**Embedding and Developing TPACK with LLM Prompt Writing: Developing a Translanguaging Chatbot**

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**Abstract:** In this paper, we explore the integration and development of Technological Pedagogical Content Knowledge (TPACK) through the creation of prompts for large language models (LLMs), through the development of a translanguaging chatbot. The study investigates how designing LLM prompts can both benefit from and enhance the designer’s TPACK. By analyzing the process of developing a chatbot prompt to support bilingual students in elementary schools, we identify elements of TPACK in the interactions between the prompt designer and the LLM. The findings suggest that constructing LLM prompts may serve as a valuable tool for pre- and in-service teachers, not only in their teaching practices but also in developing the TPACK necessary for effective and critical use of AI in education.

**Keywords**: Large language models (LLMs), technological pedagogical content knowledge (TPACK), pre-service teacher education

The increasing speed of development and release of generative artificial intelligence (genAI) tools, particularly large language models (LLMs), has led to much talk about how these technologies can be used for teaching and learning. Potential uses have spanned from teacher tools such as producing lesson plans (Zhang & Tur, 2024) to student applications like the interactive tutor Kahnmigo  (Singer, 2023). However, less research has considered applications beyond what is already being done in the classroom, instead only replacing or amplifying current practices.

The Technological, Pedagogical, Content Knowledge (TPACK, see Mishra & Koehler, 2006) is often cited as key to successful technology integration. Central to TPACK is the focus on designing new learning opportunities with technology, which requires an understanding of the affordances of the technology along with pedagogical knowledge, content knowledge, and the intersection of each (Mishra & Koehler, 2006). Although useful, many current applications of AI do not reflect their creators’ or users’ TPACK, but rather serve as a general tool to support current practices.

Ethan Mollick (2023) posited that effective LLM prompts have embedded expertise: the prompt itself includes specialized knowledge created by the prompt designer. He described these as “prompts that encode our hard-earned expertise in ways that AI can help other people apply . . . to gift others with your own abilities.”  We have been constructing LLM prompts for various tasks and considered how our own knowledge and expertise may become embedded in the prompt. Rather than construct the prompts from scratch, we commonly describe what we want the prompt to do to an LLM and have it help us develop the prompt. We have wondered whether the LLM-supported prompt creation process could develop expertise—in other words, if formal prompts are developed with the support of an LLM, would the LLM bring in expert knowledge to refine and reinforce the user-designer’s knowledge?

In this paper, we explore how interactions with LLMs—specifically using an LLM to design a prompt to create a translanguaging chatbot—both benefit from and develop the designer’s TPACK. We analyze our own experience developing the chatbot prompt to identify elements of TPACK in both our prompts and the LLM’s responses. We posit that activities that support teachers in constructing prompts for various pedagogical tasks can serve not only as a tool for their teaching, but also to develop the TPACK they need to use AI successfully and critically.

**Literature Review**

Before presenting our experience designing a chatbot prompt, we will briefly review several key areas of literature: translanguaging and culturally relevant pedagogy, AI in education, and TPACK. Then we will describe our process and analysis and present our findings.

**Translanguaging and Culturally Relevant Pedagogy**

Educators need to have a clear understanding of the language assets that students bring to their learning (Caires-Hurley et al., 2024). Translanguaging can support the development of this understanding. Translanguaging recognizes the crucial role of students' cultural and linguistic backgrounds in language learning and views language as constantly evolving based on users' needs. Cummins' (2021) critical analysis of language learning supports bilingual education and sees students' home languages as assets rather than deficits. His Hypothesis of Interdependence emphasizes celebrating student identities as diverse and crucial for language development and views languages as interdependent, where the growth of one language supports the development of others.

Language and culture are intertwined, and both are components of a student's identity. Gloria Ladson-Billings’(1995) theory of Culturally Relevant Pedagogy stresses the importance of acknowledging and validating students' home cultures as a key part of their learning(Paris & Alim, 2014). When students' home cultures, interests, and perspectives are included in the classroom, all students feel affirmed and empowered**.**

**AI in Education**

Technology in general—and specifically AI—may be useful in supporting culturally relevant translanguaging practices, but there is limited research on the use of AI in the K-5 dual language classroom. Current research on AI in education focuses on uses for teachers (lesson planning, etc.) with some student-centered and multilingual applications. For example, Zhang and Tur (2024) considered the potential of ChatGPT for curriculum development, lesson planning, material generation, differentiation, and personalized learning, while also noting concerns around academic integrity and quality output. Tian and Boyer (2023) explored teaching and using Natural Language Processing in K-12 classrooms but found a lack of studies on children under 11 due to the complexity of the learning environments. Both Zhang and Tur, and Tian and Boyer identified a need for greater support for diverse learners through scaffolding and adaptability. Casal-Otero et al. (2023) conducted a literature review of AI literacy in K-12, finding AI learning experiences at the K-12 level to be nascent and requiring a literacy framework still under development. Overall, more research is needed on AI use in K-5 grades, particularly in bilingual contexts.

**TPACK**

This study considers the use of AI to support culturally relevant translanguaging pedagogies. We will apply Technological Pedagogical Content Knowledge (TPACK; see Mishra & Koehler, 2006) in our analysis. The TPACK framework emphasizes the interplay between technology, pedagogy, and content in educational settings. Central to TPACK is the call for teachers to be designers of technology-supported learning experiences (Mishra & Koehler, 2006). Studies have investigated how teachers' design beliefs evolve through targeted professional development, revealing that deliberate design-focused interventions can significantly enhance teachers' TPACK competencies (Harris et al., 2009).

The role of contextual knowledge (or XK, see Mishra, 2019) has been increasingly recognized as a critical factor in TPACK development. A systematic literature review by Brianza et al. (2022) highlights the increasing emphasis on XK, proposing its inclusion as an essential domain to enhance the framework's applicability across diverse educational settings.  In this study, we consider XK as a unique knowledge domain that may be demonstrated through and impacted by LLM prompt development.

**Methodology and Method**

In this study, we explore how the development of LLM chatbots is impacted by and impacts the prompt designers’ TPACK. We do this by experimenting with LLM-supported prompt construction and analyzing the resulting conversations.

**Educational Design Research**

This study serves as an initial stage of an educational design research (EDR, see McKenney & Reeves, 2020) study. EDR research focuses on both theoretical and practical outcomes. It involves iterative cycles of developing and implementing interventions, using data to refine these interventions, and conceptualizing the theoretical basis for their effectiveness. The cyclical process of intervention development and theoretical conceptualization informs and enhances each other. The result of EDR is knowledge that is both theoretically and practically relevant, directly impacting practical applications.

In this case, the “intervention” is a learning activity for pre- or in-service teachers. In this activity, they use an LLM to develop a prompt that creates a chatbot addressing a pedagogical problem. The theoretical element considers what type of thinking and learning occurs through this practice.  The first phase (exploration and analysis, see McKenney & Reeves 2020) consisted of exploring the process of building a prompt with an LLM and then analyzing the resulting conversation. Although this step is relatively simple, it is important for developing the practical and theoretical framework around the intervention, allowing us to consider how the intervention may be applied with pre-service or in-service teachers.

Next, we report on both parts of the first EDR stage: Exploration and Analysis. Exploration focuses on our own interactions with an LLM to create a translanguaging chatbot, and analysis reports on how we analyzed the resulting conversation through the lens of TPACK. Because of the nature of this type of research, methods, analysis, and findings are discussed together.

**Exploration of the Intervention: Creating the Chatbot Prompt**

Because of the geographical and cultural community we live in, we wanted to create a chatbot that would support translanguaging in elementary schools. Our local elementary schools are almost all bilingual schools, offering instruction in both Spanish and English, and we wondered whether this might be something that could be supported by a chatbot. Initially we were not quite sure what the chatbot could do, so we asked ChatGPT 4o for ideas. Our first prompt was:

I would like to create a chatbot to support emerging bilingual students in 3rd - 5th grade in culturally relevant translanguaging practices. It should include integration with academic vocabulary in science and social studies as aligned with common core standards. I think it should have some type of conversation with students that includes both languages and discussing academic topics. I want it to use the affordances of LLMs. What types of things might this chatbot do?

ChatGPT provided a list of interesting tasks a chatbot could offer, such as supporting translanguaging conversations, academic vocabulary support, providing culturally relevant learning, supporting storytelling, scaffolding academic discussions, and more. It then asked “Would you like suggestions on platforms, tools, or APIs to implement this chatbot?” We knew that we wanted to create the chatbot with a simple prompt and asked what a core set of features might be. The LLM provided a focus (bilingual conversations and academic topics), prompt structure, example prompt, and example interaction.

Next, we asked the LLM to create a prompt that focused on Spanish/English emerging bilingual students, as this is our target population. After creating the initial prompt, we asked it to open it in “canvas,” a ChatGPT feature that opens a content editing window next to the regular chat window, supporting ongoing revisions to content. As we developed the prompt, we experimented with each iteration, identified what we wanted to adjust in the chatbot, and returned to the original prompt-creating conversation to ask ChatGPT to adjust the prompt to fix problems. These refinements included having the chatbot detect which language students tended to answer in and making appropriate adjustments, such as using simpler language for the secondary language while still encouraging use of the new language. In part, ChatGPT used sentence starters as scaffolding to accomplish this task. We also asked for the chatbot to tell students they could say “I don’t understand” for more help. The full creation conversation can be found in Appendix A.

**Theoretical Analysis**

To understand the types of knowledge present in the prompt-creation conversation, we coded each part of the conversation (both the user input and the LLM responses) using the TPACK framework. This allowed us to observe what type of knowledge we brought to the conversation (knowledge that many pre-service teachers would not yet have) as well as what knowledge the LLM displayed and reinforced. We will report on our knowledge first, then offer an analysis of the LLM’s responses. Although we discuss each role separately, each impacted the other, leading to dynamic interaction and knowledge development.

As the LLM users who wrote the initial prompts to create the chatbot prompt, we naturally used TK, PK, XK, TPK, and TPACK through our interactions. Basic TK can be seen in our understanding of what the LLM *could* do: we knew we could create a prompt that would make a chatbot, and we knew that one of the affordances of LLMs is their ability to have conversations, leading to the original chatbot idea. Our original prompt—focusing on translanguaging and academic vocabulary—illustrate pedagogical knowledge. We also demonstrated pedagogical knowledge through the refinements we asked of the chatbots: to encourage students to report lack of understanding and scaffold secondary language use. We also demonstrated PK when we introduced the use of translanguaging. Our XK was evident in our focus on emerging Spanish/English bilingual students and emphasis on culturally responsive pedagogy.

In addition to direct evidence of existing knowledge, our very first prompt—asking the LLM what types of things the chatbot could do—offered a way to develop TK and TPK. Although our prompt provides evidence of a basic TK, our TPK expanded as the LLM listed the types of support a chatbot could offer.

The LLM responses also demonstrated various types of knowledge. Some of this knowledge was an extension of our own prompt. For example, we asked the chatbot to be “culturally responsive,” and the LLM operationalized this idea with “if the student mentions something from their background, connect it to the topic.” When we asked it to better support students in their secondary language, it implemented the idea of scaffolding through sentence starters. Other evidence of elements of TPACK were added automatically by the chatbot, such as the instruction to “keep the conversation interactive and fun, not too long or overwhelming.”

The final prompt (see Appendix B) embeds expert concepts including translanguaging, culturally responsive pedagogy, scaffolding, academic vocabulary, modeling, critical thinking, and attention to the motivational and affective needs of learners. The specific content was developed through a collaboration between us (the users) and the LLM.

**Discussion and Implications**

Our analysis highlighted that the TPACK expertise embedded in the final chatbot prompt emerged from an interaction between the user and the LLM. In the initial phase of the chat, we gained TK and TPK as the LLM suggested possible uses of a translanguaging chatbot, highlighting the types of tasks that AI may be effective at supporting. Later in the conversation, we would often provide a general term of what we wanted (translanguaging, etc.) and the LLM would operationalize it into a more specific command. Ultimately, the success of the conversation arose because of TPACK on both ends: the user and the LLM. In some instances, this built on and reinforced our ideas, helping us better embed our expertise in the prompt.

What isn’t known is how this interaction would be different if the user had less expertise in teaching and learning with technology. LLMs are sensitive to slight changes in prompts. If a user with less expertise were to engage in this process, they may not use the same key terms and language. Would the result be a conversation with less embedded expertise, or would the LLM fill in the gaps, exposing the user to effective pedagogical techniques that could expand their learning?

The next stage of this study includes studying the transcripts of early pre-service teachers when they use an LLM to create a chatbot prompt. Central questions include:

* How does the language of the student-entered prompts change the tone of the conversation and final prompt created?
* What elements of TPACK do the pre-service teachers, as well as the LLM, exhibit?
* Would this type of activity be useful for supporting the development of TPACK in pre-service teachers?

Ultimately, interactive prompt development may prove to support both teachers and students: they may help teachers develop TPACK while at the same time resulting in a product—a prompt with embedded TPACK expertise—to support student learning.

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**Appendix A: Prompt Creation Conversation**

The chat used to produce the prompt can be found at this link:<https://chatgpt.com/share/679cff40-7ce4-800f-9a29-26b8e4c86c65>

**Appendix B: Final Chatbot Prompt**

You are a friendly and engaging bilingual learning assistant for 3rd-5th grade students who are emerging bilinguals in Spanish and English. Your goal is to help students discuss Science and Social Studies topics while supporting translanguaging in a natural and culturally relevant way.

* Greet the student warmly using both English and Spanish.
* Ask what they are learning about in Science or Social Studies. If they don’t know, suggest a fun topic like planets, ecosystems, or historical figures.
* Detect the student’s home language based on the language they use first. If they start in English, assume English is their home language and encourage more Spanish practice. If they start in Spanish, assume Spanish is their home language and encourage more English practice.
* Adjust responses accordingly by providing more content in the language they are not using as much, while still maintaining a mix of both languages.
* Provide sentence starters and scaffolded support **only in the language they are not using as much** to encourage practice.
* Encourage the student to use both languages by modeling translanguaging. If they write in English, mix in Spanish words, and vice versa.
* Highlight key academic vocabulary by introducing words in both languages and explaining them in simple terms.
* Ask open-ended questions to promote critical thinking and engagement.
* Use emojis and fun expressions to make the conversation lively.
* Be culturally responsive—if the student mentions something from their background, connect it to the topic.
* Let the student know they can write "I don't understand" or "No entiendo" if they need help, and provide simpler explanations when needed.
* Keep the conversation interactive and fun, not too long or overwhelming.

**Example Conversation**

**Chatbot:** "Hi! ¡Hola! I’m your bilingual learning buddy. What are you learning about in Science or Social Studies? ¿Qué estás aprendiendo en Ciencia o Estudios Sociales?"

**Student:** "Planets."

(Since the student started in English, the chatbot assumes English is their home language and encourages Spanish practice.)

**Chatbot:** "¡Genial! Jupiter (*Júpiter*) es el planeta más grande de nuestro *sistema solar* (solar system). It’s called a *gas giant* (*gigante gaseoso*). Try saying: 'Júpiter es...' 😊"

**Student:** "Júpiter es grande."

**Chatbot:** "¡Muy bien! Now let’s try a little English. Jupiter does not have *suelo sólido* (solid ground). Can you say: 'Jupiter does not have...'? If you need help, say 'No entiendo'. ¡Tú puedes! 🌟"