Leveraging Teacher Values to Bridge Barriers in STEM Technology Integration

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The Issue

This year, I have taken on the empowering modern learner lead role, a position responsible for driving the meaningful use and integration of technology in the school. I will be designing hands-on professional learning opportunities and collaborating with staff to encourage meaningful integration of digital tools and technology-rich experiences for multiple subjects (including math and science) for grades six through eight. Throughout this course, I have unpacked my own assumptions of technology-use, explored its advantages in the STEM classroom, analyzed real-world video case studies, and gathered perspectives from colleagues. In my interview with Mr. C, an experienced math and science teacher, he emphasized the importance of vulnerability in practice saying, "...if you're too afraid to try something and fall on your face in front of students, then you've got a problem…. you should be throwing yourself at these things and just trying it for your own sake" (personal communication, September 24, 2025). In week 3 discussions, I referenced my own value system that emphasizes curiosity, risk-taking and vulnerability in the math and science classroom, which are qualities I hope to model for both my colleagues and students this year. In the video cases we analysed, I noted that experienced STEM teachers held stead-fast with their approaches to integrating new digital tools. For example, Video 3 from Case 5, the teacher admits being nervous to try new things is one of her barriers to technology integration. Similarly, in Video 1 from Case 6, a pre-service teacher hesitates to adopt new technology in the classroom, again referencing comfort levels as a constraint.

Foundational research established the assumption that teacher beliefs critically influence practice and are linked to meaningful technology integration (Ertmer et al., 2012;

Kim et al., 2013). This literature emphasizes the intrinsic “second-order” barriers to technology integration and how they often outweigh “first-order” barriers like access or training factors. More recent work (Cheng et al., 2020; Backfisch et al., 2020, 2021; Segal et al., 2025) extends this discussion by examining motivational constructs like expectancy-value and utility, suggesting that teacher motivation and context shape integration just as strongly as knowledge or skill. While it is tempting to frame the issue as needing a belief change, my course reflections, professional experience, and new research has led me to a new perspective. Subsequent STEM-focused research suggests that this relationship is complex and often moderated by contextual and motivational factors. The issue of focus is how we may leverage teachers’ existing pedagogical or identity-laden beliefs, like inquiry or creativity, to overcome barriers to technology integration in STEM education.

Article Selection Process

The foundational articles forming the basis of my research were suggested by Dr. Hartwell (Ertmer et al., 2012; Kim et al., 2013). Building on this research, I used the UBC Library Database to search for empirical peer-reviewed articles with the broad term: “technology integration beliefs”. This uncovered an influential systematic review by Tondeur et al., (2017) demonstrating bi-directional relationships between teachers’ pedagogical beliefs and technology use in education. Keeping recency and relevance to STEM in mind, I also searched for, “technology integration beliefs science math”, narrowing results and filtering for empirical peer-reviewed articles from the past five years. Along the way, but not included, I reviewed the foundational work mentioned earlier as well as work by Cheng et al., (2020); Backfisch et al., (2020, 2021); and Segal et al., (2025). They help set context for this multifaceted issue, particularly around expectancy-value theory, utility beliefs, and teacher emotions. When selecting my final articles for the annotation, I considered their connection to STEM as well as their ability to advance the framing of this issue for further conversation. The work of Cheng, Antonenko, & Ritzhaupt (2024), Segal et al. (2025), and Bereczki & Kárpáti (2021) showcase a strong evolution of this issue to where we are now, draw clear connections to STEM education, and highlight my own evolution of thinking and learning.

Annotated Bibliography

Cheng, L., Antonenko, P. D., & Ritzhaupt, A. D. (2024). The impact of teachers' pedagogical beliefs, self-efficacy, and technology value beliefs on 3D printing integration in K–12 science classrooms. *Educational Technology Research and Development*, 72(1), 181–208. https://doi.org/10.1007/s11423-023-10233-9

The study seeks answers to how teachers' pedagogical beliefs, self-efficacy for integration, and technology value beliefs are related to their 3D printing technology integration into the science classroom across K-12. This directly relates to my issue, underscoring that teacher beliefs are important, but examines to what effect they can influence integration of technologies in a science of math setting. The quantitative study analyzed 26 in-service science teachers who participated in a nationally funded project aimed at engaging K-12 students in STEM learning through 3D printing integration. Data was collected using four surveys for teacher beliefs on 3D printing integration, teacher pedagogical beliefs, teacher 3D printing value beliefs, and teacher self-efficacy in 3D printing. The latter was grounded in the Technological Pedagogical Content Knowledge (TPACK) framework to capture teachers' knowledge domains (TK, TPK, TCK, TPACK, and PCK). Lesson plans were analyzed using a codebook to determine STEM integration levels. In reference to their research question, a descriptive statistical analysis on the beliefs data was performed, followed by coded lesson plan analysis, correlations between beliefs and integration levels, and a thematic analysis of open-ended survey responses. Results showed no significant correlations between teacher beliefs and integration levels, except a negative relationship between self-efficacy in pedagogical content knowledge (PCK) and STEM integration ($r = -.457$) (p. 195). The authors were admittedly surprised and concluded that beliefs alone may not predict 3D technology integration outcomes and postulated that the difference between this outcome and the outcomes by previous research (Tondeur et. al., 2017; Ertmer et. al., 2012) might be due to first-order barriers (e.g., technical issues and time) or even the short duration of the study (a few classes).

The study has several gaps that limit the interpretation. With a small sample of 26 participants and a correlational design, the findings cannot actually establish causation. The lesson plan analysis doesn’t capture the realities of a busy classroom that would be better served by observation. The authors acknowledge that positive outcomes may not appear in short interventions and that integration “requires sustained investment and continuous support for teachers” (p. 203). In my own science teaching, I have experienced similar technical challenges with 3D printers as I tried to print my students' designs. However, a new avenue for study may ask whether students can experience deep conceptual learning even when the technology itself fails as supporting pedagogical outcomes could lead to greater confidence in educator technology integration. This research responds directly to my issue by demonstrating that beliefs alone are insufficient for successful technology integration, especially when the complexity of tools, like 3D printing, introduces additional barriers. It is at the beginning of the annotation to demonstrate recent research that highlights the mixed-relationship between teacher beliefs and technology integration in science.

Segal, R., Miedijensky, S., Klemer, A., Raveh, I., Lavie, I., & Wagner-Gershgoren, I. (2025). The relationship between TPACK and emotions when mathematics and science teachers integrate computer technology. *International Journal of Mathematical Education in Science and Technology*, 1–20. https://doi.org/10.1080/0020739X.2025.2543816

This study examines how mathematics and science teachers' TPACK relates to their emotions when using computer technology for presenting information, assessment, and inquiry. It also seeks to answer to what extent the variance of teacher emotions can be explained by TPACK. In the first study, I established the mixed relationship between teacher beliefs and technology integration in STEM. Segal et al., (2025) is a recent study included to highlight that emotions and TPACK might moderate this relationship, specifically in the science and math context. Researchers used a quantitative set up and administered an online survey of 97 in-service elementary, middle and high school mathematics and science teachers. The survey used was based on two main theories, TPACK (Koehler & Mishra, 2009) and the PANAS (Positive and Negative Affect Schedule) (Watson et al., 1988). Teachers reported mostly positive emotions (e.g., interest, enthusiasm, engagement) when integrating technology, with negative emotions (anxiety, fear) rated notably lower. Positive emotions correlated significantly with technology use across instructional purposes: presenting information ($r = .24$, $p < .05$), assessment ($r = .34$, $p < .01$), and inquiry ($r = .28$, $p < .05$). Negative emotions showed weak or nonsignificant relationships (Table 6, p. 10). There are several key takeaways, notably the authors found that the higher a teacher reported their TPACK the more positive their emotions were, suggesting a bi-directional mutual influence. The authors point to prior work (Dong et al., 2020; Özgür, 2020) on TPACK's ability to mitigate "technostress" triggered by using educational technology (p. 13). The study did have a medium sample size. A major limitation includes the self-reported design of the survey which would be better corroborated by observations to ensure reliability. In connection to the main issue, we can start to see how emotions and knowledge confidence can fit into the relationship between teacher beliefs and their technology integration. It seems as if knowledge confidence (TPACK) increases positive emotion and reduces anxiety, helping beliefs translate into practice. For my own practice, I should not only be looking to offer development sessions for my staff that aim to increase technical and pedagogical knowledge, but also ensure emotional safety and well-being to allow them to act on their beliefs.

Bereczki, E. O., & Kárpáti, A. (2021). Technology-enhanced creativity: A multiple case study of digital technology-integration expert teachers' beliefs and practices. *Thinking Skills and Creativity*, 39(1), 1–27. https://doi.org/10.1016/j.tsc.2021.100791

This study investigates how expert teachers integrate technology to foster creativity in technology-enhanced learning environments, and how their beliefs about creativity shape their practice. I believe this final study offers the synthesis point for my issue. The prior annotations showed that beliefs, knowledge, and emotion shape technology integration, but Bereczki and Kárpáti (2021) reveal that change can happen when teachers' existing values, such as creativity, are intentionally connected to their use of digital tools. Twelve "expert" technology teachers from Hungary (both primary and secondary) participated in a qualitative multiple case study conducted through classroom observations, semi-structured interviews both pre- and post-observation, and the collection of lesson materials. Four teachers participating taught math or science. A focus was on how and why teachers were going to use technology to promote creativity and the exploration of connected pedagogical beliefs. There was an overarching alignment between teachers' creativity-fostering beliefs and their classroom practices, but the results show considerable variation in how those beliefs translated into action. Using the SCALE instrument (Richardson & Mishra, 2018), the authors report differences in support for creativity across learning environments ($M = 1.87$, $SD = .72$), particularly in the physical environment, learning climate, and learner engagement categories. For example, observations revealed four cases of “replacement” (where technology merely substituted existing practices) and eighteen instances of “amplification”, (where technology enhanced efficiency without fundamentally changing pedagogy). Even when beliefs about creativity align, contextual factors such as time, resources, and class size continue to shape teachers’ ability to enact technology-based creative instruction (Bereczki & Kárpáti, 2021, p. 18). Limitations include a small sample size, which lead to very detailed results when coupled with observations, but reduce the generalizability of the results. The study was done over four months, but only one site visit was conducted with each teacher, making each individual case cross-sectional. Finally, this last annotation connects directly to my issue by showing that lasting change in technology integration emerges not from transforming teachers’ beliefs but from connecting technology use to what they already value in their practice. Again, for me, this highlights the importance of designing professional learning that begins with teachers’ strengths such as curiosity, creativity, or even a subject passion, and looks to build technology integration around those anchors.

Conclusion

I started this analysis hoping to discover a way to utilize teachers' existing beliefs to increase meaningful technology integration. Across the three studies, a consistent theme emerges: the real work may not be about changing beliefs, but creating conditions that let those beliefs come to life. Cheng et al. (2024) reveal that even when teachers hold these strong pedagogical beliefs, self-efficacy and contextual constraints can prevent effective integration. Segal et al. (2025) build on this view by demonstrating that positive emotions and knowledge confidence (TPACK), can bridge the gap between belief and practice, reducing anxiety and promoting action. Finally, the inclusion of Bereczki and Kárpáti (2021) completes this progression by illustrating that integration becomes most powerful when teachers' existing values, such as creativity or inquiry, are intentionally leveraged. I believe that together, these studies indicate that the relationship between belief and practice can be moderated by emotion, TPACK, and value alignment. There is an opportunity here for longitudinal or observational research that examines how teachers' beliefs and practices evolve in real classrooms over time. The studies reviewed rely on self-report data and short-term interventions. Two of the three studies were strictly science and math focused. For math and science educators, this annotation suggests that professional learning must extend beyond technical skill development. It should intentionally inspire confidence, create emotional safety, and leverage value-based entry points that help teachers connect technology especially in math and science. In my role as an empowering modern learner lead, this means designing professional development that allows teachers to begin from what they already believe in, curiosity, problem solving, or creativity, and helping them explore how technology can deepen those strengths. This also raises new questions about vulnerability, another area of interest for me. I began this annotation with a quote from a colleague who encouraged "throwing yourself at these things" even if you fail. I now wonder whether vulnerability itself, teachers' willingness to experiment publicly, take risks, and recover from failure, could be a moderating factor that links TPACK with actual technology integration in math and science. Future research could explore how vulnerability interacts with beliefs and emotion, and whether it can be intentionally cultivated through professional learning.

Works Cited

Backfisch, I., Lachner, A., Hische, C., Loose, F., & Scheiter, K. (2020). Professional knowledge or motivation? Investigating the role of teachers' expertise on the quality of technology-enhanced lesson plans. *Learning and Instruction*, *66*, 101300. https://doi.org/10.1016/j.learninstruc.2019.101300

Backfisch, I., Lachner, A., Stürmer, K., & Scheiter, K. (2021). Variability of teachers' technology integration in the classroom: A matter of utility! *Computers & Education*, *166*(104159), 104–159. https://doi.org/10.1016/j.compedu.2021.104159

Bereczki, E. O., & Kárpáti, A. (2021). Technology-enhanced creativity: A multiple case study of digital technology-integration expert teachers' beliefs and practices. *Thinking Skills and Creativity*, *39*(1), 1–27. https://doi.org/10.1016/j.tsc.2021.100791

Cheng, L., Antonenko, P. D., & Ritzhaupt, A. D. (2024). The impact of teachers' pedagogical beliefs, self-efficacy, and technology value beliefs on 3D printing integration in K–12 science classrooms. *Educational Technology Research and Development, 72*(1), 181–208. https://doi.org/10.1007/s11423-023-10233-9

Cheng, S.-L., Lu, L., Xie, K., & Vongkulluksn, V. W. (2020). Understanding teacher technology integration from expectancy-value perspectives. *Teaching and Teacher Education*, *91*, 103062. https://doi.org/10.1016/j.tate.2020.103062

Dong, Y., Xu, C., Chai, C. S., & Zhai, X. (2020). Exploring the structural relationship among teachers' technostress, technological pedagogical content knowledge (TPACK), computer self-efficacy and school support. *Asia-Pacific Education Researcher,* 29(3), 147–115. https://doi.org/10.1007/s40299-019-00461-5

Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship.

Computers and Education, 59(2), 423-435. https://doi.org/10.1016/j.compedu.2012.02.001

Kim, C., Kim, M. K., Lee, C., Spector, J. M., & DeMeester, K. (2013). Teacher beliefs and technology integration. Teaching and Teacher Education, 29, 76-85. https://doi.org/10.1016/j.tate.2012.08.005

Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education*, 9(1), 60–70.

Özgür, H. (2020). Relationships between teachers' technostress, technological pedagogical content knowledge (TPACK), school support and demographic variables: A structural equation modeling. *Computers in Human Behavior*, 112, p. 106468. https://doi.org/10.1016/j.chb.2020.106468

Segal, R., Miedijensky, S., Klemer, A., Raveh, I., Lavie, I., & Wagner-Gershgoren, I. (2025). The relationship between TPACK and emotions when mathematics and science teachers integrate computer technology. *International Journal of Mathematical Education in Science and Technology*, 1–20. https://doi.org/10.1080/0020739x.2025.2543816

Tondeur, J., van Braak, J., Ertmer, P. A., & Ottenbreit-Leftwich, A. (2017). Understanding the relationship between teachers' pedagogical beliefs and technology use in education: a systematic review of qualitative evidence. *Educational Technology Research and Development*, *65*(3), 555–575. https://doi.org/10.1007/s11423-016-9481-2

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology,* 54(6), 1063–1070. https://doi.org/10.1037/0022-3514.54.6.1063