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Leveraging Virtual Exchange (VE): Outcomes of an International Science Teaching and Learning Experience between Preservice Teachers and K-12 Students

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ABSTRACT

This qualitative research explores an innovative instructional approach in STEM teacher preparation that situates virtual exchange (VE) and project-based learning (PBL) within an international, synchronous, middle school teaching context. The results of this study suggest that VE provides a unique opportunity to enhance teacher preparation by exposing preservice teachers (PSTs) to an instructional method that allows for authentic virtual teaching practices, fosters intercultural competence, facilitates the development of STEM pedagogical content knowledge, provides scaffolded support for multiple language learners (MLLs), and cultivates impactful global classroom interactions.

Keywords: project-based learning, teacher preparation, virtual exchange, STEM

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INTRODUCTION

Innovative teaching practices are often best learned through experiential learning processes, where educators "provide students with experiences and then help them reflect upon them so that learning occurs" (Wurdinger, 2005, p. 8). Teacher educators who have preservice teachers (PSTs) learn in the manner that they profess to be effective lead by example. This provides the pedagogical tools and vision PSTs need to imagine their future classrooms as places of inquiry, inclusion, and inspiration for the wonderfully diverse students they teach.

"Flattening classrooms," a figurative method that eliminates classroom walls to facilitate collaboration with others from around the world, is an innovative teaching practice (Lindsay & Davis, 2013). Today's teachers and students must see themselves as members of a global community, and classroom instruction should support this vision. This article describes a study of a unique partnership born out of a shared passion for virtual exchange (VE) between instructors in a university-based STEM teacher preparation program in Texas, USA, and teachers at a private preK-12 school in Argentina, both of whom believe that engaging and learning both *with* and *from* international others is necessary for students' successful participation in an increasingly global society.

LITERATURE REVIEW

VE Defined

VE, which also includes such names as telecollaboration, collaborative online international learning (COIL), and classroom-based global collaboration (CBGC), is an approach in which there is "the engagement of groups of learners in extended periods of online intercultural interaction and collaboration with partners from other cultural contexts or geographical locations as an integrated part of their educational programmes and under the guidance of educators and/or expert facilitators" (O'Dowd, 2018, p. 5). More specifically, according to O'Dowd (2021), "class to class virtual exchanges... are usually short and intensive affairs

(usually 6 – 8 weeks) where students engage in a series of carefully designed pedagogical tasks related to their subject area with a limited number of international partners and with the support of their teachers or facilitators" (p. 212). Multiple resources are dedicated to establishing and facilitating VE in both the K-12 and higher education contexts (Lindsay & Davis, 2013; Rubin & Guth, 2023).

VE experiences provide numerous benefits to K-12 students, in-service teachers, and PSTs. They serve to increase students' global awareness, success (soft) skills, cultural appreciation, empathy, and language acquisition (Copen, 2002; Gibson, Rimmington, & Landwehr-Brown, 2008; Union, 2011). This is also true for in-service teachers and PSTs (Chitanana, 2012; Cifuentes & Shih, 2001; Copen, 2002; Gibson, Vialle, & Rimmington, 2003; Gleason & Jaramillo Cherrez, 2021; Hilliker & Yol, 2022; Lenkaitis, Hilliker, & Roumeliotis, 2020; Lock & Redmond, 2006; Neal, Mullins, Reynolds, & Angle, 2013; Yang, Kinshuk, Yu, Chen, and Huang, 2014; York & Hite, 2021; York, Hite, & Donaldson, 2019). Research also suggests that PSTs who engage in VE experiences during their teacher preparation are more likely to use them in their eventual classrooms (Dooly, 2020).

Historically, VE has been most often seen in language development, cultural awareness, and cultural appreciation contexts; this includes even the most recent studies reporting on VE in PST preparation (Ingrisch-Rupp & Symeonidis, 2025). Less research exists on the use of VE to develop further PSTs' instructional design and delivery skills in science and math content areas, although what does exist indicates positive outcomes (Gibson, Watters, Alagic, Rogers, & Haack, 2003). Furthermore, there is limited, but positive, research on PSTs instructing K-12 students using a VE format and the associated learning outcomes of such instructional delivery (Xu, Hinds, Rakisheva, El Souefi, & Witt, 2025).

Note that VE is a unique application of virtual education that can utilize both synchronous and asynchronous modalities for international collaboration and instruction. Research on virtual teaching and learning environments is abundant and focuses on practical implementation and organization, benefits and challenges, student learning outcomes, instructional effectiveness, student engagement, issues of equity and access, mental health, and other related topics, particularly in the post-COVID-19 era. With respect to PSTs, there is a growing call for training and supporting future teachers in virtual teaching best practices, particularly in the postpandemic era. Research on the inclusion of virtual teaching practices in teacher preparation prior to the pandemic was limited; no states included it in their teacher certification requirements, and few teacher preparation programs reported incorporating virtual teaching practices into their curriculum and instruction (Moore-Adams, Jones, & Cohen, 2016; Graziano & Bryans-Bongey, 2018). Recently, steps have been taken to intentionally incorporate virtual teaching instruction into teacher preparation coursework. For PSTs seeking certification in Texas, updated curriculum requirements specify instruction on virtual teaching

environments (Educator Preparation Curriculum, 2024), and numerous Texas universities are incorporating intentional curriculum pieces to support PSTs in developing virtual teaching skills (Allen, 2022).

Project-based Learning Explained

Project-based learning (PBL) is an instructional method that allows students to engage with real-world, personally relevant problems through projects (PBLWorks, 2025). The key components of PBL include a driving question, which promotes sustained inquiry and whose answer is presented to an authentic audience through some form of public display with an emphasis on collaborative work. Ranging from a few days to a semester or longer, students answer or design solutions to this complex question guided by constructivist teaching practices (Krajcik & Blumenfeld, 2005). Used in many educational contexts across all age groups and content areas, PBL projects differ from traditional projects in that the standards-based content is framed, delivered, and learned through the project itself.

The well-documented benefits of PBL include long-term content retention, the development of success skills, social-emotional learning gains, and increased satisfaction among students and teachers (Larmer, 2021). Numerous studies have demonstrated that PBL instruction yields student achievement gains that surpass those of traditional instruction (Kingston, 2018). PBL has proven to be particularly effective for STEM teaching and learning in both elementary (Krajack et al., 2023) and secondary (Terada, 2021) classrooms. Many teacher preparation programs, recognizing that PBL can be challenging to facilitate without proper training, have incorporated it into methods courses and residency models (Alrajeh, 2021; Lee & Galindo, 2021). The UTeach replication model was an early adopter of PBL because of its value in preparing STEM teacher candidates to implement inquiry-based methods (Goodell & Koç, 2020).

Virtual PBL was bolstered during the pandemic as teachers tried new ways to engage students during distance learning. As technologies that advanced virtual learning (VL) became ubiquitous, teachers already competent in PBL methodologies used them to bring meaning, engagement, and collaboration to VL (Hira & Anderson, 2021; Miller, Kelly, & Krajcik, 2021).

A Novel Context for VE and PBL

Pairing VE and PBL is not a new concept. Dooly and O'Dowd (2018) make a compelling argument for the shared characteristics of VE and PBL in language learning contexts during PST preparation. VE platforms, such as iEARN (https://us.iearn.org), have routinely designed PBL-facilitated experiences via VE to engage K-12 students, in-service teachers, and PSTs with their international peers and colleagues (iEARN, 2024).

However, an innovative design using both VE and PBL has been implemented between PBL course instructors within the UTeach Dallas program

at The University of Texas at Dallas (UTD) and teachers at Colegio Bayard in Buenos Aires, Argentina. Colegio Bayard is a private, English-language immersion school that serves preschool through secondary students from around the world (many students are concurrently learning Spanish alongside English). In this context, PSTs in the PBL course utilize VE to teach a mini-PBL STEM lesson synchronously to middle school students at Colegio Bayard. Mini-PBLs "are shorter projects that still encompass most of the elements of PBL…. there's still a depth involved and an opportunity for an authentic audience/context. Students learn the building blocks of basic project management as they develop collaboration skills" (Spencer, 2024, Table 1). This condensed format was ideal for PSTs to practice the PBL process while navigating time constraints within the VE. Implementing VE and PBL in this manner is a novel approach. The following includes the outcomes of a qualitative case study that explored perceptions of PST involvement in the VE during the Fall 2022 and Fall 2023 (US) semesters. Specifically, it sought to capture responses to the following questions:

1) What were the benefits, if any, of engaging in VE this semester?
2) What were the challenges, if any, to engaging in VE this semester?
3) What value, if any, would there be for using a VE experience like this one in future teacher preparation program courses?

Additionally, the adjustments and next steps suggested between and after the two iterations of VE are explored. The results of this study may be beneficial to those involved in secondary STEM PST preparation (with potential extension to additional grade levels and content areas), student learning/in-service teacher professional development in K-12 education, and efforts to provide equitable teaching to culturally and linguistically diverse learners.

RESEARCH METHOD

This study used a case study research design (Creswell, 2014). Parental consent was obtained from all the participating Colegio Bayard students, as was consent from all the participating PSTs. Data were collected from coursework, video recordings of planning meetings and lessons, lesson debriefs, informal class discussions, and a postsurvey about the VE experience (specific to PSTs). The data were analyzed via conventional content analysis methods for qualitative data (Hsieh & Shannon, 2005). Credibility was established via the criteria established by Lincoln and Guda (1985). PST participants were assigned pseudonyms.

Participants

PSTs enrolled in the upper-level PBL course at UTD (Fall 2022— 25 students; Fall 2023— 18 students) were partnered with science teachers and their students in the 6th and 7th forms (grades) at Colegio Bayard (Fall 2022— 43

students in the 6th form, 34 students in the 7th form; Fall 2023— 42 students in the 6th form, 41 students in the 7th form). Although most PSTs and students had limited or no prior VE experience, the course instructors and teachers had engaged in numerous global collaborations.

Context and timeline of the VE

This partnership was established through a "cold call" email exchange initiated by teachers at Colegio Bayard to the course instructors at UTD in Spring 2022 (US). Colegio Bayard had an established VE collaboration with another institution of higher education in the U.S.; the faculty at that institution had read a journal article about VE published by the UTD course instructors and sent the article to the Colegio Bayard teachers. They then reached out directly to the UTD course instructors about a possible collaboration, specifically for a science, technology, engineering, and mathematics (STEM) VE.

The initial planning between the instructors at UTD and the teachers at Colegio Bayard began in Spring 2022 (US). It consisted of three synchronous virtual meetings in addition to regular email and text communication. In any VE, all parties must establish relevant learning goals; these goals do not necessarily have to be shared or common outcomes, but the design of the VE should serve to promote and support all respective objectives (Doscher, 2023). The learning goals established by each VE partner are listed below.

PSTs enrolled in the PBL course will:

1) gain experience teaching inquiry-based science lessons in virtual formats,
2) support English-language development in the context of science and mathematics learning,
3) increase instructional design and delivery skills of inquiry-based science and mathematics lessons, specifically PBL, through practice,
4) use VE to engage with members of the teaching profession beyond the US, and
5) increase personal cultural competencies and success skills development.

Colegio Bayard teachers and students will:

1) engage in inquiry-based lessons incorporating the 6th and 7th forms' science and mathematics content
2) increase English-language practice and development,
3) use VE to engage with members of the teaching and learning community beyond Argentina, and
4) increase personal cultural competencies and success skills development.

For the first attempt at this type of VE, it was decided that the PBL course instructors would design the two mini-PBL lessons. There were several reasons for this decision: 1) while PSTs had engaged in an introductory, in-class PBL STEM lesson wearing student hats ("asking teachers to engage in learning activities while acting like their students" (Lowell & McNeill, 2020)), they were new to both PBL design processes and virtual teaching. The scaffolded lesson design allowed PSTs to focus on these two novel situations; 2) early lesson development ensured that content, materials, and virtual documents were aligned, available, and accessible; UTD course instructors also sent several lesson activities and university spirit items to Colegio Bayard prior to the VE (the students liked these, and it helped build rapport); 3) PSTs were able to become familiar with and thoroughly rehearse the lesson in a virtual format and receive feedback from instructors prior to instructing Colegio Bayard students; and 4) advanced lesson access provided Colegio Bayard teachers with opportunities to preteach the content vocabulary to their students since all VE activities were purposefully conducted in English to increase the skill development of multiple language learners (MLLs).

The 6th form PBL lesson addressed stars and galaxies. The 7th form PBL addressed the concepts speed, velocity, and relevant mathematical calculations. Both topics aligned with the Buenos Aires City Educational Standards, thus constituting an authentic experience of content- and language-integrated learning. In both experiences, two PSTs from UTD were assigned to a team of approximately 7- 8 students from Colegio Bayard who worked together during the project.

All the student teams were tasked with answering the same broad driving question, which was developed by the UTD course instructors and Colegio Bayard teachers, according to the grade-level lesson. However, student teams had the opportunity to ask additional questions through a "know and need-to-know" process, tailored to their specific needs, with their PSTs during the lesson (Brengard, 2018). Given the short duration of the VE, student products were intentionally specified within the lesson to assist with scaffolding content and navigating time constraints rather than allowing for more ideal student choices. Notably, PSTs did not have the opportunity to provide feedback on Colegio Bayard students' final products, so only formative assessment feedback was provided to students during the actual enactment of the VE lesson activities.

The Colegio Bayard classroom teachers acted as physical monitors during the VE instruction. The English proficiency level of the Colegio Bayard students was B2 (upper intermediate), and an emphasis was placed on consistently using English during the lessons. The platforms Blackboard Collaborate (Fall 2022) and Microsoft Teams (Fall 2023) were used to facilitate the VE.

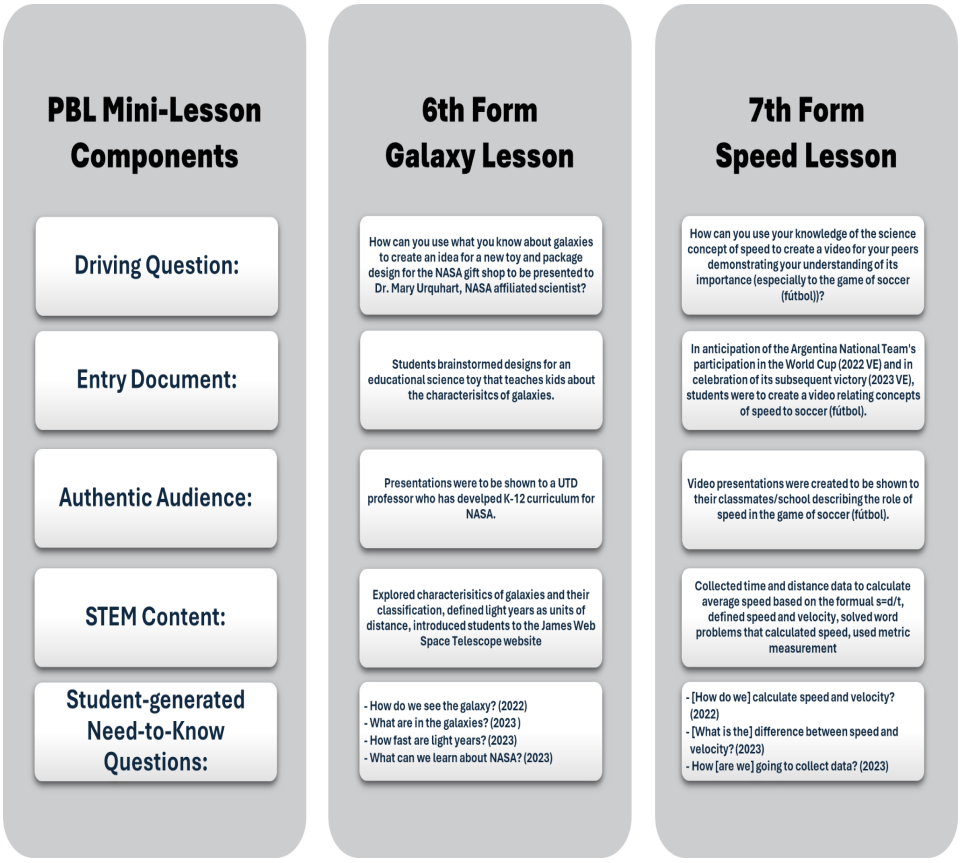
Figure 1 depicts a detailed timeline of planning meetings, teaching experiences, and modifications to the second iteration. A key change included the addition of a "meet and greet" for PSTs and their student teams prior to teaching

the first VE lesson. Figure 2 illustrates the mini-PBL lesson design, which includes the driving question, activities, expected student products, and sample "know and need-to-know" lists generated from select teams.

Figure 1

Timelines of VE Implementation

Figure 2
Mini-PBL Lesson Design



RESULTS

The results of the PSTs' perceptions of participation in the VE are summarized in Table 1, which includes emergent themes derived from their expressed perceived benefits (RQ1), challenges (RQ2), and relevance of the experience (RQ3) for Fall 2022 and Fall 2023.

Table 1

PSTs' Perceptions of Virtual Exchange Lesson Teaching Experience— Emergent Themes

Benefits			Challenges			Relevance (To Teacher Preparation Coursework)		
	Fall 2022 (n=25)	Fall 2023 (n=18)		Fall 2022 (n=25)	Fall 2023 (n=18)		Fall 2022 (n=25)	Fall 2023 (n=18)
Practice teaching in a virtual setting	12 (48%)	6 (33%)	Technology usage, connectivity, and communication	18 (72%)	11 (61%)	Yes	21 (84%)	15 (83%)
Practice supporting MLLs in science and mathematics contexts	10 (40%)	2 (11%)	Classroom management/ student engagement in a virtual setting	10 (40%)	6 (33%)	Possibly	3 (12%)	0 (0%)
Practice implementing science and mathematics instruction for students of diverse backgrounds	9 (30%)	5 (28%)	Time constraints Instructional Organizational	 6 (24%) 0 (0%)	 0 (0%) 6 (33%)	No	0 (0%)	1 (6%)
Virtual exchange (VE) exposure	0 (0%)	3 (17%)	Language/ communication	4 (16%)	1 (6%)	Other[a]	1 (4%)	2 (12%)
Other	0 (0%)	2 (11%)	Assessing learning in a virtual setting	2 (8%)	0 (0%)			
			Other	4 (16%)	0 (0%)			

Note. [a]PST's response was blank or did not address the question.

Results of RQ1

PSTs expressed multiple benefits to VE, including gaining experience in teaching in virtual settings, practicing supporting MLLs, and being exposed to VE as an instructional tool. One PST, Jordan (Fall 2022), said,

> "The [VE] experience allowed me to interact with non-native English learners and caused me to think about how to navigate my teaching in a way that makes learning easy for them. There were many considerations I had to put into practice like enunciating my words clearer, adding many visual cues, and being understanding of the time it takes for them to do certain activities."

Additionally, Ali (Fall 2022) summarized multiple benefits of engaging in the VE, saying,

> "For the Argentinian collaboration the greatest benefit came from the fact that it was taught virtually. As this was the first time I had ever taught virtually it brought the unique challenges of virtual teaching to the forefront. Things that I had to think about were being able to transition smoothly between materials, having activities to keep students engaged if they finished early, [and] managing technical issues either with the computer or the internet itself. Outside of the virtual aspect[,] the ELL side of the students also made my group consider the language that we were using and the speed at which we spoke. Overall, the Argentinian collaboration really served to make us as teachers truly consider our students and their unique backgrounds before teaching them and having us adapt lesson plans to suit them."

Results of RQ2

As with any instructional approach, challenges were expressed. PSTs most frequently noted difficulties resulting from technology usage, connectivity, and communication, in addition to classroom management, student engagement in virtual settings, and various time constraints. Alex (Fall 2023) noted that "the main challenge for... the virtual exchange projects was the unreliability of technology and the internet... it was challenging to observe and keep the students engaged."

Both Nilam and Kai (Fall 2022) mentioned time considerations and the inability to build relationships with students, saying that

> "… it was sad that we were only able to work with them [students] the same day we met them," and "I felt as if there was not enough time to really develop and rehearse the lesson, which made the day of the lesson very stressful. The fact that we also taught them in one day made it hard to establish a connection with the students and also felt like the amount of content we were covering with them was too rushed for them to really understand the concepts."

Notably, the lack of rapport-building was mentioned less in the Fall 2023 VE; this is addressed in the "Discussion, Next Steps, and Practical Considerations" section.

Results of RQ3

PSTs from both semesters overwhelmingly indicated that VE was a worthy preparation component. Although one PST from Fall 2023 expressed that they did not find any personal value in the collaboration and would not recommend VE, all other responding PSTs had favorable experiences and noted that VE opportunities should continue to be incorporated in coursework. The rationale

provided by PSTs for including VE largely mirrored the benefits that PSTs noted in response to RQ1. Dylan (Fall 2022) said,

> "I definitely recommend continuing [this VE experience] for upcoming PBI classes because it's such an eye-opening experience for student teachers as most may not have a global education/learning experience. It will at least to some degree enhance their cultural awareness which is necessary to become a teacher."

Isha (Fall 2022) mentioned,

> "I think that practicing working with students where [E]nglish is their second language is beneficial and something I wish we had practiced more in the… program."

While acknowledging its relevance, several PSTs suggested the need for tweaks to make the VE more effective. PSTs mentioned this more frequently in the first VE iteration. For example, Cooper (Fall 2022) said,

> "Yes, I definitely consider this… a worthy activity. However, I do believe that drastic changes needs [sic] to be bought [sic] in this collaboration so that both parties can take the best out of this activity."

Staci (Fall 2023) echoed those same changes but with less fervor, stating that

> "I believe this is a useful activity for future PBI classes! I think there are some logistics that could be ironed out in the future, especially with regard to how to contact our collaborators. Even so, the activity is certainly a beneficial experience, especially with regard to interacting with ELLs."

Course instructors reported high PST engagement with VE (in both quantity and quality of participation), greater PST attention to supporting MLLs, and higher-quality course products related to lesson design and delivery for in-person teaching experiences in local schools.

Teachers from Colegio Bayard reported high enthusiasm among both teachers and students for participating in the VE experience, as well as adequate opportunities to practice emerging English language skills. PBI course instructors and teachers from Colegio Bayard both expressed a need to strengthen content facilitation and student content learning due to a variety of challenges, many of which are echoed in the PSTs' perceptions in Table 1 and are discussed in greater detail below.

DISCUSSION, NEXT STEPS, AND PRACTICAL CONSIDERATIONS

According to Hilliker and Yol (2022), "Integrated into teacher education, virtual exchange practices enhance teacher candidates' professional and pedagogical knowledge and practices" (p. 11). The data analyzed from the PSTs revealed that engaging in this VE supported progress toward the established outcomes. Specifically, PSTs reported benefits in virtual science and mathematics teaching skills (learning goal #1), English language development support for MLLs (learning goal #2), and an increase in instructional design and delivery in the context of culturally diverse learners (learning goals #3, #4, and #5). Additionally, most PSTs expressed that this was a valuable pedagogical experience worthy of inclusion in future courses.

However, PSTs did face challenges within the VE. Technology limitations, time constraints, assessing student content learning, effective classroom management, and student engagement were all expressed as hurdles to implementing a more effective VL experience. This is unsurprising, given that this was the first time most PSTs had taught via a virtual format. While inexperience and the global context may have amplified these challenges, they are common to many virtual teaching experiences (Francom, Lee, & Pinkney, 2021; Leech, Gullett, Cummings, & Haug, 2020), suggesting that PSTs need more support and practice teaching in multiple virtual contexts. Several PSTs also noted language and communication challenges with students, although this was expressed less in the Fall 2023 responses. PSTs would benefit from additional instruction and resources in supporting MLLs.

Notably, the time spent in live VE experiences did not count toward the PSTs' required field experience hours for certification due to specific language regarding field hours in the Texas educator preparation curriculum. However, the virtual exchange was still deemed valuable for meeting the teacher certification curriculum requirements for virtual instruction, and the course instructors are actively exploring ways these VE teaching experiences could be considered for field requirements in future enactments.

Overall, the unique integration of VE instruction has been positive; future VE collaborations between UTeach Dallas faculty and Colegio Bayard teachers have already been planned. On the basis of PSTs' perceptions and course instructors' and teachers' reflections, "next steps" have been identified that may be beneficial for future enactments of this collaboration and for others interested in engaging in similar VE collaborations.

Several "keep doing" components were flagged. These included continuing planned meetings between instructors and PSTs to better understand each other's needs and goals between each iteration of VE, designing instruction

aligned with the curriculum, integrating language acquisition with inquiry-based STEM content practices, and using interactive platforms to introduce participants.

Additional "start doing" practices were implemented during the Fall 2023 VE, building on the experience from Fall 2022. In Fall 2022, PSTs were unable to meet and interact with their students until the actual lesson teaching date. All the stakeholders agreed that an extra virtual "meet and greet" between PSTs and their student teams was necessary for future collaboration to help build rapport. This also allowed for opportunities to troubleshoot technology (adjustments to the Argentinian partners' internet access and changes to the virtual platform were made) and provided exposure to language components (ex. accents) prior to teaching the lesson. Oral language instruction was also supported through real-time transcripts and written "chat" functions, which significantly improved the quality of the interactions and learning.

Providing multiple VE lesson teaching opportunities between PSTs and their student teams would be ideal and has been discussed; the logistics of feasibility are still being analyzed. Specifically, in the PBL course, instructors revised the lesson plans after the Fall 2022 VE to better align with pacing, content quantity, and student assessment, considering time constraints. Instructors also added more virtual teaching rehearsal support for PSTs in preparation for live student instruction.

An ongoing area of necessary refinement in the VE is the assessment and feedback of student products. This was limited to formative assessment only during these two VE experiences, as PSTs were unable to obtain the final products from Colegio Bayard. Conversations between UTD course instructors and Colegio Bayard teachers have taken place to ensure the creation and submission of final products to PSTs for assessment and feedback after live VE teaching in future collaborations, starting with the Fall 2024 enactment.

For teacher preparation programs seeking to incorporate VE experiences, there are a growing number of resources available for finding partners and designing successful collaborations, such as online collaboration platforms (ex. iEARN, which is primarily for pre-K-12 partnerships, along with offering a PST component), university support through VE and international education departments, personal contacts, and, in the case of this VE, direct messaging with potential collaborators. To implement synchronous experiences, finding VE partners that reside in closer time zones may prove beneficial for scheduling purposes; however, there are creative ways to implement synchronous VE even with larger time differences. For example, teacher preparation program instructors could schedule several strategic outside-of-class meeting times into the syllabus to account for time differences (which the UTD course instructors have implemented before), or there could be instances where a morning class for one partner aligned with a late afternoon class for the other, allowing for partner options with slightly greater distance.

IMPLICATIONS

VE is a promising approach to enhancing teacher preparation. Collaborations between international educational institutions that fulfill the needs of all partners are bound to be the way forward. Instituting this approach can bring professionals from diverse contexts together to establish innovative and relevant educational experiences worldwide. Harnessing VE's potential in preparing future teachers for an increasingly globalized world enables teacher educators to expose PSTs to novel ways of bridging borders, fostering intercultural competence, facilitating an understanding of academic content, and encouraging meaningful connections between global classrooms.

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