

Pedagogical Awareness and What Pre-Service Teachers Learned in Teacher Training Course

- Cross-Analysis of Survey Responses and Course Reflections by LLM -

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Abstract. This study investigated what teacher training students learned in an introductory programming education course by analyzing their reflection papers using large language models. Participants were grouped based on their TPACK scores and authentic teaching experience. The results showed that students with higher TPACK and authentic experience scores produced more reflective and thoughtful reflections, focusing on philosophical aspects of programming education, compared to those with lower scores, focusing on specific examples and practical teaching aspects. TPACK scores were associated with flexible teaching and learner-centered perspectives, while authentic experiences added an enthusiastic and creative tone to the reflections.

Keywords: TPACK, programming education, professional development, reflection paper, large language models

Introduction

It is crucial for teacher training instructors to understand which aspects of teaching practices and philosophy students are focusing on to enhance the teacher training curriculum and better align it with their learning trajectories. Previous studies have assessed students' awareness of pedagogy and technology using primarily surveys and have identified factors such as TPACK, authentic teaching experiences, and technology anxiety as predictors of future teaching practices. However, these factors were examined separately, making it unclear what their individual and collective impact is on what student teachers learn in teacher training programs.

This study explored what teacher training students learned in an introductory programming education course by administering batteries of survey questionnaires and comparing the outcomes with the students' written course reflections. The course reflections were analyzed using a Large Language Model (LLM), which has been increasingly recognized for its efficiency in summarizing texts (e.g., Gesnoin et al., 2024).

Methodology

Survey Administration and Data Collection

A survey was administered to teacher students in Japan as part of a large international survey. Additionally, we collected reflections on the lessons at the end of ten classes of a fifteen-hour introductory course on computer programming education. Participants were asked to submit reflection papers, each with a 200-character description of what they learned in each class, as proof of attendance.

Instruments

Due to space limitations, this paper details only the survey being analyzed in relation to the reflections.

The Synthesis of Qualitative Design (SQD) survey (24 items) focuses on strategies necessary for preparing pre-service teachers for technology integration (Tondeur et al., 2012). The six strategies include: Role models, Reflection, Instructional design, Collaboration, Authentic experiences, and Feedback. The TPACK Core survey (Fisser et al., 2013; 8 items) is a questionnaire on the intersecting concepts of the TPACK framework, which aims to facilitate technology integration in an integrated approach for various forms of knowledge important for effective integration. Participants were asked to indicate their level of agreement with each item on a scale from 1 = Strongly Disagree to 5 = Strongly Agree.

Participants

A total of 142 university students (49 male, 89 female, 4 undisclosed) who completed the Introductory Course in Programming Education, a teacher training course offered at Gunma University and Utsunomiya University in the spring semester of 2024, agreed to participate in the analysis under the condition of anonymity.

Analysis of the Survey and the Reflections

We performed factor analysis (Promax rotation, Principal Components) in R (version 4.1.3) to obtain factors. Subsequently, we conducted text analysis of the written reflections. In the text analysis, we first employed a Large Language Model (LLM) to compress each participant's classroom reflections using the information extraction prompt (Katz et al., 2023) with some modifications. Next, for each factor, we created two sets of compressed reflections based on the participants' factor scores. A "Well-aware" set included reflections from participants with factor scores greater than 0.5, while a "Less-aware" set included reflections from participants with factor scores less than -0.5. These two sets were then resubmitted to the LLM to explain the differences.

Due to the upper limit on the number of tokens for the LLM and the processing capacity of the PC, we created and tested 40 different datasets, each containing around 60 to 80 sentences randomly selected from the compressed reflections. We employed two LLMs, namely, Ministral-8B-Instruct-2410 and Llama-3.1-8B, to assess the consistency of the results. Since we found no significant difference in the outcomes, we did not distinguish between the LLMs in the following analysis.

Results

The factor analysis yielded five factors from the survey items, with a Cronbach's alpha reliability measure of .89. In this paper, we report on two of these factors: "TPACK" from the TPACK CORE survey and "Authentic Experience" (AE) from the SQD survey.

The TPACK factor includes items such as "I can choose technologies that enhance students' learning processes" and "I can choose technologies that enhance the pedagogy of a lesson." The AE factor includes items like "Students were encouraged when they attempted to use technology in an educational setting" and "I received sufficient feedback about the use of technology in my lessons."

The LLM generated over 40 pages of responses that characterized the differences in students' reflections due to random sampling. Many of these responses highlighted similar points, so we selected and edited portions to emphasize their differences in pedagogical awareness (Table 1). To assess the solo and combined impacts of TPACK

Table 1. LLM's summary of students' reflections by pedagogical awareness

TPACK	
Well-Aware participants (N=36)	Less-Aware participants (N=46)
The text shows a more personal, narrative, and reflective tone. The language is often more informal, conversational, and anecdotal with a focus on sharing ideas and insights.	The text shows a more general and introductory tone. The language is often formal and objective, and specific to the topic of programming education.
Emphasis on the importance of critical thinking and problem-solving in programming education.	Emphasis on the importance of hands-on experience and experimentation in learning.
Many responses provide more in-depth analysis or critique of programming education, such as its potential benefits and limitations.	Many responses mention specific examples or experiences related to programming education, such as using Scratch or other tools.
The text is more focused on the benefits, possibilities, and the theoretical aspects of programming education, including importance, applications, and teaching methods.	The text is more focused on the practical applications, personal experiences, and feelings about programming education, such as initial fears and insecurities.

Table 2. LLM's characterizations of reflections categorized by obtained factors

Factor	Characteristics of the reflections
Both "Authentic Experience" and "TPACK" (N=12)	The texts are characterized by their reflective and introspective tone. These texts often express the writer's personal thoughts and feeling about the topics they are discussing, such as the importance of allowing children to think freely or the potential benefits of using unplugged programming.
"Authentic Experience" (N=30)	The texts are characterized by their enthusiastic and creative tone. These texts often express the writer's passion and excitement about the topics they are discussing, such as the potential benefits of programming education or the importance of allowing children to think freely.
"TPACK" (N=24)	The texts are characterized by their more formal and objective tone. These texts often present information in a clear and concise manner, without expressing a personal opinion or emotion. The language used is often more technical and specialized, with a focus on specific concepts and ideas.

and AE awareness, we compared reflections from students whose factor scores were positive for both TPACK and AE, only for TPACK, and only for AE (Table 2).

Discussion

Table 1 demonstrates that teacher training students generally held positive and enthusiastic views about programming education. However, there was a notable difference in emphasis and tone between students with higher and lower TPACK factor scores. Students in the higher group focused more on theoretical aspects and provided deeper analysis of programming education, while those in the lower group emphasized specific examples and experiences related to programming lessons, focusing on practical teaching methods. Their tone was more neutral and reserved compared to the higher group. It appeared that the lower group was still learning about teaching computer programming, focusing on practical aspects such as classroom management and the use of programming tools and materials. In contrast, students in the higher group displayed confidence in teaching, connected university course lessons to their personal experiences, and discussed theoretical aspects in their reflections. Therefore, we suggest that TPACK scores can serve as an effective indicator of students' readiness to teach.

Table 2 demonstrates that students who scored higher on both AE and TPACK survey items exhibited the most positive attitudes toward programming education. They emphasized the significance of guiding students to notice and understand through active engagement with trial and error in programming, and showed openness to new ideas, encouraging students to think critically and creatively. Students who scored high on AE items but not on

TPACK items focused on the importance of student-centered learning and the need for teachers to encourage students to take ownership of their learning. Those with high TPACK scores highlighted the importance of programming education and its relevance to daily life, as well as the integration of programming into various subjects. However, their discussions did not delve into further detail compared to the other groups, suggesting that while they were aware of various teaching methodologies and the need for technology integration, they had not yet fully explored the issues and challenges of implementing programming into their teaching. Therefore, we argue that the AE score, rather than the TPACK score, is more indicative of students' readiness for a teaching job.

Conclusion

Our analysis of the reflection papers indicated that the content and tone of the reflections were associated with the levels of TPACK and Authentic Experience (AE) scores. A lower TPACK score suggests that the teacher student is still in the early stages of professional development (PD). Similarly, AE scores were a significant indicator of PD levels, with higher scores aligning with enthusiasm for teaching and the educational belief that learners should be given freedom in the learning process.

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