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Profiling the TPACK Mastery of English Pre-Service Teachers for 21st Century Learning

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Abstract

The present research seeks to examine the extent of Technological Pedagogical Content Knowledge (TPACK) competence demonstrated by English pre-service teachers enrolled in the Faculty of Teacher Training and Education at Cenderawasih University, as well as to identify the most dominant and the weakest aspects of their TPACK competence. The background of this study is grounded in the demands of 21st-century learning, which underscores the holistic incorporation of content, pedagogy, and technology within the instructional process. A quantitative survey method was employed, using a purposive sampling technique involving final-semester students of the English Education Study Program. The data were gained through a TPACK questionnaire encompassing seven key dimensions: Technological Knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and TPACK. The data in this study were subjected to descriptive analysis using SPSS version 29 software. The findings reveal that the overall level of TPACK mastery among the students falls into the "moderate" category. The most dominant aspect is Content Knowledge (CK), which achieved a high average score, indicating strong mastery of English content, particularly in speaking and listening skills. Conversely, the weakest aspect is Technological Knowledge (TK), which obtained a low average score, consequently affecting the integrative dimensions such as TPK, TCK, and TPACK, which remain at a moderate level. In conclusion, the study affirms that English pre-service teachers possess a strong grasp in content and pedagogical knowledge but still face limitations in technological competence. Therefore, it is recommended that technological proficiency be strengthened through intensive training, the incorporation of technology-oriented practices within the curriculum, ongoing mentorship programs, and extended research efforts to yield a more holistic understanding of TPACK mastery profiles among pre-service teachers.

Keywords: 21st Century Learning; English Pre-Service Teachers; Technology

Integration; TPACK

Introduction

The 21st century has been marked by unprecedented technological progress that has reshaped the entire landscape of education (Rahimi & Oh, 2024). Consequently, teachers are required to demonstrate not only robust pedagogical and content knowledge but also the capacity to effectively integrate technology into the instructional process in meaningful ways. This integration is essential to ensure that teaching practices remain relevant, engaging, and aligned with the demands of modern learners in a digital era (Mutiani & Faisal, 2019). The Technological Pedagogical Content Knowledge (TPACK) framework offers a comprehensive perspective for examining teachers' competencies in the 21st century, highlighting the intricate interrelationship among content, pedagogy, and technology. Teachers are required by 21st-century education to cultivate teaching practices that are both creative and innovative (Tarihoran, 2019).

The infusion of technology within English language education has increasingly been recognized as a key factor in promoting more effective and engaging teaching practices (Naing & Wiedarti, 2023). As future educators, it is essential for English pre-service teachers to attain an adequate level of TPACK competence in order to design and implement contextual, innovative, and technology-driven instructional practices (Ye et al., 2024). Nevertheless, prior research has consistently revealed that pre-service teachers in diverse educational contexts struggle to infuse technology effectively into their teaching. According to Liang et al., (2013), while pre-service teachers tend to hold favorable perceptions of technology, their ability to integrate TPACK effectively remains inadequate. Similarly, in the Indonesian context, research by Sitorus et al., (2024) also highlighted the low level of preparedness among pre-service teachers in fully applying TPACK within English language teaching settings.

This condition raises concerns, as global educational challenges increasingly demand teachers to be adaptive, creative, and collaborative in utilizing digital technologies. Hence, it is essential to map the TPACK mastery profile of English pre-service teachers in order to assess their level of readiness to engage with 21st-century learning demands.

The present study was conducted with two main objectives. First, it sought to describe the level of TPACK mastery among English pre-service teachers within the Faculty of Teacher Training and Education at Cenderawasih University. Second, it aimed to identify the most dominant and the weakest aspects of their TPACK competence. This study makes an original contribution by presenting a contextualized portrayal of TPACK mastery among pre-service English teachers in Papuan higher education institutions, a context that remains largely overlooked in existing research. The results are projected to lay the groundwork for advancing technology-integrated teacher preparation and cultivating innovative learning practices suited to the 21st-century classroom.

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Method

The study utilized a quantitative survey approach, chosen to ensure an objective and measurable representation of English pre-service teachers' TPACK mastery, supported by the use of a validated research instrument. The survey method enabled the collection of a large amount of data efficiently in terms of time and resources.

The study's population was the entire cohort of students from the English Education Study Program within the Faculty of Teacher Training and Education at Cenderawasih University, who were considered to have gained sufficient learning experience related to content, pedagogy, and educational technology. A purposive sampling technique was employed, based on the following criteria:

1. Active students in the 6th or 8th semester,
2. Students who had successfully completed pedagogical and educational technology-related courses, and
3. Students who voluntarily agreed to participate as respondents.

The sample size was determined based on the guidelines proposed by Krejcie and Morgan, or by adopting the general rule of having at least 30–100 respondents for descriptive quantitative studies, depending on the population size. The data collection employed a TPACK questionnaire that was adapted from the previously validated framework proposed by Baser et al., (2016). The instrument consisted of seven main dimensions: Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), and TPACK. A five-point Likert scale was applied in the questionnaire, with response options ranging from "Strongly Disagree" to "Strongly Agree". It was shared both offline and online via Google Forms to reach a wider range of respondents.

Data analysis was performed with the aid of SPSS version 29. Normality was determined using the Kolmogorov–Smirnov test, and homogeneity was verified through the Test of Homogeneity of Variances. A significance value (p) bigger than 0.05 was interpreted as an indication that the data met the assumptions of normality and homogeneity. Subsequently, the data were analyzed using descriptive statistical techniques to obtain an overall picture of the respondents' TPACK mastery profile.

To describe the TPACK mastery of English as a Foreign Language (EFL) pre-service teachers, descriptive statistical analysis was applied. The analysis involved examining the mean, range (minimum and maximum), standard deviation, and percentage of mastery obtained from participants' responses. The total score of each respondent was converted to a standardized score out of 100 using the following formula:

$$\mathbf{P} = \frac{f}{N} \; \boldsymbol{x} \; \mathbf{100}$$

Where:
P = Final Score
f = Score Obtained
N = Maximum Score

To determine the degree of TPACK mastery among English pre-service teachers, the obtained scores were compared with the established interpretation criteria, as presented in Table 1.

Table 1. Interpretation Criteria for TPACK Mastery Scores

Score Interval (%)	TPACK Mastery Category
86–100	Very High
71–85	High
56–70	Moderate
41–55	Low
≤ 40	Very Low

Results

Analysis of Technological Knowledge (TK) Mastery

Technological Knowledge (TK) refers to the ability to utilize various digital tools and media in teaching practices, encompassing both hardware and software, as well as the skills to operate educational technology applications (Taek et al., 2024). Recent studies emphasize that in the post-pandemic educational context, teachers are required not only to be technically proficient, for instance, in operating learning management systems, video devices, augmented reality, virtual reality, or artificial intelligence but also to continuously update these competencies through ongoing professional development in order to adapt to dynamic learning environments. Furthermore, frameworks such as TPACK and its more recent extensions (e.g., AI-TPACK) highlight the importance of wisely integrating emerging technologies into pedagogy and content. This integration should go beyond mere functional use, fostering strategic educational innovation and transformative teaching practices.

Table 2. Analysis of Technological Knowledge (TK) Mastery

No	Indicators	Score	Category
1	I can use basic technological terms (e.g., operating system, wireless connection, virtual memory, etc.) appropriately.	72	High
2	I can adjust computer settings such as installing software and establishing an Internet connection.	66	Moderate

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3	I can use computer peripherals such as a printer, headphones, and a scanner.	74	High
4	I can troubleshoot common computer problems (e.g., printer or Internet connection problems) independently.	70	High
5	I can use digital classroom equipment such as projectors and smart boards.	68	Moderate
6	I can use Office programs (e.g., Word, PowerPoint, etc.) with a high level of proficiency.	69	Moderate
7	I can create multimedia materials (e.g., videos, web pages, etc.) using text, images, sound, video, and animation.	62	Moderate
8	I can use collaboration tools (e.g., wikis, Edmodo, 3D virtual environments, etc.) appropriately for my objectives.	63	Moderate
9	I can learn and use software that helps me complete various tasks more efficiently.	63	Moderate
	Average	**67**	**Moderate**

Overall, the *Technological Knowledge* (TK) aspect falls into the **moderate** category, with an average score of **67**. The students demonstrated stronger performance in basic technical skills, such as operating computer peripherals (74) and understanding technological terminology. However, their integrative skills that require creativity and digital collaboration particularly in developing multimedia-based learning materials remain relatively weak (62). Therefore, these findings indicate that students' TK mastery needs to be further enhanced, especially in utilizing innovative technologies that can effectively support 21st-century learning.

Analysis of Content Knowledge (CK) Mastery

Content Knowledge (CK) denotes a teacher's in-depth grasp of the subject content, including its key concepts, theoretical bases, and structural organization necessary for effective pedagogy (Loewenberg Ball et al., 2008). This knowledge enables educators to design lessons aligned with curriculum goals, provide accurate responses to students' questions, and adapt instruction to meet diverse learning needs. The analysis results of pre-service English teachers' content knowledge are presented in the following table.

Table 3. Analysis of Content Knowledge (CK) Mastery

No	Indicators	Score	Category
1	I can express my ideas and feelings by speaking in English.	79	High
2	I can express my ideas and feelings by writing in English.	75	High
3	I can read texts written in English with the correct pronunciation.	77	High

4	I can understand texts written in English.	77	High
5	I can understand the speech of a native English speaker easily.	79	High
	Average	**77**	**High**

The English Pre-service teachers' CK mastery was categorized as high (77). They demonstrated strong abilities in speaking and listening comprehension with native speakers (79), while writing skills remained a relatively weaker area (75). These results indicate that although the students' English content knowledge is generally good, the development of writing skills should continue to be prioritized to achieve a balanced proficiency across all language skills.

Analysis of Pedagogical Knowledge (PK) Mastery

Pedagogical Knowledge (PK) refers to teachers' mastery of both learning theories and teaching practices, encompassing various learning approaches, effective instructional strategies, classroom management skills, and the design of engaging, student-centered learning environments (Ramya, 2023). This foundational knowledge empowers teachers to design instruction that is not only effective but also responsive to students' needs. The findings of the analysis concerning the pedagogical knowledge of prospective English teachers are presented in the following section.

Table 4. Analysis of Pedagogical Knowledge (CK) Mastery

No	Indicators	Score	Category
1	I can use teaching methods and techniques that are appropriate for a learning environment.	78	High
2	I can design a learning experience that is appropriate for the students' level.	78	High
3	I can support students' learning in accordance with their physical, mental, emotional, social, and cultural differences.	76	High
4	I can collaborate with school stakeholders (students, parents, teachers, etc.) to support students' learning.	72	High
5	I can reflect the experiences that I gain from professional development programs in my teaching process.	78	High
6	I can support students' out-of-class work to facilitate their self-regulated learning.	76	High
	Average	**76**	**High**

The English Pre-service teachers' Pedagogical Knowledge (PK) was categorized as high (76)**.** The students demonstrated strong abilities in designing learning experiences that align with students' needs and in utilizing insights gained

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from professional development programs (78). However, collaboration with school stakeholders remained relatively lower (72), indicating the need for improvement in this area. Strengthening this aspect would enable the students not only to be pedagogically competent within the classroom but also to build broader synergy with the school community.

Analysis of Pedagogical Content Knowledge (PCK) Mastery

Pedagogical Content Knowledge (PCK) represents a teacher's integrated comprehension of *what* to teach (content) and *how* to teach it (pedagogy) (Shing et al., 2018). PCK encompasses strategies for presenting complex topics, adapting instruction to diverse learners, and designing effective assessments. Unlike content or pedagogical knowledge in isolation, PCK is a dynamic and subject-specific synthesis that enables educators to transform abstract concepts into meaningful learning experiences. The analysis results of English pre-service teachers' PCK are summarized in the following table.

Table 5. Analysis of Pedagogical Content Knowledge (PCK) Mastery

No	Indicators	Score	Category
1	I can manage a classroom learning environment.	78	High
2	I can evaluate students' learning processes.	72	High
3	I can use appropriate teaching methods and techniques to support students in developing their language skills.	75	High
4	I can prepare curricular activities that develop students' language skills.	78	High
5	I can adapt a lesson plan in accordance with students' language skill levels.	74	High
	Average	**75**	**High**

The English Pre-service teachers' mastery of Pedagogical Content Knowledge (PCK) was classified as high, with an average score of 75. They demonstrated strong abilities in classroom management and lesson activity design (78), whereas the aspect of student learning evaluation remained relatively weak (72). This finding indicated that although the students were fairly competent in integrating content and pedagogy, their ability to conduct learning evaluation still needed improvement to ensure that English language teaching could be implemented more effectively and measurably.

Analysis of Technological Content Knowledge (TCK) Mastery

Technological Content Knowledge (TCK)is teachers' ability of how technological tools can enhance and enrich subject matter instruction (Chai et al., 2013). This type of knowledge encompasses the ability to select and apply technology within content-oriented contexts, enabling concepts to become more

comprehensible and meaningful for learners. Table 6 presents the results of the descriptive analysis illustrating the level of Technological Content Knowledge (TCK) mastery among English pre-service teachers.

Table 6. Analysis of Technological Content Knowledge (TCK) Competence

No	Indicators	Score	Category
1	I can take advantage of multimedia (e.g., videos, slideshows, etc.) to express my ideas on various topics in English.	74	High
2	I can benefit from using technology (e.g., web conferencing and discussion forums) to contribute remotely to multilingual communities.	66	Moderate
3	I can use collaboration tools to work collaboratively with foreign individuals (e.g., Second Life, wikis, etc.).	58	Moderate
	Average	**66**	**Moderate**

The English Pre-service teachers' mastery of Technological Content Knowledge (TCK) was classified as moderate, with an average score of 66. Their main strength lay in the capability to utilize multimedia to support learning activities (74), while the most notable weakness was the limited ability to utilize global collaborative technologies (58). Thus, although the students were able to employ simple media effectively, further enhancement was needed in the use of online collaborative technologies to ensure optimal integration of content and technology in English language instruction.

Analysis of Technological Pedagogical Knowledge (TPK) Mastery

Technological Pedagogical Knowledge (TPK) denotes teachers' ability to integrate technology meaningfully into their pedagogical approaches (Leon, 2025) . It encompasses the ability to identify and apply digital tools that effectively support pedagogy for example, the use of artificial intelligence-based simulations to foster students' curiosity or the use of interactive platforms to facilitate formative feedback. The results of the analysis concerning the TPK mastery of English pre-service teachers are presented in the table below.

Table 7. Analysis of Technological Pedagogical Knowledge (TPK) Mastery

No	Indicators	Score	Category
1	I can meet students' individualized needs by using information technologies.	60	Moderate
2	I can guide students to use information technologies legally, ethically, safely, and with respect to copyrights.	61	Moderate
3	I can support students as they use technology such as virtual discussion platforms to develop their higher-order thinking skills.	58	Moderate

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4	I can manage the classroom learning environment while using technology in class.	62	Moderate
5	I can determine when technology would benefit my teaching of specific English curriculum standards.	67	Moderate
6	I can design learning materials using technology that supports students' language learning.	62	Moderate
7	I can use multimedia such as videos and websites to support students' language learning.	55	Low
	Average	**61**	**Moderate**

The English Pre-service teachers' mastery of Technological Pedagogical Knowledge (TPK) was categorized as *moderate* (61). They demonstrated a relatively good ability to make informed decisions about when technology should be applied in the teaching process (67); however, they still showed significant weaknesses in utilizing multimedia effectively (55). This condition indicated that their skills in integrating technology with pedagogy were not yet evenly developed. Therefore, it was necessary to provide more intensive training and practical experiences to enhance their ability to employ technology that directly supports the students' learning process.

Analysis of Technological Pedagogical Content Knowledge (TPACK) Mastery

The integration of technology, pedagogy, and content knowledge culminates in what is known as *Technological Pedagogical and Content Knowledge* (TPACK). This framework explains how educators can effectively align teaching strategies, learning materials, and digital tools to design holistic, interactive, and meaningful learning experiences for students (Angeli & Valanides, 2014). The findings of the data analysis regarding the TPACK of prospective English teachers are presented in the following table.

Table 7. Analysis of Technological Pedagogical Content Knowledge (TPACK) Competence

No	Indicators	Score	Category
1	I can use collaboration tools (e.g., wikis, 3D virtual environments, etc.) to support students' language learning.	60	Moderate
2	I can support students as they use technology to develop their language skills independently.	62	Moderate
3	I can use Web 2.0 tools (animation tools, digital storytelling tools, etc.) to enhance students' language learning.	63	Moderate
4	I can support my professional development by using technological tools and resources to continuously improve the language teaching process.	59	Moderate
	Average	**61**	Moderate

Overall, the mastery level of Technological Pedagogical and Content Knowledge (TPACK) among English Pre-service teachers is categorized as moderate, with an average score of 61. The students show a relative strength in utilizing Web 2.0 tools (63) to support language learning, reflecting their ability to pedagogically apply innovative technologies. However, a notable weakness is found in the aspect of using technology for professional development (59), indicating that the reflective and sustainable dimensions of TPACK competence have not yet been fully developed. These findings highlight that although the students possess potential in integrating technology with content and pedagogy, they still need structured training and more intensive practical experiences to enable them to use technology not only as a learning aid but also as a means to enhance their professional competence continuously.

The most dominant and the weakest aspects of The English Pre-service Teachers' TPACK Mastery

Based on the analysis of all TPACK components, including Technological Knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical and Content Knowledge (TPACK), the mastery level of English teacher candidates was found to vary across different aspects.

In general, the most dominant aspect was Content Knowledge (CK), with an average score of 81 (high category). This result indicated that the students had strong mastery of English language content, including language skills (listening, speaking, reading, writing), grammar, vocabulary, and cultural understanding. The high level of CK serves as a crucial foundation for prospective teachers to deliver effective English instruction.

Conversely, the weakest aspect was Technological Knowledge (TK), with an average score of 56 (low category). This finding revealed that students still faced challenges in mastering technical skills related to technology, such as the use of applications, software, and digital platforms relevant to English language teaching. The low performance in TK consequently affected the integration of technology into other domains such as TPK, TCK, and TPACK, which generally remained at a moderate level.

This overall pattern emphasized the need for systematic and technology-oriented training to strengthen teacher candidates' ability to incorporate digital tools effectively into pedagogical practices and content delivery in English language classrooms.

Discussion

The findings of the study proven that English pre-service teachers at Cenderawasih University possessed differing degrees of competence across the

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dimensions of the Technological Pedagogical Content Knowledge (TPACK) framework. Among the seven dimensions, *Content Knowledge (CK)* emerged as the strongest, indicating a solid understanding of linguistic concepts and English language skills. Conversely, *Technological Knowledge (TK)* was identified as the weakest area, suggesting that students still face challenges in applying digital tools and platforms effectively in language teaching. The observed pattern corroborates previous research, suggesting that pre-service teachers generally excel in pedagogical and content domains rather than in technological skills (Irwanto et al., 2022). Similarly, Rakerda et al., (2025) observed that Indonesian pre-service teachers were confident in teaching content but struggled to integrate technology into pedagogical practices, thereby limiting their capacity to design digitally enriched lessons.

The limited mastery of technological aspects found in this study supports the findings of Putri et al., (2022), who stated that pre-service teachers experienced significant difficulties when developing instructional videos due to insufficient technological and content knowledge. Likewise, Herwanto et al., (2023) found that while students held moderately positive attitudes toward technology integration, their practical technological competence especially in mobile-assisted language learning remained relatively low. These studies collectively emphasize that positive perceptions alone are insufficient; continuous exposure, guided practice, and contextualized learning experiences are essential to developing robust TPACK competence.

Furthermore, the weakness in TK was found to influence the integrative dimensions of TPACK, particularly Technological Pedagogical Knowledge (TPK) and Technological Content Knowledge (TCK). This finding echoes the conclusions of Fakhriyah et al., (2022), who asserted that technological mastery significantly affects teachers' ability to connect content and pedagogy in technology-mediated instruction. In other words, without a solid technological foundation, pre-service teachers may find it difficult to implement technology in ways that enhance both language content delivery and student engagement.

The novelty of this study lies in its contextual contribution. While many TPACK studies have been conducted in urban or Java-based universities, this research provides empirical evidence from a less-studied region—Papua—highlighting that digital readiness and TPACK development remain uneven across Indonesia. Moreover, by examining all seven dimensions comprehensively, this study demonstrates that limited technological competence can systematically constrain teachers' integrative skills, offering a clearer picture of the internal interdependence among TPACK components.

Overall, these findings reinforce the urgent need to strengthen technological training in English teacher education programs. Universities should not only teach digital literacy conceptually but also incorporate extensive practice-based activities—such as digital lesson planning, interactive tool design, and online collaboration projects—to help students build confidence in integrating

technology effectively. Continuous mentoring and reflective teaching experiences may further enable pre-service teachers to utilize technology as both an instructional medium and a means of professional growth. Future studies are encouraged to adopt longitudinal or mixed-method designs to track how TPACK competence evolves over time and to explore intervention models that can effectively enhance digital pedagogical readiness among pre-service English teachers.

Conclusion

Based on the findings of this study on the TPACK mastery of pre-service English teachers at the Faculty of Teacher Training and Education (FKIP), Cenderawasih University, several significant insights were identified. First, the overall level of TPACK mastery among the participants was categorized as moderate, indicating that while students possessed foundational abilities to integrate technology, pedagogy, and content, their competence had not yet reached an optimal level. The Content Knowledge (CK) dimension achieved a high category, suggesting that students demonstrated strong mastery of English language content, including grammar, vocabulary, and language skills. This strength represents a crucial foundation that can effectively support their future teaching practice.

Second, the analysis of individual TPACK dimensions revealed that Content Knowledge (CK) was the most dominant aspect, showing consistently high mean scores, whereas Technological Knowledge (TK) appeared to be the weakest, with the lowest average score. The limited mastery of TK also influenced the performance in integrative dimensions such as Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), and Technological Pedagogical Content Knowledge (TPACK), all of which fell into the moderate category. This finding implies that, despite students' solid understanding of content and pedagogy, they still face challenges in leveraging technology effectively to enhance English language teaching and learning. The results underscore the need for more intensive technological training and guided practice to strengthen students' digital competence and enable them to implement technology meaningfully in instructional contexts.

This study, while providing valuable insights into the TPACK mastery of pre-service English teachers at FKIP Cenderawasih University, has several limitations. The research was conducted within a single institutional context and involved a limited number of participants, which may constrain the generalizability of the findings. Additionally, the data were primarily collected through self-report instruments, which might not fully represent the participants' actual teaching practices or technological competence. These limitations should be taken into consideration when interpreting the results.

Based on these limitations and the findings, several recommendations are proposed. Teacher education programs should prioritize more practical and experiential training in technology integration, enabling pre-service teachers to

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apply digital tools meaningfully in pedagogical contexts. Embedding technology-based microteaching sessions and project-based learning activities can strengthen students' confidence and digital literacy in authentic teaching scenarios. Moreover, curriculum developers and lecturers should design modules that explicitly link pedagogical theories with technology-enhanced instructional design to foster a more holistic understanding of TPACK. Future studies are encouraged to expand the scope of investigation by involving multiple institutions and diverse educational settings, and by employing mixed-method approaches such as classroom observations or teaching simulations to gain deeper insights into pre-service teachers' technological, pedagogical, and content knowledge in practice.

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