Research Article

Needs Analysis for Developing an Imaginative Thinking Model to Enhance Engineering Students' Innovative Entrepreneurial Employability in Western China

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Abstract

Background: China's transition toward an innovation-driven economy has exposed a structural imbalance in the engineering programmes of local universities in Western China, where technical training remains strong but the cultivation of imaginative thinking—the cognitive foundation of innovation and entrepreneurship—is weak.

Purpose: This study conducted a systematic needs analysis, the first phase of a Design and Development Research (DDR) project, to confirm whether an imaginative thinking model is needed and to identify its required content dimensions.

Methods: A convergent mixed-methods design was employed. Quantitative data were collected through a 30-item, five-point Likert questionnaire administered to 150 engineering educators across twelve provincial-level regions of Western China, while qualitative data were gathered through semi-structured interviews with nine experts in engineering education, innovation, and entrepreneurship. Instrument reliability was confirmed through a pilot study (Cronbach's $\alpha = 0.946$, $n = 30$).

Results: All 30 questionnaire items attracted high agreement, with means ranging from 3.99 to 4.28. Five preliminary dimensions were identified: Imaginative Learning Integration, Entrepreneurial Learning Activities, Innovation Ecosystem Support, Industry Engagement, and Design Thinking Process. Interview themes converged fully with the survey dimensions: three themes were mentioned by all nine experts and by eight of the nine.

Conclusion: A clear, triangulated perceived need for the model exists. The five dimensions are the output of this Phase 1 needs analysis, and the findings provide a preliminary, empirically grounded content basis for the subsequent design and development phase of the DDR project.

Keywords: imaginative thinking; engineering education; needs analysis; innovative entrepreneurial employability; design and development research; Western China.

1. Introduction

China is in the midst of a profound economic transition from a manufacturing-based economy toward an innovation-led one, a shift enshrined in national strategies such as the Mass Entrepreneurship and Innovation initiative and successive reforms of higher engineering education (Shen et al., 2020; Wang & Ma, 2022). Within this transition, engineers are no longer expected merely to apply established technical knowledge; they are increasingly required to originate novel solutions, recognise entrepreneurial opportunities, and adapt to rapidly changing industrial demands (Higuera Martínez et al., 2021; Charosky et al., 2022). Universities, as the principal incubators of engineering talent, have consequently been called upon to embed innovation and entrepreneurship education throughout their curricula (Mei & Symaco, 2022; Qiu et al., 2023).

This national imperative, however, is unevenly distributed. Local universities in Western China—which educate a substantial share of the country's engineering undergraduates—face a structural dilemma that can be summarised as "strong in technique, weak in innovation" (Zhou & Zheng, 2021; Feng et al., 2024). Several interlocking constraints account for this imbalance. First, engineering pedagogy in the region remains dominated by lecture-based, examination-centred instruction inherited from a long tradition of standardised testing, which leaves limited room for open-ended, exploratory learning (Raza et al., 2024). Second, compared with coastal counterparts, western institutions command fewer innovation infrastructures—maker spaces, incubators, interdisciplinary platforms—and weaker links to high-technology industries (Cai et al., 2020; Mei & Symaco, 2022). Third, teaching staff receive little systematic preparation in creativity-oriented pedagogy, and institutional evaluation systems continue to reward conventional, easily standardised outputs (Zhou et al., 2024). The result is a persistent gap between the imaginative capacities that the innovation economy demands and the capabilities that western engineering graduates actually develop (Kang & Xiong, 2021; Huang et al., 2025).

At the heart of this gap lies imaginative thinking: the cognitive capacity to envision possibilities that do not yet exist, to connect seemingly unrelated ideas, and to project novel solutions to ill-defined problems (Egan, 2005; Raza et al., 2024). Defined precisely against its neighbouring constructs, imaginative thinking is narrower than creativity—which additionally requires the production of outcomes judged original and useful—and broader than design thinking, which is one disciplined methodology for channelling it; innovation, in turn, denotes the successful exploitation of imaginative outputs in practice. Imaginative thinking is thus best understood as the upstream cognitive resource on which creativity, design thinking, and innovation all draw. A growing body of scholarship treats imagination not as a decorative adjunct to engineering competence but as its generative core—the precursor of design insight, technological innovation, and entrepreneurial opportunity recognition (Brown, 2008; Amabile, 1996; Baričević & Luić, 2023). For engineering students who will pursue innovative entrepreneurship or innovation-oriented employment, imaginative thinking functions as a form of employability capital: it underwrites the divergent ideation, user-centred empathy, and iterative prototyping behaviours that innovative employers and venture ecosystems value (Charosky et al., 2022; Naseer et al., 2025). Yet imaginative thinking is precisely the capability that conventional, examination-driven engineering curricula cultivate least (Xu et al., 2024; Rabello-Mestre & Otondo, 2021).

Despite expanding research on creativity and design thinking in engineering education, three limitations mark the existing literature. First, most documented interventions originate in well-resourced institutions in developed regions, and their transferability to resource-constrained contexts such as Western China is largely untested (Cai et al., 2020; Maritz et al., 2022). Second, existing studies tend to evaluate isolated pedagogical techniques—project-based learning, maker education, design thinking workshops—rather than articulating the integrated content architecture that a comprehensive imaginative thinking model should contain (Jiang & Pang, 2023; Seidel et al., 2020). Third, and most critically, model development in this field has rarely been preceded by a rigorous, mixed-methods needs analysis grounded in the perceptions of front-line engineering educators, even though instructional design scholarship identifies needs analysis as the decisive first step of any defensible development effort (McKillip, 1987; Richey & Klein, 2007). Without such analysis, models risk being theoretically elegant yet contextually irrelevant. The gap can therefore be stated plainly: the field has accumulated trials of isolated interventions, but it has not established—empirically and in context—the integrated set of content requirements that should precede model development. Nor can the requirement set simply be imported: creativity and design-thinking interventions developed in well-resourced institutions presume maker spaces, trained facilitators, and proximate high-technology industry that western institutions frequently lack, so a context-sensitive model must be derived from the requirements of the context itself rather than transplanted wholesale (Cai et al., 2020; Wang et al., 2024).

The stakes of this deficit are distributional as much as economic. Local universities in Western China enrol large numbers of first-generation and rurally sourced students, for whom innovation-oriented employability is the most realistic channel through which imaginative capability converts into livelihood (Huang et al., 2025; González-Cespón et al., 2024) ; if their programmes in the region cannot cultivate such capability, their graduates risk exclusion from the very innovation economy that national policy is building (Cai et al., 2020; Kang & Xiong, 2021).

The present study addresses this gap. Situated within a Design and Development Research (DDR) project that ultimately aims to construct and validate an imaginative thinking model for engineering students of local universities in Western China, it reports the project's first phase: a systematic needs analysis combining a survey of 150 engineering educators with in-depth interviews of nine domain experts. Two research questions guided the inquiry:

RQ1: Is there a need to develop an imaginative thinking model to enhance innovative entrepreneurial employability among engineering students of local universities in Western China?

RQ2: What content dimensions should such a model incorporate?

The study contributes to the literature in three ways. Empirically, it provides the first triangulated, region-specific evidence base on the requirements for imaginative thinking cultivation in Western China's engineering education. Conceptually, it distils these requirements into five content dimensions that bridge imaginative education theory, entrepreneurial learning, and innovation ecosystem perspectives. Methodologically, it demonstrates how a disciplined needs analysis can anchor subsequent model development within the DDR tradition, offering a replicable template for educational model builders working in other resource-constrained settings. These are deliberately the contributions of a first phase. The eventual contribution of the full DDR project—a validated and usable imaginative thinking model—rests on the present evidence base but is not claimed by this article.

2. Literature Review

2.1 Imaginative thinking: concept and theoretical anchors

Imaginative thinking denotes the cognitive process through which individuals visualise possibilities beyond immediate reality, recombine disparate ideas, and generate original responses to open-ended situations (Egan, 2005; Samaniego et al., 2024). Although adjacent to creativity, the construct carries a distinctive emphasis on prospection—the capacity to mentally simulate what does not yet exist—which makes it foundational to both innovation and entrepreneurship (Raza et al., 2024). Three theoretical traditions inform the present study. First, design thinking frames imagination as a disciplined, human-centred process in which empathy with users, divergent ideation, and iterative prototyping convert imaginative insight into workable innovation (Brown, 2008; Meinel & von Thienen, 2022). Second, Innovation Diffusion Theory explains how a pedagogical innovation—such as an imaginative thinking model—gains adoption within a social system according to its perceived relative advantage, compatibility, complexity, trialability, and observability (Rogers, 2003); these attributes imply that any new model must demonstrably outperform, fit, and be testable within existing curricula. Third, entrepreneurial ecosystem theory positions individual capability development within a wider configuration of institutional policies, resources, networks, and culture that collectively enable or constrain entrepreneurial outcomes (Stam & van de Ven, 2021; Adner, 2017). Two further frameworks inform the construct's operationalisation. Amabile's (1996) componential theory holds that creative output arises from the interaction of domain-relevant skills, creativity-relevant processes, and intrinsic task motivation, all conditioned by the surrounding environment—implying that imaginative thinking is teachable yet ecosystem-dependent. The Entrepreneurial Event Model (Shapero & Sokol, 1982) similarly positions entrepreneurial action at the intersection of perceived desirability and perceived feasibility, both of which imaginative education is expected to raise. Together, the five lenses suggest that cultivating imagination in engineering students is simultaneously a cognitive, curricular, motivational, and ecological undertaking—too complex for any single-technique intervention, and therefore a proper object of model-level development.

2.2 Fostering imagination and creativity in engineering education

Internationally, a substantial literature documents efforts to strengthen creativity and imagination among engineering students. Systematic reviews report that creativity-oriented interventions—open-ended design tasks, interdisciplinary projects, arts-infused activities—yield consistent gains in students' creative dispositions and design performance (Higuera Martínez et al., 2021; Rabello-Mestre & Otondo, 2021). Design thinking, in particular, has matured from a professional method into an established pedagogical framework: studies show that design thinking instruction enhances engineering students' empathy, ideation fluency, innovation competences, and collaborative behaviours (Charosky et al., 2022; Jiang & Pang, 2023; Turcios-Esquivel et al., 2024; Dorland, 2024). Closely related work demonstrates that project-based learning anchored in authentic industry problems improves both design thinking and future work readiness (Naseer et al., 2025), while maker-education integrated with design thinking strengthens creative tendencies and professional perceptions (Xu et al., 2024). Narrative and storytelling approaches have likewise been shown to raise creative thinking awareness among engineers (Caratozzolo et al., 2020). Notwithstanding these advances, critics note that such interventions are typically short-cycle and course-bound, and that few studies specify the full set of curricular, institutional, and ecosystem elements required to sustain imaginative development at programme level (Quaiser & Pandey, 2023; Seidel et al., 2020). Taken together, these studies establish convincingly that imagination-responsive pedagogies work at the level of the course or workshop. What they leave unresolved is how such techniques should be assembled—in what combination, in what sequence, and under what institutional conditions—to sustain imaginative development across an entire programme. That is a model-level question, and it cannot be answered by adding yet another isolated intervention trial; it requires an empirically derived specification of content requirements, which is precisely what a needs analysis supplies.

2.3 Engineering and innovation–entrepreneurship education in Western China

Within China, the "New Engineering Education" reform has pressed universities to reorient engineering programmes toward innovation, interdisciplinarity, and industrial relevance (Shen et al., 2020). Implementation, however, is regionally uneven. Universities in the western provinces operate with thinner innovation infrastructures, fewer high-technology industry partners, and more constrained funding than their eastern counterparts (Cai et al., 2020; Zhou & Zheng, 2021). Research on innovation and entrepreneurship education in Chinese universities documents persistent challenges: curricula dominated by knowledge transmission, weak university–industry linkage, insufficiently trained instructors, and evaluation systems that poorly accommodate creativity-oriented learning (Wang & Ma, 2022; Mei & Symaco, 2022; Zhou et al., 2024). These constraints have measurable consequences for graduate outcomes: although entrepreneurship education demonstrably improves employability and employment quality (Huang et al., 2025; Jia et al., 2021), its reach and quality in western institutions remain limited, and graduate unemployment pressures have kept the employability question high on the policy agenda (Kang & Xiong, 2021). For Western China specifically, scholars argue that imported, one-size-fits-all models of entrepreneurship and creativity education fit local conditions poorly, and that context-sensitive frameworks are needed (Wang et al., 2024; Shao et al., 2024). Parallel employability research sharpens the picture. Employer surveys and graduate-outcome studies consistently rank creative problem-solving, adaptability, and opportunity recognition among the most demanded—and most deficient—engineering graduate attributes (Huang et al., 2025; González-Cespón et al., 2024). Project-based and interdisciplinary learning demonstrably narrow this deficit where they are implemented (Naseer et al., 2025), yet implementation is precisely what the western context impedes. The confluence of high demand for innovation-capable graduates, thin regional ecosystems, and unreformed pedagogy constitutes a textbook case for needs-driven model development. This diagnosis directly motivates the present needs analysis.

2.4 Needs analysis within design and development research

Design and Development Research (DDR) provides a systematic methodology for constructing educational models, tools, and interventions, proceeding through needs analysis, design and development, and evaluation phases (Richey & Klein, 2007). The needs analysis phase is decisive: it establishes whether a development effort is warranted and specifies the content requirements that subsequent design must satisfy (McKillip, 1987). Methodologically, best practice couples quantitative breadth with qualitative depth—surveys to gauge the distribution of perceived needs across a stakeholder population, and expert interviews to interpret and enrich those perceptions—so that convergent findings can be triangulated (Creswell, 2007; Cohen et al., 2007). Recent DDR studies in educational settings illustrate the value of this disciplined first phase, showing that empirically derived element lists carry greater legitimacy into later expert-consensus procedures (Abdul Latiff et al., 2024; Ghazali et al., 2021). Following this tradition, the present study treats the needs analysis not as a preliminary formality but as the empirical foundation upon which the entire imaginative thinking model is to be built.

One conceptual clarification guides the analysis that follows. The content domains examined in this study are needs-derived content requirements for the prospective model, not five equivalent psychological subscales of imaginative thinking itself. Two of them—Industry Engagement and Innovation Ecosystem Support—function as contextual or enabling requirements: they do not describe facets of students' imagination but conditions under which its cultivation becomes possible within a specific institutional ecology. This reading follows directly from the theoretical lenses of Section 2.1, which map onto distinguishable requirement families—pedagogical process requirements (design thinking), adoption-feasibility requirements (diffusion attributes), motivational-feasibility requirements (the Entrepreneurial Event Model), and contextual-enabling requirements (ecosystem theory)—and it avoids the category error of mistaking support structures for components of the cognitive construct.

3. Methodology

3.1 Research design

The study employed a convergent mixed-methods design embedded in Phase 1 (Needs Analysis) of a DDR project (Richey & Klein, 2007). The division of labour between the two strands was deliberate: the survey identified the breadth of perceived needs and preliminary content requirements across the educator population, while semi-structured expert interviews complemented, clarified, and corroborated those findings with the rationale and detail that closed-ended items cannot carry. The two strands were analysed independently and then integrated through triangulation, allowing the content requirements for the prospective model to be confirmed by two independent evidentiary sources (Creswell, 2007). The resulting preliminary dimensions and elements are the designated output of Phase 1, carried forward into Phase 2 of the DDR process, where they will be refined, prioritised, and structurally organised through expert consensus techniques. Questionnaire items were adapted from validated instruments in prior model-development studies and contextualised for engineering education, with item design informed by Imaginative Education Theory (Egan, 2005), the Entrepreneurial Event Model (Shapero & Sokol, 1982), the Creativity Component Theory (Amabile, 1996), and the adoption attributes of Innovation Diffusion Theory (Rogers, 2003).

The choice of a convergent design over a sequential one was deliberate: because the questionnaire's content domains were already anchored in established theory and validated instruments, the two strands could be fielded against the same content architecture and compared directly, maximising the evidentiary yield of a single phase (Creswell, 2007). Under this logic the interviews were positioned as complementary and corroborative to the survey—not as an exploratory precursor on which the questionnaire depended—so that convergence between the strands could function as a genuine triangulation test. The design also mirrors the dual purpose of needs analysis in the DDR tradition—confirming that a development effort is warranted (a prevalence question, best answered quantitatively) and specifying what the artefact should contain (a content question, best enriched qualitatively) (McKillip, 1987; Richey & Klein, 2007).

3.2 Participants

Purposive sampling was used to recruit information-rich participants directly involved in engineering education (Etikan et al., 2016; Campbell et al., 2020). For the quantitative strand, 150 engineering educators teaching innovation-, entrepreneurship-, or design-related subjects at local universities across Western China constituted the main sample; a separate group of 30 educators, drawn from the same population but excluded from the main survey, participated in the pilot study. A sample of 150 exceeds commonly recommended thresholds for survey-based descriptive research and supports stable statistical interpretation (Cohen et al., 2007; Connelly, 2008). For the qualitative strand, nine experts were recruited from the fields of engineering education, innovation and entrepreneurship education, industry collaboration, and educational management, each possessing more than ten years of relevant professional experience; this size is consistent with qualitative conventions that prioritise depth over breadth (Patton, 1990) and with expert-panel norms in model-development research.

3.3 Instruments

The questionnaire comprised two parts: Part A elicited demographic information (gender, age, teaching experience, primary teaching area, and university location), and Part B presented 30 statements on the requirements for developing an imaginative thinking model, each rated on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). The 30 items spanned five a priori content domains derived from the literature: curricular integration of imaginative learning, entrepreneurship-oriented learning activities, institutional innovation support, industry engagement, and design thinking pedagogy; the feasibility-oriented items operationalised Rogers' (2003) adoption attributes so that the survey could gauge not only what educators value but also whether the conditions for pedagogical adoption are present. Items were adapted from instruments reported in previous model-development and innovation-education studies and recontextualised for engineering education in Western China. Table 1 specifies, for each dimension, the constituent items, their original or adapted source, and the theoretical basis on which they were drafted. Where no suitable published item could be located—particularly for requirements specific to the regional context, such as the availability of seed funding or micro-grants (Item 15) and exposure to real market or user needs (Item 20)—items were newly drafted by the research team. All adapted and newly drafted items underwent expert review by two specialists in educational innovation, who assessed each item for relevance, clarity, and fit to the theoretical domain; items judged ambiguous or redundant were revised or merged before piloting.

Table 1. Dimension–item structure of the questionnaire with item sources and theoretical basis

Dimension	Item(s)	Original/Adapted Source	Theoretical Basis
Imaginative Learning Integration	Items 1, 3, 4, 5, 7	Adapted from curriculum-integration and creativity-instruction items in prior model-development studies, recontextualised for engineering education	Imaginative Education Theory (Egan, 2005); adoption-feasibility attributes (Rogers, 2003)
Entrepreneurial Learning Activities	Items 2, 6, 9, 10, 15	Adapted from entrepreneurial learning and innovation-education instruments; Item 15 newly drafted for the regional funding context	Entrepreneurial learning; Entrepreneurial Event Model (Shapero & Sokol, 1982)
Innovation Ecosystem Support	Items 8, 11, 16, 17, 18	Adapted from institutional innovation-support items in innovation-education studies	Innovation ecosystem theory (Stam & van de Ven, 2021; Adner, 2017); diffusion attributes (Rogers, 2003)
Industry Engagement	Items 12, 13, 14, 19, 20	Adapted from university-industry collaboration instruments; Item 20 newly drafted to capture market-need exposure	Entrepreneurial ecosystem theory (Stam & van de Ven, 2021; Adner, 2017)

Dimension	Item(s)	Original/Adapted Source	Theoretical Basis
Design Thinking Process	Items 21-30	Adapted from design thinking pedagogy instruments covering empathy, ideation, prototyping, and testing cycles	Design thinking (Brown, 2008; Meinel & von Thienen, 2022)

The interview protocol consisted of open-ended questions exploring experts' views on the necessity of the model and the elements it should contain; open-ended formats are recommended when probing complex expert judgements (Patton, 1990). The protocol was reviewed by the same two specialists for relevance and clarity, and revised accordingly before use.

3.4 Validity and reliability

Content validity was established through expert judgement: specialists in teaching pedagogy, entrepreneurship, and creative thinking verified that the instruments covered the key dimensions of the study's conceptual framework and that items were appropriate, meaningful, and useful for their intended purpose. Face validity was checked during the pilot, in which respondents confirmed that items were clear and understandable; minor wording revisions followed. Reliability was assessed with Cronbach's alpha computed in SPSS version 29. The pilot administration ($n = 30$, 30 items) yielded $\alpha = 0.946$, far exceeding the conventional threshold of 0.70 (Nunnally, 1978), indicating excellent internal consistency. It should be stressed that this reliability evidence concerns the internal consistency of the overall questionnaire; it does not by itself validate the five-dimensional structure. The dimensional structure identified in Phase 1 represents a theoretically informed and empirically supported preliminary structure to be further refined and validated in subsequent DDR phases.

3.5 Data collection procedure

Data collection proceeded in six explicit steps. Step 1: the theoretical and literature domains were established, defining the content architecture within which both instruments would operate. Step 2: the questionnaire and the interview protocol were developed in parallel from those domains and underwent expert review for content and face validity. Step 3: the survey was conducted—the pilot study was administered online (Google Forms, one-week window) to the 30 pilot respondents, followed by the main survey distributed to the 150 engineering educators. Step 4: following the survey, semi-structured interviews with the nine experts were conducted, transcribed, and analysed to further elaborate, clarify, and corroborate the needs and content requirements identified through the quantitative findings. Step 5: both strands were analysed independently using the procedures described in Section 3.6. Step 6: the two strands were compared and integrated through triangulation to establish the preliminary content requirements to be carried forward into Phase 2 of the DDR process. Participation in both strands was voluntary, and responses were collected anonymously.

3.6 Data analysis

Quantitative data were analysed descriptively using SPSS version 29, reporting frequencies, percentages, means, and standard deviations. Mean scores were interpreted against a four-band scale: 1.00–2.00 (low), 2.01–3.00 (average), 3.01–4.00 (medium-high), and 4.01–5.00 (high). Qualitative interview data were analysed thematically following a deliberate sequence: transcripts were first coded line by line; the resulting codes were collated into candidate themes; candidate themes were reviewed against the full dataset and refined to ensure internal homogeneity and external distinctiveness; and only after the theme set was finalised was the number (and percentage) of experts mentioning each theme calculated (Creswell, 2007). Because no formal consensus technique (Delphi, NGT, or FDM) was applied in this phase, these percentages are reported as expert mention/agreement coverage—that is, the proportion of experts who raised each theme—rather than as formal consensus scores; formal consensus procedures are reserved for Phase 2 of the DDR project. Finally, findings from the two strands were compared to determine convergence.

3.7 Ethical considerations

The study adhered to standard research ethics for educational inquiry. All participants were informed of the study's purpose, the voluntary nature of participation, and their right to withdraw at any time without consequence. Informed consent was obtained prior to data collection. Questionnaire responses were gathered anonymously, and interview data were de-identified, with experts referenced only by code (Expert 1–Expert 9). Data were stored securely and used solely for research purposes.

4. Findings

4.1 Pilot study

The pilot study was conducted to assess the clarity and internal consistency of the instrument before the main survey. Pilot respondents judged the questionnaire items clear and comprehensible, supporting the instrument's face validity; minor wording adjustments were made without altering item meaning. Reliability analysis produced a Cronbach's alpha of 0.946 for the 30-item scale (Table 2), confirming that the instrument was suitable for the main data collection.

Table 2. Reliability of the needs analysis questionnaire (pilot, n = 30)

No. of items	Cronbach's alpha
30	0.946

4.2 Demographic profile of survey respondents

Table 3 summarises the demographic characteristics of the 150 survey respondents. Gender distribution was nearly balanced (52.0% male, 48.0% female). Age was bimodally distributed, with the youngest (below 30 years) and the most senior (50 years and above) groups each contributing 31.3%, ensuring the inclusion of both early-career and veteran educators. Nearly half of the respondents (54.7%) had more than ten years of teaching experience. All major engineering disciplines were represented, led by electrical engineering (25.3%), civil engineering (22.0%), and mechanical engineering (20.0%). Geographically, respondents were drawn from universities in twelve provincial-level regions of Western China, with the largest contingents from Yunnan Province and the Tibet Autonomous Region (12.0% each). Given the purposive sampling frame, this disciplinary and geographic spread is reported not as statistical representativeness but as broad contextual coverage of the needs assessment.

Table 3. Demographic profile of survey respondents (N = 150)

Variable	**Category**	**n**	**%**
Gender	Male	78	52.0
	Female	72	48.0
Age	Below 30 years	47	31.3
	31–40 years	25	16.7
	41–50 years	31	20.7

Variable	Category	n	%
	50 years and above	47	31.3
Teaching experience	Less than 5 years	30	20.0
	5–10 years	38	25.3
	11–15 years	37	24.7
	More than 15 years	45	30.0
Primary teaching area	Electrical Engineering	38	25.3
	Civil Engineering	33	22.0
	Mechanical Engineering	30	20.0
	Software Engineering	21	14.0
	Other engineering fields	28	18.7
University location	Yunnan Province	18	12.0
	Tibet Autonomous Region	18	12.0
	Chongqing Municipality	15	10.0
	Xinjiang Uyghur Autonomous Region	15	10.0
	Gansu Province	14	9.3
	Sichuan Province	12	8.0
	Qinghai Province	12	8.0
	Inner Mongolia Autonomous Region	12	8.0
	Guizhou Province	8	5.3
	Shaanxi Province	7	4.7
	Ningxia Hui Autonomous Region	6	4.0
	Guangxi Zhuang Autonomous Region	5	3.3
	Other	8	5.3

4.3 Quantitative findings: high agreement on all requirement items

Across all 30 items, mean scores ranged from 3.99 to 4.28 (Table 4). Twenty-nine items fell within the high interpretation band (4.01–5.00), and the remaining item—institutional policy support for innovation and entrepreneurship education (M = 3.99)—fell at the upper edge of the medium-high band. No item attracted disagreement at any meaningful level. The inferential boundary of this evidence should be stated precisely. Because the items asked respondents to evaluate requirements for developing the model, high means directly index educators' perceived importance of the listed development requirements; they demonstrate strong perceived support for the development requirements, and they do not, by themselves, prove that any resulting intervention will improve employability. RQ1 is accordingly answered in terms of perceived need: the uniformly high endorsement—read together with the convergent interview evidence in Section 4.4—constitutes robust evidence that front-line engineering educators perceive a need for a model that systematically cultivates imaginative thinking for innovative entrepreneurial employability.

Table 4. Means and dimension structure of the 30 requirement items (N = 150; five-point scale)

Dimension / Item	M	Band
Dimension 1: Imaginative Learning Integration (dimension M = 4.11)		
1. Integrating imaginative thinking activities improves students' ability to generate innovative solutions	4.23	High
3. Imaginative thinking tasks align well with existing engineering curriculum outcomes	4.03	High
4. Innovation and entrepreneurship learning fits students' background and needs	4.15	High
5. Imaginative thinking tasks can be implemented within current teaching load	4.12	High
7. Small imaginative/design tasks can be piloted without overhauling the course	4.04	High
Dimension 2: Entrepreneurial Learning Activities (dimension M = 4.08)		
2. Embedding entrepreneurship tasks provides clear advantages over traditional assignments	4.17	High
6. Assessing entrepreneurship-oriented projects is manageable in my teaching context	4.08	High
9. Benefits of imaginative and entrepreneurial learning are visible in students' project quality	4.10	High
10. Improved student motivation is observed after integrating innovation tasks	4.07	High
15. Seed funding or micro-grants are available for student prototypes or startups	4.00	High
Dimension 3: Innovation Ecosystem Support (dimension M = 4.09)		
8. Programme allows trial runs of innovation activities before full adoption	4.02	High

Dimension / Item	M	Band
11. University policies support innovation and entrepreneurship education	3.99	Medium-high
16. Labs, maker spaces, or prototyping facilities are sufficiently accessible	4.19	High
17. Academic culture encourages responsible risk-taking and experimentation	4.23	High
18. Failure in innovation projects is recognised as a valuable learning opportunity	4.03	High
Dimension 4: Industry Engagement (dimension M = 4.12)		
12. Clear incentives exist to integrate industry-linked innovation projects	4.26	High
13. Access to mentors or partners (industry, alumni, startups) for student projects	4.09	High
14. Students can access alumni or external networks for venture guidance	4.17	High
19. Industry partners contribute to the design or assessment of innovation coursework	4.04	High
20. Students receive exposure to real market or user needs during projects	4.03	High
Dimension 5: Design Thinking Process (dimension M = 4.16)		
21. Guiding students to understand users' needs before proposing solutions	4.15	High
22. Framing clear problem statements grounded in stakeholder insights	4.11	High
23. Use of divergent idea generation methods (e.g., brainstorming, SCAMPER)	4.21	High
24. Students explore multiple solution pathways before narrowing ideas	4.28	High
25. Students develop early prototypes (low- to mid-fidelity) to test key assumptions	4.28	High
26. Prototyping is embedded as an iterative activity throughout the course	4.07	High
27. Students regularly test prototypes with users and gather feedback	4.09	High
28. Course schedules allow sufficient time for iteration based on test results	4.20	High
29. Explicit teaching of a human-centred, iterative problem-solving mindset	4.17	High
30. Design thinking is integrated across assessments, not just a single assignment	4.03	High

Read by dimension, the pattern of endorsement is coherent. For Imaginative Learning Integration, the highest item affirmed that imaginative activities improve students' generation of innovative solutions (M = 4.23), and the feasibility items within the dimension were likewise endorsed, indicating that integration is perceived as both relevant and feasible. For Entrepreneurial Learning Activities, the clearest advantages were perceived over traditional assignments (M = 4.17), with assessment manageability and visible benefits close behind. For Innovation Ecosystem Support, material and cultural elements—accessible facilities (M = 4.19), risk-tolerant culture (M = 4.23)—outranked formal policy support, which registered the instrument's lowest mean (M = 3.99). For Industry Engagement, incentives for industry-linked projects attracted the strongest agreement of any institutional item (M = 4.26). For the Design Thinking Process, endorsement was uniformly strong across all ten items, with the apex on exploring multiple solution pathways and developing early prototypes (both M = 4.28).

Three features of Table 4 warrant emphasis. First, the Design Thinking Process dimension registered the highest dimension-level mean (4.16), and its two highest items—exploring multiple solution pathways and developing early prototypes (both M = 4.28)—were also the highest items in the entire instrument, signalling that educators see disciplined divergent–convergent ideation and prototyping as the pedagogical core of imaginative thinking cultivation. Second, Industry Engagement produced the strongest single institutional item (incentives for industry-linked projects, M = 4.26), indicating that university–industry connection is perceived not as an optional enrichment but as a central requirement. Third, the relatively lowest item concerned formal institutional policy support (M = 3.99), even though innovation infrastructure (M = 4.19) and a risk-tolerant academic culture (M = 4.23) were strongly endorsed—an early sign that respondents distinguish between formal policy on paper and the lived cultural and material conditions of innovation.

4.4 Qualitative findings: five convergent expert themes

Thematic analysis of the nine expert interviews yielded five themes that correspond exactly to the five questionnaire dimensions (Table 5). Three themes—Design Thinking Process, Entrepreneurial Learning Activities, and Innovation Ecosystem Support—were mentioned by all nine experts (100% mention coverage), while Industry Engagement and Imaginative Learning Integration were each mentioned by eight of the nine experts (89%). These figures represent the proportion of experts who raised each theme during the interviews—an index of mention/agreement coverage—and should not be read as formal Delphi, NGT, or FDM consensus scores, which belong to Phase 2. The quotations presented below are illustrative: each theme rests on the full set of coded extracts across the eight or nine mentioning experts, and no theme derives from any single quotation.

Table 5. Interview themes and expert mention coverage (N = 9 experts)

Theme	Experts mentioning	Mention coverage
Design Thinking Process	9	100%
Entrepreneurial Learning Activities	9	100%
Innovation Ecosystem Support	9	100%
Industry Engagement	8	89%
Imaginative Learning Integration	8	89%

Imaginative Learning Integration. Experts emphasised that embedding imaginative activities shifts students from passive knowledge acquisition to active problem exploration. One observed that "the most significant change is the transformation of students from passive problem solvers to active problem definers" (Expert 1), while another noted that "creative activities provide the perfect melting pot for integrating different professional knowledge to solve complex real-world problems" (Expert 5).

Entrepreneurial Learning Activities. Experts highlighted project-based learning and innovation competitions as authentic training environments: “students have transitioned from being knowledge consumers to becoming knowledge integrators and creators” (Expert 2); “innovation competitions often serve as real training grounds that complement professional knowledge taught in the classroom” (Expert 1).

Innovation Ecosystem Support. Experts stressed that innovative pedagogy requires material and institutional backing—“access to maker spaces, laboratories, and innovation platforms plays a critical role in supporting students’ innovation projects” (Expert 7)—while cautioning that prevailing evaluation regimes can suppress it: “creative teaching activities are often difficult to evaluate using traditional standardized assessment methods” (Expert 1).

Industry Engagement. Experts valued external mentors for injecting market realism: “industry mentors often provide market insights and point out practical limitations of student prototypes” (Expert 1); “external mentors bring the impact of market authenticity and force teams to reconsider real application scenarios” (Expert 2).

Design Thinking Process. The most extensively discussed theme. Experts linked meaningful innovation to user insight—“true innovation stems from deep insight into user needs and specific contexts” (Expert 4)—and to the disciplined interplay of divergence and convergence: “innovation activities encourage divergent thinking followed by convergence based on evaluation criteria” (Expert 6).

4.5 Triangulation of survey and interview evidence

The two strands converged completely. Every dimension that educators endorsed statistically was independently articulated by the expert panel, and the rank ordering of emphasis was broadly consistent: design thinking dominated both datasets, and industry engagement ranked high in each. The interviews additionally explained the survey’s most subtle result—the policy-culture gap—by identifying assessment regimes, rather than formal policy, as the practical bottleneck. Table 6 summarises the triangulation dimension by dimension: for each of the five dimensions, high survey endorsement coincided with near-complete or complete expert mention coverage, and each dimension is accordingly interpreted as a supported preliminary content requirement, with the Design Thinking Process the most strongly supported.

Table 6. Triangulation of survey and interview evidence by dimension

Dimension	Survey Evidence	Interview Evidence	Phase 1 Interpretation
Imaginative Learning Integration	High item means (dimension M = 4.11)	8/9 experts	Supported as preliminary requirement
Entrepreneurial Learning Activities	High item means (dimension M = 4.08)	9/9 experts	Supported as preliminary requirement
Innovation Ecosystem Support	High item means (dimension M = 4.09)	9/9 experts	Supported as preliminary requirement
Industry Engagement	High item means (dimension M = 4.12)	8/9 experts	Supported as preliminary requirement
Design Thinking Process	Highest dimension mean	9/9 experts	Strongly supported as

Dimension	Survey Evidence	Interview Evidence	Phase 1 Interpretation
	(M = 4.16)		preliminary requirement

Triangulation therefore strengthens the credibility of the needs analysis (Creswell, 2007): RQ1 is answered by two independent evidence sources pointing to the same perceived need, and RQ2 is answered by a stable set of five preliminary content dimensions (Figure 1). These triangulated findings constitute the Phase 1 output to be carried forward into Phase 2, where the elements will be refined, prioritised and structurally organised.

Figure 1. Five preliminary content dimensions for the prospective imaginative thinking model, derived from survey and interview triangulation.

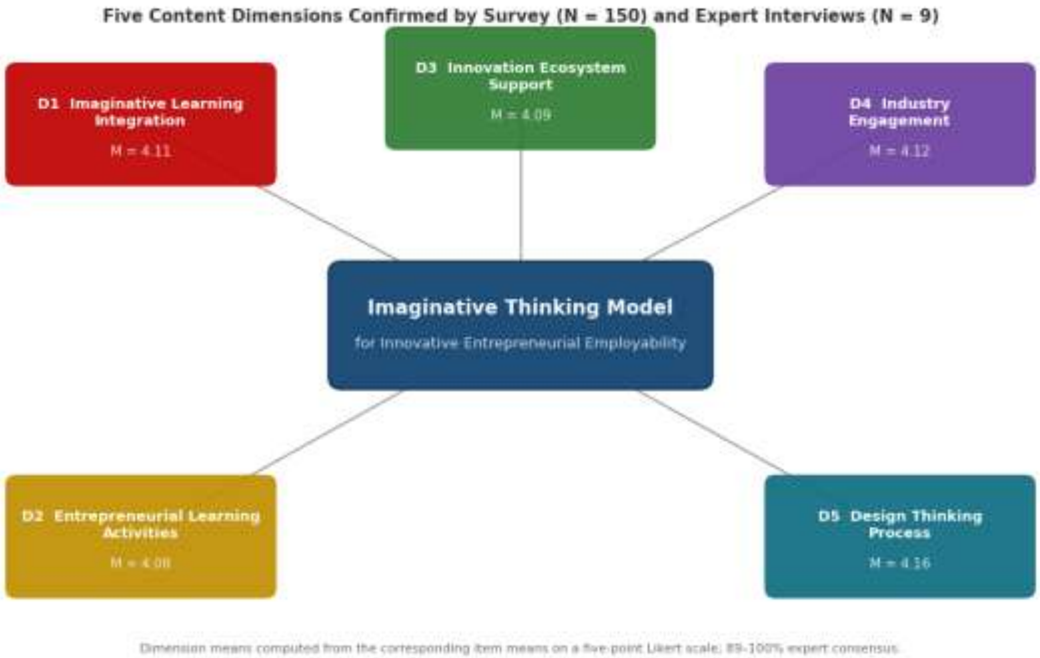

Figure 1. Five preliminary content dimensions for the prospective imaginative thinking model, derived from survey and interview triangulation.

5. Discussion

5.1 A confirmed and multidimensional need

The strong confirmation of perceived need (RQ1) merits interpretation beyond its surface uniformity. The ten items addressing feasibility and advantage map closely onto Rogers' (2003) five attributes of adoptable innovations: respondents endorsed the relative advantage of imaginative and entrepreneurial tasks over traditional assignments (M = 4.17), their compatibility with curriculum outcomes and student backgrounds (M = 4.03–4.15), their manageable complexity within existing teaching loads (M = 4.08–4.12), their trialability through small-scale pilots and programme-level trial runs (M = 4.02–4.04), and their observability in project quality and student motivation (M = 4.07–4.10). In diffusion terms, the findings suggest that the educator population is signalling willingness to adopt: the barrier appears to be not willingness but the absence of a structured, context-appropriate model through which to act. This reading should be bounded precisely: the survey measured perceptions rather than adoption behaviour, so the evidence indicates favourable perceived conditions for adoption rather than demonstrated adoption readiness.

5.2 Design thinking as the pedagogical core

The primacy of the Design Thinking Process dimension—highest dimension mean, both of the instrument's highest items, and mention by all nine experts—aligns with international evidence that design thinking is the most mature vehicle for converting imagination into innovation capability (Brown, 2008; Charosky et al., 2022; Jiang & Pang, 2023). The two apex items (multiple solution pathways; early prototyping, M = 4.28 each) mirror the divergent–convergent rhythm that experts described ("divergent thinking followed by convergence based on evaluation criteria"), corroborating studies in which structured ideation and prototyping produced the largest innovation-competence gains (Meinel & von Thienen, 2022; Turcios-Esquivel et al., 2024). For Western China, the finding carries a practical corollary: rather than importing elaborate creativity programmes, a model can build on pedagogical behaviours—brainstorming, SCAMPER, low-fidelity prototyping, user testing—that educators already value and partially practise, lowering the adoption threshold identified by diffusion theory (Xu et al., 2024; Naseer et al., 2025). Equally instructive is what the lower-ranked items within the dimension reveal. Integrating design thinking across assessments (M = 4.03) and securing iteration time within course schedules (M = 4.20) lag the ideation and prototyping apex, suggesting that educators find the activities of design thinking easier to endorse than its assessment regime. This echoes international reports that design thinking gains stall when institutions fail to align evaluation practices with iterative, process-based learning (Dorland, 2024; Quaiser & Pandey, 2023), and it previews a design requirement: the model must specify not only what teachers do in class but how imaginative work is evidenced and assessed.

5.3 Industry engagement as a compensating mechanism in a thin ecosystem

The strong endorsement of Industry Engagement (incentives item M = 4.26; mentioned by eight of nine experts) must be read against the region's structural weakness: Western China possesses fewer high-technology industries and thinner innovation networks than the coastal belt (Cai et al., 2020; Zhou & Zheng, 2021). Entrepreneurial ecosystem theory predicts that where formal ecosystem elements are scarce, actors compensate by intensifying the use of available relational channels (Stam & van de Ven, 2021; Adner, 2017). One possible interpretation of the present findings, supported by the interview evidence, is that educators prize precisely those mechanisms—industry-linked project incentives, alumni and mentor networks, industry participation in coursework assessment—because they may partially substitute for missing market proximity. This compensatory reading remains an interpretation rather than a demonstrated causal mechanism. Experts' accounts of mentors who "force teams to reconsider real application scenarios" illustrate how external stakeholders may supply the market authenticity that the local environment cannot yet provide organically (Maritz et al., 2022; Jurgelevičius et al., 2025). If this interpretation holds, a model for this region should treat industry engagement not as an ancillary partnership but as a designed-in complement to the thin local ecosystem. A diffusion logic points the same way: mentors, alumni networks, and industry assessors act as external opinion leaders whose visible involvement raises the observability and trialability of innovation pedagogy (Rogers, 2003), and comparative studies likewise find relational infrastructures predicting programme vitality more strongly than physical facilities alone (Maritz et al., 2022; Jurgelevičius et al., 2025; Boodai & Boodai, 2025)—a pattern with which the present findings are consistent.

5.4 The policy–culture gap within innovation ecosystem support

The most diagnostic survey result is the contrast between the lowest item (formal policy support, M = 3.99) and the high endorsement of innovation infrastructure (M = 4.19) and risk-tolerant culture (M = 4.23). The interviews offer a plausible resolution of this apparent paradox: policies supporting innovation nominally exist, but evaluation systems—"traditional standardized assessment methods"—appear to blunt their effect, a complaint echoing national studies of Chinese entrepreneurship education (Wang & Ma, 2022; Mei & Symaco, 2022; Zhou et al., 2024). The finding suggests that ecosystem support operates less through formal policy instruments than through material resources and cultural signals: recognising exploratory failure as learning (M = 4.03) and rewarding responsible risk-taking matter more to educators than additional policy documents. This has direct design implications for the model's support dimension, which must embed evaluation reform and failure-tolerant norms rather than merely invoke policy alignment (Stam & van de Ven, 2021).

5.5 A region-specific signature: the centrality of teacher capacity

A distinctive feature of the interview corpus is how persistently experts returned to teacher-side conditions—pedagogical capability, methodological coaching skills, institutional recognition of innovative teaching—as prerequisites for any imaginative thinking intervention. It should be clarified that teacher capacity was not itself represented among the 30 questionnaire items or within the five dimensions; it emerged from the expert interviews as an additional, cross-cutting implementation consideration, rather than constituting a fully established sixth dimension. This emphasis is considerably weaker in studies from well-resourced systems, where design thinking faculty development is comparatively institutionalised (Charosky et al., 2022; Seidel et al., 2020). In Western China's local universities, by contrast, instructors are themselves products of examination-centred training and have few opportunities to acquire creativity-oriented pedagogy (Zhou & Zheng, 2021; Feng et al., 2024). The interview evidence thus carries a clear message for Phase 2: the model should allocate explicit elements to educator training, role transformation, and professional recognition, or its student-facing components may not be implementable. The point connects to a broader observation in the employability literature: pedagogical innovation travels only as far as teacher capability carries it, and employability-oriented reforms that neglect faculty development systematically underperform (Huang et al., 2025; González-Cespón et al., 2024). In diffusion terms, teachers are simultaneously the adopters and the adoption channel; a model that ignores their incentives and preparation violates the compatibility and complexity conditions that Rogers (2003) identifies as decisive.

5.6 Theoretical and methodological implications

Theoretically, the study extends imaginative education scholarship (Egan, 2005; Raza et al., 2024) by suggesting that the need for imagination cultivation is not uniform but appears to take a specific five-dimensional shape in a resource-constrained regional system, thereby linking a cognitive construct to curricular and ecological conditions. The five dimensions integrate the three guiding lenses—design thinking (pedagogy), diffusion attributes (adoption feasibility), and entrepreneurial ecosystems (support structures)—into a single, empirically grounded preliminary content architecture, offering a transferable analytical template for imagination-oriented curriculum research. Methodologically, the study exemplifies how the DDR needs analysis phase can be executed with mixed-methods rigour: a reliable instrument ($\alpha = 0.946$), a broad educator sample, expert thematic analysis with mention-coverage quantification, and explicit triangulation (Richey & Klein, 2007; Creswell, 2007). This disciplined sequencing addresses a common weakness of educational model studies, whose element lists are too often asserted rather than demonstrated (McKillip, 1987; Abdul Latiff et al., 2024).

5.7 Limitations

Four limitations qualify these findings. First, the geographic scope is confined to local universities in Western China; the five dimensions may require recalibration before use in other regions or institutional types. Second, the sample comprised engineering educators and experts only; student and industry-employer perspectives, though indirectly represented through educator judgements, were not measured directly. Third, survey data are self-reported perceptions of need rather than observed teaching behaviour, and purposive sampling limits statistical generalisability (Etikan et al., 2016). Fourth, the cross-sectional design captures needs at a single point in a rapidly reforming policy environment. Fifth, the five-dimensional structure was not subjected to factorial validation (for example, exploratory or confirmatory factor analysis) in Phase 1; the dimensions are theoretically derived and empirically endorsed, but their psychometric structure awaits testing. This is not necessarily a weakness—the study is intentionally a needs analysis, which identifies content requirements rather than validating measurement structures—but the boundary should be transparent. These limitations are inherent to a needs analysis phase and will be partially mitigated as the model undergoes expert-based development and usability evaluation in subsequent DDR phases.

6. Conclusion

This study set out to establish whether an imaginative thinking model is needed to enhance engineering students' innovative entrepreneurial employability in Western China's local universities, and what content such a model should contain. Five conclusions follow. First, the need for the model is strongly supported as a perceived need: survey evidence from 150 engineering educators showed uniformly high agreement (M = 3.99–4.28) across all 30 requirement items. Second, the needs analysis yielded five preliminary content dimensions—Imaginative Learning Integration, Entrepreneurial Learning Activities, Innovation Ecosystem Support, Industry Engagement, and Design Thinking Process—which are needs-derived content requirements rather than validated psychological subscales of imaginative thinking. Third, the survey and interview findings converged fully: every dimension endorsed statistically was independently articulated by the expert panel (mention coverage of 89–100%), and the triangulated structure therefore carries the combined weight of both evidence strands. Fourth, these dimensions form the evidence base for Phase 2: they constitute the Phase 1 output of the DDR project and will now be refined, prioritised, and structurally organised through expert consensus techniques. Fifth, the boundary of the present claims should be explicit—the model itself has not yet been developed, validated, or shown to be effective; those demonstrations belong to Phases 2 and 3 of the project. The needs analysis also offers a transferable lesson beyond this project: in resource-constrained higher education systems, the demand for imaginative thinking cultivation is real and broadly shared among educators, but it is conditional—contingent on assessment regimes that reward iteration, on industry channels that compensate for thin local ecosystems, and on teachers who are trained and recognised for innovative pedagogy. Reformers are therefore advised to treat imagination not as a course topic to be added but as a system property to be engineered across pedagogy, assessment, partnership, and culture simultaneously. Future research should extend the needs perspective to students and employers, track the development and validation of the model in the subsequent DDR phases, and ultimately test whether models built on these five dimensions measurably improve imaginative capability, innovation-oriented employability, and entrepreneurial outcomes in authentic classroom settings.

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