

Investigating Preservice Teachers' Perceptions of Interdisciplinary Pedagogies in an Innovative Elementary Teacher Preparation Program

Jiwon Kim, Monmouth University, United States

Sandra Zak, Monmouth University, United States

Vecihi Serbay Zambak, Monmouth University, United States

The Paris Conference on Education 2026

Official Conference Proceedings

Abstract

Elementary teachers must teach across content areas to foster student interest, deepen understanding, and prepare learners for the world. Teacher education programs, therefore, should equip preservice teachers (PSTs) with the knowledge for implementing interdisciplinary instruction. This study examines PSTs' reflections on interdisciplinary teaching in an innovative university teacher preparation program in New Jersey, USA, focusing on their conceptions, confidence, and perceived challenges. PSTs in the program complete five courses in each of four content areas, along with pedagogy coursework. In their senior year, PSTs take a semester-long interdisciplinary capstone course, co-taught by two professors, where they learn interdisciplinary teaching strategies and design interdisciplinary units. Reflections were collected at the conclusion of the capstone course over a two-year period, focusing on participants' understanding, conceptions, and confidence regarding interdisciplinary teaching. The data were analyzed using coding and thematic interpretation, with credibility supported through peer review and investigator triangulation. Thematic analysis of reflections showed that PSTs initially had limited understanding of interdisciplinary teaching and unit design. By the end of the capstone course, they reported increased confidence and readiness to implement interdisciplinary instruction, attributing growth to exploring connections across content areas and various social and global topics. These findings underscore the importance of teacher preparation in developing interdisciplinary teaching strategies. Nonetheless, PSTs identified challenges related to aligning standards across disciplines, instructional practicality, administrative and parental expectations, and assessment. This study illustrates program-wide interdisciplinary teacher preparation and identifies ways to strengthen preservice teachers' pedagogical and dispositional readiness.

Keywords: interdisciplinary, elementary teacher, teacher preparation, preservice teachers

iafor

The International Academic Forum

www.iafor.org

Introduction

Learning opportunities during the elementary grades play a crucial role in students' early cognitive and social development and in their success in later years (Bennett, 1986). Therefore, elementary teachers play a vital role in supporting students' development of foundational content knowledge and motivation to learn (Ekmekci & Serrano, 2022; Fauth et al., 2019; Fennema & Franke, 1992; Hairrell et al., 2011). Elementary teachers must teach across content areas to foster student interest, deepen understanding, and prepare learners for the world. Teacher education programs, therefore, should equip preservice teachers (PSTs) with the knowledge for implementing interdisciplinary instruction.

Recent research has provided evidence of the observable benefits of interdisciplinary education (An, 2017; Brand & Triplett, 2012; Santau & Ritter, 2013). By connecting different areas of study, interdisciplinary education aims to facilitate greater conceptual understanding among students than if they had learned the content of each subject in isolation (Brand & Triplett, 2012; Campbell & Henning, 2010; Gerke, 2017). However, reports on interdisciplinary programs in schools have been and remain limited, and there is a lack of adequate research or guidance on methods (Lagemann & Shulman, 1999; Warkentien et al., 2022; Wood, 2015). Teacher preparation is critical in developing pedagogical content knowledge (PCK) for this interdisciplinary teaching approach.

Not all elementary education programs prepare pre-service teachers (PSTs) in the same way. Although teacher education associations provide extensive recommendations on the types of content knowledge, teaching skills, and dispositions that elementary PSTs need to develop, each program interprets those recommendations differently (Bezuk et al., 2017; Morrell et al., 2020). Scholars have called for more opportunities for teacher preparation and a more thorough examination of how pre-service teacher preparation affects the implementation and impacts of interdisciplinary education (Harrison et al., 2020).

Following recent recommendations in the literature, this study explores PSTs' discussions and reflections on interdisciplinary teaching approaches within an innovative interdisciplinary elementary teacher education program in New Jersey, USA, focusing on their conceptions, confidence, and perceived challenges.

The following research questions (RQs) guide this study:

1. In what ways do PSTs in an elementary education program reflect on interdisciplinary teaching pedagogies?
2. Which challenges do PSTs in an elementary education program recognize about interdisciplinary teaching pedagogies?

Theoretical Framework

Knowledge and Quality of Teaching Practice

Elementary teacher education programs in the U.S. vary in their required coursework and teaching experiences for candidates. Professional and subject-specific standards guide these programs to ensure a comprehensive education. The National Board for Professional Teaching Standards [NBPTS] (2012) recommends 10 standards for teachers of students ages 3–10, emphasizing subject-matter knowledge in language and literacy, mathematics, science, and social studies (Darling-Hammond, 2008).

Developing subject matter knowledge during preservice education supports PSTs' PCK and the quality of their teaching practices (König & Pflanzl, 2016; Morris & Hiebert, 2017). Teacher knowledge in literature has been defined in relation to Shulman's concept of PCK, underlying interrelationships between subject matter and pedagogical knowledge, and their intersection (McEwan & Bull, 1991; Shulman, 1986). Researchers have used various measures to assess teacher content knowledge (Blömeke & Delaney, 2012). Praxis tests are among the measures used to evaluate PSTs' knowledge of teaching (Mikeska et al., 2018; Phelps et al., 2020).

The quality of teaching practice is described in terms of teachers' essential knowledge, skills, and dispositions regarding curriculum, cultures, and the social context of teaching, and is measured with standardized tests, observations, and rubrics (Chen et al., 2011; Gore et al., 2017; Hollins, 2011). Educative Teacher Performance Assessment (edTPA) is one of the performance-based measures used to evaluate PSTs' quality of teaching in terms of planning, instruction, and assessment for student learning (Sato, 2014; Youngs & Whittaker, 2016).

Interdisciplinary Teaching Pedagogies

Although several definitions of interdisciplinary education use slightly different language, commonalities across these definitions point to an emerging consensus (Moser et al., 2020; National Academy of Sciences, 2004; Newell, 2013). Interdisciplinary education focuses on a topic, theme, or problem, reflecting the natural relationship between different disciplines of knowledge. At the same time, multidisciplinary instruction combines information from different disciplines and reports only at the end, or integrated instruction incorporates one subject within others (Wood, 2015). PSTs need to develop appropriate conceptions and confidence about the specific ways of interdisciplinary education to plan this way.

PSTs' Conceptions and Confidence in Interdisciplinary Teaching

Teachers have not been educated as students in interdisciplinary ways, have little training in designing interdisciplinary units, and may not feel prepared to extend beyond their disciplinary expertise (Wang et al., 2020; Wu et al., 2021). In addition, teachers' conceptions, motivation, and confidence in teaching interdisciplinary content are essential considerations in determining whether they are ready for this pedagogy (Applebee et al., 2007).

Harrison and colleagues (2020) have called for a more thorough examination of how PST preparation affects the implementation and impacts of interdisciplinary education. As noted by Havice et al. (2018), an interdisciplinary (or integrated) approach cannot occur overnight, particularly not without thoughtful training for future teachers. Superficial connections result partly from teachers' discomfort or unfamiliarity with the subject matter. To examine these discomforts, it is important to look into PSTs' reflections and understand their perceptions of interdisciplinary teaching approaches and challenges in implementing these pedagogies.

Interdisciplinary Program and Capstone Course

Principles of the Interdisciplinary Program

The interdisciplinary major offers substantial university-level coursework to better prepare future elementary teachers in each of the four subject areas they will teach. The curriculum includes five courses in mathematics, five in science, six in reading and language arts, and nine

in social studies. Fifteen or more credit hours in each of these areas help prepare future teachers to be highly qualified in all areas, including helping students prepare to pass all four required subject-area PRAXIS II exams. Elementary teachers with high proficiency across all subject areas are better equipped to help their students meet learning outcomes aligned with the standards.

The curriculum was constructed with reference to relevant standards and recommendations made by professional organizations. Some of these include the Common Core Standards in Mathematics (CCSS-M), the National Council of Teachers of Mathematics (NCTM), Next Generation Science Standards (NGSS), and the PRAXIS II social studies and reading/language arts content. Also, the major is a cooperative endeavor involving Arts and Sciences units and the School of Education. The program's content-area courses are delivered by Arts and Sciences departments and faculty and augmented by pedagogy-focused courses in mathematics, science, language arts, and social studies. Methods courses outside the major are delivered by School of Education faculty. Its capstone course is delivered by both the Arts and Sciences and the School of Education faculty. Program administration is housed in the Department of Curriculum and Instruction within the School of Education.

Effectiveness of Interdisciplinary Elementary Teacher Preparation

Elementary teachers' preparation to teach science or social studies in K–6 grades is also limited. In her survey study, Trygstad et al. (2013) found that fewer than half of teacher education programs offered at least one course in physics or chemistry, whereas the majority of required science coursework was in life and earth sciences. The image of elementary teacher preparation for social studies is not very different (Mimbs, 2002; Passe, 2006; Womac, 2014). Mimbs (2002) found that 32% of the programs that participated in her study did not require a geography course within their elementary teacher education programs. The status of geography courses within the elementary teacher education curriculum was even worse in 2014; Womac (2014) also found that 87% of the undergraduate elementary teacher education programs did not require their teacher candidates to take a geography course.

In light of these reports and studies, we believe the Interdisciplinary Studies for Elementary Educators undergraduate program, a 120-credit interdisciplinary degree, provides sound content preparation for elementary teacher candidates through its balanced curriculum and coursework that focus on breadth, depth, and interdisciplinary aspects of English language arts, mathematics, science, and social studies. In their senior year, PSTs take a semester-long interdisciplinary capstone course, co-taught by two professors, where they learn interdisciplinary teaching strategies and design interdisciplinary units.

Interdisciplinary Program's Capstone Course

In their senior year, PSTs take a semester-long interdisciplinary capstone course, co-taught by two professors, where they learn interdisciplinary teaching strategies and design interdisciplinary units. The teacher candidates will have completed most of their content-area courses and many of their content-based methods courses, which provide a foundation for learning interdisciplinary teaching methods. Its capstone course, by design, is to be taught jointly by one faculty member from a content-area discipline and the other from the education area. Each semester the course is taught, a broad theme is chosen. Example themes include social justice, the environment, bullying, climate change, poverty, and urbanization.

The course is divided into smaller sections: the first section introduces the interdisciplinary teaching method. The class has a chance to read about the method. The second section of the course is about six weeks in length. During this time, a series of speakers are invited to speak with the class. These lessons provide teacher candidates with the opportunity to see how a single theme can be understood and taught from multiple perspectives, illustrating its interdisciplinary potential. The third section covers about five weeks of the course, during which students read more about designing interdisciplinary lessons and preparing an interdisciplinary unit plan. The key parts in this section are a cross-curricular study and creating a web design of their interdisciplinary unit plans about a topic they choose. The web designs help PSTs connect disciplines to the topic and to each other. Finally, each PST writes a unit plan and lesson plans and presents them as micro teaching.

Methodology

Reflections were collected at the conclusion of the capstone course over a two-year period, focusing on participants' understanding, conceptions, and confidence regarding interdisciplinary teaching. The data were analyzed using coding and thematic interpretation, with credibility supported through peer review and investigator triangulation. Thematic analysis of reflections showed that PSTs initially had a limited understanding of interdisciplinary teaching and unit design.

We used qualitative methods as the primary methodology (Creswell & Plano Clark, 2017) to analyze capstone course data from 28 PSTs enrolled in IS-410 during the fall 2020 and 2021 semesters at the end of each semester. The reflections included five questions about PSTs' understanding, conceptions, and confidence in interdisciplinary teaching (see Figure 1).

Figure 1

End-of-Semester Reflection Prompts

- 1) Prior to this course (IS-410), how familiar were you with the interdisciplinary teaching model? Explain.
- 2) After taking this course, how much prepared do you feel to teach an interdisciplinary lesson in your own classroom? Explain.
- 3) In making the Unit Plan for teaching issues, did you feel you had the necessary content knowledge to research your topic? Explain.
- 4) In your opinion, how could the interdisciplinary unit plan project assist with the development of knowledge, skills or attitudes in teacher training (in any aspects, i.e., social justice, interdisciplinary instruction, personal preconception and bias, perspectives on the local and global issues)?
- 5) In doing the interdisciplinary unit plan project, what challenges or questions did you (or still) have?

We analyzed PSTs' reflections by developing coding and interpreting themes and sub-categories (Ary et al., 2002). For credibility, peer review and investigator triangulation were used (Eisner, 1998).

Results and Discussions

By the end of the capstone course, PSTs reported increased confidence and readiness to implement interdisciplinary instruction, attributing growth to exploring connections across content areas and various social and global topics. These findings underscore the importance of teacher preparation in developing interdisciplinary teaching strategies. Nonetheless, PSTs identified challenges related to aligning standards across disciplines, instructional practicality, administrative and parental expectations, and assessment. **Table 1** shows the prompt question numbers, a summary of those students' responses, and our qualitative interpretations.

Table 1

Themes, Subcodes, and Exemplary Quotes From PSTs' Reflections

Major Themes	Sub-codes	Exemplary Quotes
<i>Familiarity with Interdisciplinary Teaching Pedagogies</i>	• Overall unfamiliarity • Surface-level familiarity • Previous course experience • Previous class observation	<i>In field placements, I had seen how some teachers incorporated science or social studies into reading and language arts instruction since the two subjects were either not taught each day or only for a short amount of time. (PST14, subcode: Previous class observation)</i>
<i>Preparedness to Teach Interdisciplinary Lessons</i>	• Limited preparedness due to a lack of interdisciplinary teaching experience • Preparedness as a result of course assignments • Preparedness as a result of online course content	<i>Also, the unit plan prepared me to teach one main social justice topic and break it down into different parts, within different subject areas. (PST2, subcode: Preparedness as a result of course assignments)</i>
<i>Confidence in PSTs' own Interdisciplinary Content Knowledge</i>	• Limited confidence in some content more than others • Limited confidence in identifying relevant topics for interdisciplinary teaching • Confidence in content as a result of previous content courses	<i>I believe that I focused more on English or language arts because I feel that this content area is the easiest to base my other lessons off of as a base. (PST18, subcode: Limited confidence in some contents more than others)</i>

	• Confidence in content as a result of guest instructors	
<i>Overall Reflections on the Interdisciplinary Seminar Course</i>	• Learning to connect multiple subjects • Learning to teach content around real-world topics • Learning pedagogical strategies in lesson/unit planning	<i>[We] should be informed by content across all disciplines on how to teach issues and how to connect them because elementary educators are usually teaching all subjects in their schools. (PST13, subcode: Learning to connect multiple subjects)</i>
<i>Challenges Perceived about Interdisciplinary Teaching</i>	• Difficulty in aligning multiple contents with relevant standards • Questioning the practicality • Concerns about administrative support and parental expectations • Difficulty regarding assessments	<i>From my observations, especially as a new teacher, you have to follow the curriculum; therefore, this model would be incredibly hard to follow in the first few years of teaching. (PST6, subcode: Questioning the practicality)</i>

18 out of 28 (64%) PSTs indicated familiarity with the interdisciplinary teaching model. However, those who cited their familiarity only revealed surface-level knowledge and conceptions of interdisciplinary teaching approaches. 22 (79%) and six (21%) PSTs felt prepared and somewhat prepared to teach an interdisciplinary lesson in their field placements, respectively. All but one PST (96%) reported being confident in the content knowledge necessary to teach multiple subjects. In explaining their confidence, PSTs cited their experience in this capstone course and how it helped them explore connections among multiple content areas and real-world topics to motivate elementary students' learning across subjects.

Our analysis revealed four main challenges about interdisciplinary teaching pedagogies: i) aligning multiple contents with relevant standards, ii) the practicality, iii) administrative support and parental expectations, and iv) assessments. While PSTs described their gains as a result of the course assignments (i.e., interdisciplinary unit plan), they still highlighted that identifying relevant standards to connect multiple subject areas was the most prominent challenge.

Significance of the Study

It is critical for elementary teachers to provide opportunities for their students and to “teach across content areas to model, respond, and prepare students for the world in which they live,” addressing the challenges they face globally (Boche et al., 2021, p. 15). In that respect, teacher education programs need to be developed to prepare competent future elementary teachers in

all content areas and to be pedagogically insightful about how to design and teach an interdisciplinary curriculum.

Our study illustrates program-wide interdisciplinary teacher preparation and identifies ways to strengthen preservice teachers' pedagogical and dispositional readiness. PSTs in IS-410 reflected that they had limited experience or knowledge of what interdisciplinary teaching means and how an interdisciplinary unit or lesson plan is created. However, after taking the capstone course, PSTs indicated strong confidence and felt prepared for interdisciplinary teaching in their future classroom. These findings assure how critical teacher preparation is in developing PCK and conceptions for interdisciplinary teaching strategies (Harrison et al., 2020). Some challenges were also perceived regarding interdisciplinary teaching pedagogies, commonly identified among PSTs in other studies (Warkentien et al., 2022; Wood, 2015).

Our study presents a concrete example of a program-wide implementation of teacher training for interdisciplinary elementary education and resulting teacher outputs. Building on our results, teacher educators identify additional ways to improve PSTs' knowledge across all content areas and their pedagogical and dispositional readiness for interdisciplinary teaching.

References

- An, S. A. (2017). Preservice teachers' knowledge of interdisciplinary pedagogy: the case of elementary mathematics–science integrated lessons. *ZDM*, 49(2), 237–248.
- Applebee, A. N., Adler, M., & Flihan, S. (2007). Interdisciplinary curricula in middle and high school classrooms. *American Educational Research Journal*, 44(4), 1002–1039.
- Ary, D., Jacobs, L. C., & Razavieh, A. (2002). *Introduction to research in education* (6th ed). Wadsworth Thomson Learning.
- Bennett, W. J. (1986). *First lessons: A report on elementary education in America*. US Department of Education.
- Bezuk, N., Bay-Williams, J., Clements, D. H., Martin, W. G., Aguirre, J., Boerst, T., Burroughs, E. A., Dickey, E., Hughes, E., Huinker, D., Gutierrez, R., Karp, K., Lewis, J., Olson, T. A., Philipp, R., Rigelmann, N., Strutchens, M. E., White, D. Y., & Thomas, C. D. (2017). *AMTE standards for mathematics teacher preparation*. AMTE.
- Blömeke, S., & Delaney, S. (2012). Assessment of teacher knowledge across countries: A review of the state of research. *ZDM*, 44(3), 223–247.
- Boche, B., Bartels, S., & Wassilak, D. (2021). Reimagining an elementary teacher education preparation program: Striving for integrated teaching. *Educational Considerations*, 47(1), n1.
- Brand, B. R., & Triplett, C. F. (2012). Interdisciplinary curriculum: An abandoned concept? *Teachers and Teaching*, 18(3), 381–393.
- Campbell, C., & Henning, M. B. (2010). Planning, teaching, and assessing elementary education interdisciplinary curriculum. *International Journal of Teaching and Learning in Higher Education*, 22(2), 179–186.
- Chen, W., Hendricks, K., & Archibald, K. (2011). Assessing pre-service teachers' quality teaching practices. *Educational Research and Evaluation*, 17(1), 13–32.
- Creswell, J. W., & Plano Clark, V. L. (2017). *Designing and conducting mixed methods research*. Sage Publications.
- Darling-Hammond, L. (2008). Knowledge for teaching: What do we know? In M. Cochran-Smith, S. Feiman-Nemser & D. J. McIntyre (Eds.), *Handbook of research on teacher education* (3rd ed.) (pp. 1316–1323). Routledge.
- Eisner, E. W. (1998). *The enlightened eye: Qualitative inquiry and the enhancement of educational practice*. Merrill/Prentice-Hall.
- Ekmekci, A., & Serrano, D. M. (2022). The impact of teacher quality on student motivation, achievement, and persistence in science and mathematics. *Education Sciences*, 12(10), 649.

- Fauth, B., Decristan, J., Decker, A. T., Büttner, G., Hardy, I., Klieme, E., & Kunter, M. (2019). The effects of teacher competence on student outcomes in elementary science education: The mediating role of teaching quality. *Teaching and Teacher Education*, 86, 102882.
- Fennema, E., & Franke, M. L. (1992). Teachers' knowledge and its impact. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 147–164). Macmillan.
- Gerke, A. G. (2017). *Interdisciplinary education in the elementary curriculum: Exploring teacher perceptions and practices*. [Unpublished master's thesis]. Ontario Institute for Studies in Education of the University of Toronto.
- Gore, J., Lloyd, A., Smith, M., Bowe, J., Ellis, H., & Lubans, D. (2017). Effects of professional development on the quality of teaching: Results from a randomised controlled trial of Quality Teaching Rounds. *Teaching and Teacher Education*, 68, 99–113.
- Hairrell, A., Rupley, W. H., Edmonds, M., Larsen, R., Simmons, D., Willson, V., Byrns, G., & Vaughn, S. (2011). Examining the impact of teacher quality on fourth-grade students' comprehension and content-area achievement. *Reading & Writing Quarterly*, 27(3), 239–260.
- Harrison, L. M., Hurd, E., & Brinegar, K. (Eds.). (2020). *Integrative and interdisciplinary curriculum in the middle school: Integrated approaches in teacher preparation and practice*. Routledge Research in Education.
- Havice, W., Havice, P., Waugaman, C., & Walker, K. (2018). Evaluating the effectiveness of integrative STEM education: Teacher and administrator professional development. *Journal of Technology Education*, 29(2), 73–90.
- Hollins, E. R. (2011). Teacher preparation for quality teaching. *Journal of Teacher Education*, 62(4), 395–407.
- König, J., & Pflanzl, B. (2016). Is teacher knowledge associated with performance? On the relationship between teachers' general pedagogical knowledge and instructional quality. *European Journal of Teacher Education*, 39(4), 419–436.
- Lagemann, E. C., & Shulman, L. S. (1999). *Issues in educational research: Problems and possibilities*. San Francisco: Jossey-Bass.
- McEwan, H., & Bull, B. (1991). The pedagogic nature of subject matter knowledge. *American Educational Research Journal*, 28(2), 316–334.
- Mikeska, J. N., Kurzum, C., Steinberg, J. H., & Xu, J. (2018). Assessing elementary teachers' content knowledge for teaching science for the ETS® educator series: Pilot results. *ETS Research Report Series*, 2018(1), 1–30.

- Mimbs, C. (2002). Leadership Development as Self-Development: An Integrated Process. *Action in Teacher Education*, 24(3), 20–25.
<https://doi.org/10.1080/01626620.2002.10734427>
- Morrell, P., Rogers, M. P., Pyle, E., Roehring, G., & Veal, W. (2020). *2020 NSTA/ASTE standards for science teacher preparation*. ASTE.
- Morris, A. K., & Hiebert, J. (2017). Effects of teacher preparation courses: Do graduates use what they learned to plan mathematics lessons?. *American Educational Research Journal*, 54(3), 524–567.
- Moser, K. M., Ivy, J., & Hopper, P. F. (2020). Rethinking content teaching at the middle level: An interdisciplinary approach, In L. M. Harrison, E. Hurd, & K. Brinegar (Eds.), *Integrative and interdisciplinary curriculum in the middle school: Integrated approaches in teacher preparation and practice*. Routledge Research in Education.
- National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. (2004). *Facilitating interdisciplinary research*. The National Academies Press.
- National Board for Professional Teaching Standards. (2012). *Early childhood generalist standards for teachers of students ages 3-10* (3rd ed.). National Board for Professional Teaching Standards.
- Newell, W. H. (2013). The state of the field: Interdisciplinary theory. *Issues in Interdisciplinary Studies*, 31, 22–43.
- Passe, J. (2006). New challenges in elementary social studies. *Social Studies*, 97, 189–192.
- Phelps, G., Steinberg, J., Leusner, D., Minsky, J., Castellano, K., & McCulla, L. (2020). Praxis® content knowledge for teaching: Initial reliability and validity results for elementary reading language arts and mathematics. *ETS Research Report Series*, 2020(1), 1–44.
- Santau, A. O., & Ritter, J. K. (2013). What to teach and how to teach it: Elementary teachers' views on teaching inquiry-based, interdisciplinary science and social studies in urban settings. *The New Educator*, 9(4), 255–286.
- Sato, M. (2014). What is the underlying conception of teaching of the edTPA? *Journal of Teacher Education*, 65(5), 421–434.
- Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4–14.
- Trygstad, P. J., Smith, P. S., Banilower, E. R., & Nelson, M. M. (2013). *The status of elementary science education: Are we ready for the Next Generation Science Standards?* Horizon Research. <https://files.eric.ed.gov/fulltext/ED548249.pdf>

- Wang, H. H., Charoenmuang, M., Knoblock, N. A., & Tormoehlen, R. L. (2020). Defining interdisciplinary collaboration based on high school teachers' beliefs and practices of STEM integration using a complex designed system. *International Journal of STEM Education*, 7(3).
- Warkentien, S., Goeking, J., Dilig, R., Knapp, L., & Stanley, R. (2022). *Interdisciplinary education: Literature review and landscape analysis*. Lucas Education Research International.
- Womac, P. (2014). The unfortunate status of geography in elementary teacher education: A call for discourse. *Research in Geographic Education*, 16(2), 46–60.
- Wood, K. (2015). *Interdisciplinary instruction: Unit and lesson planning strategies K-8* (5th ed). Waveland Press, Inc.
- Wu, Y., Cheng, J., & Koszalka, T. A. (2021). Transdisciplinary approach in middle school: A case study of co-teaching practices in STEAM teams. *International Journal of Education in Mathematics, Science and Technology*, 9(1), 138–162.
- Youngs, P., & Whittaker, A. (2016). The role of edTPA in assessing content-specific instructional practices. In P. Youngs & J. Grissom (Eds.), *Improving teacher evaluation systems: Making the most of multiple measures* (pp. 37–50). Teachers College Press.