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Using Mind Maps to Make Student Knowledge Visible in an AAC Course

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Using Mind Maps to Make Student Knowledge Visible in an AAC Course

Abstract

Concept maps make students' knowledge visible. Creating a mind map gives students an opportunity to organize their knowledge and allows instructors to visualize and assess it. When students create mind maps at multiple time points, instructors can compare the maps and use the themes, patterns, and gaps that emerge to reflect on their teaching and take action. The purpose of this study was to use concept maps in an AAC course to uncover students' knowledge. A total of 61 graduate students created a mind map with AAC as the central concept at the beginning and end of the term in a graduate-level AAC course. The researchers calculated frequency counts of concepts and connections on each map and completed categorical analyses. Analysis revealed an increase in students' breadth and depth of knowledge of AAC and related concepts. Concepts related to populations of AAC users, access methods, collaboration, and high tech and no tech AAC systems appeared most frequently on participants' mind maps. Assessment, intervention, and funding concepts appeared less frequently. Benefits and challenges to implementing concept maps are discussed so educators can consider how concept mapping may be useful in their contexts.

Keywords

concept maps, mind maps, AAC

Cover Page Footnote

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"The processes students utilize to end up at their final thought destination are internal processes. We can, however, ask learners to make those internal processes available to us in the external environment" (Visconti & Ginsberg, 2024, p. 50). Concept mapping is one method of constructing visual models of student thinking that illustrate relationships between pieces of information. Despite an evidence base across health disciplines and the call for using concept maps as artifacts of student learning in communication sciences and disorders (CSD) education (Visconti & Ginsberg, 2024), the authors are aware of only one published study within the discipline. Mok and colleagues (2013) integrated concept mapping as a programmatic assessment tool. The researchers found a significant correlation between high concept map performance and undergraduate student GPA, case study performance, and exam performance (Mok et al., 2013). Thus, additional research is needed to explore the utility of concept maps in CSD learning opportunities.

The purpose of this paper is to argue for using concept maps in CSD learning opportunities to organize and assess student learning. Because there is literature to support the use of mind maps in other academic disciplines, we present a research study using mind maps to assess student learning in a graduate-level augmentative and alternative communication (AAC) course. Options for analyzing concept map data are presented, and benefits and challenges to implementing concept maps will be discussed so educators can consider how concept mapping may be useful in their contexts.

Teaching and Learning Artifacts

Concept maps are one type of teaching and learning artifact, which are defined as "byproducts of the teaching and learning process" (Hoepner & Walden, 2024, p. 42). SoTL researchers have many artifact options at their disposal across modalities, including written, audio, video, and visual. Written artifacts (e.g., student reflections, student essays, exam scores and responses, surveys), audio artifacts (e.g., student oral reflections, interviews, and think alouds), and video artifacts (e.g., video reflections, video role plays, clinical session videos) have been used more frequently to examine student learning in CSD SoTL work as compared to visual artifacts, such as concept maps. Hoepner and Walden (2024) challenge SoTL investigators to align the data source(s) (i.e., artifacts) chosen for a particular study with the research question(s) and purpose of their inquiry. Readers are referred to their chapter for a more in-depth description of methodological tools, approaches, and data sources.

When considering artifact options in their SoTL toolkit, researchers may be interested in using concept maps due to their unique combination of three qualities. First, concept maps are a visual representation of student learning. There are far fewer options for obtaining visual artifacts as opposed to written, audio, and video data sources. Second, as will be described in the sections below, concept maps make students' internal thinking external. Third, concept maps are a direct data source that has been correlated with other direct data, including problem-based examination performance (Mok et al., 2013). Direct data sources are a direct measure of students' knowledge or skills, or a change in knowledge or skills. On the other hand, indirect sources report students' perception of their knowledge, skills, or change in in these areas. In order to make meaningful claims about student learning outcomes, as opposed to reporting students' perceptions of their learning, SoTL researchers must use direct data sources (Hoepner & Walden, 2024). Concept maps can act as a tool for organization or assessment of knowledge surrounding a concept (Ambrose et al., 2010; Barta et al., 2022). Both of these uses for concept maps will be discussed in the sections that follow.

Concept Maps & Mind Maps

Structurally, concept maps begin with a central concept that branches outward to be linked with other concepts within the map, all of which are typically contained in a box or circle. Linking lines represent relationships between each concept and are labeled to specify what connection has been drawn between the concepts (Novak & Cañas, 2006). Links between concepts define the relationship between the two concepts they are connecting using phrases (e.g., “will cause”, “results in”, etc.) and ideally form a clear linear hierarchy of information (Åhlberg, 2004; Davies, 2011). Concept maps are distinctly structured to include the most general information at the top of the diagram, and information becomes more specific as concepts and cross-links descend throughout the model (Novak & Cañas, 2006). Though most concept maps follow this structure, rules vary between maps and their creators (Åhlberg, 2004). Readers are directed to Novak and Cañas (2006) to view several examples of concept maps.

Mind maps are a subgroup of concept maps which differ mainly by their comparatively loose structure, personalization, and purpose. Mind maps, a visual organizational tool developed by Buzan (1994), can reinforce knowledge and build spontaneous, informal associations between ideas, rather than drawing concrete connections between concepts as in concept maps (Åhlberg, 2004). A central idea is placed in the middle of the diagram, and related words, phrases, or illustrations stem from the central concept in branches that typically result in a radial hierarchy of information, as opposed to the linear hierarchy associated with concept maps. Mind maps provide a broader overview of the information being explored due to their simplistic nature; these models predominantly include singular words, short phrases, and/or images to create general associations between a variety of ideas and to provide a visual summary of the central idea, since visual aids are often more digestible than raw information presented in a verbal or written format (Davies, 2011). As a straightforward type of concept mapping, mind maps are particularly useful for students, who may have little prior knowledge of a topic at the beginning of a term.

Using Mind Maps for Students to Organize Knowledge

As a final product, or assessment, mind maps may be a useful tool for summarizing a student’s knowledge of information, but the process of mind map creation may be equally or more important for student learning. Engaging in the mapping process requires critical thinking and may improve clinical reasoning skills (Sauerwein et al., 2024). In educational contexts, the brainstorming process behind creating personalized associations can be beneficial for students to reinforce knowledge of general concepts and how they relate to each other (Davies, 2011). Additionally, mind mapping may be a practical method for activating and integrating prior knowledge with novel information in a meaningful way, as opposed to learning in a more linear or traditional manner (Davies, 2011). Conventional methods of introducing information such as verbal presentation often result in rote learning, which fails to incorporate previous knowledge with new information. Mind maps offer a more interactive medium for creating connections with novel ideas, because they allow the creator to refine previous knowledge rather than eliminating precursory understanding (Hay et al., 2008).

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Because they require minimal time and effort for both instructors and students, mind mapping is a quick and free "small teaching" tool that can be used across discipline to uncover and assess student learning (Hay et al., 2008; Lang, 2016). Mapping techniques have been recommended for use in higher education curricula focused on implementing problem-based learning (PBL) methods in numerous fields, including health professions such as nursing, medicine, and speech-language pathology (Barta et al., 2022; Mok et al., 2013; Pinto & Zeitz, 1997; Pudelko et al., 2012; Vacek, 2009). PBL strategies challenge traditional, linear methods of instruction by encouraging meaningful learning that will allow for knowledge transfer to practical applications, such as in the workforce (Barta et al., 2022; Hay et al., 2008). Mapping is a convenient tool for creating associations between semantic knowledge and potential real-world applications, making it useful for organizing knowledge. Transfer and application are critical components of translating knowledge obtained in the classroom to clinical practice.

Using Mind Maps to Assess Knowledge. Mapping techniques can also be beneficial for instructors to monitor students' acquisition and organization of knowledge, depth of understanding, and critical thinking skill development (Ambrose et al., 2010). One method of utilizing mapping to assess knowledge involves students creating a map based on previous knowledge, followed by an opportunity to create another map using their current knowledge after target information has been presented (Whitehill et al., 2013). This method allows instructors to analyze how student knowledge has evolved and whether it has developed appropriately and accurately (Holcombe & Shonka, 1993; Lang, 2016). In addition, when students create mind maps at multiple time points, instructors can uncover strengths, weaknesses, and gaps in their teaching (Davies, 2011; Hay et al., 2008).

Concept mapping more broadly has been used by instructors to more accurately understand students' critical thinking abilities. Throughout the analysis of critical thinking skills (i.e., abilities of analysis, deduction, evaluation, and explanation) of nursing and English students, who used the concept mapping method for learning versus students who used traditional learning methods, the former demonstrated more improvement in the development of critical thinking abilities than the latter (Barta et al., 2022). Evidence from this study shows that implementing concept mapping techniques into higher education curricula may enhance understanding of target content and critical thinking skills that will foster future learning.

Research Questions

In this SoTL study, students created mind maps to organize their knowledge at the beginning and again at the end of the term. The instructor and first author used those mind maps to assess students' knowledge at the two time points. Research questions that guided the work included the following:

1. How did the size of the mind maps change from the beginning to the end of the term?
2. How did the structure of the mind maps change from the beginning to the end of the term?
3. How did the quality of the mind maps change from the beginning to the end of the term?

Method

Participants. The study was approved by the institutional review board (IRB) at Southern Illinois University Edwardsville. Data were obtained from a total of 61 graduate students enrolled in a required AAC course taught by the first author in the Fall terms of 2018 and 2019, as well as the Summer term of 2020, using convenience sampling. All students who enrolled in the course were offered an opportunity to participate in the study. This approach was chosen over random sampling in order to collect and analyze data from as many students as possible. The participants were in their second (i.e., final) year of study in a graduate speech-language pathology program. Prior to enrolling in the class, 50.82% ($n = 31$) of participants had supported an AAC client in one or more clinical internship experiences at the university clinic. Because IRB approval to analyze the mind maps was obtained after all students had completed the course and graduated from the program, no additional demographic information was collected.

Instructional Context. The three-credit hour graduate-level AAC course was required for students in the master's degree program. It was offered in the fourth of five terms in the academic program and was one of the final four academic courses participants completed before clinical externships. The course was offered face-to-face in 2018 and 2019 and offered synchronously online in 2020. Consistent with American Speech-Language Hearing Association certification standards (2020) and other graduate-level AAC classes offered in the United States (Sauerwein & Burris, 2021), the primary learning objectives in the course were for students to gain and demonstrate knowledge of communication disorders and differences, as well as knowledge of principles and methods of prevention, assessment, and intervention for AAC users. The content was delivered and discussed in the following order: a) introduction to AAC, b) AAC assessment, c) supporting literate AAC users (e.g., users with amyotrophic lateral sclerosis, multiple sclerosis), d) supporting preliterate AAC users (e.g., users with developmental communication disorders such as autistic AAC users or users with Down syndrome), and e) supporting people with acquired postlingual (i.e., post speaking, reading, and writing) communication disorders (e.g., aphasia, traumatic brain injury, dementia). Students engaged in a wide variety of learning activities during and outside of class meetings, including lecture, small and large group discussions, hands-on time with AAC systems, and case-based assignments.

Data Collection. At the beginning of the first class of the term, the first author briefly described mind maps and showed participants a sample mind map related to sports. The instructor chose to provide minimal explanation and examples of mind maps so that students were more focused on the process of creating the map rather than the final product. She explained that mind maps have a central concept in the middle of the map with lines connecting to other concepts. Then, participants were prompted to create a mind map with AAC as the central concept. The first author told participants to include everything they knew about AAC. This activity was not timed. At the end of the final class of the term, the first author again instructed the participants to create a mind map with AAC as the central concept. This was the final activity of the semester and was not timed. Students did not have access to the mind map they created at the beginning of the term. In 2018 and 2019, data were collected face-to-face in the classrooms in which the AAC course was taught. In 2020, participants completed the activities during a synchronous Zoom meeting and submitted their mind maps using the university's learning management system.

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The data collection procedures were normal educational practices included in the course. Thus, all students enrolled in the course in 2018, 2019, and 2020 completed the procedures, and their data were used in the study. An exception was one student in 2019 who did not complete a mind map at the beginning of the term because they were absent on the first day of class. Although 62 students were enrolled in the courses, data were analyzed from the 61 students who generated two mind maps, one from the beginning and one at the end of the term.

Data Analysis. Research assistants cataloged the concepts included on the mind maps using Microsoft Excel. The Excel sheet included columns for primary, secondary, tertiary, quaternary, quinary, and senary connections for each mind map, which were represented by individual rows. AAC was the central concept on all mind maps. Primary concepts are items directly connected to the central concept (i.e., one link away from the central concept of AAC). Secondary concepts are items connected to primary concepts (i.e., two links away from the central concept), and so forth. The researchers found minimal models for concept map analysis in the academic literature. Three types of analyses were completed for each map that included the following: size, structure, and qualitative categories consistent with methods used by Cañas and colleagues (2013).

Two sample mind maps are provided from Participant 21, as Figures 1 and 2, to provide sample data and illustrate data analysis procedures. Figure 1 shows the mind map from the term's beginning, and Figure 2 is from the term's end. These mind maps were recreated using concept mapping software to deidentify the student's work and remove their handwriting.

Figure 1

Participant 21's Mind Map from the Beginning of the Term

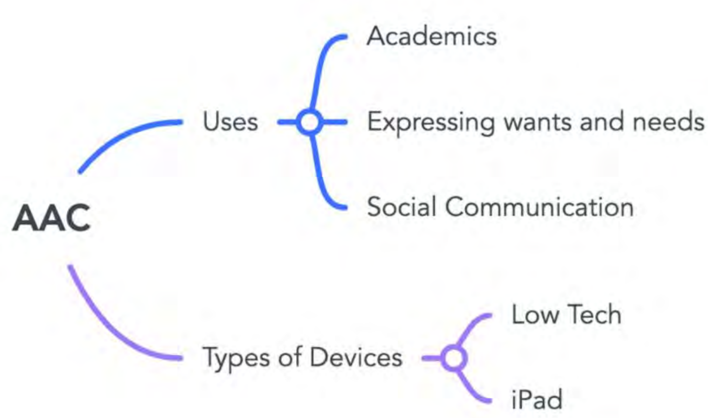


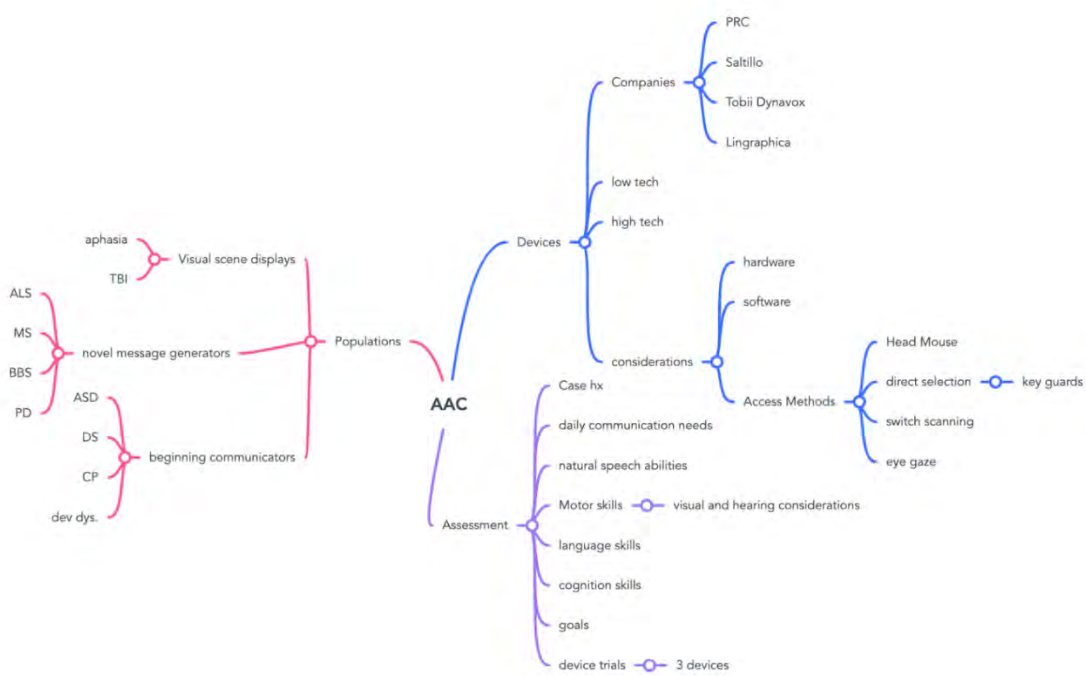
Table 1

Size, Structure and Quality Summary of Figure 1

Group	Summary
Size	7 total concepts
Structure	2 primary concepts (uses, types of devices)
	5 secondary concepts (academics, expressing wants and needs, social communication, low tech, iPad)
Quality	5 categories represented: types of AAC systems, mid/low tech, high tech hardware, intervention goals, intervention language

Figure 2

Participant 21's Mind Map from the End of the Term



Size: Concepts per Map. The research team tallied the number of concepts included on each mind map. The central concept of AAC was excluded because it was shared on all mind maps. For example, the mind map in Figure 1 includes seven concepts, whereas the mind map in Figure 2 includes 37 concepts in total.

Table 2

Size, Structure and Quality Summary of Figure 2

Group	Summary
Size	37 total concepts
Structure	3 primary concepts (e.g. devices); 15 secondary concepts (e.g. considerations)
	19 tertiary concepts (e.g. access methods); 4 quaternary concepts (e.g. direct selection); 1 quinary concept (e.g. key guard)
Quality	12 categories represented: populations, brands, high tech hardware, high tech software, high tech other feature, mid/low tech, organization/layout, access, assessment participation model, constraints and capabilities profile, system trials, data collection methods

Structure: Density. Next, the research team calculated the number of concepts on the mind map at each of the following levels: primary, secondary, tertiary, quaternary, quinary, and senary. These levels were linear in that primary concepts were directly connected to the central concept of AAC. Secondary concepts were directly connected to primary concepts, and so on. For example, Figure 1 shows two concepts at the primary level (i.e., uses, types of devices) and five concepts at the secondary level (i.e., academics, expressing wants and needs, social communication, low tech, iPad). Figure 2 shows three concepts at the primary level (e.g. devices), 15 concepts at the secondary level (e.g. considerations), 19 concepts at the tertiary level (e.g., access methods), four concepts at the quaternary level (e.g., direct selection), and one concept at the quinary level (e.g., key guard). The research team counted the number and calculated the percentage of mind maps that included concepts at each level within each cohort, at the beginning and at the end of the term.

Quality: Substantive Categories. The last step of data analysis was an inductive categorical analysis of all concepts included on the maps. Categories emerged from the analyses. Using the concepts cataloged in the Excel sheet, the first and third authors used microstructure analysis to read all concepts generated on the maps. Microstructure analysis is a thorough, line-by-line reading of the data prior to the start of the coding process (Corbin & Strauss, 2015). During microanalysis, the researchers generated research memos of patterns and potential categories that emerged from the data. The first author had a research doctorate in speech-language pathology, experience conducting qualitative research related to AAC, and had taught a graduate level AAC course five times at the time of data analysis. Although the third author did not have prior experience conducting qualitative research, she had knowledge of AAC and clinical experience in their graduate program supporting individuals who used AAC.

Following microanalysis, coding revealed nine substantive categories. Substantive categories describe and “stay close to” the data and are “based on the researcher’s understanding of what’s going on” (Maxwell, 2013, p. 108). The first author and research assistant collaboratively developed a codebook with sample concepts for each substantive category. The research assistant independently applied the codebook until all mind map concepts were coded with a substantive category.

The researchers met for consensus building and axial coding to explore the dimensions of the categories (Corbin & Strauss, 2015). During this process, the researchers identified subcategories within five of the categories. These subcategories and sample concepts were added to the codebook. The research assistant applied the codebook again until the new subcategories had been applied to all mind map concepts for which it was appropriate. Through frequent one-on-one conversations and review of the qualitative data, interrater agreement was reached on categorization for 100% of the concepts.

Methodological Integrity. Two research assistants completed the size (i.e., total number of concepts on each map) and structure (i.e., number of concepts at each level on each map) analyses independently. They met to discuss and resolve any inconsistencies until interrater agreement was reached for 100% of the quantitative data.

Because the third author did not have prior experience with qualitative research, it was important that a peer debriefer add validity to the analyses by asking questions about and providing preliminary interpretation of the data. Peer debriefers enhance the accuracy of analyses and reporting of qualitative data (Creswell & Creswell, 2018). Peer debriefers should be a content area expert of the research topic and provide critical feedback to enhance the authenticity of the findings (Brantlinger et al., 2005). The peer debriefer who assisted with this study had a research doctorate in speech-language pathology, conducted AAC-related research, and regularly taught AAC coursework. They provided an external review of the analysis procedures and the coding of all qualitative data in the study.

The first and third authors met with the peer debriefer virtually to focus on the credibility and transferability of the coding (Lincoln & Guba, 1985). The peer debriefer provided verbal feedback on the categories and subcategories, stating that they seemed reasonable and plausible. They offered no suggestions for changing them; the peer debriefer asked critical questions, however, about the coding of some concepts. The two researchers and peer debriefer met multiple times virtually to discuss all coding until 100% agreement was reached for all concepts.

Results

Size: Concepts per Map. The mean number of total concepts per map were compared from the beginning of the term to the end of the term across cohorts. Please see results in Table 3.

Structure: Density. The mind maps students created at the start of the term included up to three levels of concepts: primary, secondary and tertiary concepts. No mind maps from the start of the term included more than four levels. Mind maps from the end of the term included up to six levels of concepts: primary, secondary, tertiary, quaternary, quinary, and senary, although mind maps from only two students in the study included quinary or senary concepts. Table 4 presents the number and percentage of mind maps per cohort with concepts at each level, at the beginning and end of the term.

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Table 3

Size of Mind Maps: Mean Total Number of Concepts across Groups

	Beginning of the Term			End of the Term		
Group	*M*	*SD*	Range	*M*	*SD*	Range
2018 (*n*=22)	11.09	5.02	3-23	40.27	7.88	31-58
2019 (*n*=16)	16.44	5.70	4-28	29.50	10.45	14-50
2020 (*n*=23)	15.30	8.04	6-43	38.43	14.30	13-67
Overall (*n*=61)	14.08	6.78	3-43	36.75	12.03	13-67

Table 4

Structure of Mind Maps: Density of Concepts, by Level

	2018 (*n*=22)				2019 (*n*=16)				2020 (*n*=23)			
	Pre		Post		Pre		Post		Pre		Post	
Level	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
1	22	100.00	22	100.00	16	100.00	16	100.00	23	100.00	23	100.00
2	18	81.82	22	100.00	16	100.00	16	100.00	23	100.00	23	100.00
3	5	22.73	21	95.45	9	56.25	12	75.00	12	52.17	19	82.61
4	0	0.00	8	36.36	2	12.50	3	18.75	2	8.70	8	34.78
5	0	0.00	1	4.55	0	0.00	0	0.00	0	0.00	1	4.35
6	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	4.35

Quality: Substantive Categories. Nine categories emerged from the data and subcategories emerged within five of those categories. Categories, subcategories, and sample concepts from beginning and end of the semester mind maps are presented in Table 5.

Frequency counts are provided for each category and subcategory in Table 6, representing the number of times each category or subcategory appeared on a mind map for each group at the beginning and end of the term.

Across groups, the most frequent categories that emerged from the mind maps at the beginning of the semester were *Populations, Access*, and *Types of AAC Systems*. Across all groups at the end of the term, Populations was the most frequently coded category, and Access was the second most commonly coded category across. The next most frequently coded category was Brands in 2018, Collaboration in 2019, and No Tech Systems in 2020.

Table 5

Quality of Mind Maps: Example Concepts from Themes and Subthemes

Theme or Subtheme	Example Concepts from Mind Maps
Populations	Amyotrophic lateral sclerosis (ALS); Aphasia; apraxia; Autism; cerebral palsy; Down syndrome; intellectual disability; traumatic brain injury (TBI)
Augmentative & Alternative	Aiding; alternative; augmentative; for communication breakdowns only; replacing; speech supplement
Brands	Lingraphica; Prentke Romich Company/PRC; Saltillo; Tobii Dynavox;
Representatives	Names of local representatives from Brands
Types of AAC Systems	Forms; modalities; systems; types; uses
High Tech Hardware	Accent 800; computer; EM-10; I-15; Indie; iPad; NovaChat; PRiO; smart phone
High Tech Software	Communicator 5; Essence; LAMP; ProLoQuo2Go; Snap + Core; TouchChat; Unity; Word Power
High Tech Other Feature	Accessories; cases; chargers; high tech; synthesized voice
Mid/Low Tech	Big Mack; button; Go Talk; switch
No Tech	Alphabet board; communication board; ETRAN; gestures; PECS; picture cards; writing
System Features	Complex; costly; customizable; dedicated; expensive; functional; individualized; medically durable; portable
Color Coding	Color coding; Fitzgerald key; Goossens' coding
Organization/Layout	Dynamic; fixed; hybrid; semantic syntactic; static; taxonomy; visual scene display
Symbols	Alphabet-based; full message/phrase; icons; letters; picture-based; picture symbols; words
Access	Direct selection; eye gaze; head mouse; head pointer; key guard; partner-facilitated; scanning; switch
Intervention	Intervention; learning; therapy
Goals	Communicative competence; increase participation; multimodal communication; operational; strategic
Supports	Aided input; least-to-most; modeling; most-to-least; prompting hierarchy; strategies; time delay; visual supports
Language	Core vocabulary; expressive language; fringe vocabulary; linguistic; pragmatics; social; wants/needs
Literacy	Phonemic awareness, ALL Curriculum, adapted books; shared reading; reading, writing, and spelling
Settings	Class; home; settings; social settings
Assessment Participation Model	Assessment; diagnostic questions; evaluations; no prerequisite skills needed; procedures
Constraints & Capabilities Profile	Attention; cognition; fine motor; gross motor; hearing; language; literacy; memory; sensory; vision

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Table 5, continued

Theme or Subtheme	Example Concepts from Mind Maps
Opportunity Barriers and Supports	Access barriers; attitude; facilitator knowledge; facilitator skills; opportunity barriers; policies; practices
System Trials	Device trials; feature matching; trial at least 3 devices
Data Collection Methods	Case history; check list; interview; observation; parent interview; referral; screen
Funding	Funding report; hurdles; insurance; Medicaid; medical necessity; Medicare; out of pocket
Collaboration	AAC finder; advocacy; caregivers; communication partners; family; occupational therapist; roles of SLP; teacher; vendors

Table 6

Quality of Mind Maps: Frequency Count of Coded Categories and Subcategories across Groups

	2018 (*n*=22)		2019 (*n*=16)		2020 (*n*=23)	
	Pre	Post	Pre	Post	Pre	Post
Categories and Subcategories	*n*	*n*	*n*	*n*	*n*	*n*
Populations	39	201	89	81	55	147
Augmentative & Alternative	5	4	11	14	6	12
Brands	2	91	8	41	14	71
Representatives	0	0	0	3	0	4
Types of AAC Systems	10	5	9	3	15	6
High Tech Hardware	30	67	16	17	29	56
High Tech Software	19	87	18	19	29	48
High Tech Other Feature	10	18	7	11	25	21
Mid/Low Tech	19	27	5	15	22	27
No Tech	21	48	24	7	59	75
System Features	21	9	4	8	20	18
Color Coding	0	14	0	0	0	0
Organization/Layout	1	62	1	15	0	13
Symbols	7	17	7	11	10	13
Access	15	136	25	50	35	140
Intervention	0	3	0	23	0	16
Goals	9	22	4	28	5	36
Supports	1	1	4	17	3	9
Language	9	22	12	24	2	14
Literacy	0	3	5	6	1	14
Settings	8	4	5	1	0	0

Table 6, continued

	2018 (*n*=22)		2019 (*n*=16)		2020 (*n*=23)	
	Pre	Post	Pre	Post	Pre	Post
Categories and Subcategories	*n*	*n*	*n*	*n*	*n*	*n*
Assessment Participation Model	0	7	2	25	1	38
Constraints & Capabilities Profile	0	10	3	11	13	23
Opportunity Barriers and Supports	0	0	0	4	0	22
System Trials	0	11	1	5	1	8
Data Collection Methods	0	1	0	2	0	11
Funding	2	24	4	6	4	9
Collaboration	5	9	2	47	7	50

Discussion

In this study, students' mind maps were analyzed using multiple methods to assess their learning in a graduate-level AAC course. The purpose of the paper is to argue for using concept maps in CSD learning opportunities to organize and assess student learning. Concept map data analysis was presented and benefits and challenges will be discussed. Student knowledge that was represented visually on participants' maps will be discussed. Next, benefits and challenges of using, collecting, and analyzing mind maps, will be summarized so readers can consider how concept mapping, and mind mapping in particular, might be useful in their contexts.

Student Knowledge. It was not surprising that the size of the mind maps, represented by the number of concepts on the map, increased from the beginning to the end of the semester. This increase represents an increase in the breadth of the knowledge students acquired while completing the AAC course. It was also unsurprising that the structure of the mind maps, represented by the density of connections across concepts, improved from the beginning to the end of the semester. This increase in density revealed that the depth of students' knowledge had increased. Although these results were anticipated by the researchers prior to the start of the study, providing an opportunity for students to compare visual representations of the breadth and depth of their knowledge from the beginning to the end of the semester had a noticeable effect on students' perception of their change in knowledge as a result of completing the course. Anecdotal data will be discussed in the section that follows on benefits of using concept maps.

The qualitative themes were a bit more illuminating. By examining the themes that emerged frequently and infrequently, the instructor (first author) was able to identify the topics that were most and least interesting or memorable to the students. For example, it was intriguing that Populations of AAC users (2018-2020), Access (2018, 2020), collaboration (2019-2020), High Tech AAC Systems (2018, 2020) and No Tech AAC Systems (2018, 2020) appeared most frequently on participants' mind maps. More in-depth analysis revealed that while Populations remained the most common category of concepts represented on mind maps at both the beginning and end of the semesters, students' knowledge expanded to include many specific populations that they may not have considered as potential AAC users prior to the class.

Assessment, Intervention, and Funding concepts appeared less frequently, however, on participants' mind maps. This finding was particularly surprising, because assessment and intervention are major foci in the course learning objectives and thus, represent much of the content discussed and learned throughout the term. At least one-fourth of the in-class meeting time is dedicated to assessment, and even more is dedicated to intervention procedures, goals, and supports. In addition, students in these cohorts completed an assignment in which they wrote a funding report for a fictional client with amyotrophic lateral sclerosis (ALS) to obtain a high-tech AAC device.

Although data from qualitative coding of the mind maps revealed that participants' knowledge increased in each of these areas, there appears to be room for growth in teaching and learning around these concepts (i.e., assessment, intervention, funding)—or at least merits deeper assessment of these areas before making instructional changes. For example, asking students to generate mind maps specific to intervention with AAC users, or obtaining funding for high tech AAC devices, would further reveal students' knowledge in these areas.

Benefits and Challenges. From the instructor's (first author) perspective, the benefits of using mind maps to assess student learning far outnumbered and outweighed the challenges. First, prompting students to generate a mind map at the beginning and again at the end of the semester provided a visual way for students to compare their prior knowledge with the knowledge acquired and organized throughout the course. Anecdotally, many students were observed to make comments about how little they knew at the beginning of the semester, and how amazed they were to see that they know more than they realized about AAC at the end of the semester. Thus, in this instructor's experience, actively calling students' attention to their change in knowledge from the beginning to the end of the term has a positive effect on most students' confidence. It is impossible for students to learn everything there is to know about a particular topic in one course. When using mind maps in the future, the first author can envision providing students with individual or group feedback, or both, on their end of the semester map and using it as a reference point to set goals and take ownership over their continued learning beyond the completion of the course.

In addition, incorporating mind maps in the course provided the first author access to tangible data regarding the content students found most important at the end of the course as well as the gaps in students' knowledge. As compared to using an indirect measure of learning, for example reflections or perceptions data, using mind maps provided a more direct means of determining what students found to be important (Visconti & Ginsberg, 2024). By analyzing each cohort's maps, I was able to identify certain topics (e.g., Brands in 2018, Collaboration in 2019, and No Tech AAC Systems in 2020) that groups found particularly interesting or meaningful by evaluating patterns in the data. Across all three years, Populations of AAC users and Access appeared most frequently on mind maps, suggesting many students across cohorts found these topics to be important. Reviewing students' maps independently from the group provided insight into students' individual big takeaways.

On the other hand, it was disappointing for the first author to discover that some of the important content areas discussed frequently in the course did not appear frequently on students' mind maps. This finding led to stressing the importance of these topics in future iterations of the course, to approach teaching them differently, or to assess students' learning of these concepts differently. For example, in 2018, Collaboration was present on students' mind maps, but underrepresented when compared to other concepts. Because it is vital for students to consider with whom and for what purpose(s) they will collaborate when supporting AAC users, the first author made the pedagogical choice during the course offered in 2019 to share their own mind map around collaboration with students. This process is described in detail in (Sauerwein, 2021).

Upon reflection of implementing mind maps and analyzing that data for a scholarship of teaching and learning project, only one challenge comes to mind: time. Because the first author set out to systematically study and disseminate results of student learning, the research team engaged in in-depth, formal data analysis procedures. While it was time-consuming to complete these formal data analyses and prepare the data for presentation and publication, it would likely require less time to enter data and informally analyze maps for scholarly teaching purposes. Further, the instructor time commitment could be reduced by including students as partners in the inquiry process. In this study, the research team catalogued the mind map concepts into Excel semesters after students had completed the AAC course. Alternatively, after all students had generated their maps, instructors could ask students to enter their data on a cloud-based sheet or form. As a continuation of the learning activity, the instructor and students could work collaboratively to sort the data, run quantitative analyses, and uncover thematic patterns. This process would provide space for students to ask questions and for instructors to clear up any misconceptions or emphasize particularly important concepts.

Although it was interesting for the first author to explore her students' mind maps about AAC as the central concept, it may be more meaningful to use mind maps for more targeted, specific concepts such as access methods, collaboration as it relates to supporting AAC users, or intervention supports. To draw a parallel, asking students to develop a mind map centered around speech sound disorders may be less informative than asking them to map their knowledge of specific disorders (e.g., apraxia, phonological disorders) or intervention approaches (e.g., the traditional approach, minimal pairs, or the Cycles approach).

Overall, a big lesson learned is to dig deeper. In conversations with colleagues since completing this study, the first author has suggested that faculty and instructors ask themselves the following questions to determine concepts that might be ripe for mapping in their educational contexts. First, what concept(s) do your students struggle to deeply understand? Second, which concept(s) require your students to unlearn or challenge their prior knowledge? Third, for which concept(s) in the course is assessment particularly difficult or frustrating? The answers to these questions may be excellent entry points for utilizing concept maps.

Limitations. Because students' mind maps were analyzed after they had completed the course and academic program, participants were not available to the researcher to follow up to authenticate the data. Convenience sampling, rather than randomization, was prioritized in the study order to obtain a larger data set. Student researchers who assisted with data analysis had not participated in formal training on qualitative data. A peer debriefer with a research degree and qualitative research experience assisted with data analysis to counterbalance the students' minimal experience. The results represent the knowledge gained from 61 students who took one AAC course with one instructor. The results are not likely to generalize to all graduate students in CSD. Other students' concept maps would likely reflect their own learning experiences, as compared to those of students in the present study. In addition, other student learning artifacts were not collected for comparison in this study, which means the research team was unable to compare efficiency or effectiveness of mind maps to other assessment types. This is an important area for future study.

Future Directions. Mok and colleagues (2013) described the use of concept maps for CSD program-level assessment. Additional studies are needed that describe using concept maps in CSD learning opportunities, such as coursework or clinical practicum. Thus, future studies in CSD could explore a wide variety of topics in a wide variety of learning opportunities. Future work could build on the analyses reported here by analyzing patterns across groups. For example, in a future study, the data reported here could be further examined by grouping student participants who had supported a client who used AAC prior to the start of the study (i.e., start of the AAC class) and comparing their maps to students who had not done so. Future studies that investigate the use of mind maps in CSD could both explore more specific concepts and use additional analysis methods. For example, Cañas and colleagues (2013) described analyzing concept maps for correctness and relevancy, which is outside the scope of the present study.

Conclusion

Mind maps were useful in this study to reveal the depth and breadth of students' knowledge about AAC, as well as the concepts they found to be most important or memorable after completing the course. Analyzing the concepts for size, structure, and quality allowed the instructor to reflect on her teaching and to make meaningful changes in future course offerings. Reflection revealed more benefits to using mind maps than challenges. These benefits included increasing students' confidence, actively bringing students' attention to what they learned, providing insight into students' "big takeaways" from the course, and uncovering gaps in students' knowledge and/or areas to further assess. The major challenge was the time required to formally quantitatively and qualitatively analyze the mind maps from three cohorts of students; when using concept maps in scholarly teaching, however, instructors might engage students as partners to collaborate on data entry and review or analysis. Finally, be mindful to "dig deeper." Ultimately, prompting students to develop mind maps for more specific topics might be more helpful to uncover deeper learning.

This study adds to the existing literature that argues for the utility of mind maps in teaching and learning in CSD. As in the present study, instructors can use mind maps to uncover students' learning within a particular learning activity, such as a course or clinical experience. Faculty and instructors might use concept maps for program-level assessment, as was described by Mok and colleagues (2013). Finally, concept mapping can be a useful tool for instructors when designing or revising courses and other student learning opportunities. Amundsen and colleagues (2008) describe the process of drafting maps to conceptualize a course and provide examples of faculty maps from various stages in the process. Additional research is needed to advance the use of concept maps in CSD.

Disclosures

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