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Evaluating INSTALL as an instructional model to enhance EFL pre-service teachers' TPACK: a case of three Indonesian universities

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Purpose: This study investigates the effects of an instructional model incorporating inquiry-based, technology saturated, and flipped learning (INSTALL) on EFL pre-service teachers' TPACK in Indonesia and finds out their responses about it.

Design/approach/method: This is an explanatory mixed method research where quantitative data were further explained by qualitative data. One hundred and eighty eight pre-service teachers from three universities in Central Java province voluntarily participated in this study. Data were collected through questionnaires and observations. The quantitative data were analyzed through a paired sample *t*-test and analysis of variance while the qualitative were analyzed thematically.

Findings: The results uncovered that there was a significant improvement of the pre-service teachers' TPACK after experiencing INSTALL intervention. Additionally, the pre-service teachers responded to the model positively.

Originality/value: The finding implied that INSTALL is a promisingly effective instructional model to enhance pre-service teachers' TPACK. This study contributes to the literature scarcity of a learning mechanism synergizing inquiry-based, technology-saturated, and flipped learning in the Indonesian context.

KEYWORDS

flipped classroom, INSTALL, inquiry-based learning, English pre-service teachers, TPACK

Introduction

The debate on how teachers acquire competencies for effective technology integration into their teaching is still on going (Lachner et al., 2021). Technological pedagogical content knowledge (TPACK) (Koehler and Mishra, 2005b) is a well-known framework capable of describing teachers' competence in technology integration by looking at their knowledge in pedagogy, content, and technology and their intersections (Valtonen et al., 2023).

Pre-service teachers as the successors of our education need to be introduced to technology integration more intensively to prepare their readiness for teaching in the digitized world of the 21st century (Lachner et al., 2021). The 21st century challenges occurred because of the omnipresence and polarization of information and communication technologies (ICTs) in human life (Liesa-Orús et al., 2020). New technologies are released, new skillsets are needed, and new jobs are invented while some traditional jobs are eliminated (Kereluik et al., 2013). TPACK plays a significant role in elevating their skills and creativity in teaching with technology in the 21st century.

In Indonesia, pre-service teachers of English as a foreign language (EFL) typically possess positive attitudes toward TPACK but have low ability in actual utilization of technology for pedagogy. For instance, Megawati et al. (2024) found discrepancies between the pre-service teachers' beliefs and their actual teaching with technology. Besides, Siregar et al. (2024) found their respondents hanging back in using technologies for teaching from the lack of technological pedagogical knowledge. Sumakul et al. (2022) showed that despite their positive perception toward AI-assisted EFL teaching, the respondents are in need of deliberate training in technological pedagogical knowledge. Furthermore, some researchers, such as Hastomo et al. (2024), Syawallina and Suganda (2023), and Kasim et al. (2024) highlighted the unsatisfying results of the EFL pre-service teachers' TPACK investigation. These raise concern on how the future EFL teachers in Indonesia can deal with the challenges of ICT integration into education. Training that promotes self-directed learning, collaboration, creativity, and authentic experience is essential to develop the necessary skills for ICT integration through TPACK.

To provide an efficient TPACK training, we propose inquiry-based, technology-saturated, and flipped instructional model (INSTALL) that is deeply rooted in the constructivist and connectivist learning theories. It was designed and developed to provide instruction oriented to the enhancement of EFL pre-service teachers' TPACK. INSTALL features learning approaches that are associated with the 21st century education. Inquiry-based learning (IBL) transformed learning activity into a meaningful discovery emphasizing learner's learning agency (Dostál, 2015) and problem solving skills (Khalaf and Zin, 2018). Flipped instruction, on the other hand, facilitates the learners to construct knowledge outside the classroom and explore their understanding deeper and wider in the classroom (Lee and Wallace, 2018). Hence, it invites more learners' engagement and enhance their ownership of their learning (Widyasari et al., 2022). The two learning approaches synergized in a technology-saturated setting, which allows the learners experience the benefits of technology-enhanced teaching and find ways to deal with the technology intricacies.

Developing TPACK instructional models has taken the attention of several researchers. Learning by Design (LBD) (Koehler and Mishra, 2005a), Synthesis of Qualitative Evidence (SQD) (Tondeur, 2018), TPACK for 21 Century Learning (TPACK21CL) (Koh et al., 2018), DECODE (Cheng et al., 2022), and BOPPPS-TPACK (Zhang and Zhou, 2023) are some of the well-known models among researchers and practitioners. INSTALL serves as an innovative training mechanism with distinct features that are aimed to fill in the areas not covered by the existing models. Firstly, none of the models includes the flipped technique. The existing models are proven to be effective, but flipped learning will improve the quality since the PSTs were let to initially construct the knowledge at home and subsequently confirm their understanding in the classroom. Secondly, the blending of the three instructional approaches provides multi-stage training for the pre-service teachers to get familiarized with the technology and teaching in the 21st century.

Intending to evaluate the effectiveness of the proposed instructional model, the research questions of in this study are: (1) Does an inquiry based, technology saturated, and flipped instructional model (INSTALL) affect pre-service teachers' TPACK development? (2) How are the pre-service teachers' responses about the model?

Literature review

Constructivist and connectivist underpinings of INSTALL

Constuctivist theory serves as an apropos theory for the 21st century learning where students are positioned as the main actors of learning who actively construct their knowledge (Masethe et al., 2017). Learning is seen as students' mental activity where they connect dots of experience, objects, and new discoveries (Slavin, 2006), teachers provide stimuli for them to investigate new knowledge through posing problems, guide them in the process, and ensure the knowledge scaffolding runs smoothly (Sasan and Rabillas, 2022). This constructive learning is especially doable in the 21st century with the ubiquity of ICT. The students can laverage their exploration on digital resources in addition to the physical books. At this point, a brand new learning theory, namely connectivism is at play.

Connectivist learning theory emerges as a philosopical concept accommodating the altered epistemological process of knowledge in the digital era (Goldie, 2016). This theory suggest that the way human acquire knowledge has been fostered by the unlimited exchange of information on the internet (Siemens, 2005). Key elements of the connectivist learning are self-regulation, technology affordance, openness, and ability to connect and make connections of one discourse with another (Mariyam and Karthika, 2025; Pariyanto, Abdullah et al., 2025).

The syntax of INSTALL are deeply grounded on the constructivist and connectivist principles. The PSTs collaboratively construct pedagogical and technological knowledge by connecting information from real and virtual spaces in the first two stages: flipping and modeling and demonstrate their TPCAK in the latter two stages: designing and role-playing. Beneath, we explain how Inquiry-based learning, technology saturation, and flipped

classroom synergize under the constructivist and conectivist learning theories in a learning mechanism called INSTALL with a purpose of developing EFL pre-service teachers' TPACK.

Inquiry-based learning

Inquiry-based learning (IBL) has emerged as a transformative pedagogical approach that emphasizes student-centered learning through systematic investigation and discovery (Choowong and Worapun, 2021). Rooted in constructivist learning theory, IBL enables learners to actively construct knowledge by engaging in orientation, question formulation, investigation, and knowledge construction rather than passively receiving information (Suárez et al., 2018). This approach is particularly relevant for pre-service teachers, as research indicates that teachers often teach the way they were taught (Strat and Jegstad, 2023).

Recent research has extended our understanding of IBL's implementation and effectiveness. Hinostroza et al. (2024) identified seven critical roles of digital technologies in IBL: guiding inquiry processes, representing phenomena, providing content access, facilitating data collection, organizing information, sharing ideas, and delivering feedback. This comprehensive framework demonstrates how technology transforms IBL from traditional questioning practices into sophisticated learning experiences—particularly relevant for developing teachers' technological competencies.

The effectiveness of IBL in teacher education depends significantly on implementation quality. While Lu et al. (2021) meta-analysis confirmed positive learning outcomes when students develop explanations and connect findings to prior knowledge, Lehtinen and Viiri (2016) emphasized that teacher guidance remains essential for meaningful academic progress. This guidance-autonomy balance is particularly crucial for pre-service teachers lacking experience with inquiry approaches (Sheridan, 2016). Huang et al. (2024) empirically demonstrated this balance, showing that IBL combined with technology-enhanced assessment in structured environments not only improves performance but develops the higher-order thinking skills essential for future teachers.

IBL is particularly valuable in the context of 21st-century education due to its emphasis on developing metacognitive skills and critical thinking abilities (Nunaki et al., 2019). Through analyzing problems and drawing evidence-based conclusions, pre-service teachers develop competencies necessary for technology integration (Prince, 2004). The integration of digital tools further IBL implementation by expanding access to information and enabling sophisticated collaboration (Pedaste et al., 2015), making it particularly suitable for developing TPACK through authentic experiences in technological-pedagogical applications. Zhang and Cobern (2020) argue for highlighting the importance of connecting inquiry activities directly to pedagogical and technological knowledge—a critical consideration for effective INSTALL implementation.

Technology-saturated instruction

As mentioned earlier, hands-on activities involving various technologies could take the pre-service teachers to authentic experience enabling them to get more involved in IBL and FC. Technology-saturated instruction becomes an essential component of INSTALL.

Technology-saturated instruction has emerged as a critical component in developing pre-service teachers' digital teaching competence. As ICT literacy becomes increasingly crucial in the 21st century (Şentürk, 2021), teacher preparation programs must systematically integrate digital technologies across coursework rather than treating them as mere add-on components (Williams et al., 2023). This integration is particularly vital as pre-service teachers occupy dual roles as students and future teachers who must develop both digital competence and teaching competence to effectively integrate into the digital society (Instefjord and Munthe, 2017).

Research indicates that despite having favorable impressions of digital competence, pre-service teachers often lack sufficient proficiency to enhance the teaching process effectively (Tárraga-Minguez et al., 2021). Howard et al. (2021) found that authentic experiences, combined with proper modeling and reflection opportunities, significantly contribute to pre-service teachers' confidence in technology integration. Norhagen et al. (2024) further highlight a persistent gap between policy expectations and implementation, noting that even with substantial governmental investments, teacher education programs struggle with full-scale integration of digital competence frameworks.

Critical factors influencing effective technology-saturated instruction include technology attitudes (Gurer, 2021), technology competencies (Tondeur et al., 2018), and technology ethics (Guillén-Gámez et al., 2021). Yet, as Mnisi et al. (2024) demonstrate, infrastructure limitations often undermine these factors, with insufficient internet coverage rendering even well-designed technology initiatives ineffective in practical classroom settings. This suggests that technology-saturated instruction requires both pedagogical alignment and comprehensive technical infrastructure.

Recent research demonstrates promising outcomes in structured technology-saturated environments. Yu and Wang (2024) application of the TPCK framework in digital storytelling demonstrates how scaffolded integration enhances both technical proficiency and pedagogical application. Similarly, Lim et al. (2024) found that intensive technology integration helped improve pre-service teachers' technological pedagogical capabilities. INSTALL was developed by highly involving new technologies to accommodate the needs of the teacher candidates and tackle the challenges they face in the field.

Flipped classroom

The flipped classroom represents a transformative pedagogical approach that fundamentally restructures traditional instruction by requiring students to review course materials independently before class while dedicating in-class time to more engaging and interactive learning activities (Adnan, 2017; Yeo, 2018). This model has gained particular significance in teacher education programs as it offers a unique opportunity for developing technological pedagogical content knowledge (TPACK) through firsthand experience with technology-enhanced learning.

Bibliometric analyses reveal that research on flipped classrooms has grown exponentially since 2012, reflecting its

increasing adoption in higher education (Zhang et al., 2024), yet methodological limitations persist in assessing its effectiveness for specific educational outcomes like TPACK development (Fisher et al., 2024). The distinguishing characteristic of flipped classrooms lies in its two-phase learning structure. The first phase involves students' self-paced review of content through various media formats, while the second phase transforms classroom time into active learning through small group activities, mini-workshops, and peer instruction (Mehring, 2016; Roehling, 2017). This structure aligns with constructivist principles, emphasizing student engagement through meaningful activities that foster critical thinking and problem-solving abilities (Almulla, 2023).

While technological advances have facilitated flipped classroom implementation through multiple content delivery platforms (McLaughlin et al., 2016; O'Flaherty and Phillips, 2015), systematic reviews indicate that the pedagogy's most consistent benefit relates to student perception rather than measurable learning outcomes (Fisher et al., 2024; Qi et al., 2024) This restructuring of classroom time fundamentally changes how learning activities are distributed, as illustrated in Table 1.

Implementing flipped classrooms presents significant challenges, including technological infrastructure requirements, high-quality pre-class materials preparation, and engaging in-class activity design (Han and Røkenes, 2020). Success depends heavily on students' motivation to engage with pre-class materials (McLaughlin et al., 2016) and their self-regulated learning abilities (Jin and Harp, 2020), factors particularly relevant when implementing flipped approaches in pre-service teacher education (Qi et al., 2024)

Based on these theoretical underpinings, the flipped classroom becomes one of the core elements in developing INSTALL. The flipped classroom takes the learning first stage of INSTALL allowing the pre-service teachers to simultaneously prepare themselves for effective classroom discussion and train their technological competence.

Technological pedagogical content knowledge

Technological Pedagogical Content Knowledge (TPACK) has emerged as a prominent framework for conceptualizing teachers' professional knowledge required for effective technology integration in education (Koehler and Mishra, 2009). Building upon Shulman (1986) original conceptualization of pedagogical content knowledge, TPACK incorporates technological knowledge as an essential component for 21st-century teaching and comprises three core knowledge domains and their intersections.

TABLE 1 Flipped classroom and traditional classroom comparison.

Traditional classroom		Flipped classroom	
Activity	Time	Activity	Time
Warm-up activity	5 min	Warm-up activity	5 min
Go over previous night's homework	20 min	Q & A time on video	10 min
Lecture new content	30–45 min	Guided and independent practice and/or lab activity	75 min
Guided and independent practice and/or lab activity	20–35 min		

The framework consists of Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK) with their interactions creating additional knowledge types: Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Pedagogical Content Knowledge (PCK) (Koehler and Mishra, 2006; Lachner et al., 2021). Recent empirical evidence demonstrates positive correlations between pre-service teachers' TPACK levels and technology integration effectiveness (Demeshkant et al., 2022; Mualim and Maulana, 2023; Wright and Akgunduz, 2018).

Despite its widespread adoption, TPACK research faces persistent theoretical and methodological challenges. A systematic review by Schmid et al. (2024) revealed that after 15 years of research, the field continues "running in circles," struggling with conceptual complexity and measurement issues. Brantley-Dias and Ertmer (2013) critique TPACK as simultaneously too broad in scope yet too narrow in its individual knowledge domains. Additionally, measurement approaches predominantly rely on self-report instruments that may assess self-efficacy rather than actual knowledge (Lachner et al., 2021), prompting calls for more objective, performance-based assessments (Stinken-Rösner et al., 2023).

For effective TPACK development in teacher education programs, research indicates the necessity of both structured training and practical experience (Chang et al., 2024; Yanuarto et al., 2023). Antonio (2025) scoping review identified that successful interventions prioritize authentic learning experiences through lesson planning, practical training (76.92%), theoretical foundations (69.23%), and collaborative feedback (61.54%). Similarly, Arifuddin et al. (2025) emphasized that beyond understanding TPACK dimensions, teachers require self-confidence and analytical abilities to address implementation challenges. This aligns with recommendations for longitudinal studies and comprehensive measurement approaches that include student learning outcomes (Schmid et al., 2024; Umar et al., 2023).

Inquiry-based, technology saturated, and flipped instructional model (INSTALL)

INSTALL represents an innovative integration of inquiry-based learning, technology saturation, and flipped instruction designed to enhance pre-service teachers' TPACK development. This model emerged from the recognition that traditional approaches to teacher preparation often fail to effectively integrate technological, pedagogical, and content knowledge in ways that reflect modern educational demands (Chang et al., 2024). The theoretical foundation of INSTALL draws on constructivist learning principles, emphasizing active engagement, self-directed exploration, and meaningful integration of technology into pedagogical practice.

INSTALL encompasses four sequential yet interconnected learning stages that take place over two 100-min sessions: flipping, modeling, designing, and role-playing. In the flipping stage, pre-service teachers study theoretical content through videos and texts

while investigating various applications outside the classroom. To ensure engagement in this unsupervised activity, multiple-choice quizzes assess their understanding. The modeling stage involves group discussions about the pre-class materials and applications, followed by instructor demonstrations of practical technology applications. During this phase, pre-service teachers experience technology-enhanced learning from a student's perspective, gaining valuable insights for their future teaching practice.

During the designing stage, pre-service teachers collaborate to create lesson plans that integrate technology effectively. These plans must specify learning objectives, materials, technologies, teaching steps, and assessment methods. The fourth phase, role-playing, allows pre-service teachers to demonstrate their TPACK through teaching simulations, with one group acting as instructors while others participate as students. This progression from theoretical understanding to practical application supports the development of integrated technological, pedagogical, and content knowledge. The syntax and roles of pre-service teachers and lecturers in each learning stage are described in Figure 1.

INSTALL was developed and documented through three products: a model book explaining the theoretical foundation and development process, a user manual providing implementation guidelines, and instructional kits containing necessary documents (syllabus, teaching materials, assignments, and assessment rubrics). These products underwent validation by two experts in educational technology, focusing on completeness, clarity, coherence, and practicality. The validators rated each product on a scale from 1 (lowest) to 4 (highest), with results showing high scores in the "very good" category, as shown in Table 2.

TABLE 2 Product validation by experts.

No	Product	Total mean	Category
1	Model book	3.6	Very good
2	User manual	3.7	Very good
3	Instructional kits	3.8	Very good

Materials and methods

Research design

This study takes the third part of a larger doctoral thesis that implements design-based research (DBR). Bannan (2009) formulated integrative learning design framework (ILDF) as an analytic mechanism under the DBR concept whose design is accommodative to research in education and technology integration. ILDF encompasses three stages namely informed exploration, enactment, and evaluation with local and broader impacts. The current study focuses on the evaluation stage with local impacts.

In attempt to evaluate the effectiveness of INSTALL, we implemented a mixed method design (explanatory sequential model) in which quantitative research was done first and qualitative research was done to explain the data deeper. The quasi-experiment research with pre-post control group design was taken by deploying two tests, one test before the intervention and another one after it to experiment and control groups. The experiment groups are those experiencing INSTALL while the control groups are those taught through lecturing, group discussion, and assignment. Qualitative study was used to capture the pre-service teachers responses on INSTALL implementation.

Population and sample

The population of this research is EFL pre-service teachers in Central Java Province, Indonesia. EFL pre-service teachers from three universities in the regency of Banyumas were selected as samples. The total sample was 188 pre-service teachers, of which 97 were selected as experiment groups and 91 were picked as control groups. The samples were selected through a cluster sampling resulting in one experiment group and one control group in each

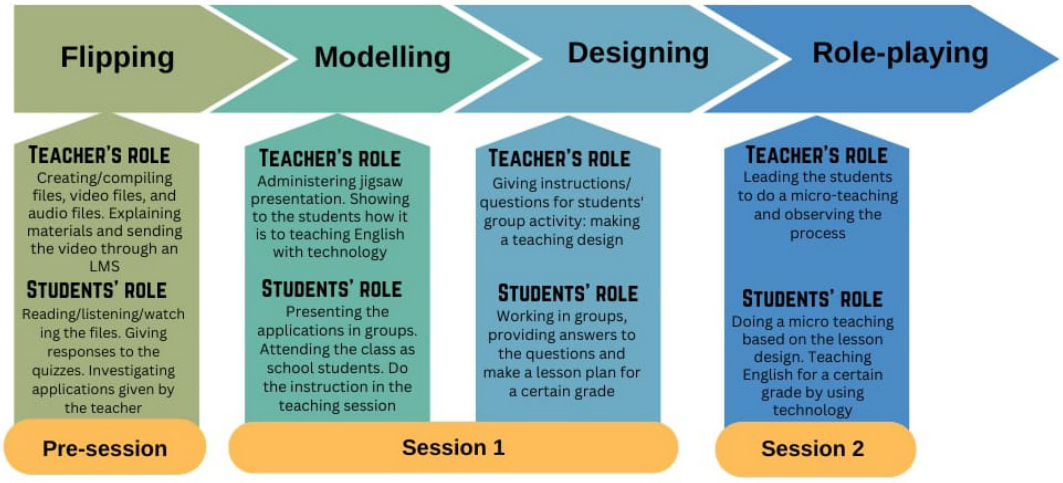

FIGURE 1
The syntax of INSTALL.

university. This sampling technique was taken because the pre-service teachers were already grouped in classes in the universities. It was unlikely to implement a total random sampling since it could disarray the class composition in the universities and eventually mess up the regular learning activity. Therefore, this study is quasi-experimental in nature. Have a look at Table 3 for the demography details of the sample.

Data collection

In an effort to investigate the effect of INSTALL on the pre-service teachers' TPACK, quantitative data were collected before and after the intervention through closed-ended questionnaires. Meanwhile, the skills developed during the intervention were observed through semi structured observations. Furthermore, to explore the pre-service teachers' attitude toward the model implementation, qualitative data were collected through a response questionnaire.

Four research instruments were crafted to collect the data. They were two TPACK questionnaires, one observation protocol and one response questionnaire. The two TPACK questionnaires were used for pre-test and post-test. They contain similar ideas representing the seven domains of TPACK, but were worded differently. They were compiled by adapting the works of Schmidt et al. (2009) and Bostancıoğlu and Handley (2018). Major modifications were made to the questionnaires to provide proximity to the context of the current study resulting in 37 four-point Likert-style items. The questionnaire consists of TK (items 1-6), PK (items 7-11), CK (items 12-16), TCK (items 17-22), PCK (items 23-28), TPK (items 29-32), and TPCK (items 33-37). They were translated to Indonesian and sent to a panel of two experts in language pedagogy and educational technology for content validation. After some minor revisions, the panel declared that the items were acceptable and valid as an instrument. The items then went to a face validity that was performed by five respondents whose characteristics replicate those of this study's sample. Some ambiguous terms were reworded and some unclear statements were paraphrased based on the feedback of the respondents. Finally, the refined questionnaires were pilot-tested to 29 pre-service teachers for the validity and reliability of the items. The result of the pre-test items was item no. 4 and no. 33 gained Sig. values above 0.05 (invalid) while the rest gained Sig. values below 0.05 (valid). Since the two items did not make a significant change to the whole questionnaire, they were eliminated rather than replaced. The Cronbach Alpha of the remaining items (35 items) was.946 implying that they are reliable. Meanwhile, the finding of the post-test questionnaire was no item gained a Sig. value above 0.05 and the Cronbach Alpha value of all items was 0.941 surpassing the minimum standard of 0.70. Hence, the post-test questionnaire was valid and reliable.

Meanwhile, the observation protocol was developed to guide the observation which captures skills that are expected to appear based on the literature. The skills include metacognition, collaboration, critical thinking, and creative thinking. Besides, the pre-service teachers' perception and attitudes on the model implementation and the problems they encountered were observed. The protocol consists of seven prompting questions for each skill and aspect. The protocol was sent to two experts (a professor in language education and an associate professor in educational technology) for validation. After minor revisions, the experts declared that the protocol was valid and ready to be used.

In attempt to see the attitudes of the pre-service teachers about INSTALL, we administered a response questionnaire. It comprises 7 close-ended questions and 3 open-ended questions. Questions 1 to 3 relate to how the synergy between inquiry-based learning, technology saturation, and flipped classroom enhanced the pre-service teachers learning and impacted their TPACK development. Questions 4 to 7 contain how the learning stages helped the pre-service teachers in understanding the materials. Meanwhile, question 8 and 9 elicit what they liked and disliked about INSTALL. Question 10 asks the aspects of INSTALL that needed enhancement. The content validity of the items was obtained from a panel of two experts in language pedagogy and educational technology.

Data collection procedure

TPACK pre-tests were administered to both the experiment groups and control groups to retrieve information on the initial TPACK state of the respondents. The experiment groups subsequently received INSTALL intervention while the control groups were taught through lecture, group presentation, and assignment.

INSTALL intervention was run for two iterations. Each iteration lasts in 2 weeks making it 1 month of intervention in total. The iteration of intervention is one of the basic features of DBR and its evaluative and transformative natures that made it a design-based research (Armstrong et al., 2022). Shortcomings, errors, and challenges found in the first iteration were documented and taken as a consideration to refine the syntax of the model for the following iteration. In the first iteration of the current research, the pre-service teachers were trained through the four stages of INSTALL with a topic of "teaching listening skills with technology." Observations were carried out along the training by inviting two research assistants. The research assistants were trained on the underlying theory of this research and the ways to identify the appearance of the derived skills guided by the protocol. They are

TABLE 3 Demography of the sample.

Gender	Male	37
	Female	151
	Total	188
Age	18 y.o.	2
	19 y.o.	63
	20 y.o.	88
	21 y.o.	28
	22 y.o.	7
	Total	188
Teaching experience	None	143
	<1 year	34
	1–2 years	9
	>2 years	2
	Total	188

TABLE 4 Paired samples *t*-test results.

University	Group	*N*	Data	*M*	*SD*	*P*	Cohen's *d*
University A	Experiment	41	Pretest—posttest	−0.48	0.32	0.00	1.50
	Control	36	Pretest—posttest	−0.15	0.50	0.09	0.29
University B	Experiment	34	Pretest—posttest	−0.28	0.32	0.00	0.85
	Control	35	Pretest—posttest	−0.06	0.28	0.21	0.22
University C	Experiment	22	Pretest—posttest	−0.29	0.44	0.01	0.68
	Control	20	Pretest—posttest	−0.16	0.43	0.11	0.37

also to write out additional skills and classroom dynamics on the open space of the field note sheets. After each observation, the two assistants coded their findings separately and met to discuss their results and gain consensus for the contradicting points. Finally, response questionnaires were distributed at the end of the training for evaluation. The findings of the observation and responses were used to refine INSTALL implementation in the second iteration with a topic of "teaching speaking skills with technology." After a month of intervention, TPACK post-tests were administered to both the experiment groups and control groups.

Data analysis

The quantitative data underwent two analyses by the help of SPSS version 25. A paired sample t-test was employed to see the difference between the pre-intervention and post-intervention TPACK of the pre-service teachers in both the experiment and control groups. Afterward, analysis of covariance (ANCOVA) was performed to see the difference of the pre-service teachers' TPACK in the experiment groups by taking the existing knowledge (pre-test scores) as the covariance. However, since the focus of the quantitative research phase was to find out the effect of INSTALL on the respondents' overall TPACK the aggregated TPACK score was analyzed instead of the individual knowledge domains.

Meanwhile, data from the observations were analyzed through a thematic analysis and following the coding of Braun and Clarke (2006) which comprises five steps. They are (1) getting familiar with the data, (2) composing initial themes and subthemes for the recurring topics, (3) selecting phrases or sentences and categorizing them into the themes and subthemes, (4) reviewing the data and themes, some data might be moved, replaced, or erased, and (5) renaming of the themes and subthemes that lead to answering the research questions. The response questionnaire were analyzed in two ways. Firstly, the close-ended responses were calculated for their percentages. This is to see the level of agreement of the respondents with the questions. Secondly, the closed-ended responses were analyzed thematically on NVIVO for its ability to organize large amount of qualitative data. The thematic analysis was done by adapting the thematic analysis model of Braun and Clarke (2006).

Ethical clearance and informed consent declaration

The ethical clearance of this study (including its instruments) was received from the Directorate of Research and Community Service, Universitas Negeri Yogyakarta, with the registration number T/3.2/UN34.9/KP.06.07/2024. The informed consent statement was provided, signed by the interview informants and agreed by the survey respondents.

Results

The effectiveness of the INSTALL model on the pre-service teachers' TPACK development

Paired sample *t*-test was employed to examine the effect of INSTALL intervention on the pre-service teachers' TPACK. The basic assumptions, data normality, were gained as indicated by the Sig value of the Shapiro-Wilk in every university, all above 0.05. Paired sample *t*-test results showed that the TPACK of the experimental groups increased after being taught through INSTALL. The Sig values (2-tailed) of every experiment groups were lower than 0.05. They were.00 for the experiment group in university A, 0.00 for those in university B, and 0.01 for those in university C. Hence, H_0 was rejected and H_a was accepted. There was an increase in the Pre-service teachers' TPACK after having INSTALL. The complete results are in Table 4.

In the meantime, the TPACK of the control groups in all research loci did not show a significant increase. The Sig values (2-tailed) of all control groups were higher than.05. They were 0.09, 0.21, and 0.11 for the control groups in university A, university B, and university C respectively. Therefore, the H_0 was accepted as the H_a was rejected. The control groups' TPACK developed insignificantly after experiencing traditional instruction comprising lecture and assignment. Have a look at Table 4 for the complete result.

TABLE 5 ANCOVA test result/between-subject effects.

Source	*SS*	*df*	*MS*	*F*	*P*	η *p2*
Corrected model	1.42[a]	3	0.47	5.75	0.00	0.16
Intercept	5.20	1	5.20	63.34	0.00	0.41
PreTest	0.55	1	0.55	6.72	0.01	0.07
University	0.80	2	0.40	4.84	0.01	0.09
Error	7.64	93	0.08			
Total	1137.79	97				
Corrected total	9.05	96				

[a]R Squared = 0.156 (Adjusted R Squared = 0.129).

Furthermore, in search for a clearer picture of the INSTALL effectiveness in enhancing the pre-service teachers' TPACK, an analysis of covariance (ANCOVA) was employed to the post-test scores of the experiment groups. The data normality and homogeneity were guaranteed by the Shapiro-Wilk Sig values and Levene's test. No violation was found. ANCOVA test revealed that the pre-service teachers' TPACK of the experiment groups developed significantly by controlling the pre-test scores (the existing knowledge). It is indicated by the Sig values of 0.01, lower than 0.05 (for detailed calculation results, see Table 5).

Observation findings on skill development during INSTALL implementation

During the implementation of INSTALL, the classrooms were observed to document the development of the pre-service teachers' skills as well as attitudes and perception of the model. The pre-service teachers were seen positively perceiving the model. They paid attention to the instructions, did the activities suggested to them, cooperated with their peers for their projects, and performed in relatively good shows. Specifically, the observers came to consensus on themes relate to metacognition, collaboration, critical thinking, and creative thinking that appeared throughout INSTALL implementation. The majority of the pre-service teachers presented well in the modeling stage that included Jigsaw discussion as they have learnt the materials and carefully investigated the technologies during the flipping stage. The interaction continued in the designing stage where they selected appropriate technologies for teaching and finding creative ways to deliver the teaching materials. These skills are related to the 21st century skills as depicted in Table 6.

The switch from one activity to another provided classroom dynamics that kept them actively engaged in the whole classroom activities. They were excited about learning new strategies for teaching English and the applications that support them. Mobile applications such as Padlet, Genially, Mentimeter, and Gimkit were well-used in their teaching simulation.

However, some problems occurred and hindered the flow of the classroom activities. First, some pre-service teachers were overwhelmed with the rapid switches in the classroom activities, from modeling to designing, and then to role-playing. The member movement from one stage to another absorbed a considerable amount of time. It was the instructors who guided the members' movement and decided spots for small group discussion. Secondly, while some pre-service teachers did well in the flipping stage, there were many of them who did the flipping stage just an hour or two before the class began. As a result, they could not present their investigation. This issue is closely related to self-regulated learning skills. Furthermore, problems relative to the Internet credits or WiFi connection and the mobile phones happened several times. While the classrooms in University A and C were equipped with excellent quality of classroom technologies and WiFi connection, the classroom in University B was lack of institutional support. This was anticipated by the researcher by providing additional modems to which the pre-service teachers could connect. As for the problems with the incompatibility of the respondents' mobile

TABLE 6 Twenty first century skills exhibited by the PSTs.

Themes	Skills acquired			
	Metacognition	Collaboration	Critical thinking	Creative thinking
The PSTs followed the learning steps in the Jigsaw discussion well	√			
The PSTs performed their roles in the Jigsaw discussion quite well	√			
The PSTs worked toward their goal in the Jigsaw discussion	√			
The PSTs asked questions on the features of the applications presented in the Jigsaw discussions			√	
The PSTs evaluated the appropriateness of the applications to enhance teaching			√	
The PSTs elected the head of the group for the co-designing phase		√		
The PSTs distributed work among the group members for designing a lesson plan		√		
The PSTs conceptualized teaching steps that might attract the students		√		√
The PSTs evaluated the applications that could enhance the learning		√	√	
The PSTs opted appropriate applications to enhance the teaching			√	√
The PSTs reviewed the complete draft of the lesson plans		√	√	
The PSTs gave opinion on the lesson plans and provided suggestions		√		√

phones, the researchers could not provide a solution except for the peers to cooperate and share their phones.

The pre-service teachers' perceptions of the INSTALL model

The pre-service teachers' response to the model was positive as evidenced by the high percentage of "Yes" responses to the statements. Statement 1 "Learning with INSTALL helped me to understand the materials" received 100% of positive responses, statement 2 "Learning with INSTALL enhances my understanding of the integration of technology into English language teaching" also gained 100%, and statement 3 "The stages of INSTALL are easy to understand and follow" obtained 98.8%.

Furthermore, statements that relate to the teaching stages yielded the following percentages. Statement 4 "The flipping stage could provide background knowledge before coming to the classroom" gained 97.6%. Meanwhile, statement 5 "The modeling stage could provide me with experience as a subject of English teaching with technology. As an impact, I gained knowledge on how students engage in a technology-aided English class" yielded 97.6%. Statement 6 "The designing stage could help me to elicit ideas of English teaching with technology" gained 100%. Finally, statement 7 "The role-playing stage helped me to understand the situation in teaching English with technology" yielded 98.8%.

Following the close-ended questions were three open-ended questions. The questions related to the aspects that the pre-service teachers liked about the model, the aspects they did not like about it, and the aspects they thought needed enhancement. In regards to what they liked about INSTALL, three themes appeared to summarize the pre-service teachers' responses relative to easing the learning, enhancing their understanding, and transforming the instruction into attractive learning. The pre-service teachers expressed that INSTALL helped them to understand materials more easily. The flipping stage prepared them for interactive discussions, the modeling stage provided information on which they confirmed their self-constructed understanding, while the role-playing enabled them to conceptualize their knowledge to realistic activities. Pre-service teacher 25 stated:

"INSTALL enabled me to have hands-on activities which helped me understand the materials in a systematic way. The learning stages of INSTALL efficiently engaged us in the learning activity. The group discussion was more meaningful since we were ready with the materials and the role-playing stage brought us from abstract theory to real practice."

Besides, INSTALL elevated their understanding of how to harness technologies for pedagogical purposes. They are very well-informed with some sites like YouTube and TedEd but using them for teaching is another level of understanding which, according to them, was attained through INSTALL. Pre-service teacher 32 pointed out:

"INSTALL enhanced my understanding of ICT harnessing for teaching EFL. I have been using some applications and websites such as YouTube and TedEd but after attending INSTALL I got knowledge on how to use them for teaching."

Furthermore, this multi-stage learning mechanism transformed regular learning into fun and attractive activities. This is especially realized through the whole new learning atmosphere that promotes independence, collaboration, and creativity. Pre-service teachers 50 posited:

"The learning activities were well-structured and interesting. The switch from one stage to another might not be smooth, but it was good to have a new learning ambience. I felt fully engaged in the collaborative and creative process of the modeling and designing stages."

Pertaining to the aspects that the pre-service teachers dislike about INSTALL, the thematic analysis resulted in four points. Technical intricacies caused by insufficient internet networks and incompatible mobile devices were seen as the least favorable aspect of INSTALL. Since INSTALL was operated with a high technological saturation, the learning flow depends on the mobile devices and the Internet as lamented by pre-service teacher 62, "Unwanted technological problems like incompatible devices and errors such as low Wi-Fi connection occurred several times. That makes the learning inefficient and hard to follow." Subscription to premium plans came up as the second disliked aspect of INSTALL. The modeling stage was often hindered by the inability to access advanced features of the applications which forcefully stopped them from exploration as complained by pre-service teacher 20, "there were applications that demanded premium subscriptions. Advertisements often occurred to access the advanced features. This hindered the learning". Besides, some pre-service teachers felt that the whole learning was too technocentric, undermining traditional learning. Some others complained of being lost in the middle of the learning, unable to navigate the learning flow. These imply the lack of guidance provided by the instructors concerning the purpose and procedure of INSTALL. Pre-service teacher 25 expressed "INSTALL focused too much on the use of technology for learning, traditional instructions are also needed."

In the meantime, inquired about the aspects of INSTALL that need enhancement, the pre-service teachers expected three points: exploring more applications, providing clearer instructions, and finding alternatives for technological glitches. To enhance the pre-service teachers' engagement in the INSTALL implementation, more varied learning media including applications for assessing the skills of English and instructional techniques including the clarity of the instructions and constant guidance were expected. Several pre-service teachers found the technologies utilized for INSTALL were already known well, hence they found the learning a bit monotonous. Pre-service teacher 77 pointed out:

"I think we need to explore more applications for learning so the learning can be more challenging. For instance, applications for assessing productive skills such as speaking skills and writing skills will help our work so much."

Some pre-service teachers were unable to navigate the learning stages questioning what exactly needed to be done. The four INSTALL stages brought traditional learning to a whole new mechanism which might be confusing. The key to successful implementation is clear and easy instructions. Pre-service teacher 80 posited:

"Explanation and simulation on the tasks that need to be done in every stage of INSTALL has to be made clearer, not everybody in the classroom understood it well."

Lastly, technical troubles remain a big hindrance in this technology integration venture, alternatives need to be prepared so as not to disrupt the overall learning process when technologies fail to assist. Technical problems such as connecting laptops to projectors, installing an application, and responding to live

surveys occurred several times. There were no actions taken by the instructors during the pauses in learning resulting in the loss of mood. Pre-service teacher 85 expressed:

"The instructors need to take more control of the learning activities and not rely too much on technologies because problems could appear anytime. They need to be prepared with alternatives to mitigate the failure of using the technologies. I felt a lot of time was wasted because of this and the learning became boring."

Discussion

The purpose of this research is finding out the effect of an instructional mechanism synergizing three conceptual parameters namely inquiry-based learning, technology-saturated classes, and flipped classroom on the pre-service teachers' TPACK. The results of both pair sample *t*-test and ANCOVA satisfied the research questions. The TPACK of the experiment groups surpassed those of the control ones after having INSTALL intervention. Furthermore, by taking the pre-test scores as a covariate, the pre-service teachers exhibited an increase in their TPACK. This suggest that the blending of inquiry-based learning, technology saturation, and flipped classroom impact the PSTs' TPACK positively. Although research that synergizes the three learning approaches as an intervention is scarce, the effectiveness of the individual approaches signifies the value of this model. Dewi et al. (2022) utilized inquiry-based learning in the project-based TPACK learning model to elevate the pre-service teachers' TPACK and design ability, which resulted in the model's effectiveness. On the other hand, Lim et al. (2024) found technology saturation as a useful mechanism to train the pre-service teachers technological proficiency for pedagogical purposes. Besides, Kadıoglu and Oskay (2023) found that flipped classroom was effective to enhance pre-service teachers' TPACK.

During the implementation of INSTALL, the pre-service teachers showed behaviors relative to metacognition, collaboration, critical thinking skills, and creative thinking skills. The pre-service teachers could navigate their independent learning, worked together in designing lesson plans, asked and responded questions about the applications, evaluated the features for teaching, and came up with innovative teaching ideas. These skills align very well with the principles of andragogy on one hand (Chaipidech et al., 2022) and 21st century education on another hand (Mudinillah et al., 2024). Inquiry-based learning promotes collaboration and creative thinking skills (Šliogerienė et al., 2025). Collaborative works and creative thinking skills during the modeling, designing, and role-playing stages of INSTALL were expected to increase the pre-service teachers' nuanced understanding on TPACK. On the other hand, its mode of delivery (technology-saturated classes) had the benefits to shape the pre-service teachers' attitude toward its integration into teaching (Wilson, 2023) and elevate their motivation (Muth and Lüftenegger, 2024; Zain, 2023). Technological intricacies that happened during the instruction demotivated some pre-service teachers. Through technology exposure, the pre-service teachers built some skills and competence in technology integration into teaching including the strategies to cope with technological glitches and dysfunctions (Aleksiæ and Politis, 2023). Meanwhile, flipped classroom enabled the pre-service teachers to develop self-regulation in learning and facilitates student-centered learning (Rincón et al., 2025). The latest research proves that in principle there is a positive relation between flipped classroom and self-regulated learning (Arsarkij, 2024; Chikeme et al., 2024; Zhang et al., 2024). The problem at hand is that this approach is extremely challenging to be implemented proportionally. Most pre-service teachers in this study found it hard to spare time to watch and read the materials from the loads of take-home assignment and insufficient internet credits. As a result, they do the pre-class activities an hour or two before coming to the classroom. Self-regulated learning and student-centered learning are paramount for developing metacognitive skills to tackle the challenges of the 21st century job market (Kereluik et al., 2013).

The synergy of inquiry-based learning, technology saturation, and flipped classroom in this study becomes a promising instructional model to enhance pre-service teachers' TPACK as evidenced by the quantitative data analyses. The synergy of the three learning approaches is unique since the literature has not spoken much about it. The literature so far has discussed the relations of these learning approaches with TPACK separately. For example, inquiry-based learning with TPACK (Chai et al., 2020; Teknowijoyo et al., 2024), technology saturation with TPACK (Hoffmann, 2024), and flipped classrooms with TPACK (Kadıoglu and Oskay, 2023). The overall positive response of the pre-service teachers reveals their perception of the model based on their personal experience. The pre-service teachers perceived INSTALL as a helpful and empowering learning mechanism to comprehend ICT harnessing for English teaching. This finding is in sync with Dellatola et al. (2020), Hsu and Lin (2020), and Irdalisa et al. (2020) who found inquiry-based learning, technology saturation, and flipped classroom affect the PST's cognitive, behavior, and affective engagement positively. However, implementing INSTALL presents several challenges that require careful consideration. The pre-service teachers experienced difficulties managing the self-directed aspects of flipped learning, integrating multiple technologies in one teaching session, and transitioning between different roles from teachers as instructors to teachers as guides and collaborators. Max et al. (2024) suggested that providing clear guides, room for familiarization, and reflective sessions is paramount to abstain from setbacks and negative emotions. Additionally, we found that institutional support, appropriate technological infrastructure, and careful scaffolding of learning experiences are requisites for this model to be successfully implemented (Nithitakkharanon and Nuangchalerm, 2022).

Conclusion

This study is aimed at finding out the effectiveness of INSTALL in developing pre-service teachers' TPACK and exploring the pre-service teachers' response. The paired-sample t-test and ANCOVA results show that INSTALL is an effective instructional mechanism to enhance the pre-service teachers' TPACK. Additionally, the majority of the pre-service teachers responded positively to the model. The limitations of this research are its analysis on the development of TPACK seen solely from the INSTALL intervention, variables that could influence the development such as belief, motivation, gender, and school support was not sought. Future works could see the TPACK development through a multivariate analysis. Besides, the field-testing employed quasi-experimental design, which has a moderate internal validity.

The cluster sampling of the quasi-experiment could not provide an equal baseline between the experimental groups and control groups. Future research could group the sample through a random sampling technique for the quality enhancement of the research. The theoretical implication of this research is its contribution as an addition to the existing instructional models oriented to TPACK with a unique modification of blending inquiry-based learning, technology-saturation, and flipped classroom. Researchers in the field of TPACK development studies can take the output of this study to broaden their reference. Teacher trainers can implement the model when educating future teachers in technology integration for pedagogical purposes. Meanwhile, the practical implication of this research is its syntax that could enhance students' preparedness before entering the classroom, strengthen their cooperation, and increase their understanding of the material. The blending of the three learning approaches is not only for a more explorative and interactive learning that cumulate in the increase of their competence, it also affects their metacognitive skill – an essential skill for the 21st century.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Directorate of Research and Community Service, Yogyakarta State University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

MMu: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. MMa: Data curation, Formal Analysis, Methodology, Writing – review & editing. AW: Data curation, Methodology, Supervision, Writing – review & editing. HN: Formal Analysis, Investigation, Writing – review & editing. KK: Writing – review & editing, Data curation, Methodology, Project administration. FF: Writing – original draft, Writing – review & editing, Data curation, Methodology, Formal Analysis. NR: Writing – original draft, Writing – review & editing, Data curation, Methodology, Project administration, Validation.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that no Generative AI was used in the creation of this manuscript.

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