Teacher education is a deeply pedagogical process rooted in values, ethics, and the social purpose of schooling. Globally, it sits at the core of educational quality and fairness, as research in comparative and international education demonstrates: the training of teachers directly influences students' learning chances, social inclusion, and the democratic aims of schools. Teachers are not simply transmitters of curricula, but active professionals whose convictions, reflective skills, and ability to manage the complexities of classroom life give shape and substance to the educational experience itself.

The pedagogical dimension of teacher education frames teaching as a relational, context-aware, and ethically grounded profession rather than just a set of procedural skills. From a research perspective, this demands robust research methodologies that can critically examine the complex realities of schools and inform evidence-based policies. Equally important is the connection between theory and practice, which helps to bridge the persistent gap between universities and schools.

The contributions gathered in this volume reflect the richness and diversity of experiences showcased during the ATEE Spring Conference 2024, held at the University of Bergamo from May 29 to June 1, 2024. The volume presents 70 selected papers out of more than 300 presented by researchers representing over 40 countries.

This broad spectrum of studies highlights promising directions that can inspire renewed inquiry and concrete proposals aimed at improving contemporary educational systems.

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ISBN:978-88-97253-27-3
DOI: 10.62336/unibg.978-88-97253-27-3

ATEE Spring Conference 2024

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May 29th – June 1st, 2024
S. Agostino, Bergamo

Edited by Nicole Bianquin and Francesco Magni

UNIVERSITÀ DEGLI STUDI DI BERGAMO

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ATEE
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BOOK OF PROCEEDINGS

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BOOK OF PROCEEDINGS ATEE Spring Conference 2024. Teacher education research in Europe: trends, challenges, practices and perspectives / Nicole Bianquin, Francesco Magni (edited by) – Bergamo: Università degli studi di Bergamo, 2025

ISBN: **978-88-97253-27-3**

DOI: **10.62336/unibg.978-88-97253-27-3**

An event organised by:

Dipartimento di Scienze Umane e Sociali, **University of Bergamo** // **www.dsus.unibg.it**

CQIIA – Centro per la Qualità dell'Insegnamento, dell'Innovazione didattica e dell'Apprendimento, **University of Bergamo** // **www.cqiia.unibg.it**

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Table of contents

Teaching and learning challenges and professional development

Inclusion in teaching and learning processes and school improvement

Digital innovation and artificial intelligence (AI): schools, teachers and students between real and virtual world

School & work and the role of teachers in Vocational Education and Training

POSTER SESSION

The contributions published in this book of proceedings have been evaluated through a double-blind peer review process. We would like to thank the members of the Scientific Committee, as well as the many other professors, researchers and experts who agreed to act as reviewers.

The Reflected Double Tetrahedron Model: Project-based learning in teacher training

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Abstract

Education's constant evolution (digitalisation, social norms, student interests) necessitates adjustments in teachers and teacher training. To bridge the gap between school reality and teacher education, and to enhance readiness for these changes, we propose the Reflected Double Tetrahedron Model to depict the parallels between educational levels. The course described serves as a test case to evaluate the model's applicability. Its design focuses on pre-service teachers experiencing school reality and fostering their confidence in innovative teaching methods. We assess the model via pre-service teachers' feedback, their evolving beliefs and our observations. Initial results suggest the model offers a valuable framework to connect school practice and teacher education.

Keywords: learning ecosystem; teacher training; framework; pre-service teachers; belief change.

ISBN: 978-88-97253-27-3
DOI: 10.62336/unibg.978-88-97253-27-3_p.11

1. Introduction

Students at all educational levels attend courses to gain new competencies and knowledge, requiring a supportive social and physical environment, and motivating questions, among many other elements. We define "student need" as any aspect facilitating learning. Following the COVID-19 pandemic, Austria digitalised lower-secondary schools and promoted interdisciplinary, project-based teaching (BMBWF, 2020), while this requires innovative teaching methods, teachers and pre-service teachers are reluctant to implement innovations due to the lack of prior experience with such methods in both university and school settings (Thurm & Barzel, 2020). Therefore, we propose that teacher training should adapt to innovation and student needs by providing pre-service teachers (PST) with opportunities to experience, reflect on, conceptualise, and experiment with teaching scenarios, aligning with Experiential Learning Theory (ELT) (Kolb et al., 2014). Based on these, we aimed at designing a course for PSTs. However, we faced difficulties due to a lack of a framework depicting the parallels between school and university education. Students, teachers, content, innovation, and the learning environment form a learning ecosystem (Liljedahl & Zager, 2021), while higher educational levels form similar ecosystems. We will call the union of these ecosystems a teaching-learning ecosystem (TLE). This study introduces the Reflected Double Tetrahedron Model (RDTM) (Figure 1) to depict this correspondence, with each tetrahedron representing a different level (school and teacher training), matching vertices, and a joining vertex for the educator bridging these levels.
This model informs the teacher training course design framed by ELT following the phases experience, reflect, think and act. While conducting the course and analysing data, we studied the RDTM to prove its applicability. The RDTM illustrates the cyclical relationship between student preferences and teacher training, highlighting the dynamic interplay across educational levels.
This study establishes a theoretical framework for our course design, highlighting the RDTM's unique contribution to bridging the gap between theory and practice in teacher education.

2. Theoretical Framework and literature review

In this section, we present existing models found in the literature and highlight the lack of models aligning school practice and teacher training. Then we present the theoretical framework for our course design, and how our model, the RDTM, was created.

2.1 Literature review

Several models depicting learning situations can be found in the literature. Brousseau`s didactic triangle (teacher, student, content) (Brousseau, 1997) has been expanded to include artefacts and social learning into a socio-didactical tetrahedron (Rezat & Sträßer, 2012; Engeström, 2014). Further research focused on technology (Rossi et al., 2018), and AI (Dasari et al., 2024). Tomaszewski's double tetrahedron model addressed collaborative learning (Tomaszewski, 2023). While such models have been used to study technology implementation (Donevska-Todorova & Trgalova, 2017), they often focus solely on school education. Prediger et al. (2019) used the three-tetrahedron model to depict all three institutional levels: school education, teacher training and teacher trainers' training. However, these models overlook the interplay between the educational levels or focus on just one level. We identified a gap in models for teacher training courses aligning school practice and higher education.

2.2 Theoretical framework for course design

Our course design is based on the Experiential Learning Theory (Kolb et al., 2014), representing a four-phase learning cycle: (1) experiencing, (2) reflecting, (3) thinking, and (4) acting. Similarly, Kuzniak et al. (2013) found that teacher training offering practice opportunities makes PSTs experience school reality and enhances PSTs' motivation to implement novel teaching approaches. Motivation and beliefs are studied by Self Determination Theory (SDT) (Ryan & Deci, 2000b.). We define beliefs as

accepting something as true or false based on knowledge, mental and social state, and affect (Goldin et al., op. 2009). Ryan and Deci (2000a) found that intrinsic motivation drives actions based on beliefs. However, some beliefs are stable and difficult to change, particularly from childhood and early school (Liljedahl et al., 2012). Davis's Technology Acceptance Model (TAM) posits that perceived usability and ease of use correlate with users' acceptance (Davis, 1985). This study uses the Innovation Acceptance Model (IAM) (Békési et al., 2024), an adaptation of TAM, to predict PSTs' innovation readiness by examining perceived usability and ease of use. We aim to foster a belief shift in PSTs by convincing them of the innovations' usability and their ease of use.

2.3 The model

Our model visualises the parallels between educational levels by reflecting one modified didactic tetrahedron and joining them. This reflected double tetrahedron model (RDTM) (Figure 1) illustrates the interplay within the TLE adding a new perspective to the existing models. A reflection preserves identities; in our case, it assigns students to PSTs. By student, we mean secondary school children, and we refer to students in higher education as pre-service teachers (PST), as we focus on would-be teachers and teacher training. However, PSTs are also considered as learners. Both students and PSTs are learners. Understanding student and societal needs is crucial for designing a responsive course. The COVID-19 pandemic accelerated digitalisation in education, increasing the demand for integrating technology. Research and our findings indicate that innovative methods, such as technology integration, outdoor learning, and collaborative project-based STEAM (Science, Technology, Engineering, Art, Mathematics) (Yakman, 2008) education, enhance student motivation and foster positive attitudes towards learning (Caton, 2021; Ulbrich et al., 2020; Békési et al., 2024). As mentioned in the introduction, innovation is an element of "student needs". RDTM suggests that innovation should be present at both levels, meaning that PSTs should be familiar with innovation at the school level and experience it in teacher training. Content* implies that PSTs are familiar with the school contents and create a new understanding of teaching these contents.

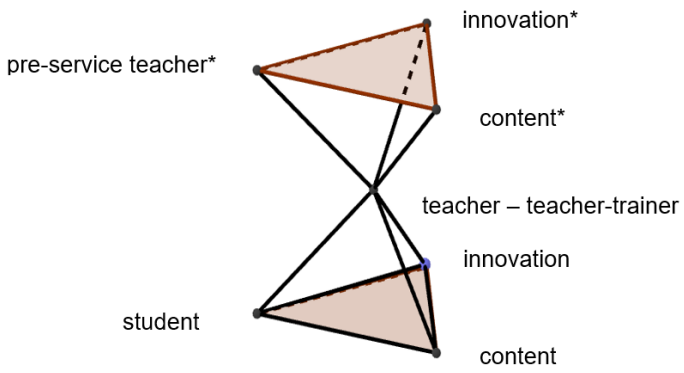

Figure 1: Reflected Double Tetrahedron Model.

This study utilises ELT (Kolb et al., 2014) for course design, and IAM (Békési et al., 2024) to investigate how PSTs' needs and beliefs evolve. We propose the RDTM to frame a course that aims to align school practice and teacher training. Our research question is:
RQ: To what extent is the reflected double tetrahedron model applicable to frame a course for PSTs aiming at a shift in their beliefs and impacting their innovation readiness?
The following sections detail the course design, the data collected from PSTs, and our findings. Finally, we discuss the RDTM's applicability.

3. Course design

Following an overview of the course design, we present a detailed example. Our teacher training course is informed by ELT and focuses on project-based learning (PBL). Given that PBL frames many school-level activities, we also followed its 5 phases in our course to enable PSTs to experience PBL through the lens of our ELT framework. PBL involves 5 phases: (1) a driving question; (2) student exploration; (3) collaboration; (4) students' self-management; (5) students creating a tangible product (Krajcik & Blumenfeld, 2005). While students learn content, PSTs engage in PBL to study PBL as a teaching method following the ELT cycle: PSTs *experience* the 5 phases of PBL, *reflect* on their experience, *think* about the main features and create similar activities, and then *test* these activities in a new experience.

Despite PSTs' daily technology use, they often lack experience integrating technology in education or with other innovative methods like project-based STEAM activities (Kuzniak et al., 2013). Therefore, the *experience* phase focuses on examples. The *reflecting* phase examines student perspectives and the learning impact to illustrate 'usefulness'. In the *thinking* phase, PSTs design similar activities, and in the *testing* phase, they enact them to experience 'ease of use'. The presentation phase encourages reflection on beliefs about innovation.

In the first phase, PSTs were introduced to current school trends, example activities, student perspectives and needs, innovative teaching methods, and their learning impact. The usefulness of innovation was illustrated using data from our previous STEAM research. This phase mirrored the first phase of ELT, while PSTs experienced PBL. Due to the paper's focus on the training course and the model, only selected school-level data is presented here for illustrative purposes. This data, collected from 100 lower-secondary students across four classes over four years (starting in 2020/21), included their views on mathematics and project feedback. A representative selection is presented in Table 1 illustrating the preferences of a Grade 5 class. The data indicates a preference for gamified learning and technology use, as opposed to written assignments or exams. SDT suggests that you are more likely to learn something you like, highlighting the importance of understanding student preferences, although other factors are equally significant.

likes		**dislikes**	
Games: Kahoot!, Quizlet, Actionbound, …	17	Homework	13
Creative: Tinkercad	3	Exams	2
Variety	3	Lot of writing	2
iPad	2	Unclear explanation	2

Table 1: Students' preferences.
Note: The table summarises the number of times each item was mentioned.

To exemplify PBL, we presented a 'Mars project' conducted in two grade 7 classes in 2023. In this project, students explored the challenges of settling on Mars and then presented their findings to their families and friends. To illustrate student and other stakeholders' perspectives, a 5-point Likert scale questionnaire was administered (1 = strongly disagree, 5 = strongly agree). Figure 2 provides an overview of the overwhelmingly positive responses.

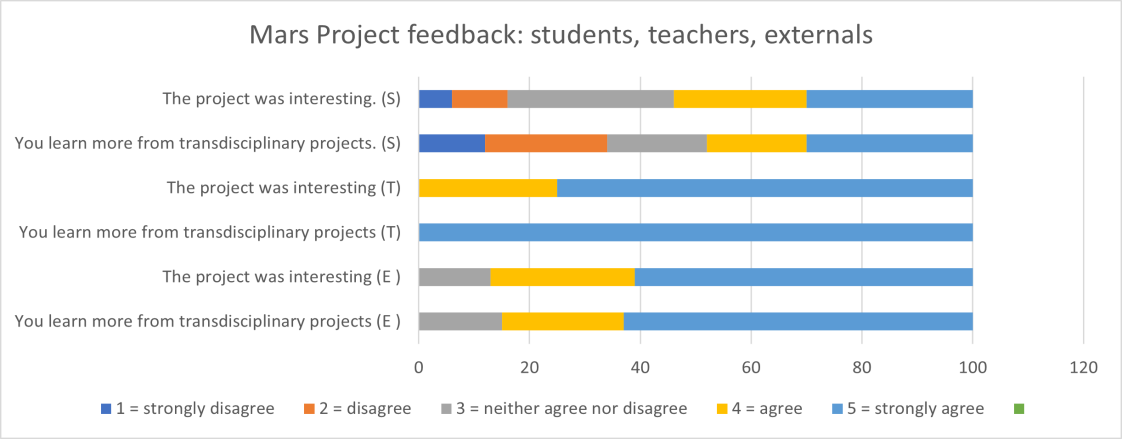

Figure 2: Feedback on the Mars project from students (S), teachers (T) and externals (E).

We consider that students' preferences reflect their needs, and addressing these may enhance learning through increased motivation, although other factors also influence learning. To illustrate the positive learning impact, PSTs were shown how positive student attitudes can correlate with increased competency, using results from the Austrian national competency test, IKM Plus[1], which showed two participating classes scoring significantly higher (186 and 182 on average) than the national average (170 out of 220) (Békési et al., 2024). This phase highlighted student preferences for real-life activities, teamwork, technology integration, and gamified learning, alongside the potential for positive learning impact while PSTs were reflecting on their experiences.

In phase 3, PSTs designed similar activities, considered possible challenges and shared their ideas on Padlet (Figure 3). For instance, they suggested studying bread and beer production and found that numerous subjects could be integrated such as history (beer as a salary in Egypt), biology (the nutrition pyramid), and mathematics (percentages). They planned a bakery visit, to study the ingredients, where they grow, and how long they need to travel, which could be discussed in geography. They even considered hands-on bread baking and explored potential links to literature and art. They created activities with real-life references, such as determining the maximum size of a coke can to fit through the bin's flap.

Figure 3: Examples of project and activity ideas PSTs collected in Padlet.

[1] IKM Plus: https://www.iqs.gv.at/themen/nationale-kompetenzerhebung/ikm-plus

Phase 4 involved implementing these activities within the course, and a teaching practice in secondary schools, allowing PSTs to test their activities. Finally, phase 5 focused on reflection, with participants discussing, sharing their experiences and starting a new learning cycle.

4. Data collection and analysis

To explore the course's impact on PSTs' views, we collected data from questionnaires, interviews, and observations. We questioned 40 PSTs about their school experiences and willingness to implement novel methods before and after the course. To triangulate the data, we conducted semi-structured interviews with 5 PSTs. Questionnaire results were evaluated using descriptive statistics, and qualitative responses were thematically analysed using an inductive coding strategy. Pre-course questionnaires revealed limited experience with PBL and technology implementation both at school and university. While PSTs could identify some benefits, they expressed concerns about disruption, curriculum and time constraints. PSTs also reported limited technology integration at the university and the lack of courses on technology implementation. Figure 4 shows the post-course questionnaire results, indicating a positive shift in beliefs.

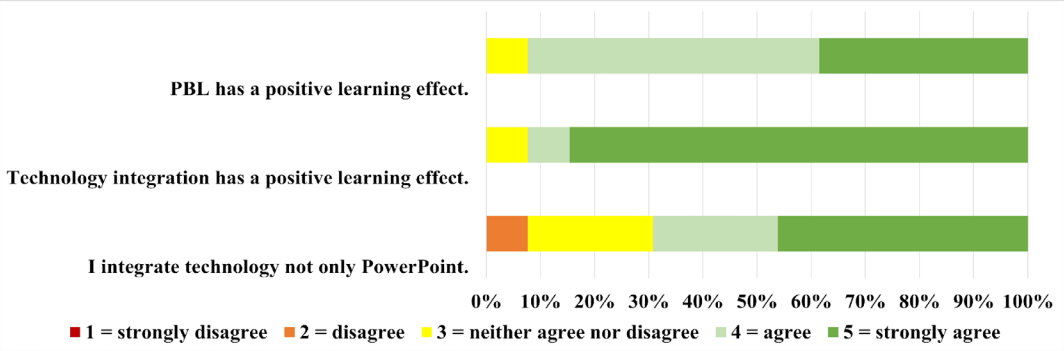

Figure 4: Pre-service teachers' views on PBL after the training.

The interviews revealed that PSTs' traditional school education was characterised by frontal teaching and limited technology use, mainly PowerPoint presentations. Higher education followed a similar pattern: passive lectures with limited technology implementation. One interviewee stated:

> «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. 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».

Another PST explained that while her school had a smart board, she couldn't recall using it. Kahoot! was used rarely, mainly for celebratory occasions, not for meaningful learning activities. Overall, PSTs positively evaluated the training, appreciating the practice and discussion opportunities. Figure 5 illustrates a positive shift in PSTs' confidence.

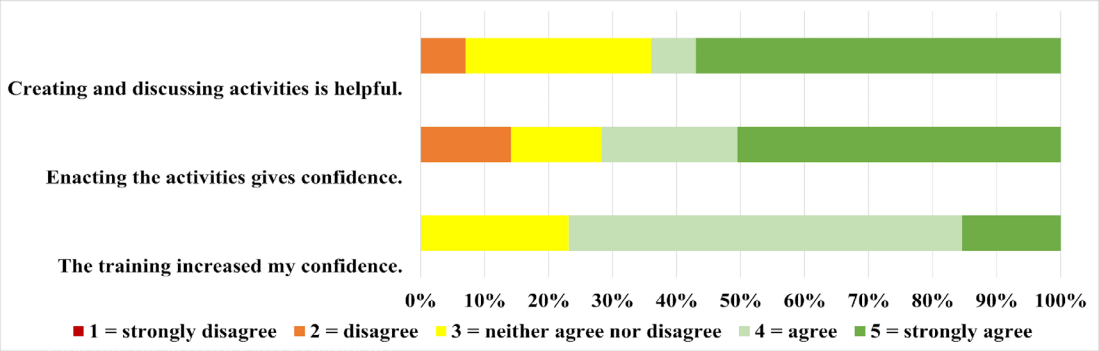

Figure 5:PSTs' confidence after the training.

The presentations in phase 5 revealed that some PSTs even implemented activities designed during the course and were pleased with their success. PSTs reported that their students praised the innovative methods, leading to increased student engagement and motivation.

5. Discussion and conclusion

Pre-course questionnaires and interviews indicated that PSTs lacked experience with innovative methods, leading to concerns and hesitation in implementing them. School-level data illustrating student preferences, perspectives, and the activities' learning impact seemed to convince PSTs of the use of innovation, a factor also studied by IAM (Békési et al., 2024). Through the course, PSTs gained insights into the benefits of these methods and increased their confidence by creating, testing, and evaluating novel activities, as suggested by post-course questionnaires (Figures 4 and 5). This evidence demonstrates a positive shift in PSTs' beliefs, which may be explained by PSTs experiencing the ease of use of these methods, the second variable studied by IAM.

These results suggest that teacher training responding to student needs impacts PSTs' views on the usefulness of innovation. By practising, they experience PBL, learn to design similar activities and become confident in implementing these novel methods. Teacher trainers practising PBL with the PSTs act as role models. Our course design enhances PSTs' innovation-readiness by engaging them in experiencing, reflecting on, creating and testing innovative activities. Findings in the literature support ours (Kuzniak et al., 2013; Thurm & Barzel, 2020). These results demonstrate the effectiveness of our course design, answering our research question. We examined the parallels between the two educational levels and found that PSTs experiencing school practice are more invention-ready. If innovation, such as PBL, is used at the school level, PSTs need knowledge about PBL, including its impact on students and how to design and conduct such activities. The same principle applies to content. PSTs, as university students, also have parallel roles and needs just like school students. Therefore, positioning the vertices of students and PSTs, content and content*, and innovation and innovation* as reflected images (Figure 1) emphasises the connections between these levels. PSTs, as university students, must learn both content and innovative teaching methods to meet school student needs. The model's joining point represents teachers, teacher trainers, and researchers or trainers of teacher trainers, connecting these levels. The RDTM effectively depicts the similarities, and dynamic interchange between the educational levels.

Presenting PSTs with innovative teaching methods, showcasing student evaluations, and demonstrating positive learning impact through IKM Plus test results positively influenced PSTs' beliefs about the usefulness of these methods. We found that creating and implementing innovative activities helps PSTs gain confidence. Therefore, teacher training needs to prioritise these opportunities, with teacher trainers acting as role models. This suggests that teacher training reflecting on school education from aspects like technology implementation and interdisciplinary project-based learning can foster innovation-readiness among PSTs. However, broader aspects of teacher education - including theory and ethics - require complementary approaches. The RDTM proved suitable for informing the course design and visualising the interconnectedness of student

needs and preferences, teacher training, and the broader TLE. However, the model fails to depict aspects - including school policy, curriculum development and ethics - not relevant at the school level. Further research, including longitudinal studies following PSTs throughout their careers assessing their innovation-readiness, would be valuable. We designed the model for PSTs majoring in mathematics, but our findings suggest its potential applicability in other disciplines, warranting further investigation. The model may also assist teacher trainers in developing courses for both novice and experienced in-service teachers, providing ongoing support to meet the evolving student and PST needs.

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