



## Visual Methods as a Window into Teacher Cognition and Technology Integration

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### Abstract

*While it is widely recognized that educational technology can enhance student learning and achievement, there are still questions about how to prepare teachers to make best use of these affordances (Kessler, 2021). Teachers' beliefs and knowledge play a vital role in how technology is integrated. Using teacher cognition as a theoretical framework and mind maps as a data source, this study examines the impact of a stand-alone CALL course on graduate teaching assistants' and undergraduate pre-service teachers' cognition in regard to teaching with technology. The results reveal highly variable cognitive development and represent a reorganization of pre-service teachers' views of technology for teaching second languages.*

**Keywords:** *Mind Maps, Teacher Cognition, Teacher Training, Computer Assisted Language Learning*

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### Introduction

There is widespread agreement among teachers, educators, and researchers regarding the capacity of technology to enhance learning (e.g., Brown & Warschauer, 2006; Chapelle & Sauro, 2017; Healey et al., 2011; Kern, 2006). Ultimately though, how technology is implemented determines if this potential is actually realized. In other words, teachers are central to the success of educational technology as “[they] and their beliefs dictate how students are taught, what they learn and the success and failure of any educational approach” (Lawrence, 2014, p. 60). The pivotal role teachers play in the success of technology-mediated learning (Kessler, 2021; Levy, 1999) underscores the importance of teacher training.

The ability to use technology effectively and appropriately is considered an essential skill for teachers of additional languages<sup>1</sup> (L2) (American Council on the Teaching of Foreign Languages, 2015; Healey et al., 2011). The recent swift pivot to online teaching during the pandemic underscored the necessity of these vital skills as all levels of instructors were impacted, including less experienced teaching assistants (Azaz, 2020). Computer-assisted language learning (CALL) holds great potential for L2 learning but there remains an “insufficient understanding of teacher knowledge about CALL, especially how pre-service teachers construct their own knowledge in learning to use CALL in teaching” (Sert & Li, 2017, p. 74).

World language departments play a pivotal role in preparing teachers to make effective use of CALL. This training often focuses on the immediate and well-defined needs of teaching assistants (TAs), who teach basic language courses and are “an integral part of the instructional staff” (Blattner & White, 2017, p. 352). Depending on the institution, CALL teacher education can also target students with somewhat

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<sup>1</sup>Throughout the article, we use the term L2 to refer to languages learned in the classroom and/or beyond and acknowledge that L2 could include not only second languages learned, but also third, fourth, etc. languages.

different needs, for example those in Masters in Teaching or TESOL (Teaching English to Speakers of Other Languages) programs. As a result, CALL courses, which remain a common format in world language departments, provide training for a diverse group of learners. The present study focuses on the CALL course as a way to provide CALL teacher education for learners from a variety of backgrounds. Using mind maps as a data source, it investigates learners' changes in teacher cognition in relation to technology use for L2 teaching.

## Review of Related Literature

Developing the ability to make effective use of CALL should start with the coursework graduate teaching assistants (GTA) and preservice teachers complete before they enter the L2 classroom. As the stand-alone CALL course remains a common format in the field of L2 teaching (see Son & Windeatt's collection of curricular reports on CALL courses, 2017), teacher educators and other stakeholders need to understand the impact of such courses, especially given the fact that there are other curricular options for technology training, such as integrating CALL teacher education into general methods courses (e.g., Honigsfeld et al., 2009; Sardegna & Dugartsyrenova, 2014).

### Teacher Cognition

The theoretical framework for the present study is teacher cognition, which has been defined as “the personal, unseen aspect of teachers' work” (Borg, 2019, p. 2), including knowledge, beliefs, feelings, perceptions, attitudes and thoughts, be they correct or incorrect. All of these factors shape how teachers teach (Borg, 2019). Teacher cognition aligns with a cognitive paradigm that “focuses on teaching as a way of thinking with a particular set of specialized knowledge and cognitive processes” (Russ et al., 2016, p. 396)<sup>2</sup>. and “seeks ... to understand teachers' minds and emotions and the role these play in the process of becoming, being, and developing as a teacher” (Borg, 2019, p. 20). We follow Kubanyiova and Feryok's (2015) larger vision of language teacher cognition, which does not focus on static, discrete mental constructs but on subjective, emergent sense-making.

Teacher cognition was chosen for two main reasons. As a superordinate term, teacher cognition provides a holistic perspective without the need to separate out factual knowledge from other, more subjective aspects like beliefs (Borg, 2019). Language teacher cognition research can illustrate “how language teachers process various knowledge, input, and contextual conditions cognitively” as they prepare for and make decisions in their teaching (Guo et al., 2019, p. 136). As argued by Ritzhaupt et al. (2016), parsing out the various components of knowledge might be especially difficult for technology integration. Furthermore, teacher cognition has been a popular framework in L2 teacher education research (Guo et al., 2019) to investigate a wide variety of L2 topics such as:

- teaching in general and the effect of mentoring, coursework and study-abroad (e.g., Cabaroglu & Roberts, 2000; Kang & Cheng, 2014; Karimi & Norouzi, 2017; Macalister, 2016);
- the teaching of specific skills, such as pronunciation (e.g., Tsunemoto, Trofimovich & Kennedy, 2020), culture (e.g., Maijala, 2020), writing (e.g., Worden, 2015), and grammar (e.g., Svalberg, 2015);
- specific teaching strategies, such as the use of learners' first language (Miri et al., 2017) and CALL (Schmid & Hegelheimer, 2014);
- the role of critical reflection in CALL teacher education (Chao, 2015).

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<sup>2</sup>Several frameworks for conceptualizing teacher learning fall within this cognitive paradigm. One of the most influential ones has been Shulman's pedagogical content knowledge framework (Abell, 2008; Shulman, 1986). Building on Shulman's model, Mishra and Koehler (2006) proposed technological pedagogical content knowledge (TPACK), describing a dynamic relationship between content, pedagogy and technology (Voithofer & Nelson, 2020).

However, as pointed out by Paesani (2020), few studies have examined “teachers’ cognition, conceptual development, personal histories, and the like as they learn how to teach language online” (p. 294), instead focusing on teachers’ uses of specific tools in their teaching. Since technological tools develop and change rapidly, it is necessary to encourage teachers to critically reflect on how they might most effectively assess and integrate technology into their teaching as well as how it fits into their own teaching contexts and beliefs (Chao, 2015).

Several cognitive processes contribute to changes in teacher cognition and can ultimately lead to changes in teaching (Guo et al., 2019). One such process is the addition of new knowledge, which plays a central role especially for preservice teachers (Russ et al., 2016). Later on, this new knowledge can be modified, fine-tuned or built on. During the entire learning process, teachers play a central role “as active thinking and feeling agents in their own development” (Kubanyiova & Feryok, 2015, p. 437).

As illustrated above, there is a considerable body of research on L2 teacher cognition, an important focus of teacher education programs (Russ et al., 2016). However, given the overall paucity of research on CALL teacher education (Kessler, 2021), it is not surprising that few studies use the framework of teacher cognition to investigate how L2 teachers learn to use technology in their teaching. The current study contributes to the research both on CALL teacher education and L2 teacher cognition by analyzing mind maps and their accompanying narratives completed by pre-service teachers at the beginning and end of a CALL course.

### **Methodological/Research Approaches**

Research on teacher knowledge has relied on a wide variety of data sources, including: interviews (e.g., Adams, 2005; Brown & Warschauer, 2006; Kang & Chen, 2014; Shah & Foster, 2015), surveys (e.g., Brown & Warschauer, 2006; Cherner & Curry, 2017; Meschede et al., 2017; Saiful, 2019; Shah & Foster, 2015; Tsunemoto et al., 2020; Willis & Cifuentes, 1997), observations and stimulated recalls (e.g., Akapame et al., 2019; Brown & Warschauer, 2006; Cherner & Curry, 2017; Kang & Chen, 2014; Siaful, 2019; Svalberg, 2015; Willis & Cifuentes, 1997; Worden, 2015), and reflections (e.g., Marra, 2004; Sert & Li, 2017; Svalberg, 2015; Worden, 2015).

Similar data has been used with the teacher cognition framework in particular. As pointed out by Borg (2012), visual methods such as photo-based interviews and drawings have potential to research teacher cognition but are rarely used. In 2019, Borg reiterated his support for “innovative approaches which take inspiration from ... visual traditions” (p. 9). This aligns with the recent visual turn in research methodologies in the field of applied language studies (Kalaja & Pitkänen-Huhta, 2018).

To our knowledge, the only L2 teacher cognition study that employs visual data is Borg et al. (2014), which relied on drawings with interpretive commentaries. Preservice L2 teachers were asked to draw a successful lesson before and after taking a teaching methods course, an activity that “had formative value – encouraging trainees to reflect on their beliefs – as well as empirical value as a source of data collection for research purposes” (p. 18). Based on the drawings, written commentaries, and interviews, no substantial changes to the participants’ beliefs were found, however there was growth that mirrored the course material. Participants tended to maintain their existing beliefs, while possibly expanding them, rather than changing them substantially (Borg et al., 2014).

The present study also relies on visual data to investigate teacher learning. Unlike Borg et al. (2014), however, it uses mind maps, that is diagrams with hierarchical structures showing relationships between ideas (Davies, 2011). In a variety of disciplines, mind maps have been used not only as research tools for analysis (Farrell, 2009; Hay et al., 2008; Kinchen, Hay & Adams 2000; Somers et al., 2014) but also as learning and teaching tools (Budd, 2004; Dhindsa et al., 2011; Erdem, 2017; Radix & Abdool, 2013; Seyihoglu, 2013). Hay (2007) categorized mind maps into three groups: (1) deep (or meaningful) learning, which showed newly learned concepts linked to prior knowledge, (2) surface (or rote) learning, where new concepts were added but not integrated, and (3) non-learning, in other words no reorganization of conceptual structures. This distinction is based on research in the learning sciences, which showed that,

unlike surface learning, deep learning enables a learner to make creative use of knowledge (Sawyer, 2022). Hay (2007) argued that mind maps enabled him to “measure and typify the quality of learning” (p. 52), which was also a goal of the current study.

Due to their graphic nature, mind maps provide a visual representation of teacher cognition. They enable “clear identification of superficial understanding” and “reveal the structure, organization, and elaboration of understanding” (Hay & Kinchen, 2006, p. 130). Because each student’s map is unique to them, it provides a window into their own mental model and reflects their personal experiences and beliefs as they relate to their understanding of the new material (Kinchin, Hay & Adams, 2000). This flexibility allows mind maps to capture various aspects of teacher cognition and development, including subjective beliefs and factual knowledge.

To our knowledge, the only study using mind maps to investigate L2 teacher learning is Farrell (2009). It is not, however, explicitly grounded in teacher cognition as a theoretical framework. In that study, on the first day of their methods course, seven preservice teachers for English as a second language (ESL) drew a mind map focused on the question “What does teaching ESL mean to you?”, followed by a peer group discussion. This activity was repeated at the end of the course, at which time students also compared both maps. Like Borg et al. (2014), Farrell concluded that using visuals to tap into beliefs and other aspects of teacher knowledge has value as a learning, teaching and research tool.

The present study relies on mind maps, a relatively new data source, and uses teacher cognition as a framework. Given its exploratory nature, it focuses on the following research question: How does a stand-alone CALL course affect the teacher cognition of pre-service L2 teachers, including GTAs, in terms of their attitude towards CALL, familiarity with tools and apps, and ability to connect technology to pedagogy?

## Methods

### Participants

Twenty-five students in CALL courses at two different large public North American universities took part in the study. At University 1, there was a total of seven students: five in the Masters in Teaching (MAT) program, one undergraduate in the teacher certification program, and one student pursuing a PhD in linguistics. The course is required for students in both teacher certification programs and the MAT students normally also work as graduate teaching assistants in their language of study. At University 2, 18 students were enrolled in the course. Thirteen students were taking the course as an elective for an M.A. in TESOL and the remaining five were undergraduate TESOL certificate students. Prior to enrolling in this course, all but one student had taken at least one teaching methods course. They had varying degrees of teaching experience, including some students without any experience. Some students were teaching that term, either as teaching assistants or as part of a teaching internship.

Both courses followed a similar curriculum: they used the same textbook and included the same assignments (refer to [Appendix A](#) for information about the curriculum). In order to broaden their access to perspectives and teaching contexts, the learners from both classes collaborated on a semester-long project. They were put into four-person groups with representatives from both universities and worked together on a curriculum project focused on the teaching of a specific skill. After sharing information from readings they found about the use of technology for their assigned skill, students individually developed a curricular unit. Group members then provided peer feedback.

In addition to the curriculum design assignment, students set personal learning goals at the beginning of the term and worked towards meeting them each week. Based on their career goals, strengths and weaknesses, they first chose one or two goals from the TESOL Technology Standards (Healey et al., 2011) or the International Society for Technology in Education (ISTE) Standards (ISTE, 2021) (ISTE, 2021). During the next seven weeks, they explored resources to further their goals and blogged about their findings.

Students followed teachers on Twitter, for example, tested and researched new technological tools and apps, searched for videos and podcasts, and found websites that could be useful in their teaching. In their final post, they reflected on how successful they were at reaching their goal(s). Ideally they were creating their own community of practice for their future careers as L2 instructors. As part of this goal setting assignment, they also completed mind maps, once at the beginning of the term and once at the end, to synthesize their knowledge of CALL. Having the visual representation of their ideas before and after taking the course allowed students to consider how their ideas had evolved and what they still needed and wanted to learn, especially after reflecting on the comparison between the two maps (Farrell, 2009). Students were encouraged to read and comment on their classmates' blogs throughout the process but were not required. It was hoped that they would share the research they conducted on sites, apps, etc., with their classmates, thereby giving everyone access to more information than they would have had alone.

We were the instructors of the course and had intermittently taught the CALL course at our universities for 15 years. Our primary research interest is CALL and we share a philosophy for CALL teacher education which de-emphasizes specific tools and instead aims to develop transferable skills by rooting the class in second language acquisition and L2 pedagogy. We encourage preservice teachers to locate and, more importantly, evaluate applications that would be most relevant for their future teaching contexts and learning objectives, as well as how they can best integrate these applications into their teaching philosophies and classroom pedagogies in order to future-proof their CALL training to the extent possible (Hubbard, 2021). Central to our approach to the CALL course were assignments where students analyzed and applied information from the readings, participated in hands-on activities (e.g., technology demos, collaborative tasks), and designed activities, lesson plans, and curricular units.

### **Mind Maps**

After analyzing examples together, students were asked to use software to draw their first mind map addressing the question: How do you see the role of technology for L2 learning/teaching? They were told that the map should reflect their personal views and that there was no right or wrong answer. They were also required to include a text description of the main views reflected in the map. At the end of the term, upon completion of the course, students drew a new concept map without reviewing their first map to address the same question. They then analyzed the key differences between the two maps.

### **Data Analysis**

Mind map studies have conducted their analyses in a variety of ways, including content analysis (Aydin et al., 2017; Baumann, 2018; Farrell, 2009; Hay, 2007; Radix & Abdool, 2013; Somers et al. 2014), structural analysis (Kandiko et al., 2008; Kinchen & Hay, 2000; Hay & Kinchin, 2006; Radix & Abdool, 2013), and dimensionality analysis (Lim, 2011). For this exploratory study, we conducted several types of content analysis (Farrell, 2009; Hay, 2007; Somers et al., 2014). The first step in the quantitative and qualitative analysis focused on tone and the connections between technology and teaching/pedagogy. These categories were then used to determine how the mind maps changed. We carefully examined how the maps changed holistically, whether they integrated technology and pedagogy, including terms and topics from class, or if students were unable to successfully integrate the topics. Unlike some studies (Baumann, 2018; Radix & Abdool, 2013; Tan et al., 2017), the mind maps were not scored as right or wrong, which reflects our view of teacher cognition as subjective.

Next, we compared the first and second mind maps by identifying similar topics between them to assess changes in students' knowledge. Similar to Hay (2007), we made a list of each word listed in the maps and categorized it as retained (present in both maps), deleted (present in the first map but not the second), or added (not present in the first but in the second). The words were then grouped inductively into 16 different themes (see [Table 1](#)). We each coded all mind maps separately in the categories of structure, tone, cohesiveness, main theme, and connection between technology and teaching, discussed our findings together, and then came to a consensus for each. For the identification of the topics, we each assigned categories to three of the learner's lists of terms (in their mind maps), discussed our findings, and then

coded two more in order to reach an interrater reliability of 85%. The remaining maps (75%) were then coded by one researcher. Using this data, we were able to organize pre-service teachers' mind maps into categories of (1) deep learning, which showed newly learned concepts linked to prior knowledge, (2) surface learning, where new concepts were added but not integrated, and (3) non-learning, no reorganization of conceptual structures, the same categories used by Hay (2007).

**Table 1.** *Change in tone from map #1 to map #2*

<b>No change: Neutral</b>	<b>No change: Positive</b>	<b>No change: Balanced</b>	
9	5	4	n = 18
<b>Change: Balanced &gt; Neutral</b>	<b>Change: Positive &gt; Neutral</b>	<b>Change: Neutral &gt; Positive</b>	<b>Change: Balanced &gt; Positive</b>
3	1	2	1 n = 7

<sup>a</sup> balanced refers to maps that included positive and negative aspects of CALL about equally.

## Results and Discussion

### Mind Map Holistic Analysis

The overarching goal of the study was to focus on changes in teacher cognition, especially the degree to which new information was integrated with existing knowledge (as opposed to merely adding fact-like knowledge) (Russ et al., 2016). The first analysis compared the tone and the integration of pedagogy and technology in the first and second mind maps. Tone refers to any positive, negative, or neutral attitudes expressed by the participant, which are part of teacher cognition (Borg, 2019).

Eighteen participants did not change the tone of their maps (see Table 1), while seven did change. It is interesting to note that even after they learned more about the possibilities of CALL, most participants maintained their tone, indicating perhaps that the stand-alone CALL course had a limited effect on the overall attitude of these preservice teachers. Among the few cases showing a shift, there was an equal number of more positive and more neutral attitudes. Only one participant became less positive and no one developed negative attitudes. Previous research has also documented different effects of coursework on belief development, including gradual changes like the ones evident in some of our participants (e.g., Cabaroglu & Roberts, 2000).

After the analysis of the maps' tones, we categorized the maps into three types based on an inductive analysis of each map: 1) maps that fully integrated technological tools, CALL, and pedagogy; 2) maps that mentioned tools and pedagogy, but did not describe how they intersect or inform each other; and 3) maps that did not show an understanding of CALL or technology in the L2 classroom. Since all but one student had previously taken at least one teaching methods course, this analysis is evidence of the different types of learning likely triggered by the CALL course. Below, we discuss three cases in more detail, one from each of the three categories.

#### 1.1. Case #1: Bryn

Bryn is an example of a pre-service teacher whose second mind map was integrated. She was a second-year graduate student in the Masters in Teaching program at University 1 and a GTA. During her first year in the program, she took two L2 pedagogy courses (one focused on college-level teaching and another on the K-12 setting) and worked in the language computing center. Bryn took the CALL course during her fourth semester in the program. The previous semester, she had taught beginning Spanish for the first time at

University 1 and interned for 20 hours each week with two different teachers in a K-12 setting. During that internship, she also taught four lessons on her own, under the supervision of her cooperating teacher. While enrolled in the CALL course, she conducted her student teaching: she began the semester observing a teacher and then slowly transitioned to take over all of the beginning and intermediate high school Spanish courses.

In Bryn's first mind map (see Figure 1), the branch labeled 'positive' seems to reflect Bryn's positive attitude towards CALL. She clearly had ideas about how technology could enhance an L2 class but was not familiar with any specific tools to facilitate that learning. Her second map, shown in Figure 2, on the other hand, references specific L2 learning outcomes and strategies, such as input, student-centered, and learning styles, and aligns those with specific tools. Bryn chose pedagogical ideas from the course and possibly her experiences in the L2 classroom and then integrated apps and tools into those themes. These connections demonstrate that Bryn, at least at a theoretical level, is beginning to connect pedagogy and tools which could serve as a basis for creating a coherent, technology-mediated lesson driven by learning outcomes. Bryn's past and concurrent experiences in L2 classrooms likely helped to inform how she could apply these new applications, which facilitated her integration of tools and pedagogy.

Figure 1. Integrated mind map 1 (Bryn)

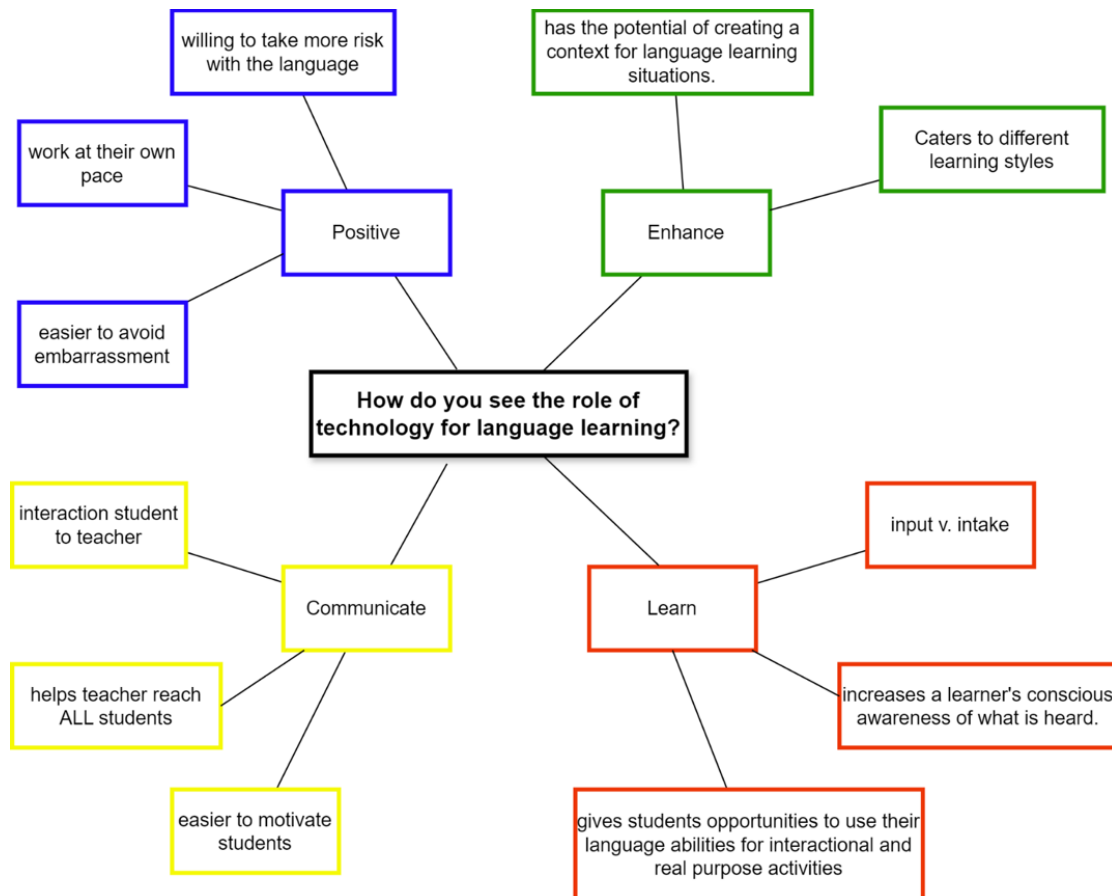
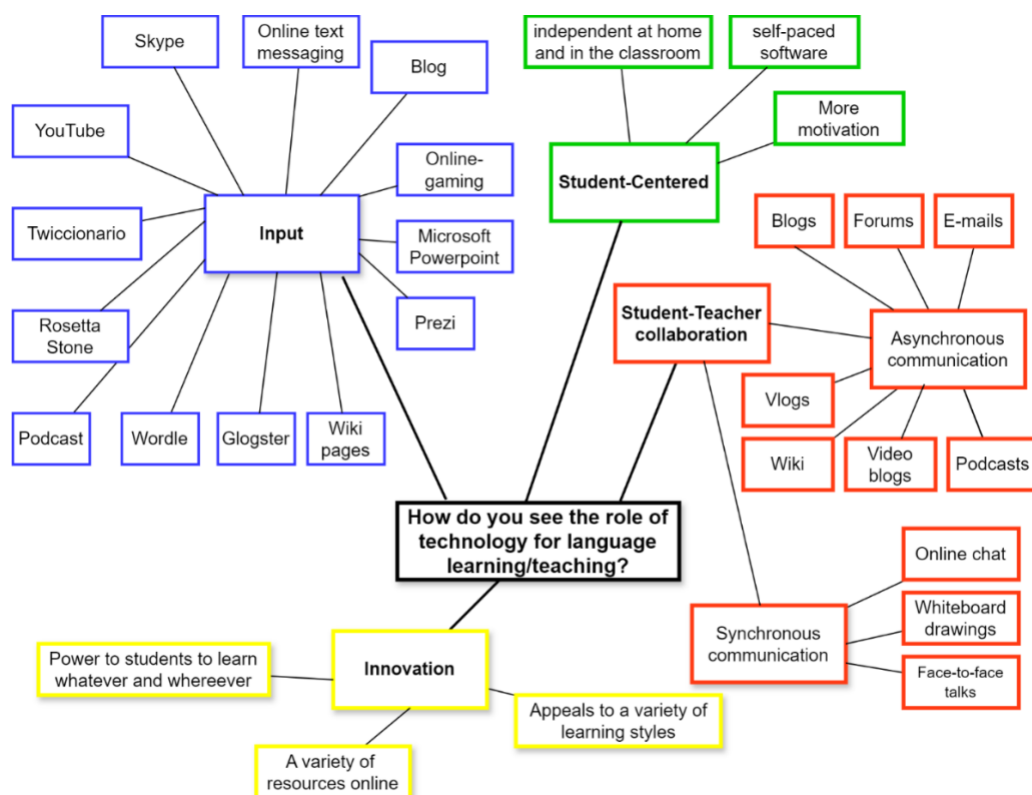


Figure 2. Integrated mind map 2 (Bryn)



In her written comparison of her mind maps, Bryn noted how different they were and commented that “the ideas we had four months ago are now branched with specific terms that now make sense.” She discussed the role of input in L2 teaching and how YouTube, chatting, and word clouds can provide comprehensible input. She also noted that she had not previously considered the student-centered aspect of teaching, something she now views as an important component of student autonomy. It appears that the CALL course, combined with her student teaching, triggered a change in her general teaching philosophy. For example, she notes that student-teacher collaboration is facilitated through asynchronous and synchronous communication, which was not mentioned in the first map. Bryn concludes the description of her map noting that “CALL has broadened my perspectives on teaching and technology and as a teacher I will be sure to take these and implement them to yield successful results in my classroom,” a statement that suggests shifts in her teacher cognition. The comparison between her two mind maps indicates that she has not only broadened her view of pedagogy in general, but also that she can identify ways that CALL can meet her L2 learning goals for her students.

The other eight pre-service teachers with integrated second mind maps were also able to intertwine specific examples of technological tools and apps with pedagogical goals. Several participants organized their maps according to types of learning or pedagogical purposes (e.g., scaffolding, feedback, collaboration), and then listed specific tools or apps under the corresponding branch. Another participant organized their mind map according to the research on each tool and connected tools with pedagogical goals or tasks, demonstrating that they had made connections between the two. Participants in this category exhibited a deeper understanding of the relationship between technology and pedagogy than the other participants: they understood the importance of connecting the pedagogical benefits and drawbacks of a tool or app to learning outcomes (the objective-driven approach promoted in both CALL courses) and then demonstrated that they knew what those are.

## 1.2. Case #2: Ted

Ted's mind maps fall into the category of non-integrated. Unlike Bryn, Ted was enrolled in the post-baccalaureate TESOL certificate program at University 2. He had taught English in Korea for two years and then at two local private language schools. Because of his almost three years of domestic and international L2 teaching experience, he was allowed to take the CALL course before the program's first teaching methods course.

Ted's second map had not fully integrated pedagogy and CALL. Although it retained its overall structure, the second version does include more nodes. In the first map, the main organizing themes were face-to-face instruction and how technology aids in L2 learning (see Figures 3 and 4). For the second map, Ted used the roles of tutor, medium, and tool (Kern, 2006) as a way to organize his nodes. This framework was covered in the course and Ted was one of six students who referenced it in their second maps. The fact that the tutor-medium-tool framework served as the organizing theme of his second map indicates that the CALL course provided Ted with a new way of thinking about CALL.

In the second map, Ted mentioned a few broad CALL terms and tools (e.g., asynchronous - asynchronous, smartboards), but most of his references had nothing to do with CALL or even pedagogy, for example 'homework' and 'supplemental worksheets'. In his comparison of mind maps 1 and 2, Ted noted that he "tried to simplify this concept map into 3 umbrella categories directly feeding into language learning: tutor, medium, tool." From this map though, it is unclear if he understands the meanings of these terms or their connection. He did acknowledge, however, that in his attempt to keep his map readable, "oversimplification has led to the omission of some concepts and terms." Ted noted that learning about CALL has "changed [his] idea of how an ESL classroom should look" because he had not focused on using technology in the past. After learning more about it in the CALL course, he even implemented asynchronous computer-mediated communication into his teaching and believed that an ESL classroom should be "less teacher-centered and much more student-centered" with "less emphasis on lecture." It is noteworthy that both his maps have a very neutral tone and do not include any words with any obvious positive or negative connotations. Unlike Bryn, for example, who included an entire branch labeled 'positive' in her first map, Ted's maps include neutral terms such as 'classroom' and 'feedback'. In his reflection, however, he did point out that he has changed his perspective on the importance of integrating technology into the ESL classroom.

Figure 3. Non-integrated mind map 1 (Ted)

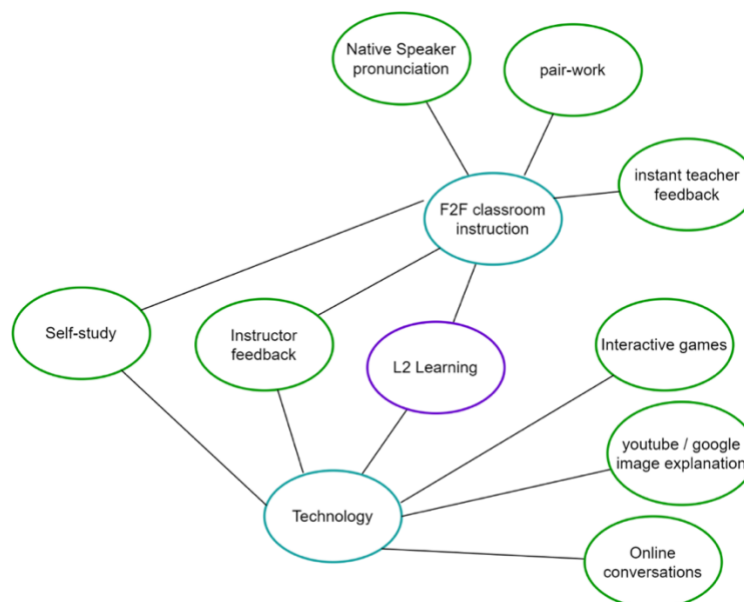
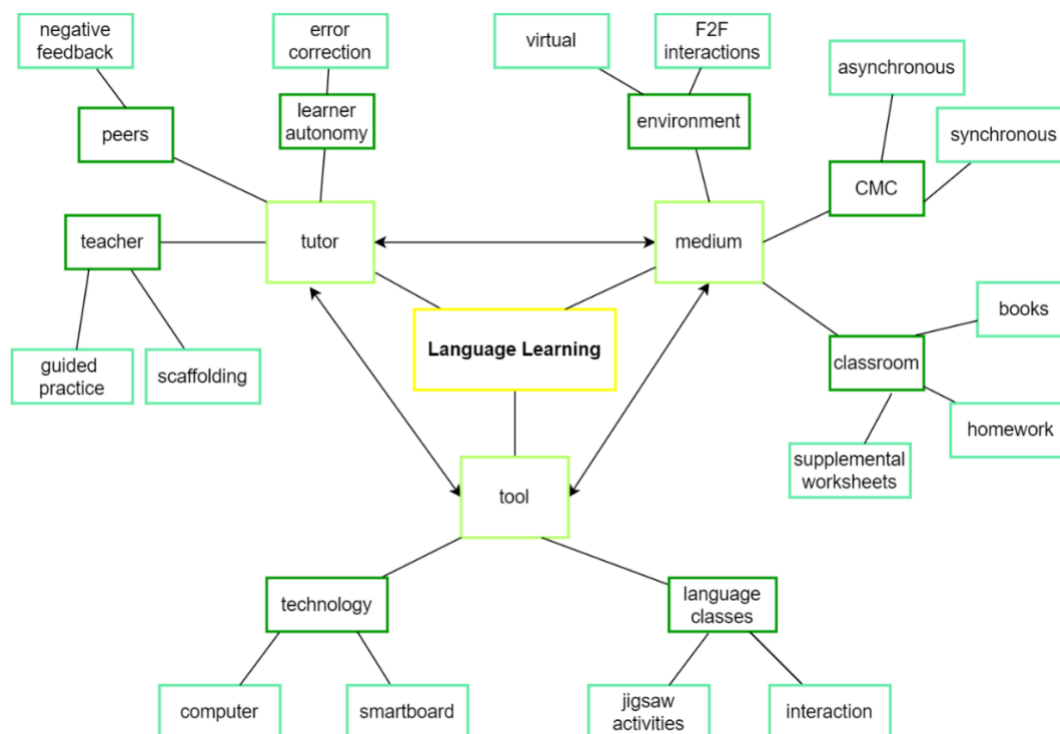


Figure 4. Non-integrated mind map 2 (Ted)



Just like Bryn, Ted's experience speaks to the value of concurrent coursework and practice teaching, a curricular model of teacher education for which Dawson et al. (2003) and others have advocated. He hopes to continue to learn how to integrate CALL in order "to promote learner autonomy both in and out of the classroom." From his comments, it seems Ted had much to learn in regard to both pedagogy and CALL, which could explain why he was not yet able to integrate the two fully. While he values CALL and student-centered learning, the next step will be to learn and practice ways to leverage CALL to insert more student-centered tasks in his teaching. Overall, Ted's maps suggest limited cognitive change, but openness to learning and applying new techniques.

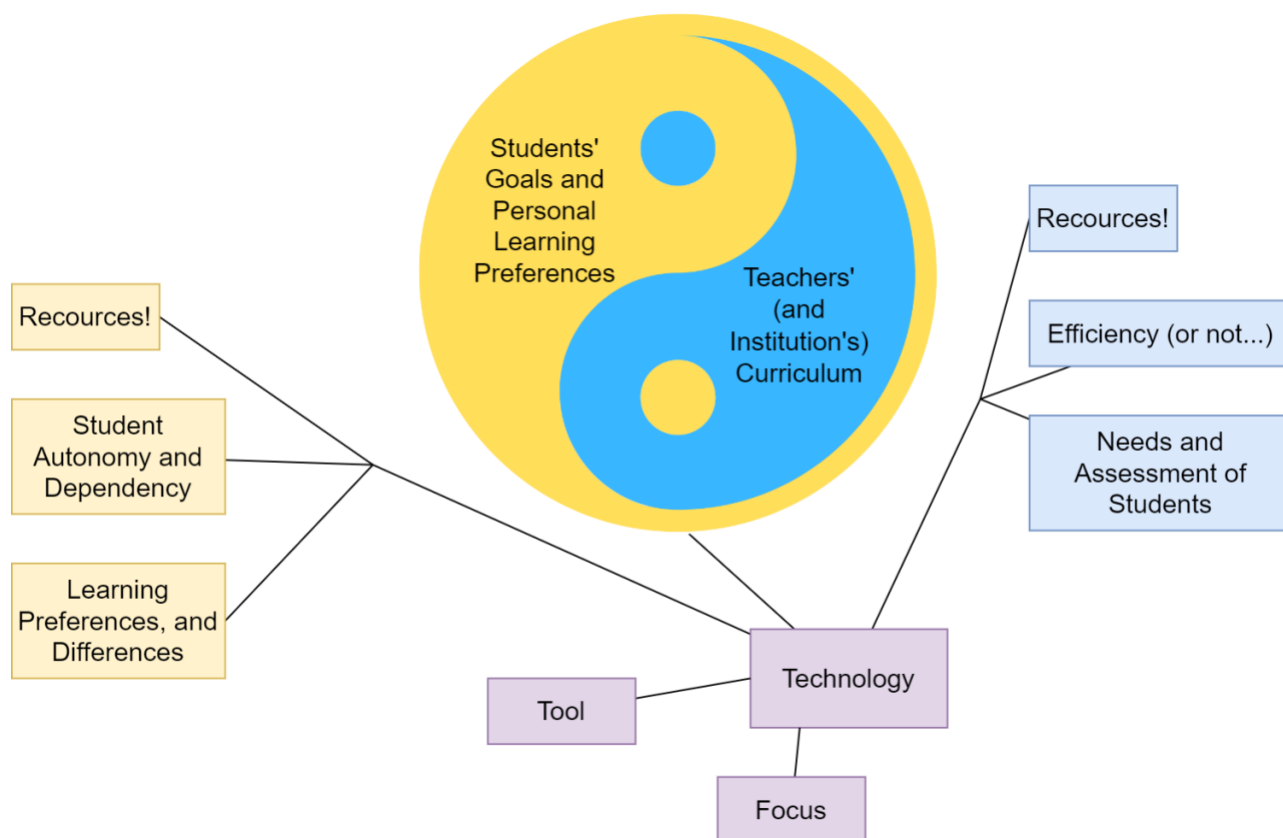
Of the 12 participants who, similar to Ted, did not make connections between pedagogical and technological tools, most merely mentioned newly learned tools, but did not consider their pedagogical implications. Some included both L2 learning and technology into their maps but did not connect them. They included tools or apps and terms related to topics such as writing, reading, culture, and input/output, but did not show how the two overlap. A few participants mentioned the computer as a tool, tutor, or medium (Kern, 2006), but without any references to technology (e.g., specific tools). These pre-service teachers demonstrated that they had learned new material in the course but had not yet integrated those tools into their existing knowledge about L2 teaching. Perhaps once they experience these tools in use in a classroom or apply them during their own teaching, they will be able to more easily integrate them into their pedagogical toolbox.

### 1.3. Case #3: Alissa

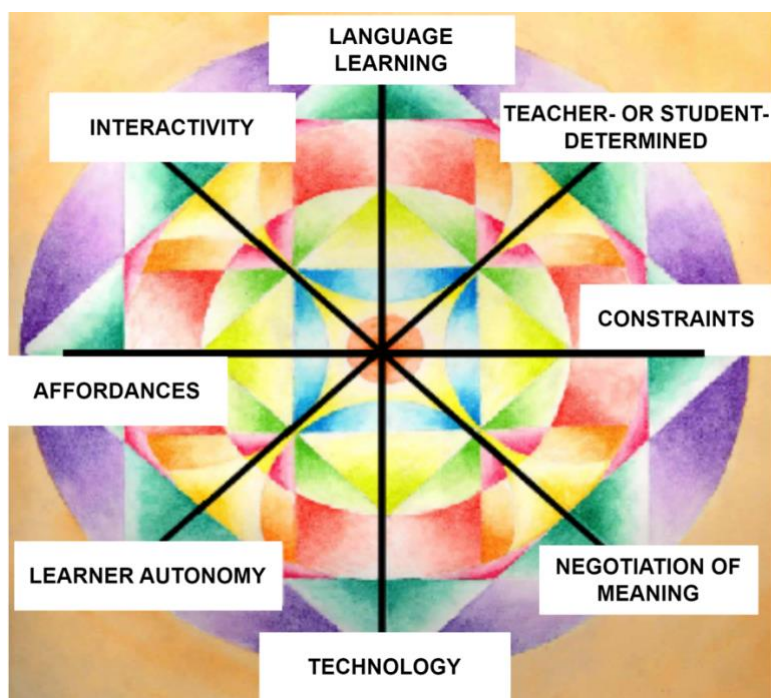
Alissa's mind maps demonstrated no examples of the integration of technology and pedagogy. Like Ted, Alissa was a TESOL certificate student at University 2. The term prior, she had completed the first methods course and was enrolled in the second methods course concurrently with the CALL course. She did not have any prior teaching experience. Alissa completed three maps: one at the beginning of the term and two at the conclusion of the course. She mentioned in her reflection that she chose to include the third map to demonstrate how she anticipated her path going forward.

Alissa began the semester with, as she described, a “hazy idea of what CALL could be.” Her “previous experience in working with technology as a second language learner had not been positive, and [she] struggled to visualize what affordances exactly technology could offer.” This conflict is evident in [Figure 5](#), her first mind map, where she used vague terms when referring to technology and did not clearly link tools to teaching. Although her second map (see [Figure 6](#)), which looks more like a mandala, does not mention specific tools or pedagogical goals, it is beginning to acknowledge the relationships between technology and language learning, including its affordances and constraints. Alissa even notes that she has a “more holistic, bird’s eye view of CALL” and recognizes that her ideas “will continue to evolve, dissolve, or begin totally anew”. This de/reconstruction of ideas is represented in her third concept map (see [Figure 7](#)), which looks more like a painting and includes no words. A third map was not required, and she was the only student who chose to include it to further illustrate her thoughts and how murky the concepts still were to her. This third, final map seems to anticipate a period of disjuncture where new information is irreconcilable with prior knowledge (Hay et al., 2008). Although Alissa did not include any specific apps, tools, objectives, or pedagogical strategies in her second map, she feels she is beginning to recognize the advantages of CALL and anticipates her ideas will evolve as she begins to implement some of these tools.

[Figure 5](#). No technology mentioned mind map 1 (Alissa)



*Figure 6.* No technology mentioned mind map 2 (Alissa)



*Figure 7.* No technology mentioned mind map 3 (Alissa)



Similar to Alissa, five other participants did not mention technology in their mind maps and seemed unable to integrate pedagogy and technology. As new members of the teaching profession to whom both topics were relatively new, it is possible that they could not yet consider how technology and pedagogy intersect before establishing a deeper understanding of each topic on its own.

As our analysis has shown, mind maps are an effective way to visualize changes in teacher cognition and view the process in which new information is (or is not) integrated into existing knowledge (Kinchin et al., 2000). Similar to Hay (2007), we found examples of deep learning, surface learning, and non-learning (Sawyer, 2022). The majority of students fall into the second category: twelve students focused on either apps or pedagogy but did not merge them, which indicates surface learning (Hay, 2007). Despite engaging in hands-on activities using new apps and applying them to teaching various skills, these pre-service teachers demonstrated they had learned new information about tools or pedagogy but were unable to integrate the two. Another category of mind maps suggested little or no learning as these five participants did not exhibit an understanding of CALL or pedagogy in the L2 classroom and certainly did not integrate the two. Eight students showed evidence of deep learning because they were able to connect the topics of tools, CALL, and pedagogy. These participants were able to integrate their new knowledge of tools and CALL into their prior knowledge of L2 pedagogy to show how they would apply all three in their lessons. In fact, Torsani (2016) has argued that CALL teacher education's "main objective is to develop in teachers the knowledge of the technological options available and the ability to combine them with their knowledge of language teaching" (p. xvi), just like these pre-service teachers were able to do. While not all pre-service teachers achieved deep learning, it is hopeful that the course laid a foundation that these pre-service teachers can build on as they apply CALL in their classrooms and explore new tools and apps (Russ, Sherin & Sherin, 2016).

## 2. Content Analysis

In addition to a holistic analysis of changes, we also performed an inductive analysis of the terms that were added or deleted from mind map 1 to 2, similar to Hay (2007) and Farrell (2009). As is evident in [Figure 8](#) below, students mentioned many more tools and apps in their second mind maps (e.g., Reddite, Voicethread, Duolingo). They also referenced more learning outcomes (e.g., literacy, communication, reading comprehension), and categories of CALL, including in/out-of class, synchronous/asynchronous, or mobile (see [Table 2](#) for a list of categories and examples). Similar to the findings of Sert and Li (2017), the participants in our study also found that CALL enhances authenticity in the classroom due to its easy access to apps, tools, and authentic materials. While motivation was another advantage listed by Sert and Li, it was not explicitly noted in the added words, but did come up in the category of additional benefits. Topics that extend beyond the classroom (i.e., the digital divide, and social justice concerns) were deleted more often than added in mind map 2.

[Table 2.](#) *Coding scheme of the inductive content analysis*

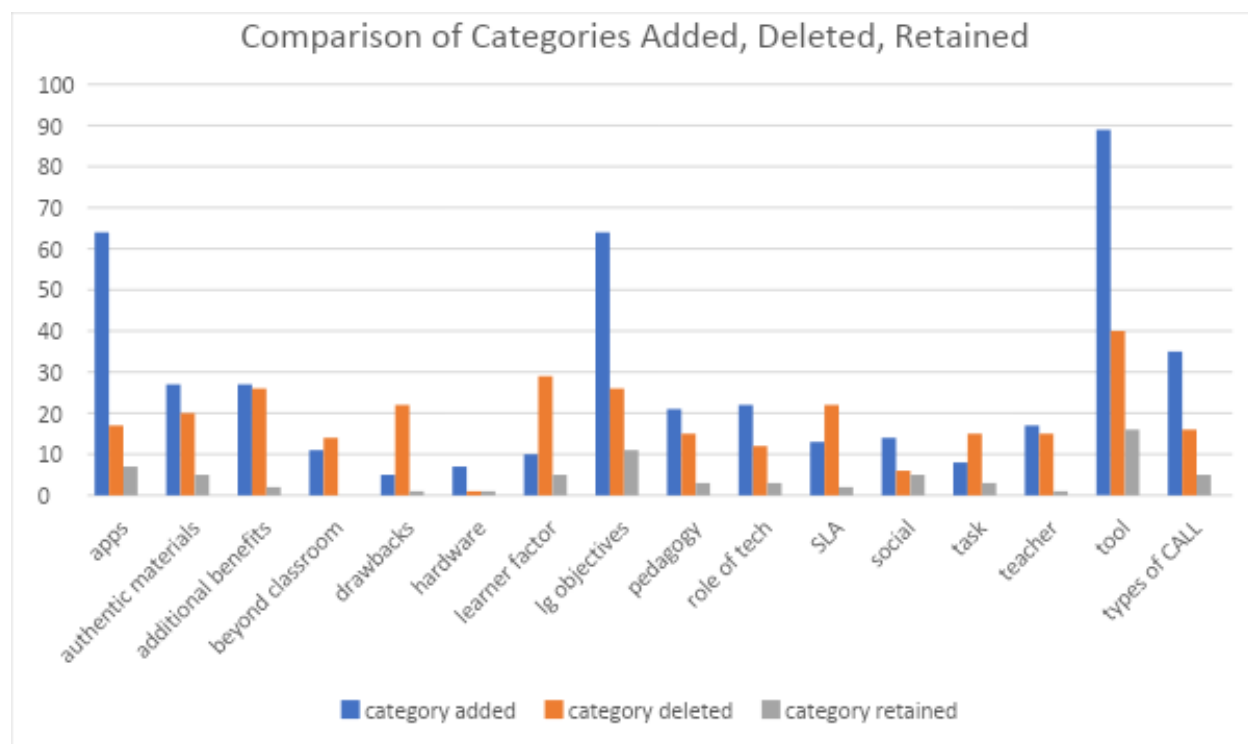
Category	Description	Examples
Role of Technology	General purposes for using technology	Tutor-tool-medium, assessment, feedback, input, output
Frameworks/Theories	Concepts from second language acquisition and learning theories	Constructivist, socio-cultural
Types of CALL	Broad categories of CALL	In-class, out-of-class, mobile Synchronous-asynchronous
Type of Tech	Different types of devices	Tablet, computer, smartboard

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Tools	General technological tools	Blogs, corpus, flashcards, social networking, online dictionary
Apps (interactive)	Brand names of specific interactive applications	Duolingo, Reddit, Skype, YouTube
Authentic Materials	Authentic materials used for consumption	TED talks, videos, music, podcasts
Tasks/Assignments	Activities students complete	Presentation, jigsaw, pairwork
Learner Factors	Individual learner factors	Motivation, identity, autonomy
Social Factors	Factors referring to the social nature of learning	Collaboration, community, social connections
Beyond Classroom	Important issues related to technology outside the classroom	Social justice, digital divide
Teacher (teacher-centered)	Topics that pertain to the teacher	Professional development, evaluations, lesson plans
Pedagogy	Student-centered pedagogical issues	Student-centered, scaffolding
Language learning outcomes	Learning objectives	Reading comprehension, genre awareness, communicative competence
Additional Benefits/Outcomes	Benefits of CALL	Inclusion, affordances, positive affect, provide context
Drawbacks	Negatives of CALL	Gizmos, distraction, time waster, cost, frustration

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Figure 8. Comparison of categories added, deleted, and retained



As these pre-service teachers became more familiar with concrete examples of CALL, their ability to imagine how they would use it in their own teaching increased and was no longer based as much on their knowledge of technology outside the classroom. Learner factors, tasks, and references to concepts from second language acquisition and learning theories (e.g., sociocultural and interactive theories) were also often deleted. Students were likely more tuned in to these categories at the beginning of the semester when they had recently been in other methods classes but concentrated more on technology after this course. It could be that these pre-service teachers were more concerned with how they would apply the new tools than the tools' influence on student learning, which would match the common focus of beginning teachers on themselves (Meskill et al., 2002). It was, however, encouraging to note that many students deleted the drawbacks they mentioned in the first map (e.g., distraction, waste of time), a possible sign of increased comfort with technology and a positive change in attitudes. Positive or negative attitudes can influence practice in the classroom (Borg, 2019), so these pre-service teachers could now be more likely to integrate technology. Perhaps some of their concerns about technology were allayed as they gained more confidence.

The increased mention of specific apps in the second maps, such as Duolingo, indicates the impact of the class: While the readings and discussions did not focus on specific apps, but rather on the process of finding and vetting them for various classroom contexts and evaluating their effectiveness, students explored apps during in-class activities, in their collaborative curriculum project, and for lesson plans they wrote. They also regularly came across apps and tools while working on their personal learning goals and learned from their classmates as they read each other's blog posts and commented on them. Research has shown that pre-service teachers often hope to learn about specific tools in a technology course (Gronseth et al., 2010; Wilson et al., 2020), which these results also suggest.

Looking at the second maps, the category of learning outcomes also had a large increase. This result suggests that as students gained knowledge about tools and apps, they were able to relate them to specific language objectives, which we also noticed in the more holistic view of the maps. Both CALL classes stressed the importance of objective-driven uses of technology, an approach reflected in those mind maps.

There were a few categories with a similar number of additions and deletions, including authentic materials, additional benefits, pedagogy, and the teacher. There do not seem to be any clear patterns in these categories, but participants' inclusion or deletion of specific categories likely depended on their previous coursework and teaching experiences. We had hoped for more mentions of pedagogy, but as mentioned above, not all participants were able to connect technology to pedagogy. There seemed to be small gains in participants' understandings of hardware, the role of technology in the classroom (e.g., assessment, instruction), the social aspects of CALL, as well as the types of CALL, which are all aspects of CALL to which these pre-service teachers had likely not previously been exposed.

Judging from the terms they included in their second maps, it seems that these pre-service teachers became more aware of tools and apps that can be applied in the classroom as well as how to leverage them for certain L2 learning objectives. Participants were more familiar with the various types of CALL by the end of the term as they were able to fit these terms into a larger, still developing, framework of CALL. They seemed less concerned with drawbacks but just as aware of the benefits. The topics raised in their mind maps could have been influenced by the apps they, and their classmates, found for their personal learning goals. As such, the curriculum aligned with Torsani's view that CALL teacher education's "main objective is to develop in teachers the knowledge of the technological options available and the ability to combine them with their knowledge of language teaching" (2016, p. xvi).

## Conclusion and Pedagogical Implications

Teacher knowledge is one of several factors that can facilitate or impede technology implementation (Ertmer, 1999; Hew & Brush, 2007; Wilson et al., 2020), which suggests that teacher cognition is an important piece of understanding and ultimately improving CALL implementation. While the results of this study are context-specific, they illustrate important trends in teacher CALL development. Similar to previous research, the present study revealed highly variable cognitive development and, for most participants, gradual or even minimal changes (Borg et al., 2014; Cabaroglu & Roberts, 2000, Chao, 2015) that seemed to consist mostly of the simple addition of new knowledge (Russ et al., 2016). While such addition is the most basic cognitive process, "there may need to be substantial learning of this sort" in teacher learning, especially in early teacher learning (Russ et al., 2016, p. 400). Ultimately, however, we cannot predict how this cognition translates into practice in the L2 classroom.

Our results also suggest that pre-service teachers' cognition is highly individual. While some beliefs changed during the course, they were likely dependent on previously held beliefs, knowledge and/or experiences as students and/or pre-service teachers (Feryok, 2010). Previous research has also shown the individual trajectories of pre-service teachers (Cabaroglu & Roberts, 2000). Worden (2015), for example, reported that the teacher cognition of two preservice teachers developed in very different ways even after consulting the same website and receiving the same feedback from their instructor. The present study further aligns with past studies that have found cognitive growth to be mostly consistent with pre-service teachers' starting points where "beliefs were confirmed and extended rather than ... subject[ed] to any radical reform" (Borg et al., 2014, p. 19). Some students slightly changed their attitude towards technology, but most maintained a positive or neutral position on CALL. The participants whose mind maps did not integrate technology and pedagogy, but only focused on one or the other, were likely influenced by the previous knowledge they brought to the course (Borg, 2019).

Future research should extend beyond this early learning to gain a more in-depth understanding of the impact of a CALL course in the larger context of a teacher education program or GTA preparation, especially in regard to practical teaching experiences. Studies could examine how cognition translates into actual lesson plan development and teaching in the classroom. As several participants noted, they realized how much more hands-on practice they need working with students to effectively apply technology in the classroom. While they were able to develop lesson plans in our courses in an attempt to bridge technical and pedagogical knowledge, without implementing them, they were unable to evaluate how these lessons could work with actual learners. Bryn's case illustrates how the CALL course combined with teaching

experience might have a greater impact on the teacher cognition of pre-service teachers, something that was also noted by Dawson et al. (2003). Future research could also investigate the impact of a CALL course “in relation to the immediate and broader contexts that shape teachers’ lives” (Borg, 2019, p. 6), such as other courses and teaching experiences, and trace its long-term effects, including the modifying or even fine-tuning of knowledge (Russ et al., 2016). Following up with these teachers once they are established in their specific teaching contexts, as in Chao’s study (2015), would allow researchers to trace the evolution of beliefs and the impact of the teaching contexts on CALL implementation.

The results of our study add to the discussion of the value of a stand-alone CALL course for GTAs and other L2 pre-service teachers. It is clear that the course did trigger changes in teacher cognition. While these changes were for the most part modest, they provide evidence that participants identified key themes from course readings, lectures, and student-centered activities. It is particularly encouraging to note that these pre-service teachers not only gained information about various tools, but also considered new ways of thinking about technology and its role in L2 learning. On the other hand, at the end of the course, half of the L2 pre-service teachers were only able to focus on either tools or pedagogy, but not both. It seemed that adding new information to what they already knew about teaching and technology led first to a cognitive reorganization as they attempted to make new connections while integrating new with existing knowledge. In other words, their previous knowledge was disrupted with the addition of new information and ideas. The second mind map was then an example of the beginnings of this reorganization. Clearly, training benefits from a long-term approach that starts with a CALL course to lay a foundation for practical experiences to build on. Experiencing CALL in practice, pre-service teachers might be able to integrate new knowledge, similar to the eight students who finished the term with integrated mind maps. One way to accelerate this process could be to combine practical experiences with theoretical information learned in class so that pre-service teachers and GTAs can more easily visualize the connections in action, which supports the idea of combining a CALL course with field experiences. CALL teacher education could also be reinforced in coordination meetings, through classroom observations, or meetings with a CALL mentor.

Last but not least, an important conclusion of this study relates to the value of mind maps to investigate teacher cognition. Any research investigating learning is limited by our inability to see actual cognition and instead has to rely on external evidence. Given these inherent limitations, this novel visual data source proved to be a valuable window into aspects of pre-service teachers’ cognition. Furthermore, drawing a mind map at the beginning and end of the course documented cognitive change and “the developmental pathways employed by a student” (Kinchin et al. 2000, p. 52).

## References

- Abell, S. (2008). Twenty years later: Does pedagogical content knowledge remain a useful idea? *International Journal of Science Education*, 30(10), 1405-1416. <https://doi.org/10.1080/09500690802187041>
- Adams, S. (2005). A strategy for technology training as part of a master’s program conducted at a school site. *Journal of Technology and Teacher Education*, 12(3), 493-514. <https://eric.ed.gov/?id=EJ723723>
- Akapame, R., Burroughs, E., & Arnold, E. (2019). A clash between knowledge and practice: A case study of TPACK in three pre-service secondary mathematics teachers. *Journal of Technology and Teacher Education*, 27(3), 269-304. <https://eric.ed.gov/?id=EJ1240084>
- American Council on the Teaching of Foreign Languages. (2015). *ACTFL/CAEP Program Standards for the Preparation of Foreign Language Teachers*. [https://www.actfl.org/sites/default/files/caep/ACTFLCAEPStandards2013\\_v2015.pdf](https://www.actfl.org/sites/default/files/caep/ACTFLCAEPStandards2013_v2015.pdf)

- Aydin, G., Baysan, S., & Aydoğan, S. (2017). Perceptions in the mind maps of Turkish children living in England at primary education level about their home country, Turkey, and the world. *International Journal of Languages' Education and Teaching*, 5(4), 521-541. <https://doi.org/10.18298/ijlet.2418>
- Azaz, M. (2020). Language program coordination during the pandemic: Challenges encountered and lessons learned. *Second Language Research & Practice*, 1(1), 174-178. <http://hdl.handle.net/10125/69852>
- Baumann, A. (2018). Concept maps: Active learning assessment tool in a strategic management capstone class. *College Teaching*, 66(4), 213-221. <https://doi.org/10.1080/87567555.2018.1501656>
- Blattner, G., & White, J.P. (2017). Leadership in foreign language departments: It's not just language. In V. Wang & P. Cranton (Eds.), *Encyclopedia of Strategic Leadership and Management* (pp. 350-360). IGI Global.
- Borg S. (2012). Current approaches to language teacher cognition research: A methodological analysis. In R. Barnard & A. Burns A (Eds), *Researching language teacher cognition and practice: international case studies* (pp. 11-29). Multilingual Matters.
- Borg, S. (2019). Language teacher cognition: Perspectives and debates. In X. Gao (Ed.), *Second Handbook of English Language Teaching* (pp.2-23). Springer.
- Borg, S. Birello, M., Civera, I., & Zanatta, T. (2014). The impact of teacher education on pre-service primary English language teachers. *ELT Research Papers*, 14(3). British Council.
- Brown, D. & Warschauer, M. (2006). From the university to the elementary classroom: Students' experiences in learning to integrate technology in instruction. *Journal of Technology and Teacher Education*, 14(3), 599-621.
- Budd, J. W. (2004). Mind maps as classroom experiences. *The Journal of Economic Education*, 35(1), 35-46.
- Cabaroglu, N. & Roberts, J. (2000). Development in student teachers' pre-existing beliefs during a 1-year PGCE programme. *System*, 28, 387-402. [https://doi.org/10.1016/S0346-251X\(00\)00019-1](https://doi.org/10.1016/S0346-251X(00)00019-1)
- Council for the Accreditation of Educator Preparation. (2022). 2022 CAEP Standards. <http://caepnet.org/standards/2022-itp/introduction>
- Chappelle, C., & Sauro, S. (Eds.) (2017). *The handbook of technology and second language teaching and learning*. John Wiley & Sons, Inc.
- Chao, C. (2015). Rethinking transfer: Learning from CALL teacher education as consequential transition. *Language Learning and Technology*, 19(1), 102-118. <https://dx.doi.org/10.1257/44404>
- Cherner, T. & Curry, K. (2017). Enhancement or transformation? A case study of preservice teachers' use of instructional technology. *Contemporary Issues in Technology and Teacher Education*, 17(2), 268-290. <https://eric.ed.gov/?id=EJ1143713>
- Clarke, D. & Hollingsworth, H. (2002). Elaborating a model of teacher professional growth. *Teaching and Teacher Education*, 18, 947-967. [https://doi.org/10.1016/S0742-051X\(02\)00053-7](https://doi.org/10.1016/S0742-051X(02)00053-7)
- Davies, M. (2011). Concept mapping, mind mapping and argument mapping: What are the differences and do they matter? *Higher Education*, 62, 279-301. <http://dx.doi.org/10.1007/s10734-010-9387-6>
- Dawson, K., Pringle, R., & Adams, T.L. (2003). Providing links between technology integration, methods courses, and school-based field experiences: A curriculum-based and technology-enhanced microteaching. *Journal of Computing in Teacher Education*, 20(1), 41-47.

- Dhindsa, H.S., Kasim, M., & Anderson, O. R. (2011). Constructivist-visual mind map teaching approach and the quality of students' cognitive structures. *The Journal of Science Education and Technology*, 20, 186-200. <https://doi.org/10.1007/s10956-010-9245-4>
- Erdem, A. (2017). Mind maps as a lifelong learning tool. *Universal Journal of Educational Research*, 5(12a), 1-7. <https://doi.org/10.13189/ujer.2017.051301>
- Farrell, T. (2009). Critical reflection in a TESL course: mapping conceptual change. *ELT Journal*, 63(3), 221-229. <http://dx.doi.org/10.1093/elt/ccn058>
- Freeman, D. (1993). Renaming experience/Reconstructing practice: Developing new understandings of teaching. *Teaching and Teacher Education*, 9(5/6), 485-497. [https://doi.org/10.1016/0742-051X\(93\)90032-C](https://doi.org/10.1016/0742-051X(93)90032-C)
- Guo, Q., Tao, J., & Gao, X. (2019). Language teacher education in System. *System*, 82, 132-139. <https://doi.org/10.1016/j.system.2019.04.001>
- Gronseth, S., Brush, T., Ottenbreit-Leftwich, A., Strycker, J., Serdar, A., Easterling, W., Roman, T., Sungwon, S., & van Leusen, P. (2010). Equipping the next generation of teachers. *Journal of Digital Learning in Teacher Education*, 27(1), 30-36. <https://doi.org/10.1080/21532974.2010.10784654>
- Hay, D. B. (2007). Using concept maps to measure deep, surface, and non-learning outcomes. *Studies in Higher Education*, 32(1), 39-57. <https://doi.org/10.1080/03075070601099432>
- Hay, D., & Kinchin, I. (2006). Using concept maps to reveal conceptual typologies. *Education and Training*, 48(2/3), 127-142.
- Hay, D., Kinchin, I., & Lygo-Baker, S. (2008). Making learning visible: The role of concept mapping in higher education. *Studies in Higher Education*, 33(3), 295-311. <https://doi.org/10.1080/03075070802049251>
- Healey, D., Hanson-Smith, E., Hubbard, P., Ioannou-Georgiou, S., Kessler, G., & Ware, P. (2011). *TESOL technology standards: Description, implementation, integration*. Teachers of English to Speakers of Other Languages.
- Honigsfeld, A., Giouroukakis, V., Cohan, A., & Walsh, M. (2009). Ten ways to incorporate technology into a TESOL teacher preparation program. *Contemporary Issues in Technology and Teacher Education*, 9(2), 208-221.
- Hubbard, P. (2021). *An invitation to CALL: Foundations of computer-assisted language learning*. APACALL. <https://www.apacall.org/research/books/6/>
- International Society for Technology in Education (2021). *International Society for Technology in Education Standards*. <https://www.iste.org/standards/for-educators>
- Kalaja, P., & Pitkänen-Huhta, A. (2018). ALR special issue: Visual methods in Applied Language Studies. *Applied Linguistics Review*, 9(2-3), 157-175. <https://doi.org/10.1080/03075070802049251>
- Kandiko, C. B., Kinchin, I. M., & Hay, D. B. (2008). Longitudinal studies of cognitive change among students and their supervisors in the course of research supervision leading to a Ph.D. (Eds.) A. J. Cañas, P. Reiska, M. Åhlberg & J. D. Novak. *Proceedings of the Third International Conference on Concept Mapping*, Finland.
- Kang, Y. & Cheng, X. (2014). Teacher learning in the workplace: A study of the relationship between a novice EFL teacher's classroom practices and cognition development. *Language Teaching Research*, 18(2), 169-186. <https://doi.org/10.1080/03075070802049251>

- Karimi, M. & Norouzi, M. (2017). Scaffolding teacher cognition: Changes in novice L2 teachers' pedagogical knowledge base through expert mentoring initiatives. *System*, 65, 38-48. <https://doi.org/10.1016/j.system.2016.12.015>
- Kern, R. (2006). Perspectives on technology in learning and teaching languages. *TESOL Quarterly*, 40(1), 183-210. <https://doi.org/10.2307/40264516>
- Kessler, G. (2021). Current realities and future challenges for CALL teacher preparation. *CALICO Journal*, 38(3), i-xx. <https://doi.org/10.1558/cj.21231>
- Kinchin, I. M., Hay, D. B. & Adams, A. (2000). How a qualitative approach to content map analysis can be used to aid learning by illustrating patterns of conceptual development. *Educational Research*, 42(1), 43-57. <https://doi.org/10.1080/001318800363908>
- Kubanyiova, M. & Feryok, A. (2015). Language teacher cognition in applied linguistics research: Revisiting the territory, redrawing the boundaries, reclaiming the relevance. *Modern Language Journal*, 99(3), 435-449. <http://dx.doi.org/10.1111/modl.12239>
- Lawrence, G. (2014). The role of teachers and their beliefs in implementing technology-mediated language learning: Implications for teacher development and research. *International Journal of Computer-Assisted Language Learning and Teaching*, 4(4), 59-75. <http://dx.doi.org/10.4018/ijcallt.2014100105>
- Levy, M. (1999). Computer assisted language learning: What teachers need to know. In C. Ward & W. Renandya (Eds.), *Language Teaching: New Insights for the Language Teacher*. SEAMEO Regional Language Centre.
- Lim, H. (2011). Concept maps of Korean EFL student-teachers autobiographical reflections on their professional identity formation. *Teaching and Teacher Education*, 27, 969-981. <https://doi.org/10.1016/j.tate.2011.05.001>
- Macalister, J. (2016). Tracing it back: Identifying the impact of a trans-national language teacher education programme on classroom practice. *RELC Journal*, 47(1), 59-70. <https://doi.org/10.1177/0033688216631204>
- Maijala, M. (2020). Culture teaching methods in foreign language education: Pre-service teachers' reported beliefs and practices. *Innovation in Language Learning and Teaching*, 14(2), 133-149. <http://dx.doi.org/10.1080/17501229.2018.1509981>
- Marra, R. (2004). An online course to help teachers "use technology to enhance learning": Successes and limitations. *Journal of Technology and Teacher Education*, 12(3), 411-429. <https://www.learntechlib.org/primary/p/11463/>
- Meschede, N., Fiebranz, A., Möller, K., & Steffensky, M. (2017). Teachers' professional vision, pedagogical content knowledge and beliefs: On its relation and differences between pre-service and in-service teachers. *Teaching and Teacher Education*, 66, 158-170. <http://dx.doi.org/10.1016/j.tate.2017.04.010>
- Meskill, C., Mossop, J., DiAngelo, S., & Pasquale, R. (2002). Experts and novice teachers talking technology: Precepts, concepts, and misconcepts. *Language Learning and Technology*, 6 (3), 46-57.
- Miri, M., Alibakhshi, G., & Mostafaei-Alaei, M. (2017). Reshaping teacher cognition about L1 use through critical ELT teacher education. *Critical Inquiry in Language Studies*, 14(1), 58-98. <http://dx.doi.org/10.1080/15427587.2016.1238286>
- Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A new framework for teacher knowledge. *Teachers College Record*, 108(6), 1017-1054. <https://doi.org/10.1111/j.1467-9620.2006.00684.x>

- Ottenbreit-Leftwich, A., Glazewski, K., & Newby, T.J. (2010). Preservice technology integration course revision: A conceptual guide. *Journal of Technology and Teacher Education*, 18(1), 5-33.  
<https://eric.ed.gov/?id=EJ896287>
- Paesani, K. (2020). Teacher professional development and online instruction: Cultivating coherence and sustainability. *Foreign Language Annals*, 53, 292-297. <https://doi.org/10.1111/flan.12468>
- Radix, C., & Abdool, A. (2013). Using mind maps for the measurement and improvement of learning quality. *Caribbean Teaching Scholar*, 3(1), 3-21.
- Ritzhaupt, A. D., Huggins-Manley, A. C., Ruggles, K., & Wilson, M. L. (2016). Validation of the survey of pre-service teachers' knowledge of teaching and technology: A multi-institutional sample. *Journal of Digital Learning in Teacher Education*, 32(1), 26-37.  
<https://doi.org/10.1080/21532974.2015.1099481>
- Rowley, J., Dysard, G., & Arnold, J. (2005). Developing a new technology infusion program for preparing tomorrow's teachers. *Journal of Technology and Teacher Education*, 13(1), 105-123.
- Russ, R.S., Sherin, B.L., & Sherin, M.G. (2016). What constitutes teacher learning? In D. Gitomer & C.A. Bell (Eds.), *Handbook of research on teaching* (pp. 391-438). American Education Research Association.
- Saiful, J.A. (2019). EFL teachers' cognition in the use of Youtube vlog in English language teaching. *Journal of Foreign Language Education and Technology*, 4(1), 52-71.
- Sardegna, V.G., & Dugartsyrenova, V.A. (2014). Pre-service foreign language teachers' perspectives on learning with technology. *Foreign Language Annals*, 47(1), 147-167.  
<https://doi.org/10.1111/flan.12078>
- Sawyer, R. K. (2022). An introduction to the learning sciences. In R.K. Sawyer (Ed.), *The Cambridge Handbook of the Learning Sciences* (pp. 1-24) (3rd ed.). Cambridge University Press.  
<https://doi.org/10.1017/9781108888295.002>
- Schmid, E. & Hegelheimer, V. (2014). Collaborative research projects in the technology-enhanced language classroom: Pre-service and in-service teachers exchange knowledge about technology. *ReCALL*, 26(3), 315-332. <http://dx.doi.org/10.1017/S0958344014000135>
- Sert, O. & Li, L. (2017). A Qualitative study on CALL knowledge and materials design: Insights from pre-service EFL Teachers. *International Journal of Computer Assisted Language Learning and Teaching*, 7(3), 73-87. <https://doi.org/10.4018/IJCALLT.2017070105>
- Seyihoglu, A. & Kartal, A. (2013). Views of the student on mind mapping technique in social studies course. *Ankara University Journal of Faculty of Educational Sciences*, 46(2), 111-132.  
[https://doi.org/10.1501/Egifak\\_0000001297](https://doi.org/10.1501/Egifak_0000001297)
- Shah, M. & Foster, A. (2015). Developing and assessing teachers' knowledge of game-based learning. *Journal of Information Technology for Teacher Education*, 23(2), 241-267.  
<https://eric.ed.gov/?id=EJ1063573>
- Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4-14. <https://doi.org/10.2307/1175860>
- Somers, M. J., Passerini, K., Parhankangas, A., & Casal, J. (2014). Using mind maps to study how business school students and faculty organize and apply general business knowledge. *The International Journal of Management Education*, 12, 1-13.  
<http://dx.doi.org/10.1016/j.ijme.2013.11.001>
- Son, J. & Windeatt, S. (Eds.) (2017) *Language Teacher Education and Technology: Approaches and Practices*. London: Bloomsbury Academic.

- Staus, N., Gollow-Wiles, H., & Niess, M. (2014). TPACK development in a three-year online masters program: How do teacher perceptions align with classroom practice? *Journal of Technology and Teacher Education*, 22(3), 333-360. <https://eric.ed.gov/?id=EJ1040808>
- Svalberg, A. (2015). Understanding the complex processes in developing student teachers' knowledge about grammar. *The Modern Language Journal*, 99(3), 529-545. <https://doi.org/10.1111/modl.12241>
- Tan, S., Erdimez, O., & Zimmerman, R. (2017). Concept mapping as a tool to develop and measure student's understanding in science. *Acta Didactica Napocensia*, 10(2), 109-122. <http://dx.doi.org/10.24193/adn.10.2.9>
- Torsani, S. (2016). *CALL teacher education: Language teachers and technology integration*. Springer.
- Tsunemoto, A., Trofimovich, P., & Kennedy, S. (2020). Pre-service teachers' beliefs about second language pronunciation teaching, their experience, and speech assessments. *Language Teaching Research*. <https://doi.org/10.1177/1362168820937273>
- Voithofer, R. & Nelson, M. (2020). Teacher educator technology integration preparation practices around TPACK in the United States. *Journal of Teacher Education*, 72(1). <https://doi.org/10.1177/0022487120949842>
- Worden, D. (2015). Developing writing concepts for teaching purposes: Preservice L2 writing teachers' developing conceptual understanding of parallelism. *Journal of Second Language Writing*, 30, 19–30. <https://doi.org/10.1016/j.jslw.2015.08.001>
- Willis, J. & Cifuentes, L. (1997). Training teachers to integrate technology into the classroom curriculum: Online versus face-to-face course delivery. *Journal of Technology and Teacher Education*, 12(1), 43-63.
- Wilson, M., Ritzhaupt, A., & Cheng, L. (2020). The impact of teacher education courses for technology integration on pre-service teacher knowledge: A meta-analysis study. *Computers and Education*, 156. <https://doi.org/10.1016/j.compedu.2020.103941>

## Appendix A. List of topics in CALL courses

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Review of L2 teaching and CALL	CALL and SLA
Research in CALL	Interpersonal Communication
Listening	Reading
Writing	Evaluating Technological Tools
Culture	Digital Literacies
Gaming/Mobile Learning	Social Networking
Pronunciation	Language for specific purposes
Assessment	Online and Blended Learning

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