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University Support Environment, Learning Engagement, and the Cultivation of Undergraduate Students' Innovation Capacity: Findings from PLS-SEM and fsQCA

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Abstract: *Innovation capacity is a core competency for the 21st century. Developing undergraduates' innovation capacity to nurture top talents is a pressing task for universities. This study draws on Astin's Input-Environment-Output (I-E-O) model and student involvement theory to create a framework exploring how the university support environment and learning engagement jointly influence undergraduates' innovation capacity. Data from 543 Chinese undergraduates were analyzed using a hybrid approach combines partial least squares - structural equation modeling (PLS-SEM) and fuzzy set qualitative comparative analysis (fsQCA). The PLS-SEM findings indicate that university support—through curriculum, extracurricular activities, faculty, and facilities—along with learning engagement, positively affects innovation capacity. While PLS-SEM suggests that institutional support does not significantly impact innovation capacities, fsQCA reveals the potential role of all factors in promoting innovation capacity. The findings provide valuable theoretical insights and practical implications for universities and higher education administrators aiming to enhance undergraduates' innovation capacity.*

Keywords: *Innovation capacity, University support environment, Learning engagement, Undergraduate students*

1. Introduction

Innovation capacity is recognized as a core competency of the 21st century.[1][2] As the backbone of future national development, Undergraduates play a critical role in shaping an innovative society. Higher education institutions are essential in cultivating talent and are responsible for training exceptional innovators. Consequently, enhancing undergraduates' innovation capacity has become a top priority for universities today.

Recently, strategies for developing undergraduates' capacity for innovation have attracted significant academic attention. Scholars approach this issue from two main perspectives. The first is the institutional perspective, which investigates how university resources and service provision can enhance undergraduates' innovation capacity. Proposed strategies include pedagogical innovation [3][4][5][6] (Mayhew et al., 2018; Selznick and Mayhew, 2019; Acar and Tuncdogan, 2018; Keinänen and Kairisto-Mertanen, 2019), enhancing teachers' TPACK abilities [7] (Sulistyarini et al., 2022) and creating a makerspace-oriented teaching and learning environment [8] (Saorin et al., 2017). The second perspective focuses on the students themselves, exploring how individual characteristics and behaviors influence their capacity for innovation. Research indicates that participation in extracurricular activities, such as academic competitions, research projects, and social practice programs [9] (Bock et al., 2020), as well as active engagement in the classroom [4] (Selznick and Mayhew, 2019), positively affects innovation capacity. While existing research offers valuable insights, it often has limitations. Many studies tend to focus exclusively on either institutional or student perspectives, rely heavily on theoretical or case studies with limited empirical research, and primarily examine the independent effects without considering the configurational influence of multiple factors on innovation capacity.

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To address these research gaps, this paper proposes a model to investigate how the university support environment and learning engagement jointly influence undergraduates' innovation capacity. Utilizing survey data from 543 Chinese undergraduates, it conducts an empirical analysis through partial least squares - structural equation modeling (PLS-SEM) and fuzzy set qualitative comparative analysis (fsQCA). In the first phase, PLS-SEM is used to assess the net effects of antecedent variables on innovation capacity. In the second phase, fsQCA examines the configurational effects of combinations of these antecedent variables on innovation capacity.

2. Literature Review and Hypothesis Development

Drawing on Astin's Input-Environment-Output (I-E-O) model and the theory of student involvement, this study explains how the university support environment and learning engagement impact undergraduates' innovation capacity while proposing relevant research hypotheses.

2.1. Definition of Undergraduate Innovation Capacity

Undergraduate innovative capacity refers to the comprehensive skills required for students to successfully engage in innovation activities. Specifically, innovation typically involves introducing new elements (such as ideas, methods, devices, inventions, processes, etc.) or improving existing ones. It includes both the generation and implementation of new ideas to benefit individuals, organizations, or society (Keinänen et al., 2018). [10] Capacity is understood as the knowledge, skills, and attitudes necessary for adapting to current realities and addressing future challenges (Doll, 2012). [11]

According to Perez-Penalver's Framework for Innovation Competencies Development and Assessment (FINCODA), innovative capacity is a multidimensional construct comprising five dimensions: creativity, critical thinking, initiative, teamwork, and networking (Perez-Penalver et al., 2018). [12] Specifically, creativity is the ability to transcend traditional ideas, rules or relationships, and generate or adapt meaningful alternatives, regardless of their possible practicality and future added value. Critical thinking is regarded as the ability to analyze and deconstruct issues with a purpose by evaluating advantages and disadvantages, foreseeing how events will develop or estimating the risks involved. Initiative refers to the ability to make decisions or take actions that operationalize ideas fostering positive changes, as well as to mobilize and manage creative individuals and those responsible for implementing ideas. Teamwork is defined as the ability to work effectively with others in a group, while networking is the ability to engage external stakeholders.

2.2. University Support Environment and the Cultivation of Undergraduate Innovation Capacity

Research in educational theory indicates that the university environment significantly impacts students' learning outcomes. According to Astin's Input-Environment-Output (I-E-O) model [13] (Astin, 1991), the output variable (O) of a university student's learning experience results from the interaction between individual input variables (I) prior to enrollment and environmental variables (E) throughout the educational process. Building on existing research, this study defines the university support environment as the range of resources and services offered by the university to foster student learning and development, which includes five aspects: curriculum support, extracurricular activity support, faculty support, facility support, and institutional support. According to the I-E-O model, the quality of the university environment can significantly influence students' learning outcomes and overall development. When the environmental support provided by the university effectively addresses the needs for developing students' innovation capacity, it positively impacts their innovation capacity development; conversely, inadequate support may hinder the development of their innovation capacity.

2.2.1. Curriculum Support

Classroom instruction serves as the primary means through which undergraduates acquire knowledge and skills, playing a crucial role in enhancing their innovation capacity. The availability of innovation-related courses and the implementation of innovative pedagogies significantly influence this development (Jorgensen and Kofoed, 2007). [14] An experimental study by Mayhew and colleagues demonstrates that targeted, innovation-specific curricula effectively stimulate the growth of undergraduates' innovation capacity (Mayhew et al., 2018). [3] Furthermore, some scholars have noted that innovative teaching methods and practices, such as experiential learning through "learning by doing"[14] (Jorgensen and Kofoed, 2007) and inquiry-based learning[5] (Acar and Tuncdogan, 2018), are beneficial for promoting innovation capacity. Thus, the closer the alignment of courses and teaching

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methods with the needs for developing undergraduates' innovation capacity, the more they contribute to fostering these essential skills. Based on this understanding, the following hypothesis is proposed:

H1a: Curriculum support has a significant positive impact on enhancing undergraduates' innovation capacity.

2.2.2. Extracurricular Activity Support

Beyond classroom learning, university students' extracurricular experiences also play a crucial role in developing their innovation capacity. These activities create an open learning environment, enhance teamwork and communication, provide practical applications of classroom knowledge, and offer platforms to showcasing talent. Empirical studies by Selznick et al. (2022) [2] and Bock's team (2020) [9] reveal a strong positive correlation between extracurricular engagement and innovation capacity. Specifically, participation in student organizations, academic competitions, research projects, creative contests, and business plan competitions enhances students' innovation capacity (Bock et al., 2020). [9] Therefore, the better the university's extracurricular offerings align with the development of undergraduates' innovation capacity, the more they will benefit from these experiences. Based on this premise, the following hypothesis is proposed:

H1b: Extracurricular activity support has a significant positive impact on enhancing undergraduates' innovation capacity.

2.2.3. Faculty Support

As key figures in the growth and success of university students, teachers act as innovative "role models" and "gatekeepers". First, teachers with high levels of creativity can inspire students by showcasing innovative thinking and character, thereby promoting their innovative capacity through observation and learning mechanisms (Shi et al., 2017). [15] Second, teachers with strong innovative teaching skills can further boost students' innovation capacity by employing effective pedagogical practices (Bock et al., 2020).[9] This includes promoting active learning, providing opportunities for collaborative engagement, and motivating students to generate innovative ideas, propose solutions, and apply course knowledge to real-world challenges. Consequently, the better the alignment of teachers' skills with the needs of undergraduates in developing their innovation capacity, the more significant the benefits will be for enhancing that capacity. Based on this understanding, the following hypothesis is proposed:

H1c: Faculty support has a significant positive impact on enhancing undergraduates' innovation capacity.

2.2.4. Facility Support

The facilities and resources provided by universities—such as libraries, laboratories, and study spaces—play a crucial role in developing undergraduates' innovation capacity. Research by Mayhew et al. (2018) indicates that students' functional experiences, or their perceptions of the functionality of facilities like libraries and workspaces, significantly positively influence their innovative capacity. [3] Additionally, studies suggest that makerspace environments can effectively enhance students' innovation capacity. For instance, an experimental study by J. Saorin et al. (2017) [8] involving 44 engineering design students at the University of La Laguna demonstrated that a teaching environment equipped with 3D scanners, 3D printers, and 3D software substantially boosted students' creativity. Thus, the better university resources and facilities align with the needs for developing undergraduates' innovative capacity, the more beneficial they will be for enhancing these skills. Based on this understanding, the following hypothesis is proposed:

H1d: Facility support has a significant positive impact on enhancing undergraduates' innovation capacity.

2.2.5. Institutional Support

The talent development systems at universities significantly affect the cultivation of undergraduates' innovation capacity. First, institutional frameworks influence resource allocation; the implementation of these systems primarily involves the mobilization and alignment of various educational resources (Shi et al., 2017; Bock et al., 2020).[15][9] The scale and forms of investment in educational resources directly impact students' utilization of these resources, thereby affecting their development of innovation capacity. Second, institutions play a guiding role by establishing evaluation systems and management practices that foster students' innovation capacity, universities can inspire and motivate students' creativity and autonomy, facilitating the growth of their innovation capacity. Based on this,

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the following hypothesis is proposed:

H1e: Institutional support has a significant positive impact on enhancing undergraduates' innovation capacity.

2.3. Learning Engagement and the Cultivation of Undergraduates' Innovation Capacity

The impact of undergraduates' learning engagement on their innovation capacity is primarily grounded in Astin's student involvement theory. According to Astin's research, learning engagement refers to the total physical and psychological energy that students invest in academically related activities. Highly engaged Students are those who dedicate more energy to their studies, spend more time on campus, actively participate in student organizations, and frequently interact with teachers and peers (Astin, 1984).[16] Astin argues that the extent of students' learning and development within any educational program is directly proportional to their level of involvement in that program (Astin, 1985).[17]

Innovation capacity is viewed as a learning outcome that is also influenced by students' learning engagement. Wang (2021) found that the level of classroom participation among undergraduates has a significant positive impact on the development of their innovation capacity, based on data from 184 research-oriented undergraduate classes.[18] The qualitative study by Guo Hui et al. found that undergraduate students can benefit in areas such as professional knowledge, problem-solving skills, interpersonal communication, confidence, persistence, and resilience by actively participating in "College Student Innovation and Entrepreneurship Competitions". [19] These benefits are closely linked to the development of innovation capacity. Based on this, the following hypothesis is proposed:

H2: Undergraduate students' learning engagement has a significant positive impact on enhancing their innovation capacity.

This study first constructs a research model of factors influencing undergraduates' innovation capacity from the perspective of PLS-SEM, as shown in Figure 1. It explores the effects of the five dimensions of the university support environment (H1a-H1e) and learning engagement (H2) on undergraduates' innovation capacity. Additionally, this study employs the fsQCA method to further investigate the effects of multiple factor combinations on undergraduates' innovation capacity, as illustrated in Figure 2.

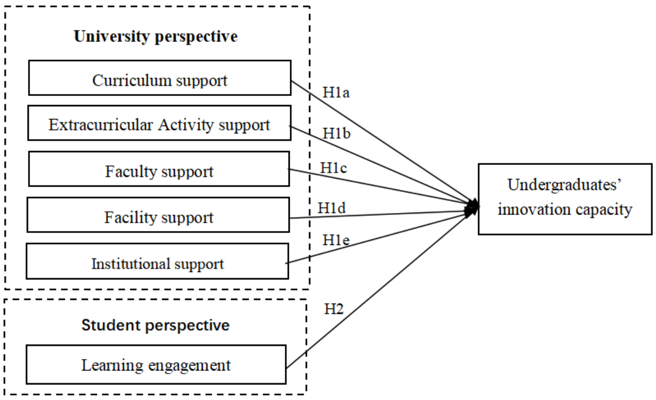

Figure 1: PLS-SEM Model of Determinants of Undergraduates' innovation Capacity

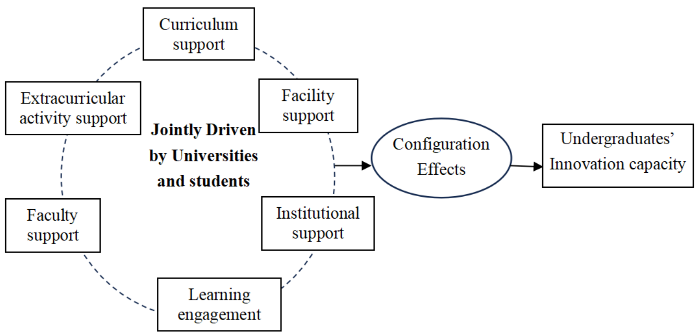

Figure 2: fsQCA model of Determinants Influencing Undergraduates' Innovation Capacity

3. Data and Methodology

3.1. Data and Sample

This study employs an online questionnaire survey to collect data through the survey platform “Wenjuanxing”. The questionnaire link was distributed to respondents via WeChat for online completion. A trial survey involving a small group of undergraduate students validated the questionnaire, resulting in modifications to language, question format, and in order to enhance the respondent experience. The homepage of the questionnaire featured completion prompts that emphasized anonymity and confidentiality, reminders for missing responses, and a resume function to facilitate the completion process. Based on feedback from the trial study, the minimum time estimated for thoughtful completion was set at three minutes, with only those responses exceeding this duration retained for analysis.

A snowball sampling method expanded the sample size through undergraduates who completed the survey and shared the link. Conducted from March to May 2023, the survey yielded 553 responses, of which 543 were valid after excluding ineffective submissions. The sample demographic included 64.09% female students, 32.23% freshmen, 28.18% sophomores, 25.05% juniors, and 14.55% seniors, with 32.97% majoring in STEM and 91.9% having parents with an annual income of 500,000 RMB or below.

3.2. Measures

Undergraduate Innovation capacity is measured using the FINCODA model by Perez-Penalver et al (2018) [12], encompassing five dimensions: creativity, critical thinking, initiative, teamwork, and networking. Respondents self-reported their improvement in these areas on a five-point Likert scale from “no improvement” (1) to “significant improvement” (5). University Support Environment reflects how well universities provide necessary resources for developing innovation capacities, measured across five dimensions: curriculum, extracurricular activities, faculty, facility, and institutional support, using adapted validated scales on a five-point Likert scale (Bock et al., 2020[9]; Selznick and Mathew, 2019[4]; Keinänen and Kairisto-Mertanen, 2019[6]) (1 = "strongly disagree"; 5 = "strongly agree"). Learning Engagement is gauged through a single item "How much time and effort do you invest in academic-related activities?" rated from 1 (very little) to 5 (very much). Additionally, gender, political affiliation, academic stage, major, and parental income serve as control variables in the PLS-SEM analysis, as these may influence learning outcomes (Bock et al., 2020[9]; Selznick and Matthew, 2019[4]). Table 1 outlines the measurement items and their sources.

Table 1: Construct Measurements

Construct	Measurement items	Source
Innovation capacity (IL)	IL1: Degree of creativity enhancement	Perez-Penalver et al. (2018)[12]
	IL2: Degree of critical thinking enhancement	
	IL3: Degree of Initiative enhancement	
	IL4: Degree of teamwork enhancement	
	IL5: Degree of networking enhancement	
Curriculum support (CS)	CS1: The innovation curriculum offered aligns well with my desire to enhance my innovation capacity	Bock et al. (2020)[9]; Selznick & Mathew (2019)[4]; Keinänen & Kairisto-Mertanen (2019)[6]
	CS2: The teaching program is designed to strengthen my innovation capacity	
	CS3: Overall, the curriculum provision meets my needs for improving my innovation capacity	
Extracurricular activity support (ES)	ES1: The university’s innovation and entrepreneurship competition enhance my innovation capacity	
	ES2: The scientific research projects and their financial support provided by the university contribute to improving my innovation capacity	
	ES3: The social practice activities organized by the university play a significance role in enhancing my innovation capacity	
Faculty support (FS)	FS1: My innovation capacity is nurtured and enriched through my interactions with the school faculty	

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	FS2: The faculty consistently encourages and fosters critical thinking in their teaching	
	FS3: The content and teaching methods employed by the faculty stimulate and guide my innovative thinking	
	FS4: The overall quality of the faculty is exceptional	
Facility support (FSE)	FSE1: The library resources effectively support my efforts to enhance my innovation capacity	
	FSE2: The teaching spaces and laboratories fulfill my needs for improving innovation capacity	
	FSE3: The student extracurricular activity venues contribute significantly to my development of innovation capacity	
Institutional support (IS)	IS1: The student evaluation system established by the university, including scholarship assessments, enhances my innovation capacity	
	IS2: The specialized training programs developed by the university significantly contribute to my innovation capacity	
	IS3: The educational management policies implemented by the university effectively support the improvement of my innovation capacity	
	IS4: The university has established a strong institutional framework for cultivating innovation capacity	

3.3. Analytical Techniques

This study employs a combined PLS-SEM and fsQCA approach for data analysis. Previous research indicates that these two methods combinations can enhance the descriptive, predictive, and explanatory power of social science theories (Sisu et al., 2024). [20] PLS-SEM examines complex causal relationships, enabling the estimation of structural relationships between latent variables without being affected by measurement error (Fornell and Larcker, 1981).[21] Given that both undergraduate innovation capacity and university support environment are latent variables, PLS-SEM is used to test the related research hypotheses. Additionally, PLS-SEM can handle small sample sizes and does not require the data to follow a normal distribution (Hair et al., 2016) [22], making it suitable for this research. The PLS-SEM analysis is conducted in two steps: first, assessing the reliability and validity of the measurement model, and second, examining the hypothesized relationships within the structural model.

In the light of the limitations of PLS-SEM in capturing non-linear relationships among the drivers of innovation capacity, this study employs fsQCA, an asymmetrical approach, to complementarily assess the configurational effects of predictors. In fact, the cultivation of undergraduate innovation capacity is not solely influenced by a single factor; it may depend on a combination of multiple interdependent and interconnected antecedent elements that collectively impact innovation capacity. As a configurational analysis method, fsQCA effectively handles interactions among three or more variables (Fiss, 2011)[23], enhancing the analysis of how different combinations of factors influence undergraduate innovation capacity.

4. Data and Methodology

4.1. Analytical Techniques

First, we assessed the composite reliability (CR) of all latent variables to evaluate the reliability of the model data. As shown in Table 2, the CR values for all latent variable measurement scales range from 0.787 to 0.898, exceeding the threshold of 0.7 (Hair et al., 2016) [22]. This indicates that the data demonstrates good composite reliability.

Next, we calculated the factor loadings and average variance extracted (AVE) for all items to verify the convergent validity of the model. The results in Table 3 indicate that all standardized factor loadings exceed the threshold of 0.7. Additionally, the AVE values range from 0.599 to 0.783, surpassing the threshold of 0.5 (Chin, 1998) [24], suggesting that the data possesses strong convergent validity.

Finally, we assessed the discriminant validity using two methods: comparing the correlation matrix

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with the square roots of the AVE and evaluating the heterotrait-monotrait ratio (HTMT). As indicated in Table 3, the square root of the AVE for each latent variable is greater than the correlation coefficients with other latent variables (Fornell and Larcker, 1981) [21], and the HTMT ratios for all latent variables are significantly below 0.9 (Gold et al., 2001) [25]. These findings confirm that the discriminant validity among the various latent variables is satisfactory.

Table 2: Reliability, Convergent Validity, and Discriminant Validity Test Results of the Constructs

Constructs	Items	Factor loadings	Cronbach's alpha	Combinatorial reliability (CR)	Mean extraction variance (AVE)
Innovation capacity (IL)	IL1	0.817	0.832	0.837	0.599
	IL2	0.801			
	IL3	0.778			
	IL4	0.745			
	IL5	0.724			
Curriculum support (CS)	CS1	0.836	0.785	0.787	0.699
	CS2	0.849			
	CS3	0.823			
Extracurricular activity support (ES)	ES1	0.895	0.861	0.861	0.783
	ES2	0.900			
	ES3	0.860			
Faculty support (FS)	FS1	0.766	0.809	0.813	0.637
	FS2	0.813			
	FS3	0.839			
	FS4	0.771			
Facility support (FSE)	FSE1	0.839	0.828	0.829	0.744
	FSE2	0.894			
	FSE3	0.855			
Institutional support (IS)	IS1	0.828	0.894	0.898	0.759
	IS2	0.887			
	IS3	0.886			
	IS4	0.883			

Table 3: Correlation Coefficient Matrix, AVE Square Root and HTMT Ratio of the Constructs

Constructs	IL	FS	CS	ES	FSE	IS
Innovation capacity (IL)	0.774					
Faculty support (FS)	0.509 (0.613)	0.798				
Curriculum support (CS)	0.469 (0.574)	0.627 (0.780)	0.836			
Extracurricular activity support (ES)	0.455 (0.535)	0.539 (0.641)	0.644 (0.782)	0.885		
Facility support（FSE）	0.426 (0.513)	0.520 (0.630)	0.623 (0.774)	0.609 (0.721)	0.863	
Institutional support (IS)	0.395 (0.453)	0.538 (0.627)	0.657 (0.782)	0.657 (0.747)	0.689 (0.802)	0.871

Note: The shaded diagonal is the square root of the AVE. HTMT ratios are presented in parentheses.

4.2. Common Method Variance

Given that all questionnaire items were completed by the same respondent, there is a potential for common method variance (CMV). To assess this risk, we employed Harman's single-factor method. The results revealed that the first factor accounts for 41.73% of the total variance, which falls below the 50% threshold (Podsakoff, 1986)[26]. Thus, we conclude that common method bias is not a significant concern in this study.

4.3. The Structural Model

The structural model was utilized to test the research hypotheses. We implemented a standard bootstrapping procedure using Smart PLS 4.0 software, performing 5,000 resamples from a total of 543

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samples to evaluate the model and its associated hypotheses. The analysis indicated that the structural model exhibits strong explanatory power, with an R^2 of 34.4% for the dependent variable, undergraduates' innovation capacity.

Table 4 presents the results of the structural model assessment. Significant positive effects on undergraduates' innovation capacity were found for curriculum support (β = 0.296, $p < 0.05$), extracurricular activity support (β = 0.152, $p < 0.05$), faculty support (β = 0.296, $p < 0.001$), and facility support (β = 0.124, $p < 0.05$), thus supporting hypotheses H1a to H1d. Conversely, institutional support (β = -0.027, $p > 0.05$) did not have a significant impact on undergraduates' innovation capacity, leading to the rejection of hypothesis H1e. Additionally, undergraduates' learning engagement demonstrated a significant positive effect on their innovation capacity (β = 0.097, $p < 0.01$), supporting hypothesis H2.

Table 4: Results of Hypothesis Testing

Hypothesis	**Path relationship**	**Standard coefficient**	**Standard error**	**Decisions**
H1a	Curriculum Support → Innovation Capacity	0.142*	0.065	Support
H1b	Extracurricular activity Support → Innovation Capacity	0.152*	0.064	Support
H1c	Faculty Support → Innovation Capacity	0.296***	0.052	Support
H1d	Facility Support → Innovation Capacity	0.124 *	0.061	Support
H1e	Institutional Support → Innovation Capacity	-0.027	0.062	Not support
H2	Learning Engagement → Innovation Capacity	0.097**	0.036	Support
Control variables				
Gender → Innovation Capacity		-0.106	0.075	
Political Status → Innovation Capacity		0.059	0.045	
Major → Innovation Capacity		-0.015	0.080	
Grade → Innovation Capacity		0.071	0.045	
Parental annual income → Innovation Capacity		0.031	0.036	

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

5. fsQCA Analysis Results

5.1. Calibration

The initial step in conducting fsQCA analysis involves calibrating variables into fuzzy sets. Building on established practices, we apply direct calibration to align both causal conditions and the outcome variable (Ragin, 2008)[27]. Specifically, we first compute an index for each variable by averaging the relevant indicators. For the fuzzy set calibration, three anchor points are established: full membership (fuzzy score = 0.95), full non-membership (fuzzy score = 0.05), and a crossover point (fuzzy score = 0.50). To address fsQCA's limitation with values at the crossover point (0.50), we uniformly added 0.001 to the calibrated scores (Fiss, 2011), ensuring all values are analyzable.

5.2. Analysis of Necessary Conditions

After calibrating the data into fuzzy set, we performed the necessary analysis to identify whether any of the antecedents are always present (or absent) in all cases where the outcome is present (or absent) (Rihoux & Ragin, 2009) [28]. As shown in Table 5, the consistency coefficients of all antecedents generated by the necessary analysis are below the 0.9 threshold, indicating that none of the antecedents is necessary for determining undergraduate's innovation capacity.

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Table 5: Analysis of Necessary Conditions

Causal conditions	Consistency	Coverage
Curriculum support	0.774	0.782
~ Curriculum support	0.621	0.604
Extracurricular activity support	0.796	0.762
~ Extracurricular activity support	0.578	0.595
Faculty support	0.764	0.791
~ Faculty support	0.607	0.577
Facility support	0.762	0.604
~ Facility support	0.602	0.591
Institutional support	0.762	0.748
~ Institutional support	0.612	0.612
Learning Engagement	0.761	0.655
~ Learning Engagement	0.558	0.651

Note: ~ denotes "negation".

5.3. Analysis of Sufficient Conditions

We conducted an analysis using a truth table to identify potential combinations of causal conditions. Following the methodology of recent studies, we set the raw consistency threshold at 0.8, the frequency threshold at 3, and the PRI consistency threshold at 0.55 (Greckhamer et al., 2018) [29]. The fsQCA analysis produced three solutions: complex, parsimonious, and intermediate. The intermediate solution was chosen for interpretation due to its completeness and interpretability (Loh et al., 2023) [30].

Table 6 presents the results of the fsQCA analysis, revealing three pathways that lead to high innovation capacity. The first pathway indicates that a university support environment characterized by a high curriculum, extracurricular activities, faculty and facility support, combined with high student learning engagement, may lead to high undergraduate innovation capacity (consistency = 0.917; coverage = 0.462). The second pathway indicates that a university support environment featuring high extracurricular activities, faculty, facility and institutional support, along with high student learning engagement, can also lead to high undergraduate innovation capacity (consistency = 0.911; coverage = 0.461). The third pathway suggests that a university support environment with high curriculum, extracurricular activities, faculty, facility and institutional support collectively constitutes a sufficient condition for high undergraduate innovation capacity (consistency = 0.892; coverage = 0.546).

Table 6: Sufficient Configurations of Innovation Capacity

Configuration	Path 1	Path 2	Path 3
Course Support	●		●
Activity support	●	●	●
Teacher support	●	●	●
Facility support	●	●	●
Institutional support		●	●
Learning engagement	●	●	
Raw coverage	0.462	0.461	0.546
Unique coverage	0.021	0.019	0.105
Consistency	0.917	0.911	0.892
Solution Coverage	0.588		
Solution Consistency	0.887		

Note: ●means the core condition exists; ● means the edge condition exists, space means optional.

6. Discussion and Conclusions

Enhancing undergraduates' innovation capacities is a central focus of higher educational research. This study, grounded in Astin's I-E-O model and student involvement theory, develops a theoretical model to examine the combined influence of the university support environment and learning engagement on undergraduates' innovation capacity. By employing PLS-SEM and fsQCA methods, this study empirically investigates the key factors affecting innovation capacity and identifies the configurations that trigger them, yielding valuable insights.

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First, the PLS-SEM analysis shows that curriculum support, extracurricular activity support, faculty support, and facility support provided by universities all have a significant positive impact on undergraduates' innovation capacity. These findings align with the I-E-O model, emphasizing that creating a favorable university learning environment is essential for fostering innovation capacity. However, the study also reveals that institutional support does not significantly affect innovation capacity, likely due to its more intangible nature, which makes it less perceptible to undergraduates compared to the other support dimensions. While the university's talent cultivation system can influence the development of innovation capacity through resource allocation and guidance, its low perceived value among undergraduates diminishes its significance in the model results.

Furthermore, the PLS-SEM results indicate that undergraduates' learning engagement positively influences their innovation capacity. Specifically, when students invest more time and energy in academic activities, their innovation capacity increases, thereby supporting the theory of student involvement.

Second, the fsQCA research identifies three pathways that lead to high innovation capacity among undergraduates: "curriculum support * extracurricular activity support * faculty support * facility support * learning engagement", "extracurricular activity support * facility support * faculty support * institutional support * learning engagement" and "curriculum support * extracurricular activity support * faculty support * facility support * institutional support". These three pathways explain 58.8% of the variance in undergraduates' innovation capacity, which is significantly greater than the explanatory power of the single PLS-SEM model (34.4%). The higher explanatory power of fsQCA results indicates that undergraduates have diverse needs and desires, suggesting that a single model cannot adequately capture all the behaviors important for shaping their innovation capacity (Sisu et al., 2024) [20]. Notably, while institutional support appears as a core condition in the second and third pathway, PLS-SEM results did not identify a significant impact of institutional support on innovation capacity. This suggests that while institutional support may not have a significant standalone impact, it can influence innovation capacity when combined with other antecedent variables. In this way, its individual insignificance transforms into a collaborative effect that promotes the development of undergraduates' innovation capacity.

6.1. Theoretical Implications

The present research contributes to the existing literature on student innovation capacity in several ways. First, this study develops an integrative model that encompasses both institutional and student perspectives on the factors influencing undergraduates' innovation capacity. This approach extends the traditional focus of existing research, which often examines the topic from a singular perspective of either institutional or student, as noted previously.

Second, this study empirically examines the impact of the university support environment and student learning engagement on innovation capacity. Furthermore, it moves beyond the conventional approach of exploring how to enhance innovation capacity through isolated dimensions by differentiating the university support environment into five dimensions: curriculum support, extracurricular activity support, faculty support, facility support, and institutional support. It examines how each of these dimensions, in conjunction with student learning engagement, influences undergraduates' innovation capacity.

Third, methodologically, this study demonstrates the benefits of employing both PLS-SEM and fsQCA as complementary analytical tools in educational research. PLS-SEM provides valuable insights into the net effects of individual antecedent variables on the outcome variable, while fsQCA reveals how different combinations of antecedent variables interact to influence outcome variable. Notably, while PLS-SEM indicates that institutional support does not significantly affect innovation capacity, fsQCA suggests it may still serve as one of the configurational conditions leading to high innovation capacity. By using this mixed-method approach, we obtain a more comprehensive understanding of the factors influencing undergraduates' innovation capacity, ultimately leading to more robust and actionable insights for educational researchers and administrators.

6.2. Practical Implications

The findings of this study have significant practical implications for universities seeking to enhance undergraduates' innovation capacity. As primary providers of educational resources and services, it is essential to cultivate an educational environment that fosters innovation. This includes reforming

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course design and pedagogies, implementing extracurricular activities, developing faculty resources, and providing adequate infrastructure.

Given that the various configurations arising from the five dimensions of the university support environment and student learning engagement can enhance innovation capacity in diverse ways, universities should systematically leverage their existing resources to promote synergistic combinations of university support and student engagement. Targeted measures can then be implemented to effectively nurture and enhance undergraduates' innovation capacity.

Additionally, universities should prioritize fostering and supporting undergraduates' intrinsic motivations for learning, exploration, and research, guiding them to actively utilize the rich educational resources available on campus. Engaging meaningfully in classroom activities, practical experiences, and campus facilities will be crucial to continuously enhancing undergraduates' innovation capacity.

6.3. Limitations and Future Directions

This study has two limitations that further research should address. First, data were collected through a snowball sampling method via an online survey. This approach, relying on interpersonal referrals, may result in a homogeneity sample that does not accurately represent the overall population. Future studies could employ random sampling methods to ensure sample representativeness. Second, the analysis is based on cross-sectional data, meaning that undergraduates' assessments of the factors influencing their innovation capacity may change over time. Therefore, longitudinal studies could provide a more accurate analysis of these factors.

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References

[1] Ovbiagbonhia, A. R., Kollöffel, B., & den Brok, P. (2019). Educating for innovation: Students' perceptions of the learning environment and of their own innovation competence. Learning Environments Research, 22(3), 387–407.

[2] Selznick, B. S., Mayhew, M. J., Winkler, C. E., & McChesney, E. T. (2022). Developing innovators: A longitudinal analysis over four college years. Frontiers in Education, 7, 1-12.

[3] Mayhew, M. J., Selznick, B. S., Zhang, L., Barnes, A. C., & Staples, B. A. (2018). Examining Curricular Approaches to Developing Undergraduates' Innovation Capacities. The Journal of Higher Education, 90(4), 563–584.

[4] Selznick, B. S., & Mayhew, M. J. (2019). Developing first-year students' innovation capacities. Review of Higher Education, 42(4): 1607-1624.

[5] Acar, O. A., & Tuncdogan, A. (2018). Using the inquiry-based learning approach to enhance student innovativeness: a conceptual model. Teaching in Higher Education, 24(7), 895–909.

[6] Keinänen, M. M., & Kairisto-Mertanen, L. (2019). Researching learning environments and students' innovation competences. Education + Training, 61(1): 17-30.

[7] Sulistyarini, O., Joyoatmojo, S., & Kristiani, K. (2022). Ulistyarini O, Joyoatmojo S, Kristiani. A Review Correlations between TPACK of Teacher towards Learning and Innovation Skills of Students. International Journal of Multicultural and Multireligious Understanding, 2022, 9(2): 507-516.

[8] Saorin, J., Melian-Diaz, D., Bonnet, A., Carrera, C., Meier, C., & Torre-Cantero, J. (2017). Makerspace teaching-learning environment to enhance creative competence in engineering students. Thinking Skills and Creativity, 23: 188-198.

[9] Bock, C., Dilmetz, D., Selznick, B. S., Zhang, L., & Mayhew, M. J. (2020). How the university ecosystem shapes the innovation capacities of undergraduate students – evidence from Germany. Industry and Innovation, 28(3), 307–342.

[10] Keinänen, M., Ursin, J., & Nissinen, K., (2018). How to measure students' innovation competences in higher education: Evaluation of an assessment tool in authentic learning environments. Studies in Educational Evaluation, 2018, 58: 30-36.

[11] Doll, W. E. (2012). Developing Competence. In Doll, W. E. (Eds.) Pragmatism, Post-Modernism,

ISSN 2522-6398 Vol. 7, Issue 12: 23-34, DOI: 10.25236/FER.2024.071204

and Complexity Theory (pp. 67-76). Routledge.
[12] Pérez-Peñalver, M. J., Aznar-Mas, L. E., & Montero-Fleta, B. (2018). Identification and Classification of Behavioral Indicators to Assess Innovation Competence. Journal of Industrial Engineering and Management, 2018, 11(1):87–115.
[13] Astin, A. W. (1991). Assessment for excellence: The philosophy and practice of assessment and evaluation in higher education. New York: American Council on Education.
[14] Jorgensen, F., & Busk Kofoed, L. (2007). Integrating the development of continuous improvement and innovation capabilities into engineering education. European Journal of Engineering Education, 32(2), 181–191.
[15] Shi, B. G., Liu, X., & Yu, F. (2017). Connotation of innovative competencies from the perspective of key competence. Curriculum, Teaching Material and Method, 37 (2): 55-60.
[16] Astin A W. (1984). Student Involvement: A Developmental Theory for Higher Education. Journal of College Student Personnel, 25: 297-308.
[17] Astin A. W. (1985). Achieving educational excellence. San Francisco: Jossey-Bass.
[18] Wang, H. (2021). The influence of classroom teaching on the development of college students' innovative ability: Based on the observation of 184 undergraduate classroom teaching in research universities. Journal of National Academy of Education Administration, (10): 86-95.
[19] Guo H.(2021). Research on the influence of university education system reform on college students' innovation ability. The International Journal of Electrical Engineering & Education, 2021: 00207209211002082.
[20] Sisu, J.A., Tirnovanu, A.C., Patriche, C.-C., Nastase, M., & Schin, G.C. (2024). Enablers of students' entrepreneurial intentions: findings from PLS-SEM and fsQCA. International Journal of Entrepreneurial Behavior & Research, 30(4): 856-884.
[21] Fornell, C., & Larcker, D. (1981). Structural equation models with unobservable variables and measurement error. Journal of Marketing Research, 18(1): 39~50.
[22] Hair, J. F., Hult, G. T., Ringle, C. & Sarstedt, M. (2016). A primer on partial least squares structural equation modeling (PLS-SEM). Sage.
[23] Fiss P. C. (2011). Building Better Causal Theories: A Fuzzy Set Approach to Typologies in Organizational Research. Academy of Management Journal, 54: 393-420.
[24] Chin, W. (1998). The partial least squares approach to structural equation modeling. In Marcoulides, G. A. (Eds.), Modern Methods for Business Research. Mahwah, NJ: Lawrence Erlbaum Associates.
[25] Gold, A. H., Malhotra, A., & Segars, A. H. (2001). Knowledge Management: An Organizational Capabilities Perspective. Journal of Management Information Systems, 18(1), 185–214.
[26] Podsakoff, P. M. & Organ, D. W. (1986). Self-Reports in Organizational Research: Problems and Prospects. Journal of Management. 1986, 12(4): 531~544.
[27] Ragin C. (2008). Redesigning Social Inquiry: Fuzzy Sets and Beyond, University of Chicago Press.
[28] Rihoux, B., & Ragin, C. C. (2009). Configurational Comparative Methods: Qualitative Comparative Analysis (QCA) and Related Techniques, Sage Publications.
[29] Greckhamer, T., Furnari, S., & Aguilera, R. V. (2018). Studying Configurations with Qualitative Comparative Analysis: Best Practices in Strategy and Organization Research. Strategic Organization, 16(4): 482-495.
[30] Loh, X., Lee, V., Leon, L., Aw, E. C., Cham, T., Tang, Y., & Hew, J. (2023). Understanding consumers' resistance to pay with cryptocurrency in the sharing economy: A hybrid SEM-fsQCA approach. Journal of Business Research, 159, 113726.