Shaping Pre-Service Teachers' Beliefs on Their Uses of Technology and Teaching Innovations

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Abstract: This paper explores how pre-service teachers' beliefs about educational innovation develop during participation in a targeted teacher training course. Building on the Technology Acceptance Model, we introduce the Innovation Acceptance Model to better capture the complexity of innovation readiness in education, including affective and experiential dimensions. Using a mixed-methods approach, data were collected over three consecutive course cycles through questionnaires, interviews, and observations. The course was designed using the Hothousing method, enabling participants to engage directly with innovative teaching practices. Results indicate a positive shift in participants' perceived usefulness and ease of implementation of educational innovations, as well as increased confidence and motivation. These findings support the applicability of IAM and highlight the value of hands-on, collaborative learning environments for fostering belief change in teacher education.

Keywords: innovation, TAM, change in belief systems, pre-service teachers, Hothousing.

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1 Introduction

This study addresses the reluctance of teachers (Drijvers, 2019) to implement innovative teaching methods like technology integration, project-based learning, and outdoor mathematics, despite evidence of their motivational and learning benefits for students. This reluctance is often rooted in teachers' beliefs and concerns. Our research focuses on a teacher training course designed to positively impact pre-service teachers' (PSTs') beliefs about educational innovation, moving beyond simple knowledge transfer to enhance their confidence and innovation readiness. PSTs' beliefs about teaching are often shaped by their own experiences as students in traditional classrooms with limited exposure to innovative practices (Castro, 2010). These deeply ingrained beliefs, formed from childhood experiences, can be resistant to change (Liljedahl et al., 2012), even when the value of new approaches is acknowledged. As beliefs are intertwined with affect (emotions, motivation, interest) (Goldin et al., 2009; Picard et al., 2004), we will examine PSTs' beliefs through this affective lens. Drawing on Davis's (1985) Technology Acceptance Model (TAM), which posits that 'perceived usefulness' and 'perceived ease of use' predict technology adoption, we extend this to a broader Innovation Acceptance Model (IAM) to study innovation acceptance (Békési et al., 2024). Our course, based on the Hothousing workshop method (Houghton et al., 2022), aims to positively influence PSTs' beliefs about the usability and ease of use of educational innovations. By fostering self-confidence and providing practical experience, we intend to increase their readiness to implement these methods. This study will describe PSTs' beliefs about innovative teaching in relation to their past educational experiences. We build on research showing that practical experience in professional development can shift teachers' beliefs (Thurm & Barzel, 2020), a core principle of the Hothousing method. Our investigation will explore how exposure to innovative teaching methods within this course, focusing on affect and experience, leads to changes in PSTs' beliefs. This approach innovatively shifts the focus from mere knowledge acquisition to belief transformation. We will review relevant literature, present our methodology and findings, and finally, suggest potential applications of IAM and our course design in other contexts.

2 Theoretical background

First, we review relevant literature to establish a suitable theoretical framework focusing on PSTs' and teachers' beliefs, followed by the presentation of our theoretical framework and the research question.

2.1 Literature review

Despite being digital natives, current PSTs do not consistently use technology in education, potentially due to a lack of confidence and personal experience. Drijvers uses an orchestra metaphor to represent the learning environment, with the teacher as conductor (Drijvers et al., 2010). Responding to this, Haspekian (2014) defines the instrumental distance - the gap between school reality and innovative learning environments – as a key factor hindering the adoption of new tools. However, teacher beliefs and motivation are central (Drijvers, 2019). Accepting usefulness is linked to positive emotions and motivations, while negative feelings harm learning (Picard et al., 2004). Following Goldin and colleagues (2009), we define beliefs as judgements of truth or falsehood based on knowledge, social or mental state, and affective status. Beliefs arise from our perception and interpretation of our surrounding world (Davis, 1985). Goldin et al. (2009) stated that beliefs are related to affect and objects. In our study, this object is innovation. Liljedahl and his colleagues explored the stability of beliefs and carried out a literature review (2012) to investigate core and peripheral beliefs. Green's 1971 study (as cited in Liljedahl et al., 2012) described core beliefs as more stable and peripheral beliefs as less stable and more flexible. Early childhood experiences and the experienced teacher models involve stable beliefs that are difficult to change (Liljedahl et al., 2012). While case studies demonstrate the learning and motivational benefits of project-based learning, STEAM activities, and technology implementation (Caton, 2021; Ludwig & Jesberg, 2015), teachers seem to be still reluctant (Drijvers, 2019) or unaware of these findings, possibly due to the practice-research gap (Vanderlinde & van Braak, 2010). Teacher professional development courses offer a solution by bridging these gaps and shifting beliefs through experience, emotionally engaging and collaborative activities (Thurm & Barzel, 2020). Research suggests that positive beliefs about an innovation's usefulness and its ease of use outweigh the concerns (Davis et al., 2023; Thomas & Palmer, 2014). Andrà et al. (2019) found that professional development can influence teacher beliefs through an affective lens, with emotions acting as both barriers and motivators for change, while also enhancing teachers' self-confidence. They also noted the positive effect of an initial, surprising success and the necessity of post-course guidance for implementation. Although early childhood experiences result in stable beliefs influencing teaching practices, professional development courses supporting positive attitudes towards the subject and teaching can facilitate change (Pezzia & Di Martino, 2011).

This underscores the need for a course enhancing pre-service teachers' (and maybe in-service teachers') affect for inventions and providing support to increase their self-confidence. Since it is hard to overcome resistance, our course is designed to foster confidence in a supportive environment. Achieving these goals requires a theoretical framework centred on teachers' beliefs.

2.2 Theoretical framework

Several theories address teachers' beliefs and concerns. Valsiner's zone theory (Blanton et al., 2005) explains teachers' concerns and reluctance to leave their comfort zone, a secure space that must be pushed to leave either intrinsically (e.g., recognising usefulness) or extrinsically (e.g., the COVID-19 pandemic) (Deci & Ryan, 2000), sometimes even necessitating support (Lynch et al., 2021). Schoenfeld's

Teaching for Robust Understanding (TRU) claims that teachers' knowledge is dynamic and needs continuous reframing to support effective teaching (Schoenfeld, 2020). Both theories explore teachers' actions and responses to changes. Similarly, Davis (1985) developed the Technology Acceptance Model (TAM) based on perceived usefulness and ease of use, predicting system adoption. TAM has also been applied in the educational context, demonstrating the applicability of its variables to teaching intentions (Maričić et al., 2024), however, the focus has been on technology. Our study is framed by IAM (Békési et al., 2024), an extension of TAM. IAM applies the same variables within a broader educational context, focusing on the affective aspects of beliefs with educational invention as the object (Goldin et al., 2009). The course design is based on the intensive and effective Hothousing workshop method often used in industry (Houghton et al., 2022). This method involves three phases: short introduction, small-group problem-solving with time constraints, and group presentations followed by a consensus-building discussion. The Hothousing method has also proven effective in education. Framed by IAM and employing the Hothousing method, this study investigates how PSTs' beliefs evolve through an affective lens during a teacher training course. Specifically, this study addresses the following research question:

RQ1: To what extent does the course design based on the Hothousing method foster a shift in PSTs' beliefs regarding the usability and ease of use of innovation?

3 Study design and implementation

This teacher training course, based on the Hothousing workshop method, was designed and conducted over three consecutive years, starting in 2021. We hypothesised that its intensive and practice-oriented structure would enhance PSTs' self-confidence, leading to positive shifts in their beliefs about the perceived usefulness and ease of use of innovative teaching methods. This belief shift was expected to increase their readiness to implement innovative teaching methods such as project-based learning activities, STEAM tasks and technology.

3.1 The course design

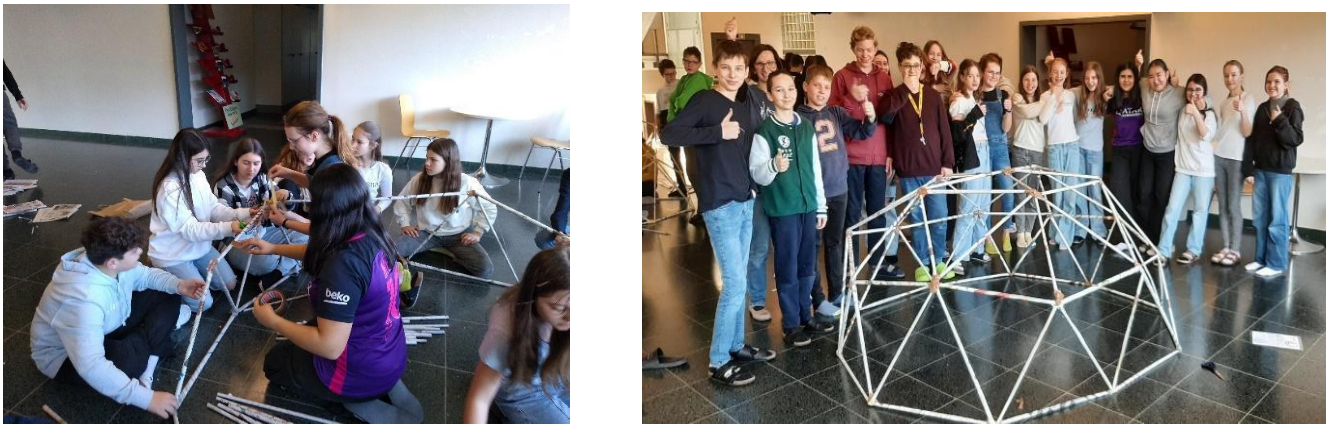
Following the COVID-19 pandemic, the Austrian government launched a two-week summer school for elementary and lower secondary school students in English, German, and Mathematics. PSTs served as teachers in this novel setting, without the usual in-class mentorship known from their practical training. To support these PSTs, the government offered a preparatory course, recognised with two credits for their studies. We designed our course using the Hothousing workshop method (Houghton et al., 2022) due to its intensity and effectiveness, emphasising practical application to build PSTs' self-confidence. The course comprised three phases aligning with the Hothousing method: (1) demonstrating literature-supported ans successfully implemented activities, applications and games; (2) providing limited time for PSTs to design similar activities; and (3) practice-teaching these activities during the course, followed by feedback and discussion. Phase 1 aimed to showcase the usefulness and the applicability of the activities, including student feedback and general views on mathematics (examples detailed in Section 3.2). Phase 2 highlighted the time and complexity involved in designing such activities, for instance, leaving the school for the sake of a math path means that the students may need their coats, however, it is something that simply needs practice. Phase 3 intended to demonstrate the positive reception of PSTs' activities by students, mirroring the appreciation shown by their peers in the course. These three phases were structured to foster experience, build confidence, and ultimately influence PSTs' beliefs.

3.2 Example activities

We integrated activities both with and without technology. Examples included constructing a geodesic dome from newspaper, origami, and using the paved floor as a coordinate system. We also designed mathematical scavenger hunts using paper-based clues or QR codes, and applications such as MathCityMap[1] or Actionbound[2]. Furthermore, we utilised gamified applications such as Kahoot[3], Quizlet[4] and Blooket[5]. The common goal across all activities was to enhance student motivation and affect, and consequently their learning. We incorporated project-based learning and STEAM activities, emphasising transdisciplinarity and its advantages (e.g., positive team building through teacher collaboration) and disadvantages (e.g., demanding collaboration. Figure 1 and Figure 2 illustrate the enthusiasm observed in both students and PSTs upon completing a task.

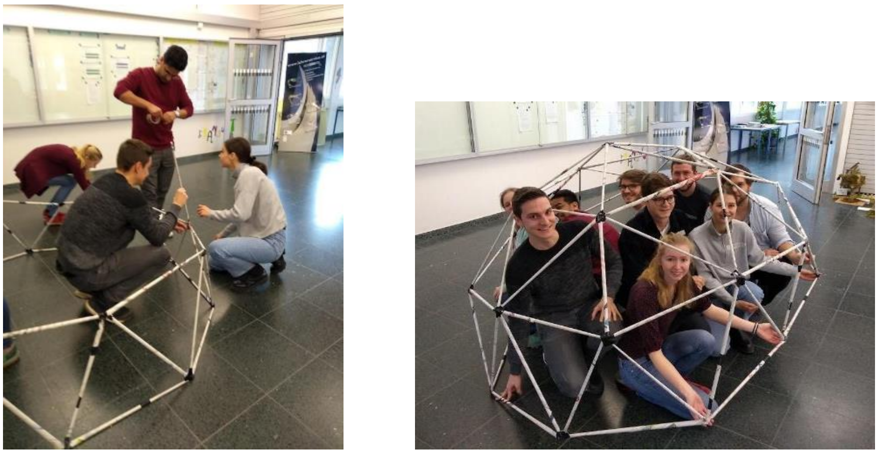
[1] https://mathcitymap.eu/en/
[2] https://de.actionbound.com/
[3] https://kahoot.com/
[4] https://quizlet.com/latest
[5] https://www.blooket.com/

Figure 1. Geodesic dome with students



Note. The pictures were taken by the first author with the permission of all stakeholders in 2023.

Figure 2. Geodesic dome with pre-service teachers



Note. The pictures were taken by the first author with the permission of the involved pre-service teachers attending a workshop on STEAM activities in 2023.

3.3 Data collection methods

Consistent with the theoretical framework, IAM, our questionnaires were designed to explore PSTs' prior experiences, readiness to implement innovative activities, and their perceptions of these activities' usefulness and ease of preparation and execution. Over three years, we administered these questionnaires to PSTs (9 in 2021; 15 in 2022; and 16 in 2023) at the beginning of the course to assess their previous experiences with technology integration, learning applications, project-based learning, and STEAM activities as both students and university PSTs (Figure 3). Most questions were based on a five-point Likert scale with 1 standing for "absolutely disagree" and 5 standing for "absolutely agree", with final open-ended questions for qualitative insights. A second questionnaire, administered post-course, evaluated changes in

PSTs' confidence in implementing innovations. Additionally, 5 PSTs were interviewed, 2 in 2022 and 3 in 2023 to ensure a broad spectrum of their second major and school backgrounds. We will refer to them with fictitious first names: Anna, Marie, Linda, Bianca and Georg. All majored in mathematics and another subject: Anna in biology, Marie in ethical studies, Linda in media studies, and Bianca and Georg in history. Bianca attended a traditional secondary grammar school from year 5 to year 12, while the others frequented different high schools before switching to an upper secondary school from year 9 to year 12. Georg attended a high school focused on computer science. All were at a similar stage in their studies, near or just having completed their bachelor's degree. We also collected observational data from various activities involving PSTs, including discussions on the advantages and disadvantages of technology implementation and project-based learning (documented on a Padlet, Table 1), and feedback sessions following their school practice.

We used descriptive analysis methods for Likert scale questions because of the small sample. Open-ended responses were analysed by defining categories and counting the number of mentions. Similar methods were used to analyse PSTs' written work collected on Padlet. Interviews, open-ended responses, and Padlet entries were analysed using qualitative methods: transcripts and PSTs' written work were read to identify categories and indicators of belief changes. We compared PSTs' pre- and post-course beliefs to identify changes and their potential reasons.

4. Findings

To illustrate the evolution of PSTs' beliefs throughout the course, we present our findings before and after completing the course, followed by a summary of the key changes.

4.1 Pre-course PSTs' beliefs

The initial questionnaire revealed that none of the 40 PSTs had experience with project-based learning, and only two were aware of STEAM activities but had never participated in them. Moreover, only 18% reported technology implementation in their schools. To further explore their initial beliefs, in 2023, PSTs worked in three groups and engaged in a collaborative activity listing pros and cons of technology implementation and project-based learning on a Padlet (Table 1). These responses, largely based on preconceptions due to a lack of practical experience, reflected their beliefs about usability and ease of use. Notably, all three groups considered STEAM activities time-consuming and difficult to manage due to the necessary collaboration between more colleagues; they were also concerned about possible distractions and the risk that the lesson wouldn't go as planned. However, they acknowledged these activities' potential as an engaging, good alternative to normal lessons and their ability to enhance soft skills and provide real-life reference. As for technology implementation, they mentioned distraction, the fear that students stop thinking critically about the problems and just keep trying till they get the right answer. One group also mentioned that students rely on the internet for information without questioning its validity. Conversely, they recognised technology's capacity to enable focus on more complex problems and promote autonomous learning through personalised pacing. Table 1 summarises the frequencies of these remarks regarding PSTs' beliefs about project-based learning and technology implementation. The three groups made their contributions without seeing the other contributions, these were made visible just after completing the task. Table 1 summarizes the frequency of these remarks across the three independent groups, highlighting a consensus on most points, with some unique mentions by individual groups.

Table 1. PSTs' beliefs collected on Padlet, 2023

Project-based learning				**Technology implementation**			
Pros	**#**	**Cons**	**#**	**Pros**	**#**	**Cons**	**#**
good alternative	3	time-consuming	3	varied lessons and methods	3	disruption	3
motivating	3	disruption	3	illustrate/explain	3	screen-time	3
soft skills	3	no more regular lessons	1	playful learning	2	just trying and not thinking	3
real-life reference	3			autonomous learning	1	technical problems	3
playful learning	1			more time for challenging tasks	1	students believe everything they find	1

Note. The table shows the number of mentions PSTs made on a Padlet.

The interviews showed a similar picture. Even Georg, despite attending a high school focused on computer science, noted that technology use at his school was limited to using overhead projectors for visualising. Linda's school had a smart board, but it was rarely used. With the spread of mobile phones, Kahoot! slowly reached schools.

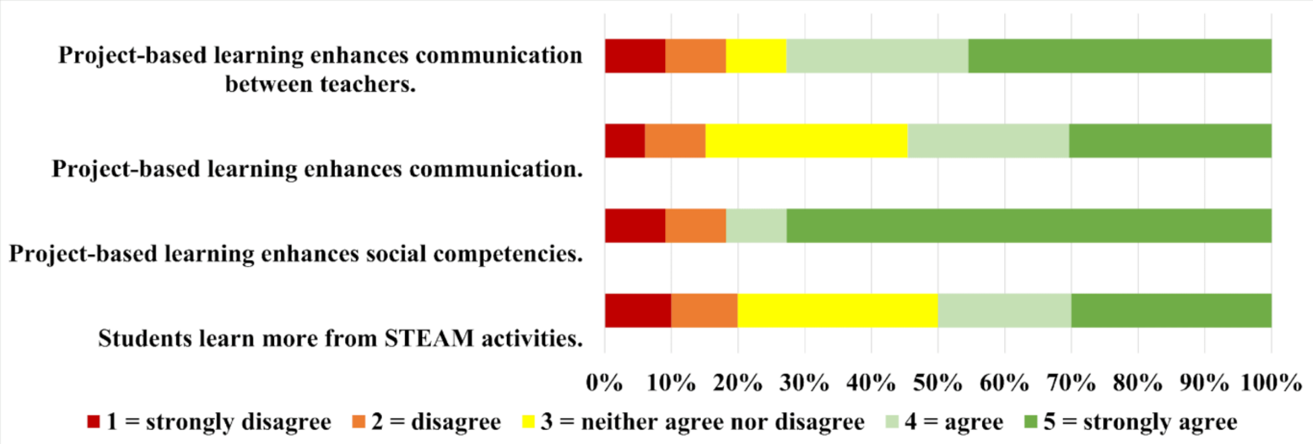
> Not everybody had a smartphone with internet. We played Kahoot! once or twice a year. It was all so complicated. It was always like a Christmas present. Now, in some classes, you get ‘booed out’ by students saying ‘Oh no, Kahoot again!’ (Linda)

At the university level, 54,6% of the PSTs reported frequent technology implementation, primarily as PowerPoint presentations or lecture recordings, with lectures remaining traditional and lacking interaction.

4.2 Post-course PSTs’ beliefs

During the course, PSTs engaged with project-based learning, STEAM activities, meaningful technology implementation, and designing and testing activities. A post-course questionnaire assessed their resulting beliefs and attitudes towards these innovative teaching methods. The findings indicated a positive attitude and increased readiness for implementation. Specifically, 81,8% of PSTs found STEAM projects beneficial for soft skills, 72,7% believed collaborative STEAM tasks enhanced communication and reasoning skills, and 50% recognised the positive learning effect of project-based learning (Figure 3). While acknowledging the longer preparation time for transdisciplinary lessons, they expressed interest in designing and participating in longer multi-subject projects. In 2023, data collection included questionnaires and a Padlet (as described in Section 4.1 and presented in Table 1). Comparing initial Padlet data with the end-of-course open-ended responses regarding STEAM activities provided deeper insight into belief changes. Seven PSTs responded to “What are the benefits of a project-based STEAM task?”, with all mentioning transdisciplinarity and real-life reference, and two citing motivation. Figure 3 presents a comprehensive overview of relevant questions and responses from the 2023 post-course questionnaire concerning project-based and STEAM activities.

Figure 3. Post-course questionnaire, 2023



Five PSTs were questioned about their learning during the course and any changes in their views as mentioned earlier. These interviews confirmed the questionnaire findings. Anna, for instance, noted a significant difference between her school experiences and the varied teaching strategies and open-ended questioning, while referring to another seminar where deep understanding and open-ended questions were discussed:

> I think it would be important to learn about different strategies, how to solve a problem and more open-ended questions. For instance, how to measure something creatively by comparing the length of your shoes with the length you want to measure. It became more important for me to do something, to do something actively. We learn a lot of theories at the university, but we never create anything, a task, an activity. It would be important to learn how to create activities that are meaningful for the students. (Anna)

Bianca and Georg reported primarily using GeoGebra for visualising, occasionally incorporating a game. Marie started using Actionbound and other applications during the course. Responses given to the open-ended questions in the second questionnaire indicated that many PSTs started using applications more regularly, felt more confident in time management, and felt better prepared to handle larger projects, even without prior experience. They noted that increased practice led to greater confidence, as Linda stated:

> The more I practise, the more confident I am. It helped that we had a small group first to try the activities with and not a whole class. (Linda)

PSTs feedback across all years indicated that the course's emphasis on creating, testing, and evaluating activities in a safe environment significantly enhanced their confidence, aligning with Linda's experience.

4.3 Summarising the findings

To investigate how PSTs' beliefs shifted during the course, based on the IAM, we studied how their views on usefulness and ease of use concerning innovation changed. We analysed data from questionnaires, interviews, Padlets, and written reflections collected over three course cycles. We presented the findings in two parts: (1) pre-course beliefs and concerns, and (2) post-course beliefs and indications of change.

Comparing pre-course and post-course questionnaires revealed notable shifts in PSTs' beliefs. Initially, lacking experience, they were concerned about time management, distraction, and extensive screen time. However, post-course questionnaires and the interviews indicated a change in these concerns. While time management remained a challenge, they believed effective teacher collaboration could mitigate it, suggesting a positive change in perceived ease of use. Concerns about distraction diminished as they accepted the usefulness of project-based learning, as illustrated in Figure 3. Open-ended responses and interview quotes support this change. Linda explicitly mentioned increased confidence in her interview. These changes were particularly evident among participants who had no prior experience with innovation. Their narratives suggest that belief shifts occurred not only through new knowledge, but through emotionally engaging experiences and peer validation—key mechanisms emphasised in the IAM framework.

In summary, the results indicate that the course facilitated measurable and meaningful belief shifts among PSTs. Addressing our research question, our findings suggest that positive changes in PSTs' perceptions of the usefulness and ease of use of innovation positively influenced their attitude and readiness to implement these innovations, as suggested by IAM.

5 Discussion

This section discusses the results in the light of existing literature. We discuss how IAM helped to analyse the observed belief changes, which mechanisms supported these changes, and the possible implications for teacher education. The findings provide empirical support for IAM as a meaningful extension of TAM. While the original TAM dimensions—perceived usefulness and perceived ease of use—remained central in how PSTs evaluated educational innovations, they alone could not explain the observed belief shifts. Affective components such as anxiety, motivation, and emotional safety played a decisive role, especially at the beginning of the course. This confirms the argument made by Andrà et al. (2019) that emotions can act as both barriers and drivers in teacher development. The observed emotional readiness and increasing confidence among participants align with the affective dimension of belief change described by Goldin et al. (2009). Moreover, the progression from reluctance to curiosity supports findings by Pezzia and Di Martino (2011), who documented similar affect-driven transformations in teacher training contexts. Together, these results indicate that IAM captures a broader and more educationally realistic view of innovation acceptance than TAM. This supports the applicability of IAM as a tool for analysing belief structures and predicting innovation-readiness in educational contexts.

The Hothousing format proved to be an effective intervention for activating belief shifts, directly addressing our RQ. It provided three conditions identified in prior literature as necessary for changing stable beliefs: (1) Experience-based engagement: Participants actively created and tested their own activities. This approach echoes findings by Thurm and Barzel (2020), who emphasised the importance of authentic, hands-on experiences in shifting teachers' perceptions of technology use. (2) Social validation: Peer feedback and collaborative reflection supported participants in reframing their initial concerns. This social aspect corresponds with observations by Andrà et al. (2019), who found that collegial support strengthens self-confidence and fosters openness to change. (3) Emotional safety: The low-stakes environment enabled participants to take risks and experiment, which fostered positive affect and agency. These conditions directly supported belief change along the IAM dimensions: participants began to see innovation as both useful and manageable, while also developing the emotional resilience needed for implementation. Thus, the course structure itself—particularly its practical, collaborative, and affect-sensitive elements—proved to be a key driver of belief transformation answering our RQ.

The results suggest that teacher education programs should not only inform PSTs about innovations but also provide emotionally and socially rich learning environments. As highlighted by Davis et al. (2023), perceived usefulness and ease of use are important predictors, but as our findings and those of others (e.g., Thomas &

Palmer, 2014) show, these need to be embedded in wider experiential contexts to foster real change.

In summary, our research question was addressed through the integration of IAM and the evaluation of the Hothousing-based course structure through an affective lens studying PSTs' affect and beliefs.

6 Conclusion

Consistent with existing literature, our findings demonstrate that teachers' beliefs can change when an innovation's usefulness is recognised and opportunities for learning in a supportive environment are provided. Teachers, like everyone, fear sudden changes, failures, and losing credibility. Providing them with sufficient practice time fosters confidence and security. This study contributes to research and the MAVI community by proposing a course design grounded in IAM and the Hothousing workshop method, emphasising the affective dimension of learning and teaching in a broader educational context. By aiming to overcome reluctance (a negative emotion) and achieve acceptance (a positive emotion), this research shows that recognising usefulness and experiencing ease of use are key to the acceptance and implementation of innovation. Future research should explore the applicability of this course design and IAM in diverse contexts and identify effective strategies for supporting PSTs to ensure innovation reaches schools. Longitudinal studies tracking the teaching habits of course participants are planned over the coming years.

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Tony Houghton: methodology, review and editing

Jana Trgalova: review and editing

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Informed consent statement

Informed consent was obtained from all research participants.

Data availability statement

Data will be provided by the authors at request.

References

Andrà, C., Rouleau, A., Liljedahl, P., & Di Martino, P. (2019). An affective lens for tensions emerging from teacher professional development. *For the Learning of Mathematics*, *39*(1), 2–6.

Békési, B., Ulbrich, E., Houghton, T, Trgalova, J., & Lavicza, Zs (2024). What makes project-based STEAM tasks motivating? How do they enhance learning? In E. Faggiano, A. Clark-Wilson, M. Tabach, H.G. Weigand (Eds.), *Proceedings of the 17th ERME Topic Conference MEDA4* (pp. 73-80). University of Baril Aldo Moro.

Blanton, M. L., Westbrook, S., & Carter, G. (2005). Using Valsiner's zone theory to interpret Teaching practices in mathematics and science Classrooms. *Journal of Mathematics Teacher Education*, *8*(1), 5–33. https://doi.org/10.1007/s10857-005-0456-1

Castro, A. J. (2010). Themes in the research on preservice teachers' views of cultural diversity: Implications for researching millennial preservice teachers. *Educational Researcher*, *39*(3), 198–210. https://doi.org/10.3102/0013189X10363819

Caton, J. (2021). Don't Run Out Of STEAM! Barriers to A Transdisciplinary Learning Approach. *Journal of STEM Teacher Education, 56*(1), 38–45. https://doi.org/10.30707/jste56.1.1624981200.219832

Davis, F. D. (1985). *A technology acceptance model for empirically testing new end-user information systems: Theory and results* (Doctoral Dissertation). Massachusetts Institute of Technology. http://hdl.handle.net/1721.1/15192

Davis, F. D., & Granić, A. (2024). *The technology acceptance model. 30 years of TAM*. Springer. https://doi.org/10.1007/978-3-030-45274-2

Deci, E. L., & Ryan, R. M. (2000). The "What" and "Why" of Goal Pursuits: Human Needs and the Self-Determination of Behavior. *Psychological Inquiry*, *11*(4), 227–268. https://doi.org/10.1207/S15327965PLI1104_01

Drijvers, P. (2019). Head in the clouds, feet on the ground – A realistic view on using digital tools in mathematics education. In A. Büchter, M. Glade, R. Herold-Blasius, et al. (Eds.), *Vielfältige Zugänge zum Mathematikunterricht: Konzepte und Beispiele aus Forschung und Praxis* (pp. 163–176). Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-24292-3_12

Drijvers, P., Doorman, M., Boon, P., Reed, H., & Gravemeijer, K. (2010). The teacher and the tool: instrumental orchestrations in the technology-rich mathematics classroom. *Educational Studies in Mathematics*, *75*(2), 213–234. https://doi.org/10.1007/s10649-010-9254-5

Goldin, G., Rösken, B., & Törner, G. (2009). Beliefs – No Longer a Hidden Variable in Mathematical Teaching and Learning Processes. In J. Maass & W. Schlöglmann (Eds.), *Beliefs and Attitudes in Mathematics Education: New Research Results* (pp. 1–18). Brill | Sense. https://doi.org/10.1163/9789087907235_002

Haspekian, M. (2014). Teachers' Instrumental Geneses When Integrating Spreadsheet Software. In Clark-Wilson, A., Robutti, O., Sinclair, N. (Eds.), *The Mathematics Teacher in the Digital Era* (pp. 241–275). Springer. https://doi.org/10.1007/978-94-007-4638-1_11

Houghton, T., Lavicza, Z., Diego-Mantecón, J.-M., Fenyvesi, K., Weinhandl, R., & Rahmadi, I. F. (2022). Hothousing: Utilising industry collaborative problem solving practices for STEAM in schools. *Journal of Technology and Science Education*, *12*(1), 274. https://doi.org/10.3926/jotse.1324

Liljedahl, P., Oesterle, S., & Bernèche, C. (2012). Stability of beliefs in mathematics education: A critical analysis. *Nordic Studies in Mathematics Education, 17*(3-4), 23–40.

Ludwig, M., & Jesberg, J. (2015). Using Mobile Technology to Provide Outdoor Modelling Tasks - The MathCityMap-Project. *Procedia - Social and Behavioral Sciences*, *191*, 2776–2781. https://doi.org/10.1016/j.sbspro.2015.04.517

Lynch, M., Kamovich, U., Longva, K. K., & Steinert, M. (2021). Combining technology and entrepreneurial education through design thinking: Students' reflections on the learning process. *Technological Forecasting and Social Change*, *164*, 119689. https://doi.org/10.1016/j.techfore.2019.06.015

Maričić, M., Anđić, B., Soeharto, S., et al.(2024). The exploration of continuous teaching intention in emerging-technology environments through perceived cognitive load, usability, and teacher's attitudes. *Education and Information Technologies*, 1–30. https://doi.org/10.1007/s10639-024-13141-9

Pezzia, M., & Di Martino, P. (2011). The effect of a teacher education program on affect: the case of Teresa and PFCM. In Pytlak, M., Rowland, T., & Swoboda, E. (Eds.), *Proceedings of the 7th the Seventh Congress of the European Society for Research in Mathematics Education* (pp. 1259–1268). University of Rzeszów (Poland) and ERME.

Picard, R. W., Papert, S., Bender, W., et al. (2004). Affective Learning — A Manifesto. *BT Technology Journal*, *22*(4), 253–269. https://doi.org/10.1023/B:BTTJ.0000047603.37042.33

Schoenfeld, A. H. (2011). *How we think: A theory of goal-oriented decision making and its educational applications*. Routledge.

Schoenfeld, A. H. (2020). Reframing teacher knowledge: A research and development agenda. *ZDM – Mathematics Education*, *52*(2), 359–376. https://doi.org/10.1007/s11858-019-01057-5

Thomas, M. O. J., & Palmer, J. M. (2014). Teaching with Digital Technology: Obstacles and Opportunities. In A. Clark-Wilson, O. Robutti, N. Sinclair. (Eds.), *The Mathematics Teacher in the Digital Era, 2,* 71–89. Springer. https://doi.org/10.1007/978-94-007-4638-1_4

Thurm, D., & Barzel, B. (2020). Effects of a professional development program for teaching mathematics with technology on teachers' beliefs, self-efficacy and practices. *ZDM – Mathematics Education*, *52*(7), 1411–1422. https://doi.org/10.1007/s11858-020-01158-6

Vanderlinde, R., & van Braak, J. (2010). The gap between educational research and practice: Views of teachers, school leaders, intermediaries and researchers. *British Educational Research Journal*, *36*(2), 299–316. https://doi.org/10.1080/01411920902919257