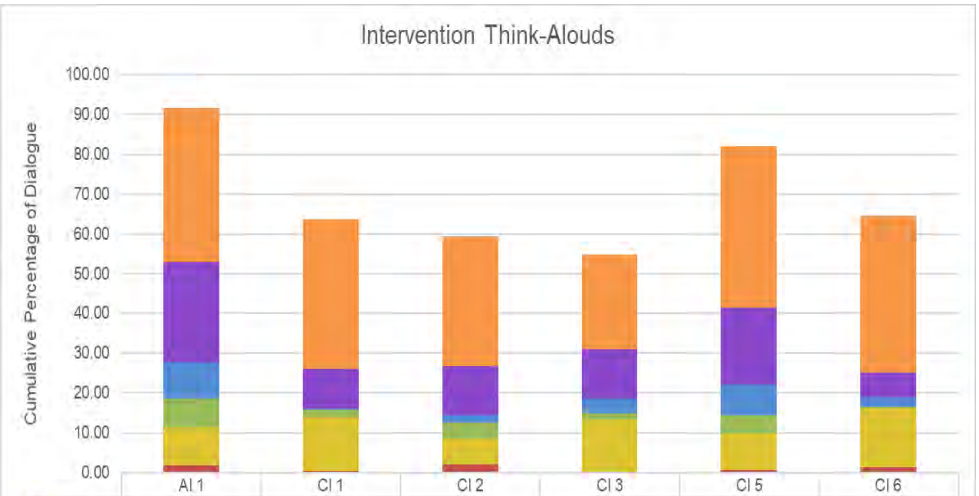
*Percentage of Assessment Think-Aloud Dialogue Coded by Bloom's Taxonomy Dimension*




| | AA 1 | CA 1 | CA 2 | CA 3 | CA 4 | CA 5 |
|---|---|---|---|---|---|---|
| Create | 32.51 | 26.58 | 36.07 | 41.64 | 26.40 | 34.81 |
| Evaluate | 10.20 | 9.71 | 13.79 | 10.34 | 5.46 | 11.73 |
| Analyze | 8.55 | 15.16 | 5.62 | 4.97 | 4.85 | 10.46 |
| Apply | 8.10 | 3.52 | 2.47 | 1.51 | 2.91 | 2.82 |
| Understand | 13.99 | 14.14 | 6.37 | 12.52 | 6.69 | 15.36 |
| Remember | 2.14 | 5.13 | 5.85 | 1.68 | 1.32 | 0.46 |

**Figure 2**

*Percentage of Intervention Think-Aloud Dialogue Coded by Bloom's Taxonomy Dimension*




| | AI 1 | CI 1 | CI 2 | CI 3 | CI 5 | CI 6 |
|---|---|---|---|---|---|---|
| Create | 38.64 | 37.60 | 32.40 | 23.87 | 40.40 | 39.46 |
| Evaluate | 25.25 | 9.91 | 12.42 | 12.36 | 19.54 | 6.27 |
| Analyze | 9.04 | 0.30 | 1.97 | 3.64 | 7.61 | 2.36 |
| Apply | 7.21 | 1.96 | 3.89 | 1.68 | 4.58 | 0.32 |
| Understand | 9.50 | 13.47 | 6.46 | 12.93 | 9.14 | 14.72 |
| Remember | 1.99 | 0.44 | 2.19 | 0.37 | 0.73 | 1.52 |

All groups remembered and demonstrated understanding, and also applied, analyzed, evaluated, and created knowledge. For most of the groups during the assessment think-aloud, 70.17% to 75.64% of their dialogue represented cognitive processes, which means that approximately 25% to 30% of the dialogue was used to read the case verbatim or repeat or recap information stated earlier by group members or in the case study itself. Recall that reading, repeating, and recapping were not cognitive processes of interest in the study, as they were considered mechanisms for completing the think-aloud task rather than representations of student learning (i.e., problem representation). Child Assessment Group 4 was an outlier in that only 47.63% of their transcript was coded. In contrast, 54.85% to 64.65% of four groups' dialogue was coded as cognitive processes for the intervention think-aloud. There were two outliers, Child Intervention Group 5 and Adult Intervention Group 1. A total of 82.00% and 91.63% of their intervention think-aloud transcripts were coded, respectively.

The data were analyzed to compare the percentage of the transcripts represented by the two most complex dimensions in the revised Bloom's taxonomy (i.e., evaluate and create). Across group differences were again present. More of the dialogue among Child Assessment Group 3 (51.98%), Child Assessment Group 2 (49.86%), and Child Assessment Group 5 (46.54%) was planning the AAC assessment and rationalizing their decisions as compared to the Adult Assessment Group 1 (42.71%), Child Assessment Group 2 (36.29%), and Child Assessment Group 4 (31.86%). For the intervention think-alouds, more of the dialogue in Adult Intervention Group 1 (63.89%) and Child Intervention Group 5 (59.94%) was planning for intervention and providing rationale as compared to the remaining groups: Child Intervention Group 1 (47.51%), Child Intervention Group 6 (45.73%), Child Intervention Group 2 (44.83%), and Child Intervention Group 3 (36.23%).

## Discussion

The aim of this study was to uncover and describe the cognitive processes students demonstrate when completing think-alouds to plan for assessment and intervention in AAC. Students in all groups engaged in cognitive processes representing each level of thinking in the revised Bloom's taxonomy when planning for assessment and intervention. Findings and implications for instructors are discussed below.

### Cognitive Processes Uncovered Using Think-Alouds.

***Assessment Think-Aloud.*** Five of the six groups of students who completed the assessment think-alouds were actively engaged in problem solution for approximately 70% to 75% of their dialogue. In contrast, only 47% of the transcript for one of the groups (Child Assessment Group 4) was coded for cognitive processes. The think-aloud transcript from Child Assessment Group 4 revealed the smallest percentage of dialogue representing the two most complex cognitive processes when compared to other the student groups. More than half of this group's dialogue was reading, repeating, and recasting information. In other words, they engaged in more problem representation, or "build[ing] a mental representation of the problem" than problem solution, or "devis[ing] a way of achieving a goal" (Anderson & Krathwohl, 2001, p. 65). In sum, the use of think-alouds revealed that most groups demonstrated complex cognitive processes illustrating at least emerging knowledge of AAC assessment planning; one group, however, had more difficulty in using their knowledge to problem solve as they planned for assessment (Anderson & Krathwohl, 2001).

***Intervention Think-Aloud.*** Far greater variability was observed in problem solution in the intervention think-alouds. Two groups (i.e., Child Intervention Group 5 and Adult Intervention Group 1) engaged in problem solution for 82.00% and 91.63%, respectively, of their overall dialogue. Also, they demonstrated far higher rates of complex thinking (i.e., rationalizing and creating) as compared to their classmates during the intervention think-alouds. For the remaining four groups, approximately 54% to 65% of the transcripts were coded as cognitive processes. These groups demonstrated rationalizing and planning less frequently during the task. The group differences suggest that some groups utilized more of their time attempting to understand and represent the problem, whereas the two outlier groups spent a greater proportion of the allotted time actively engaging in problem solving.

**Implications for Instructors.** As stated previously, scholarly teachers aim to identify strengths and weaknesses in students' learning to provide customized learning opportunities in the classroom (Middendorf & Shopkow, 2018). Further, scholarly teachers recognize the importance of designing assessment tasks that "tap the full range of cognitive processes required for transfer of learning" (Anderson & Krathwohl, 2001, p. 91). Because think-alouds were useful in this study and others in uncovering students' cognitive processes, CSD instructors might consider implementing them in their classroom. As scholarly teachers, we recognize the importance of reflecting upon our teaching. As such, we share implications for instructors who might consider using think-alouds in the classroom (i.e., scholarly teaching) or in SoTL work of their own. Major considerations are time and assessment of the work.

When considering the utility of think-alouds in the classroom, it is important to first consider the time required to evaluate students' performance on the think-aloud tasks. As mentioned in the

Methods, in order to provide students with feedback in the class, it took approximately eight hours for the researchers to review, synthesize, and discuss the think-aloud recordings. In-class time was also used for students to complete the tasks and to debrief. This time commitment would be amplified if the think-alouds were completed independently, rather than in groups. If the 19 students in this study had completed the think-alouds independently, we estimate that approximately nine hours and 30 minutes of videos would have been generated for the instructor to review for the assessment task, as well as the same amount for intervention, as compared to the three hours of videos for each task that were recorded in this study. As with any instructional decision, scholarly teachers must carefully consider the purpose of the activity related to the instructional time and effort required. Through our experience and reflections, we recognize that although students working in groups is clearly beneficial from an efficiency standpoint, it can be more difficult for the instructor to identify differences in individual student learning.

The think-alouds described in this study were used as a formative assessment opportunity in the classroom. That is, the experience was designed for student learning, and students were not assigned grades upon completion. Based on our reflection of this instructional experience and completion of the SoTL study, the researchers recommend that regardless of how instructors plan to use think-alouds (e.g., formative assessment, summative assessment, or in future SoTL studies), they utilize predetermined learning outcomes, and consider a rubric or other organized approach, to guide their review of the cognitive processes revealed in the think-aloud data. For the SoTL study, we were interested in exploring the cognitive processes students engaged in while completing the task; in the classroom, however, instructors might be more interested in evaluating students' understanding of AAC assessment framework and principles, ability to write measurable goals, or ability to plan meaningful activities and data collection methods to use during intervention sessions. The possibilities are applicable and likely to vary across AAC and other courses, as different instructors have different learning objectives and priorities for instruction. Ultimately, as described in the introduction, think-alouds can be useful in pinpointing the content with which students struggle, so that faculty can provide appropriate feedback and instruction.

Self-evaluation, peer-evaluation, or both could increase the efficiency of the grading process. If an instructor plans to use think-alouds for formative assessment, incorporating these evaluation(s) could supplement or substitute instructor-evaluation. Students could engage in self-evaluation by reflecting on the following after completing the think-aloud: their strengths while engaging in the think-aloud, what was challenging or confusing for them, and what they might do differently if presented with a similar case in the future. It could also be helpful for students to consider what additional information or resources they might need to access to continue their learning in this area. Similarly, for peer-evaluation, students could listen to or watch another group's think-aloud recording and compare and contrast their think-aloud responses to the same case, consider the group's strengths, and identify recommendations or areas for improvement. The groups could share that feedback with each other and the instructor could debrief by facilitating a large group discussion with all students after they have completed self-evaluation, peer-evaluation, or both. Finally, if utilizing group think-alouds, it may be helpful for students to evaluate their individual contributions, as well as the contributions made by their group members, perhaps using a rubric or rating scale for participation or engagement. For example, students could consider how they contributed during the think aloud, how they might have contributed differently, and reflect on their group members' contributions as well. In general, a rubric based on learning objectives would

clearly communicate to students what they are expected to have learned upon completion of the task, and provide guidance for students as they complete self- or peer-evaluations.

**Limitations and Future Directions.** Multiple limitations were present in the study. First, because the students completed the think-alouds in groups, cognitive processes were analyzed in groups rather than for individuals. Thus, it was not possible to assess individual student learning. In addition, this study described think-alouds only. Student learning was not compared to other tasks, such as written assignments or exams. To address both limitations, future research should triangulate data to compare individual performance on other course assessments to think-aloud tasks. Because students were convenience sampled and the pool included a small sample of CSD graduate students, these results are not indicative of all students' strengths and weaknesses in AAC assessment and intervention planning. Thus, the results are not necessarily generalizable to all graduate students studying speech-language pathology.

Additional research is needed to uncover student learning outcomes related to AAC assessment and intervention planning. As discussed previously, think-alouds are a useful assessment tool for CSD instructors to consider implementing in their classroom so they can uncover the cognitive processes students use during clinical decision-making tasks; future research, however, should focus on both maximizing the efficiency and effectiveness of using think-alouds in CSD coursework and utilizing them to assess student learning. Finally, social validity data from the student perspective and from additional faculty and instructors would be helpful for those considering whether and how to use think-alouds in their CSD contexts.

A potential benefit of think-alouds, if conducted as a small group activity as in the current study, is the collaboration required. While this was not directly coded in our study, the data revealed that up to 30% of think-aloud time was spent managing the group, either in reading and recalling details, recapping what group mates contributed, or recognizing and clarifying others' contributions. Given the focus on inter professional practice in CSD (American Speech-Language Association, 2022) and the importance of collaboration in AAC (Beukelman & Light, 2020), completing tasks that require collaboration provides students with opportunities to practice this skill in supported conditions (e.g., with peers, under instructor supervision). Group think-aloud data could be used in future SoTL research to explore students' ability to effectively collaborate during authentic assessment or intervention planning tasks.

## Conclusion

Approximately half of the instructors surveyed by Sauerwein and Burris (2021) reported assigning treatment plan (50.0%) and assessment plan (46.9%) tasks in their graduate AAC course. Similar to the students who completed think-aloud tasks in this study, students who complete treatment plans, assessment plans, or both for class assignments engage in thinking across the levels of Bloom's taxonomy; completed written assignments, however, typically only allow the instructor to assess the students' ability to remember (i.e., recalling concepts or terms from class) and create (i.e., describing assessment/intervention processes and procedures, such as materials, activities, and strategies). Other levels of thinking, such as understand (i.e., comparing similarities between two cases), or analyze (i.e., seeking more or outside information to complete the task) are difficult, if not impossible, to ascertain by reviewing a completed session plan. Unless instructors explicitly

ask students to provide rationale for their decisions, this information will not necessarily be included in a written plan. Finally, instructors assess the final product (i.e., the assessment or intervention plan) and do not have opportunities to observe the process students engage in to reach that final product, which could include considering a multitude of options, changing their mind, and ultimately, making decisions.

Scholarly teachers should consider the utility of incorporating think-alouds as a case-based learning and assessment tool in courses and clinical practica. In this study, think-alouds were a valuable assessment tool for uncovering the cognitive processes students engaged in while completing authentic tasks. In particular, the think-alouds provided authentic, case-based learning opportunities for students related to AAC assessment and intervention planning, and were useful for capturing types of thinking and learning that can often be missed with other assessments.

While they proved useful in this study, incorporating think-alouds in the AAC course was not without challenges. Future research should explore how CSD instructors can use think-alouds efficiently and effectively in various contexts, how think-alouds can be used to assess student mastery of learning objectives, and students' and instructors' perceptions of the tasks and the impact think-alouds have on learning.

## Disclosures

The authors have no relevant financial or nonfinancial relationships to disclose.

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# Appendix A
# Assessment Think-Aloud Case Studies

## Adult Case

Kathy is a 57 year-old woman who suffered a left hemisphere CVA 3 years ago and is coming to you for her first AAC assessment. She has a severe non fluent aphasia. Her primary communication partners are her husband and her daughter who attends college in another state. Her family describes Kathy as having been very social before her stroke, hosting parties for her friend and organizing a book club. She was also highly involved in their community, including volunteering at their church and at the local SPCA. However, since her stroke, she has been withdrawn and does not typically want to leave home. Her family would like for her to better communicate with others more effectively. They report that she understands most of what is said to her, though it may take some time for her to process what is said and that she uses short vocalizations, pointing, gestures, and writing to communicate currently. Kathy is ambulatory and can transition independently from one position to another (i.e., sitting to standing). She has some right-sided weakness and although she generally favors her left side, she is able to use her right side. Kathy uses glasses (bifocals) and audiological testing demonstrated her hearing is a not a concern.

## Child Case

Jaimie is a 10-year-old girl with spastic cerebral palsy, diagnosed at birth. She is a social young girl, who especially enjoys water play, musical instruments and listening to music (e.g. Taylor Swift, Katy Perry, One Direction). She also enjoys computer games, playing house with her 9-year-old sister, and listening to stories her dad makes up. The intake paperwork indicates that Jaimie understands what is said to her, although it may take some time for her to process the language. She communicates through a variety of gestures, including idiosyncratic signs (e.g. claps her hands for "more"), photographs, word approximations, and a dedicated device that she has had for four years. Your intake paperwork does not include any information about the dedicated device. A functional vision assessment completed by a vision specialist three years ago indicated that her visual acuity is not a concern, but visual processing may be. She has a history of cerumen build up and chronic otitis media. She had PE tubes inserted when she was 4 years old. She uses a joystick mounted on the left arm rest to control her electric wheelchair. She is transitioning to an inclusive 4th grade classroom and is assigned a para-educator for one/one support throughout the day. Next year, she will be eligible for a new high tech AAC system. The current assessment will begin the process of identifying the best one.

# Appendix B
# Intervention Think-Aloud Case Studies

## Adult Case

Michael is a 48-year-old man with amyotrophic lateral sclerosis (ALS). His primary communication partners are his wife and two sons (in middle school and high school). Michael is active in his local Rotary club and is treasurer for his neighborhood association. He enjoys emailing family members and close friends to stay in touch. Since his most recent speech evaluation revealed a speech rate of 108 words/minute and sentence-level intelligibility was judged to be 84% by an unfamiliar listener, you conducted an AAC assessment. A high tech speech-generating device was chosen (to be accessed via eye gaze) and it arrived at Michael's house last week. At this point, he has taken the device out of the box and charged it. Michael demonstrates intact cognition and language skills. Until now in therapy, you have focused therapy on speech intervention strategies which have helped him learn to conserve energy for priority speaking tasks and to rest often to reduce fatigue. In addition, you have instructed Michael to avoid adverse speaking/listening situations by muting the television or speaking with others in a quiet place rather than in a crowded room; however, it is now time to begin implementing the speech-generating device. Michael's hearing was recently screened and within normal limits; however, he wears glasses to correct his vision. Michael's muscle weakness affects his gait as well as his precision during fine motor tasks.

## Child Case

Christopher is a 4-year-old boy with a diagnosis of autism spectrum disorder. He lives at home with his mother, father, and two older sisters. He attends an early childhood center and participates in speech/language and occupational therapy at school. His expressive verbal vocabulary is limited. During a recent evaluation, the SLP noted that Christopher typically uses jargon with a few real words. An AAC evaluation was conducted approximately a year and a half ago, and a low-tech, level-based speech-generating device with 32 buttons per page was recommended. He has been using the device for a little more than one year. Christopher's language goals have primarily targeted 1) requesting, 2) responding to peers and adults, and 3) engaging in play. He uses his device to indicate his wants and needs and respond to adults using his device, sometimes independently and other times with support; however, he requires significant support during play. Some of Christopher's skills are above age level expectations, such as identifying (by pointing) all letters of the alphabet. Christopher's vision and hearing were recently screened and judged to be within normal limits. Christopher is ambulatory and is able to carry his device independently. He uses his right index finger to access the device independently.