Daengku: Journal of Humanities and Social Sciences Innovation *ISSN: 2775-6165 (online)*
Vol. 6 No. 5 (2026)
https://doi.org/10.35877/454RI.daengku5101

Investigation of Preservice Teachers' Technopreneurship and Its Determinants

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Abstract

Digital transformation has expanded the competencies expected from university graduates, including preservice teachers who are increasingly required to combine pedagogical knowledge, technological capability, and entrepreneurial orientation. This study investigates preservice teachers' technopreneurship and examines learning engagement, entrepreneurial learning, and policy support as its determinants. A mixed methods design with concurrent triangulation was employed to integrate quantitative and qualitative evidence. Quantitative data were collected from 500 second- and third-year bachelor students in education programs from five universities in Indonesia using validated Likert-scale questionnaires. The instruments measured technopreneurship, learning engagement, entrepreneurial learning, and policy support, with reliability coefficients ranging from 0.668 to 0.820. The quantitative data were analyzed using descriptive statistics, one-sample t-test, and multiple linear regression with SPSS. Qualitative data were obtained through interviews, focus group discussions, and direct observation, then analyzed using the Miles and Huberman technique to confirm and enrich the statistical findings. The results show that preservice teachers' technopreneurship remains below the expected level, with a mean score of 3.76 on a five-point scale. The one-sample t-test confirmed that this score was significantly lower than the high-indicative threshold of 4.00 ($t = -4.445$; $p = 0.000$). Multiple regression indicated that learning engagement, entrepreneurial learning, and policy support simultaneously influenced technopreneurship ($F = 4.866$; $p = 0.002$), although their explanatory contribution was relatively limited (adjusted R square = 0.023). Among the predictors, learning engagement showed the strongest and significant individual effect, while entrepreneurial learning and policy support showed weaker direct effects. Qualitative findings supported these results by revealing that preservice teachers perceived their technopreneurial competence as underdeveloped and expected stronger entrepreneurship education, collaborative learning engagement, and institutional policy support. The study concludes that technopreneurship development in teacher education requires an integrated strategy linking active learning communities, practice-based entrepreneurial learning, and systematic policy support.

Keywords: Technopreneurship, Preservice Teacher, Determinants, Learning Engagement, Entrepreneurial Learning, Policy Support, Mixed Methods.

Received: 4 July 2026 Revised: 10 October 2026 Published: 31 October 2026

1. Introduction

The development of digitalization has driven the emergence of a variety of competencies to support life's needs. This encourages each individual to possess more than one skill or competency. This demand also impacts university graduates to acquire skills beyond their specific areas of expertise. This situation ultimately pressures universities to ensure that every graduate they produce finds decent employment and does not increase unemployment rates (Adhikara et al., 2019; Howell, 2021). Given this fact, entrepreneurial skills have become a linear skill. It's no surprise that entrepreneurial skills are currently a favorite among various groups, including universities. Furthermore, the curriculum content at several universities appears to be embedding entrepreneurial skills within their educational programs (Kim & Slapac, 2015).

In keeping with the times, terms associated with entrepreneurship have become diverse, such as edupreneurship, a combination of education and entrepreneurship (Korkko et al., 2016), technopreneurship, a combination of technology and entrepreneurship (Selladurai, 2016), healthpreneurship, a combination of health and entrepreneurship, and other

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combinations. These combinations illustrate the integration of entrepreneurship with various disciplines. Considering this, it's not surprising that some educational programs incorporate the concept of entrepreneurship (Samwel, 2010).

In light of current advances, technopreneur skills can be considered a competency capable of meeting current demands. These skills can also equip prospective graduates, including prospective teachers, for their future employment. The teaching profession in Indonesia is a highly sought-after profession, even ranked among the most sought-after professions (Tolkatser, 2024). However, the relatively stagnant job market has led to a shortage of graduate capacity. The large number of graduates from educational programs working outside their fields indicates a gap between the capacity and the number of graduates (Raharjo et al., 2022). Therefore, equipping prospective educators with technopreneur skills is an effort to provide additional skills.

Entrepreneurship-related learning has begun to penetrate various levels of education, including elementary education. However, the availability of entrepreneurial-related teaching content, including its integration with technology, in educational settings is still limited. Teaching content development from the educator's perspective is also still very rare. Therefore, training prospective educators to master these skills, including developing teaching content, is an appropriate strategy.

Systemic perspectives highlight that teacher competencies develop within ecosystems of policy, institutional culture, and resources. Professional development models such as lesson study, coaching, and communities of practice have demonstrated positive effects on practice when sustained and contextualized.

Transformative learning theories highlight the importance of critical reflection in reshaping learners' perspectives. One of the theories that can be use is Mezirow's theory of transformative learning (Schnepfleitner and Ferreira, 2021). Recent scholars extend transformative concepts to teacher agency and moral purpose (Fullan, 2016; Priestley et al., 2015), arguing that effective teacher education must cultivate ethical leadership and civic responsibility. After 45 years after the theory proposed, the challenge currently more to social, economic, cultural, demographic, political, and technological transformations (Hoggan and Finnegan, 2023). Technological transformation is one of the strategic things in this theory, thus making technopreneurship the ability to respond to changes that occur.

Technopreneurship literature in education emphasizes entrepreneurial mindsets, opportunity recognition, and digital product development (Giones & Miralles, 2015; Rahman et al., 2020). Studies in higher education show that integrating entrepreneurship education with authentic project-based learning can foster transferable skills among preservice teachers (Nabi et al., 2017; Lackéus, 2015).

Studies on technopreneurship among peservice teachers are still very limited. Research conducted by Rahmawati et al. (2024) focused on technopreneur leadership in teacher. Another researcher also focused in Technopreneur Strengthening Model for special purpose in vocational education (Suryati, 2022). It can be seen that studies on technopreneurship among preservice teachers are still very limited. In order to anticipate further developments regarding technology in the future, studies on technopreneurship among prospective teachers are very important.

2. Literature Review

2.1 Technopreneurship in Preservice Teacher Education

Technopreneurship refers to the integration of technological competence and entrepreneurial orientation in identifying opportunities, developing innovative products or services, and creating value through technology-based solutions. In the context of higher education, technopreneurship has become increasingly important because graduates are expected not only to master disciplinary knowledge but also to adapt to digital transformation, create innovation, and respond to labour market uncertainty (Rahman et al., 2020; Aripradono, 2024). For preservice teachers, technopreneurship has a distinctive meaning because it connects entrepreneurship, technology mastery, and educational responsibility. Preservice teachers are not only expected to use technology as a learning tool but also to transform it into educational innovation, digital teaching media, learning platforms, and edupreneurial practices (Giones & Miralles, 2015; Rahmawati et al., 2024).

Recent studies show that digital transformation in higher education has encouraged the development of entrepreneurial mindsets and innovation-oriented learning environments. Educational technology is no longer viewed merely as an instructional support system, but also as a driver of institutional transformation, creativity, and entrepreneurial capacity (Chen et al., 2021; Aripradono, 2024). In this context, preservice teachers need to develop the ability to combine pedagogical knowledge, digital literacy, and entrepreneurial thinking. This integration is essential because future

teachers will face learning environments that are increasingly shaped by digital tools, online interaction, and technology-based educational services (Pan, 2022; Martin & Borup, 2022).

Technopreneurship in teacher education is also closely related to the development of adaptive competencies. The teaching profession is no longer limited to classroom instruction but increasingly involves curriculum innovation, digital content creation, online learning facilitation, and educational problem-solving. Therefore, teacher education institutions need to prepare preservice teachers to become creative, innovative, and technologically competent educators (Schnepfleitner & Ferreira, 2021; Tolkatser, 2024). Through technopreneurship, preservice teachers can be encouraged to identify educational problems as opportunities for innovation and to develop practical solutions that create value for learners and educational institutions (Rahman et al., 2020; Suryati et al., 2023).

However, technopreneurship among preservice teachers remains underdeveloped in many contexts. Entrepreneurship is often taught separately from technology, while technology is commonly positioned only as a medium for teaching. This separation may prevent preservice teachers from understanding the relationship between entrepreneurial opportunity, digital innovation, and their future role as educators (Nabi et al., 2017; Rahmawati et al., 2024). Therefore, technopreneurship should be developed as an integrated competence that combines entrepreneurial mindset, technology mastery, pedagogical creativity, and educational innovation.

2.2 Learning Engagement and Technopreneurship

Learning engagement is an important factor in developing students' higher-order competencies, including technopreneurship. Learning engagement refers to students' behavioral participation, emotional involvement, cognitive investment, and social interaction in the learning process. In higher education, engaged students tend to show stronger motivation, deeper learning strategies, active participation, and greater willingness to collaborate (Howell, 2021; Martin & Borup, 2022). These characteristics are highly relevant to technopreneurship because technology-based entrepreneurship requires curiosity, initiative, persistence, collaboration, and creative problem-solving.

In technology-supported learning environments, engagement becomes even more important. Online and blended learning require students to interact actively with digital platforms, manage their own learning, communicate with peers, and participate in collaborative activities. Recent studies on online learning engagement emphasize the role of interaction, communication, presence, collaboration, and learning community as important elements in maintaining students' participation (Pan, 2022; Wang et al., 2022; Martin & Borup, 2022). These elements are closely connected to technopreneurship because students who are actively engaged in learning are more likely to explore digital tools, experiment with ideas, and develop technology-based solutions.

For preservice teachers, learning engagement can support technopreneurship by connecting theoretical knowledge with practical experience. When preservice teachers are engaged in project-based learning, group discussion, digital product development, and reflective learning, they gain opportunities to apply technology and entrepreneurship in educational contexts (Howell, 2021; Chen et al., 2021). Engagement also strengthens peer learning and learning communities, allowing students to exchange ideas, evaluate problems, and develop innovations collaboratively. Therefore, learning engagement can be considered a determinant of preservice teachers' technopreneurship because it provides the motivational and social foundation for developing technology-based entrepreneurial competence (Pan, 2022; Wang et al., 2022).

2.3 Entrepreneurial Learning and Technopreneurship

Entrepreneurial learning is a learning process that develops entrepreneurial knowledge, attitudes, and skills through experience, practice, reflection, and interaction. It includes opportunity recognition, risk evaluation, creativity, resource management, innovation development, and value creation. In higher education, entrepreneurial learning is increasingly implemented through experiential learning, project-based learning, business simulation, digital entrepreneurship learning, and real-world problem-solving activities (Lackéus, 2015; Nabi et al., 2017; Chen et al., 2021). These approaches are considered more effective than purely theoretical instruction because entrepreneurship requires practical experience and active experimentation.

Recent literature on entrepreneurship education shows that online and blended entrepreneurship learning can support students' entrepreneurial competence when it is designed with interactive, experiential, and practice-oriented activities (Chen et al., 2021; Wong & Chan, 2022). Digital entrepreneurship learning also provides opportunities for students to understand how technology can be used to create business models, develop products, reach users, and solve social or educational problems (Aysi, 2024; Yulastri et al., 2025). This is highly relevant for preservice teachers because they

can apply entrepreneurial learning to develop educational products, digital learning content, online tutoring services, learning applications, and technology-based teaching innovations.

Entrepreneurial learning also supports the development of confidence and initiative among preservice teachers. Through entrepreneurial learning, students can understand that educational challenges may become opportunities for innovation. For example, limited teaching media, low student motivation, unequal access to learning resources, and the need for digital learning content can be transformed into opportunities to design educational solutions (Wasim et al., 2023; Rahmawati et al., 2024). Therefore, entrepreneurial learning provides a foundation for technopreneurship by helping preservice teachers connect educational problems with technology-based value creation.

In addition, entrepreneurial learning can prepare preservice teachers for broader career possibilities. Graduates of teacher education programs may not always enter formal teaching positions immediately. By developing entrepreneurial competence, they can explore alternative pathways such as edupreneurship, digital tutoring, learning content production, educational consulting, and technology-based educational services (Nabi et al., 2017; Wong & Chan, 2022). Thus, entrepreneurial learning is not only relevant to business creation but also to professional adaptability and innovation in education.

2.4 Policy Support and Technopreneurship Development

Policy support plays an essential role in the development of technopreneurship in teacher education. Technopreneurship cannot be developed only through individual motivation; it requires institutional and structural support. Policy support determines how entrepreneurship and technology are integrated into curriculum design, learning activities, student development programs, digital infrastructure, and graduate competency standards (Zhang et al., 2022; Aripradono, 2024). Without clear policy support, technopreneurship may remain incidental and unsystematic.

At the institutional level, policy support may include entrepreneurship courses, digital innovation laboratories, start-up incubation programs, mentoring, industry collaboration, project-based learning policies, and access to technology infrastructure. These supports can provide preservice teachers with direct experience in developing ideas, using digital tools, and transforming educational problems into innovation (Chen et al., 2021; Aysi, 2024). Institutional policy is also important for encouraging lecturers to integrate technology and entrepreneurship into teacher education courses.

At the national level, policy support can strengthen the direction of teacher education by emphasizing digital transformation, innovation, employability, and entrepreneurship as part of graduate competencies. Recent discussions on education policy and digital transformation indicate that higher education institutions need supportive policies to adapt to technological change and to prepare graduates for future work (Zhang et al., 2022; Aripradono, 2024). Policy support is also needed to reduce the gap between curriculum expectations and actual learning practices. Therefore, technopreneurship development requires alignment between national policy, university strategy, curriculum implementation, and learning resources.

Policy support is particularly important because technopreneurship is interdisciplinary. It requires cooperation between education, technology, entrepreneurship, and industry. Teacher education institutions need policies that encourage collaboration across study programs and with external partners. Such collaboration can help preservice teachers gain practical exposure to digital innovation and entrepreneurial activities (Yulastri et al., 2025; Suryati et al., 2023). Therefore, policy support can be understood as an enabling condition that strengthens the relationship between learning engagement, entrepreneurial learning, and technopreneurship.

2.5 Conceptual Relationship among Variables

Based on the literature, preservice teachers' technopreneurship can be understood as a multidimensional competence influenced by learning engagement, entrepreneurial learning, and policy support. Learning engagement contributes to technopreneurship by increasing students' active participation, motivation, collaboration, and willingness to explore digital innovation (Pan, 2022; Wang et al., 2022; Martin & Borup, 2022). Entrepreneurial learning provides the knowledge, experience, and mindset needed to recognize opportunities, develop ideas, and create value (Chen et al., 2021; Wasim et al., 2023). Meanwhile, policy support provides institutional and structural conditions that enable technopreneurship to be developed systematically in teacher education programs (Zhang et al., 2022; Aripradono, 2024).

The relationship among these variables indicates that technopreneurship is not formed through a single factor. Preservice teachers may have access to technology, but without learning engagement, they may not use it creatively. They may receive entrepreneurship education, but without practical learning experiences, entrepreneurial competence may remain theoretical. They may also have motivation to innovate, but without policy support, their ideas may not be

sustained through curriculum, mentoring, infrastructure, and institutional programs (Nabi et al., 2017; Wong & Chan, 2022; Aysi, 2024). Therefore, the development of technopreneurship requires an integrated approach involving students, lecturers, institutions, and policy makers.

In this study, learning engagement, entrepreneurial learning, and policy support are examined as determinants of preservice teachers' technopreneurship. This framework is important because it allows the study to identify whether technopreneurship is shaped more strongly by students' learning involvement, entrepreneurship-related learning experiences, or broader policy and institutional support. By examining these determinants, the study contributes to the discussion on how teacher education institutions can prepare preservice teachers to become technologically competent, entrepreneurial, and innovative educators (Rahman et al., 2020; Rahmawati et al., 2024; Yulastri et al., 2025).

3. Methods

The approach used in this study was a mixed methods study employing concurrent triangulation (Creswell, 2022). This research uses both quantitative and qualitative methods. The results of quantitative research crosschecked by results of qualitative research. Based on this concurrent triangulation, the mixed research gets the final results.

Quantitative data were collected from 500 preservice teachers in Indonesia. The demographic of respondents are students in 2nd year and 3rd year of bachelor's degree in education who come from 5 Universities in Indonesia. The sampling technique that is used in this study is proportional sampling. The subjects of entrepreneurship also provided in 2 universities that covered 160 samples of this research, that may provide different results of technopreneurship compared to other samples.

Quantitative data collection was conducted using a likert scale questionnaire that had been tested for validity and reliability. Validity of item measured by corrected item-total correlation in level of 0,3. Reliability of instruments measured by Cronbach's alpha at 0,6. The draft of instruments filled by all respondents, then analyzed. Out of 30 items in the first draft of technopreneurship instruments, 7 of them are not valid (also 3 out of 20 in learning engagement instruments, 6 out of 20 in entrepreneurial learning instruments, and 2 out of 20 in policy support instruments). Results of valid items only (with 0,688 Cronbach's alpha for technopreneurship instruments, 0,82 for learning engagement, 0,77 for entrepreneurial learning, and 0,66 for policy support) that have been used as data in this research.

The data were analyzed using multiple linear regression techniques. Before being analyzed, the data had passed the normality test at an error level of 0.05. The value of F tested in p value of 0.05. All of the process helped by SPSS statistical software. The biggest value of coefficient showed the biggest determinant.

Meanwhile, qualitative data were collected through interviews, focus group discussions (FGDs), and direct observation of preservice teachers. This research uses source and technique triangulation to validate the data. Qualitative data were analyzed using the Miles and Huberman technique.

4. Result and Discussion

4.1. Quantitative Findings

Using the quantitative approach, several outcomes were generated in this research, including the developed instruments, descriptive statistics, and hypothesis testing. The first stage of this research was the development of instruments for the research variables. Based on the explanation presented in the research methodology section, the four research variables instruments tested using validity (using corrected item-total correlation) and reliability (Cronbach's alpha).

The basic technopreneurship instrument, developed by its main indicators, namely: entrepreneurship, mastery of technology, and the main task of preservice teachers as educators. Previously, the instrument consisted of 30 items. After testing, it became 23 items as following.

Table 1. Reliability of Technopreneurship

Reliability Statistics	
Cronbach's Alpha	N of Items
.688	23

Based on the results Table 1, 23 items of instruments have reliability in level of 0,688 (upper 0,6) that is mean that the instrument is reliable. Then the results of validity testing of 23 items as in the Table 2.

Table 2. Item-Total Statistics of Technopreneurship

	Corrected Item-Total Correlation
01	.419
02	.309
04	.354
05	.491
06	.391
07	.493
08	.413
09	.395
10	.300
11	.358
12	.365
13	.478
15	.378
17	.312
18	.322
19	.433
20	.591
21	.340
22	.478
23	.307
24	.383
25	.323
29	.343

In the Table 2, it appears that all instrument items have a validity above 0.3, which indicates that all items are valid.

The instrument of learning engagement basically consists of 20 items. After testing, 3 of them are not valid. Thus, this study only took data from 17 valid items as shown in the following calculation. In the following table, it can be seen that all items (of the 17 existing items) have a validity above 0.3 and the instrument reliability is at the level of 0.820.

Table 3. Reliability of Learning Engagement

Reliability Statistics	
Cronbach's Alpha	N of Items
.820	17

Table 4. Item-Total Statistics of Learning Engagement

	Corrected Item-Total Correlation
01	.381
02	.329
03	.358
04	.391
06	.561
07	.423
08	.300
09	.395
10	.308
11	.458
12	.365
13	.498
15	.344
17	.418
18	.512
19	.432
20	.344

The results of the entrepreneurial learning questionnaire served as the basis for calculating its validity and reliability. Based on the calculations, it was found that of the 20 questionnaire items distributed, 6 were invalid. Therefore, the data for this variable only came from 14 valid items, with a reliability value of 0.776, as shown in the Table 5.

Table 5. Reliability of Entrepreneurial Learning

Reliability Statistics	
Cronbach's Alpha	N of Items
.776	14

Table 6. Item-Total Statistics of Entrepreneurial Learning

	Corrected Item-Total Correlation
01	.489
02	.509
03	.621
04	.491
05	.391
06	.493
08	.413
10	.495
11	.300
12	.521
15	.365
17	.573
19	.309
20	.328

The policy support variable, of the 20 instrument items developed, only two were invalid. Thus, this study obtained data on policy support from the remaining 18 items. Ultimately, this policy support instrument had a reliability of 0.668 (based on 18 item calculation), as shown in the Table 7.

Table 7. Reliability of Entrepreneurial Learning

Reliability Statistics	
Cronbach's Alpha	N of Items
.668	18

Table 8. Item-Total Statistics of Entrepreneurial Learning

	Corrected Item-Total Correlation
01	.383
02	.423
03	.495
04	.310
05	.428
06	.355
07	.478
10	.388
11	.312
12	.392
13	.433
14	.421
15	.340
16	.338
17	.307
18	.463
19	.323
20	.513

The results of this study indicate that preservice teachers' technopreneurship is still far from meeting expectations. This is evident from the indicators: entrepreneurship, mastery of technology, and the main task of preservice teachers as educators.

Table 9. Descriptive Statistic

One-Sample Statistics				
	N	Mean	Std. Deviation	Std. Error Mean
Techprnshp	500	3.7600	1.20719	.05399

The average level of technopreneurship only in level of 3,76 (in range 1-5). To provide scientific evidence, a one-sample t-test was performed. This calculation was based on a passing grade of 4, which is the high-indicative limit on a scale of 1-5. The results are shown in the Table 10. The table shows that the average technopreneurship score is below the threshold of -0.24. The test shows a t-value of -4.445, which is significant at a p-value of 0.000 (less than 0.05). This indicates that the technopreneurship score is still below expectations.

Table 10. One Sample T Test Results

One-Sample Test						
	Test Value = 4					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Technopreneurship	-4.445	499	.000	-.24000	-.3461	-.1339

To address the low level of technopreneurship in preservice teachers, it is necessary to identify the causes. Of the various causes, this study limits itself to learning engagement, entrepreneurial learning, and policy support. The results of calculating the influence of these three variables on technopreneurship are shown in the Table 11.

Table 11. Partial Test Results

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.473	.375		6.596	.000
	Learneng	.193	.060	.149	3.237	.001
	Entrelearn	.036	.060	.027	.596	.551
	Polysupp	.082	.054	.068	1.527	.127
a. Dependent Variable: Techprnshp						

Table 12. Simultaneous Test Results

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20.791	3	6.930	4.866	.002[b]
	Residual	706.409	496	1.424		
	Total	727.200	499			
a. Dependent Variable: Techprnshp						
b. Predictors: (Constant), Polysupp, Learneng, Entrelearn						

Table 13. R^2 Results

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.169[a]	.029	.023	1.19340
a. Predictors: (Constant), Polysupp, Learneng, Entrelearn				

Based on the Table 13, it appears that the multiple regression equation formed is $y = 2.473 + 0.149X1 + 0.027X2 + 0.068X3$. Furthermore, the F value in this multiple linear regression is at 4.866 which is significant at 0.002 (below

0.05) which means that all independent variables have a significant influence together on technopreneurship. The contribution of the three independent variables to the dependent variable is 0.023, which means that there is still a large opportunity for other variables to contribute to technopreneurship, outside of the variables in this study.

Table 14. Multicollinearity Diagnostics

Predictor	Tolerance	VIF	Interpretation
Learning Engagement	0.842*	1.188*	No multicollinearity
Entrepreneurial Learning	0.816*	1.225*	No multicollinearity
Policy Support	0.879*	1.138*	No multicollinearity

Multicollinearity was assessed using tolerance and variance inflation factor (VIF) statistics. As presented in Table 14, the tolerance values for all predictors exceeded the minimum threshold of 0.10, while the VIF values were substantially below the commonly applied threshold of 5.00. These results indicate that no problematic multicollinearity was detected among learning engagement, entrepreneurial learning, and policy support. Therefore, the estimated regression coefficients were unlikely to be substantially distorted by excessive linear relationships among the independent variables. The low explanatory power of the regression model (adjusted $R^2 = 0.023$) should consequently not be attributed to multicollinearity among the predictors. Instead, the result suggests that the three variables included in the model capture only a limited proportion of the factors associated with preservice teachers' technopreneurship.

4.2. Qualitative Findings

The qualitative findings were derived from semi-structured interviews, focus group discussions (FGDs), and classroom observations involving preservice teachers from the participating universities. Following the procedures proposed by Miles and Huberman, the qualitative data were reduced, coded, categorized, and synthesized into four major themes that explain the current condition of preservice teachers' technopreneurship. These themes not only complement the quantitative findings but also provide deeper insight into why technopreneurship remains relatively underdeveloped despite increasing exposure to digital technology.

4.2.1. Theme 1. Technopreneurship is perceived as an unfamiliar professional identity

One of the strongest themes emerging from the interviews concerns students' understanding of technopreneurship itself. Although participants demonstrated adequate digital literacy and frequently used technology for academic purposes, most did not associate these abilities with entrepreneurial opportunities. Most participants viewed technology merely as a learning support tool rather than as a medium for creating educational innovation or commercial value. Many believed that the primary responsibility of teachers is classroom instruction, while entrepreneurial activities belong to different professions.

One participant explained:

"Technology helps us prepare lesson plans, presentations, and assignments, but we have never thought about turning those ideas into educational products."

Another participant stated:

"When I hear the word entrepreneur, I imagine someone opening a business. I never imagined that teachers could also become entrepreneurs through educational technology."

The focus group discussions revealed that students generally perceived teaching and entrepreneurship as separate career paths. Consequently, they rarely explored opportunities to design digital learning applications, online tutoring services, educational media, or other technology-based educational products. Observation data further supported these perceptions. During classroom activities, students showed confidence in operating digital platforms but demonstrated limited initiative in proposing innovative solutions that could address educational problems beyond course requirements. Overall, this theme indicates that the challenge is not merely insufficient technological competence but rather the absence of an entrepreneurial mindset capable of transforming educational knowledge into innovation.

4.2.2. Theme 2. Learning engagement creates opportunities for innovation through collaboration

The second major theme concerns the importance of active participation in learning. Participants consistently reported that collaborative learning activities encouraged them to generate new ideas, solve authentic educational problems, and develop greater confidence in experimenting with technology. Students described project-based assignments, peer discussions, classroom presentations, and collaborative problem-solving as the learning experiences that most

stimulated creativity.

One participant commented:

"Working with classmates helps us exchange ideas. Sometimes one person's idea inspires another to develop something completely different."

Another participant explained:

"Group discussions make us realize that educational problems can be solved using digital technology if we think creatively."

Observation results indicated that students participating actively in collaborative activities were more willing to experiment with digital applications, develop instructional media, and provide constructive feedback to peers. Interestingly, participants emphasized that lecturers who encouraged open discussion, experimentation, and independent exploration indirectly increased students' confidence to innovate. Several participants also noted that collaborative learning created informal learning communities where students voluntarily shared technological skills and educational resources outside formal classroom sessions. These findings suggest that learning engagement extends beyond classroom participation. It creates a social environment that supports creativity, experimentation, reflection, and mutual learning, all of which are essential characteristics of technopreneurial competence.

4.2.3. Theme 3. Entrepreneurial learning emphasizes concepts more than authentic experience

The third theme relates to the implementation of entrepreneurship education within teacher education programs. Although entrepreneurship courses had been incorporated into several curricula, participants generally perceived these courses as focusing predominantly on theoretical knowledge. Classroom activities mainly discussed business concepts, entrepreneurial characteristics, and business planning, while opportunities to develop real educational products remained limited.

One participant stated:

"We learned how to write business plans, but we never experienced creating digital educational products that could actually be marketed."

Another participant explained:

"Most assignments end with presentations. We rarely continue to prototype, test, or improve our ideas."

Participants expressed a strong desire for entrepreneurship learning that includes mentoring, business incubation, prototype development, digital product commercialization, and collaboration with industry practitioners. Several respondents also suggested integrating entrepreneurship learning with educational technology courses, allowing students to develop products directly related to their future profession as teachers. Observation data supported these perceptions. Entrepreneurship activities were generally conducted as isolated classroom assignments rather than as continuous innovation projects that encouraged iterative development and real-world implementation. Consequently, students developed theoretical understanding of entrepreneurship but lacked confidence in applying entrepreneurial principles to authentic educational contexts.

4.2.4. Theme 4. Institutional policy support is perceived as fragmented and unsustainable

The fourth theme concerns the institutional environment supporting technopreneurship development. Participants acknowledged that universities had introduced several innovation-related activities, including entrepreneurship seminars, student competitions, innovation grants, and digital literacy workshops. However, these initiatives were often perceived as isolated programs rather than components of a coherent institutional strategy.

One participant remarked:

"There are many competitions, but once the competition ends, there is almost no follow-up support."

Another participant explained:

"We need mentors who can guide us from the initial idea until the product is actually implemented."

Focus group discussions revealed that students expected universities to establish innovation ecosystems involving lecturers, alumni, industry partners, educational institutions, and technology experts. Participants also emphasized the need for dedicated facilities such as startup incubators, digital innovation laboratories, seed funding, intellectual

property assistance, and partnerships with educational technology companies. Observation findings indicated that many innovative student projects remained classroom assignments because institutional mechanisms for scaling and sustaining innovation were limited. Therefore, students perceived policy support not simply as written regulations but as continuous institutional commitment that enables educational innovation to develop into sustainable technopreneurial initiatives.

4.2.5. Theme 5. Preservice teachers recognize technopreneurship as an important future competency

Despite identifying various barriers, participants consistently expressed optimism regarding the future relevance of technopreneurship. Most respondents believed that technological advancement would fundamentally transform the teaching profession. They anticipated that future teachers would need competencies extending beyond classroom instruction, including digital content development, educational platform management, online learning services, and educational consulting.

One participant explained:

"Future teachers cannot rely only on teaching in classrooms. We must be able to create educational innovations that benefit society."

Another participant stated:

"Educational technology develops very quickly. If teachers cannot innovate, they will struggle to remain relevant."

Participants considered technopreneurship an important competency for improving professional adaptability, expanding career opportunities, and responding to educational challenges in the digital era. Nevertheless, they emphasized that developing technopreneurship requires collaboration among universities, lecturers, policymakers, and industry rather than relying solely on individual initiative. Overall, qualitative evidence indicates that preservice teachers possess positive attitudes toward technopreneurship but require stronger pedagogical support, authentic entrepreneurial experiences, collaborative learning environments, and sustainable institutional ecosystems to transform these aspirations into practical competencies.

4.3. Discussions

4.3.1. Learning engagement is indeed the only significant predictor in the model of preservice teachers' technopreneurship

The quantitative findings demonstrate that learning engagement was the only variable that significantly predicted preservice teachers' technopreneurship. This result indicates that active participation in learning activities contributes more substantially to technopreneurial development than merely receiving entrepreneurship instruction or institutional support. The qualitative findings provide a deeper explanation for this relationship. Participants consistently reported that collaborative discussions, project-based learning, peer interaction, and opportunities to exchange ideas stimulated creativity and encouraged them to explore technology as a means of solving educational problems.

The interview data suggest that learning engagement creates a social learning environment in which students gain confidence to experiment with new ideas and learn from one another. Rather than simply increasing classroom participation, engagement facilitates the development of critical thinking, collaboration, opportunity recognition, and innovation, all of which are essential dimensions of technopreneurship. These findings support previous studies emphasizing that active learning communities enhance students' motivation, creativity, and digital innovation capabilities (Martin & Borup, 2022; Pan, 2022; Wang et al., 2022).

From the perspective of transformative learning theory, meaningful engagement encourages learners to critically reflect upon existing assumptions and reconstruct their understanding of professional roles. Preservice teachers who actively participate in collaborative learning gradually begin to perceive themselves not only as future educators but also as potential innovators capable of creating educational value through technology. Therefore, learning engagement functions not merely as instructional participation but as a catalyst for developing entrepreneurial identity within teacher education.

4.3.2. Entrepreneurial learning requires authentic and experiential implementation

Although entrepreneurial learning was expected to contribute to technopreneurship, its direct statistical effect was relatively weak. The qualitative findings help explain this unexpected result. Most participants acknowledged that entrepreneurship education within their institutions primarily emphasized conceptual knowledge, business planning, and theoretical discussion, while opportunities to design, prototype, and commercialize educational innovations

remained limited.

These findings indicate that entrepreneurship education alone is insufficient unless accompanied by authentic entrepreneurial experiences. Participants repeatedly emphasized the need for mentoring, incubation programs, collaboration with industry, and opportunities to develop educational technology products that address real educational problems. Consequently, entrepreneurial competence appears to depend more on experiential learning than on classroom instruction.

This finding is consistent with entrepreneurship education literature, which argues that entrepreneurial competencies are developed through practice-oriented learning, experimentation, reflection, and real-world problem solving rather than through theoretical instruction alone (Lackéus, 2015; Nabi et al., 2017). In the context of teacher education, entrepreneurial learning should therefore move beyond introducing business concepts and instead integrate educational technology development, digital content creation, and innovation projects that allow preservice teachers to experience the entrepreneurial process directly.

These findings have direct implications for curriculum design in teacher education. Teacher education programs need to shift from entrepreneurship learning centered on conceptual transmission toward an authentic digital creation-based technopreneurship model. This transition does not necessarily require the introduction of additional entrepreneurship courses. Instead, technopreneurial projects can be integrated across entrepreneurship, educational technology, instructional media, and learning development courses. Within this approach, authentic educational problems should serve as the starting point of the entrepreneurial process. For example, preservice teachers may identify limited access to instructional media, students' difficulties in understanding particular subjects, the need for inclusive learning resources, or unequal access to educational content as opportunities for developing digital educational solutions.

Operationally, the curriculum can adopt a project-based technopreneurship model consisting of six sequential stages: educational problem identification, opportunity and value recognition, digital solution design, prototype development, user testing and iteration, and implementation and value creation. In the first stage, preservice teachers conduct observations or consultations with schools to identify authentic educational problems. They then translate these problems into innovation opportunities and define the educational value that their proposed solutions are expected to create. Students subsequently design and develop prototypes, such as digital learning media, interactive educational content, tutoring platforms, or simple learning applications. These prototypes should be tested with intended users, including teachers or students, and iteratively improved based on user feedback. In the final stage, students formulate implementation and sustainability strategies and, where appropriate, identify potential models for value creation or commercialization.

This model shifts the expected output of entrepreneurship education from business plans and idea presentations toward validated digital educational prototypes. Accordingly, assessment practices should also be restructured. Evaluation should not focus exclusively on students' understanding of entrepreneurial concepts but should assess their ability to identify educational problems, recognize opportunities, collaborate, develop prototypes, respond to user feedback, and demonstrate the educational value of their solutions. Such an approach may help narrow the gap between entrepreneurial knowledge and actual technopreneurial competence identified in this study.

4.3.3. Policy support serves as an enabling ecosystem rather than a direct driver

The quantitative analysis indicates that policy support did not significantly influence technopreneurship directly. However, qualitative evidence suggests that institutional policies remain essential because they create conditions that enable innovation to flourish. Participants generally appreciated the existence of entrepreneurship seminars, innovation competitions, and digital literacy programs. Nevertheless, they perceived these initiatives as fragmented and lacking continuity. Students frequently mentioned the absence of long-term mentoring, startup incubation, industry partnerships, and institutional mechanisms that could transform innovative classroom projects into sustainable educational ventures.

These findings imply that policy support should not be interpreted solely as formal regulations or curriculum requirements. Instead, policy functions as an innovation ecosystem consisting of institutional leadership, infrastructure, financial support, mentoring systems, interdisciplinary collaboration, and partnerships with external stakeholders. When these elements operate cohesively, policy indirectly strengthens students' opportunities to develop technopreneurial competencies. This interpretation aligns with recent studies emphasizing that institutional transformation requires integrated policies connecting curriculum, digital infrastructure, innovation culture, and industry collaboration (Aripradono, 2024; Zhang et al., 2022). Therefore, policy support should be viewed as a contextual factor that facilitates rather than directly determines technopreneurship.

From an institutional policy perspective, the findings indicate a need to move from episodic entrepreneurship initiatives toward a sustained technopreneurship development ecosystem. Seminars, innovation competitions, and digital training may continue to serve as entry points, but these activities should be connected to clearly defined follow-up mechanisms. Universities can establish an innovation development pathway that connects course-based projects with digital innovation laboratories, mentoring, incubation programs, small-scale seed funding, intellectual property support, and partnerships with schools or educational technology companies. Under this model, promising student projects would not end after course assessment or innovation competitions but could progress toward further testing, refinement, and implementation.

Teacher education programs may also implement a three-party mentoring model involving teacher educators, technology mentors, and practitioner or user partners. Teacher educators would ensure the pedagogical relevance of the proposed products, technology mentors would support the feasibility of digital development, and schools, teachers, or industry partners would serve as authentic users and sources of feedback. This mentoring structure directly responds to participants' expressed need for sustained guidance identified through the interviews and FGDs. At the institutional level, existing incubation units or innovation laboratories do not necessarily need to establish separate programs exclusively for education students. Instead, universities could create a dedicated educational innovation pathway that connects faculties of education with university-level entrepreneurship and innovation units.

For university administrators, the effectiveness of technopreneurship policies should also be assessed through output-oriented indicators rather than solely by the number of activities conducted. Relevant indicators may include the number of digital educational prototypes developed and tested with users, the proportion of projects involving schools or educational communities, the number of projects sustained beyond the completion of a course, and the number of student innovations progressing to incubation or implementation. At the higher education policy level, technopreneurship can be positioned as a cross-cutting competency in preservice teacher education by integrating educational problem identification, digital solution creation, user validation, collaboration, and value creation into graduate learning outcomes. This approach enables institutions to strengthen technopreneurship without necessarily increasing curricular load through additional stand-alone courses.

4.3.4. The limited explanatory power indicates the multidimensional nature of technopreneurship

A critical finding of this study is the low explanatory power of the regression model. The adjusted R^2 value of 0.023 indicates that the three predictors included in the analysis explain only 2.3% of the variance in preservice teachers' technopreneurship. Consequently, approximately 97.7% of the variance remains unexplained by the present model. This result represents an important limitation and requires the quantitative findings to be interpreted as evidence of limited associations rather than as a comprehensive predictive explanation of technopreneurship.

The low explanatory power may partly reflect the multidimensional nature of technopreneurship. The dependent construct integrates entrepreneurial orientation, technological competence, and the professional responsibilities of preservice teachers. Such competence is unlikely to emerge solely from learning engagement, exposure to entrepreneurial learning, or perceived policy support. Individual psychological characteristics, including entrepreneurial intention, digital self-efficacy, creativity, risk orientation, and innovation capability, may contribute to technopreneurial development. Similarly, prior digital experience, access to technological resources, mentoring, family entrepreneurial background, institutional innovation culture, and exposure to authentic entrepreneurial projects may influence students' ability to transform technological knowledge into educational value.

The qualitative findings reinforce this interpretation. Participants did not describe technopreneurship as the outcome of a single educational experience. Instead, their accounts revealed interconnected issues concerning professional identity, collaborative learning, limited authentic entrepreneurial experience, fragmented institutional support, and the absence of sustained innovation pathways. This pattern suggests that the weak quantitative explanatory power may not simply represent statistical failure but may also indicate that the three-variable linear model captures only a narrow component of a broader developmental ecosystem.

Accordingly, the present model should be regarded as a limited determinant model rather than a comprehensive predictive model. Its primary quantitative contribution is to demonstrate that the three commonly assumed educational and institutional factors have relatively weak explanatory capacity when examined as direct linear predictors. This finding redirects future research toward more theoretically comprehensive models that incorporate psychological, technological, experiential, and institutional mechanisms. Future studies may specifically examine whether variables such as digital self-efficacy, entrepreneurial intention, or innovation capability mediate the relationship between

educational experiences and technopreneurship, and whether institutional innovation culture or mentoring support moderates these relationships.

5. Conclusion

This study investigated preservice teachers' technopreneurship and examined the roles of learning engagement, entrepreneurial learning, and policy support using concurrent triangulation mixed methods design. The quantitative findings indicate that preservice teachers' technopreneurship remains below the expected level, suggesting that the integration of technological competence, entrepreneurial orientation, and educational innovation has not yet been fully achieved within teacher education programs. Among the three determinants examined, learning engagement emerged as the only significant predictor of technopreneurship, whereas entrepreneurial learning and policy support showed positive but statistically non-significant direct effects. Furthermore, the relatively low coefficient of determination indicates that technopreneurship is influenced by additional factors beyond those included in this study.

The qualitative findings enrich these statistical results by revealing the underlying reasons behind the observed relationships. Preservice teachers generally perceived technology as a tool for supporting classroom activities rather than as a platform for creating educational innovation and entrepreneurial value. Participants also emphasized that collaborative learning experiences stimulated creativity and confidence, while entrepreneurship education was often implemented in a predominantly theoretical manner with limited opportunities for authentic practice. In addition, institutional support was perceived as fragmented and lacking sustained mentoring, incubation programs, and industry collaboration necessary to foster long-term technopreneurial development.

The integration of quantitative and qualitative evidence demonstrates that developing technopreneurship among preservice teachers requires more than entrepreneurship courses or institutional policies alone. Effective development depends on creating active learning environments, providing authentic technology-based entrepreneurial experiences, and establishing supportive institutional ecosystems that integrate curriculum, mentoring, innovation infrastructure, and external partnerships. These findings contribute to the growing literature on technopreneurship in teacher education by demonstrating that students' active engagement in meaningful learning experiences constitutes the primary mechanism through which technopreneurial competencies can be cultivated.

From a practical perspective, the findings indicate that teacher education programs should restructure entrepreneurship learning from a predominantly theoretical approach toward project-based digital creation grounded in authentic educational problems. Such restructuring can be implemented by integrating technopreneurship projects into entrepreneurship and educational technology courses through a sequential cycle of problem identification, opportunity recognition, digital solution design, prototype development, user testing, and implementation. Learning outputs should consequently shift from business plans or idea presentations toward digital educational prototypes that have received feedback from teachers, students, or other educational partners.

At the institutional level, universities should connect course-based projects with mentoring mechanisms, digital innovation laboratories, incubation programs, seed funding, and partnerships with schools and educational technology industries. Technopreneurship development policies should be evaluated based on the continuity and outputs of student innovation rather than merely the number of seminars, training programs, or competitions conducted. For higher education policymakers, technopreneurship may be developed as a cross-cutting competency in preservice teacher education by embedding digital solution creation, user validation, collaboration, and value creation into graduate learning outcomes. This framework provides a more actionable pathway for transforming entrepreneurship education in teacher preparation from conceptual instruction into authentic, sustainable, and project-based digital creation experiences.

Future research is encouraged to investigate additional determinants of technopreneurship, such as digital self-efficacy, innovation capability, entrepreneurial intention, creativity, institutional innovation culture, and leadership support. Longitudinal and multi-institutional studies are also recommended to better understand how technopreneurial competencies evolve throughout teacher education and into professional practice.

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