The Vertical City Studio: A Pedagogical Research Design for Integrating Vertical City Concepts into Fourth-Year Architectural Education at Khon Kaen University*

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Abstract: This study presents a three-year longitudinal pedagogical research design examining the integration of "Vertical City" studio projects into the fourth-year architectural curriculum at Khon Kaen University (KKU), Thailand. The research involved 12 students per cohort enrolled in a design studio of five studio hours per week, utilizing Khon Kaen Municipality and its surrounding non-urban periphery as the primary site contexts. Unlike conventional high-rise typologies or mixed-use towers, the "Vertical City" is defined here as a self-contained, multi-scalar urban ecosystem vertically organized to integrate residential, productive, ecological, and infrastructural systems within a single structural framework. The research employed a structured evaluation matrix assessing four dimensions: (1) creative thinking, (2) systems thinking, (3) engineering integration, and (4) structural feasibility, scored on a four-point rubric applied consistently across three cohorts through formal review panels. Results indicate progressive competency development across all four dimensions, with creative thinking and systems thinking demonstrating the most significant gains, while structural feasibility remained the least developed domain throughout all three cycles. The findings suggest that iterative thematic studios foster interdisciplinary design capability; however, structural realism and engineering collaboration require deliberate curricular reinforcement. This study contributes to the body of knowledge on speculative design pedagogy in Southeast Asian architectural education by proposing a replicable, evidence-based studio model that balances imaginative exploration with technical rigor.

Keywords: Architectural Pedagogy, Vertical City Design, Sustainable Urbanism, Design Studio Education, Longitudinal Studio Research.

Dikey Şehir Stüdyosu: Khon Kaen Üniversitesi'nde Dördüncü Sınıf Mimarlık Eğitimine Dikey Şehir Kavramlarını Entegre Etmek İçin Pedagojik Bir Araştırma Tasarımı

Özet: Bu çalışma, Tayland'daki Khon Kaen Üniversitesi'nde (KKU) dördüncü sınıf mimarlık müfredatına "Dikey Şehir" stüdyo projelerinin entegrasyonunu inceleyen, üç yıllık uzunlamasına bir pedagojik araştırma tasarımını sunmaktadır. Araştırmaya, haftada beş saatlik bir tasarım stüdyosuna kayıtlı her kohorttan 12 öğrenci katılmıştır; çalışma, Khon Kaen Belediyesi ve çevresindeki kentsel olmayan alanları birincil saha bağlamı olarak kullanmıştır. Geleneksel yüksek katlı tipolojiler veya karma kullanımlı kulelerden farklı olarak, "Dikey Şehir" burada, konut, üretim, ekoloji ve altyapı sistemlerini tek bir yapısal çerçeve içinde bütünleştirmek üzere dikey olarak organize edilmiş, kendi kendine yeten, çok ölçekli bir kentsel ekosistem olarak tanımlanmaktadır. Araştırmada, dört boyutu değerlendiren yapılandırılmış bir değerlendirme matrisi kullanılmıştır: (1) yaratıcı düşünme, (2) sistemsel düşünme, (3) mühendislik entegrasyonu ve (4) yapısal uygulanabilirlik; bu boyutlar, resmi değerlendirme panelleri aracılığıyla üç kohort boyunca tutarlı bir şekilde uygulanan dört puanlık bir derecelendirme ölçeğine göre puanlanmıştır.

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Sonuçlar, dört boyutun tamamında kademeli bir yetkinlik gelişimi olduğunu göstermektedir; yaratıcı düşünme ve sistemsel düşünme alanlarında en önemli ilerlemeler kaydedilirken, yapısal uygulanabilirlik üç döngü boyunca en az gelişme gösteren alan olarak kalmıştır. Bulgular, yinelemeli tematik stüdyoların disiplinlerarası tasarım yeteneğini geliştirdiğini ortaya koymaktadır; ancak yapısal gerçekçilik ve mühendislik işbirliği, müfredatın bilinçli bir şekilde güçlendirilmesini gerektirmektedir. Bu çalışma, hayal gücüyle yapılan keşif ile teknik titizliği dengeleyen, tekrarlanabilir ve kanıta dayalı bir stüdyo modeli önererek, Güneydoğu Asya mimarlık eğitimindeki spekülatif tasarım pedagojisi alanındaki bilgi birikimine katkıda bulunmaktadır.

Anahtar Kelimeler: Mimari Pedagoji, Dikey Şehir Tasarımı, Sürdürülebilir Şehircilik, Tasarım Stüdyosu Eğitimi, Boylamsal Stüdyo Araştırması.

1.INTRODUCTION

The accelerating pace of global urbanization has emerged as one of the defining challenges of the twenty-first century. According to recent projections, more than 68% of the world's population is expected to reside in urban areas by 2050 [1], placing unprecedented demands on urban infrastructure, ecological systems, and spatial governance. Within this context, architectural education faces a dual imperative: to equip graduates with technically rigorous professional competencies while simultaneously cultivating the visionary and speculative capacities required to reimagine urban futures beyond conventional paradigms [2, 3].

Historically, conventional architectural curricula in Southeast Asia have prioritized pragmatic training aligned with professional licensing requirements, often at the expense of speculative, systems-level design thinking[4, 5]. This pedagogical orientation tends to produce competent practitioners capable of replicating established typologies but less prepared to confront complex, cross-scalar urban problems that demand interdisciplinary synthesis [6]. The resulting gap between technical proficiency and visionary capacity represents a significant challenge for programs seeking to prepare architects for roles that extend beyond conventional building design into urban strategy, environmental stewardship, and social innovation.

The concept of the "Vertical City" offers a productive framework for addressing this pedagogical gap. Distinguished from conventional high-rise buildings, mixed-use towers, or isolated megastructures, the Vertical City is theorized in this study as a self-contained urban ecosystem that vertically integrates residential, productive, ecological, and infrastructural systems within a coherent structural and spatial logic. This definition, elaborated in the theoretical framework section, draws on and critically extends the metabolist urban visions of the 1960s [7], contemporary proposals for ecological urbanism [8], and speculative competition platforms such as eVolo and Vertical Cities Asia [9, 10].

Introducing the Vertical City as a recurring studio theme at KKU responds to two specific institutional conditions. First, the fourth-year studio structure at KKU allows students to elect specialized thematic studios aligned with faculty research, creating conditions for sustained, iterative engagement with complex design problems. Second, the regional context of Khon Kaen — a rapidly growing secondary city in northeastern Thailand confronting issues of urban densification, agricultural land loss, and climate vulnerability — provides an empirically grounded site framework for speculative design inquiry.

This paper presents the findings of a three-year longitudinal pedagogical research project examining how students' competencies in creative thinking, systems thinking, engineering integration, and structural feasibility develop across successive iterations of the Vertical City studio. The study addresses the following research questions:

- RQ1: How do students' creative thinking and systems thinking capacities develop across three successive cohorts of the Vertical City studio?
- RQ2: To what extent does iterative thematic pedagogy support the progressive integration of engineering systems in student design proposals?
- RQ3: What are the persistent gaps and limitations of the current studio model, and how might they be addressed in future iterations?

The contribution of this study is twofold: methodologically, it proposes a structured evaluation rubric applicable to speculative design studios; pedagogically, it offers an evidence-based model for integrating vertical city design into architectural education in a Southeast Asian regional university context.

2. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

Defining the "Vertical City": A Critical Distinction

The term "Vertical City" is employed in both professional and academic discourse with considerable variation, often conflated with adjacent typologies that differ in scalar, programmatic, and systemic terms. For the purposes of this study, a precise definitional boundary is necessary.

A conventional high-rise building is defined as a structure exceeding a threshold height (typically 35 meters or approximately 12 floors) designed primarily for a singular functional category — office, residential, or hotel — within an existing urban fabric [11]. A mixed-use tower extends this model by stacking multiple functional categories — typically retail, office, and residential — within a single vertical structure, but remains fundamentally dependent on surrounding urban infrastructure for mobility, energy, water, and food systems [12].

A megastructure, as theorized by Banham (1976) and elaborated through the Metabolist movement, refers to large-scale structural frameworks designed to accommodate urban growth through the insertion of interchangeable, modular units [13]. While megastructures share the scalar ambition of the Vertical City, they are distinguished by their explicit reliance on a base infrastructure that supports rather than integrates urban systems.

The Vertical City, as operationalized in this study, is defined as a vertically organized, self-contained urban ecosystem that integrates, within a single architectural framework, the following interdependent systems: (a) residential and social program, (b) food production (typically vertical agriculture), (c) renewable energy generation, (d) water collection and recycling, (e) waste processing, and (f) internal mobility networks. This integration is not merely additive or diagrammatic; it implies genuine systemic interdependence, wherein the outputs of one subsystem constitute the inputs of another, approximating a closed-loop metabolic logic. This definition aligns with and extends the concept of "ecological urbanism" proposed by Mostafavi and Doherty [8], while also engaging with emerging research on building-scale urban metabolism [14].

This definitional framework distinguishes the Vertical City not only from high-rise and mixed-use typologies, but also from competition-based speculative proposals (such as eVolo entries) that prioritize formal and conceptual innovation without requiring systemic feasibility, and from Metabolist and Archigram precedents, which envisioned urban adaptability at the infrastructure level rather than the self-contained ecosystem level.

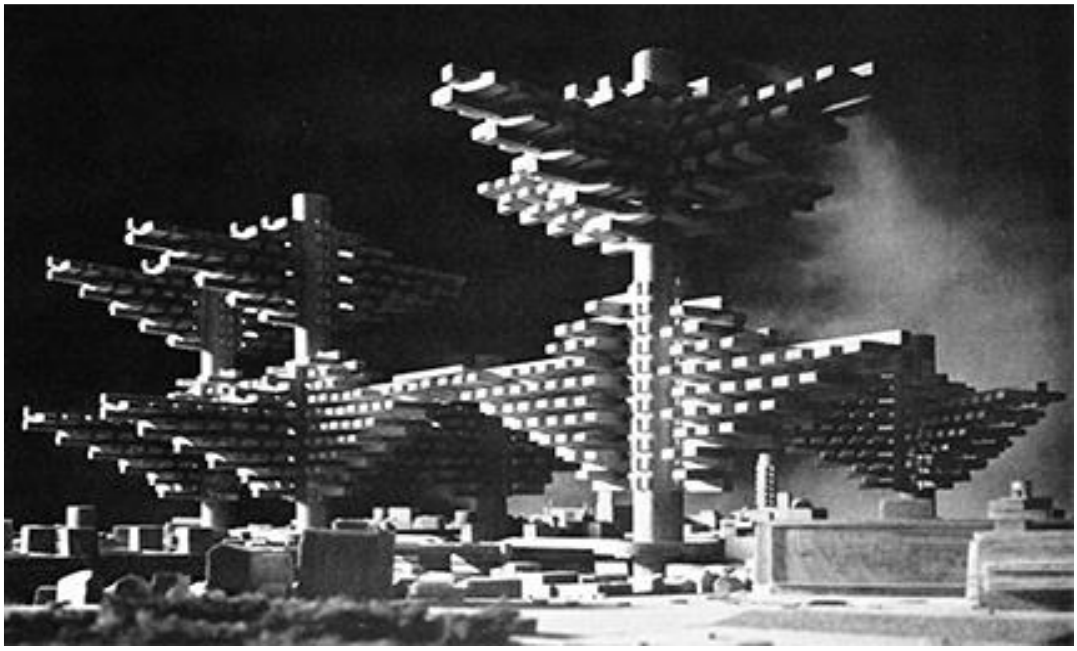

Figure 1. The City in the Air by Arata Isozaki in the Metabolism movement [15] Sources: https://architizer.com/blog/inspiration/collections/beyond-metabolism/

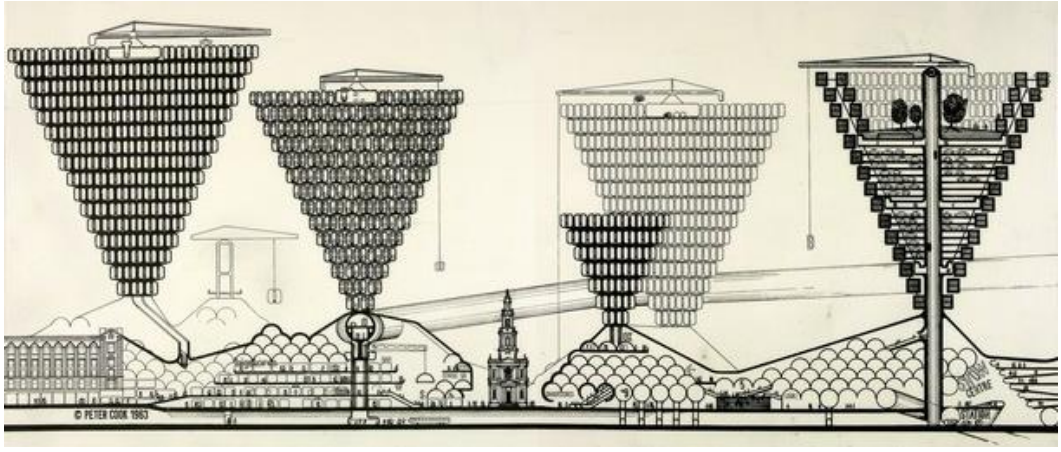

Figure 2. The Plug-In City by Peter Cook in the Archigram movement [16]

Studio-Based Teaching and Vertical City Pedagogy

Studio-based learning remains the epistemological core of architectural education, functioning as a site of reflective practice in which students engage in iterative cycles of proposal, critique, and revision [17]. Within this tradition, the design studio serves simultaneously as a laboratory, a community of practice, and a space for disciplinary socialization [18].

The integration of vertical city themes into design studios has been explored at several leading institutions. Programs at the National University of Singapore have emphasized bioclimatic adaptation within dense tropical contexts. Researchers and students at the NUS Department of Architecture integrate traditional passive design with cutting-edge technology to achieve sustainable, comfortable urban environments [19]. Studios at the University of Hong Kong have interrogated the phenomenological dimensions of vertical

living in high-density environments [20]; and initiatives at MIT have applied systems-based analysis frameworks to evaluate the performance of speculative urban proposals [21]. These precedents share a commitment to framing the studio as a site of analytical rigor rather than purely formal exploration.

In the Southeast Asian context, and specifically within Thai architectural education, research on speculative urban design pedagogy remains relatively sparse [22]. Most documented studio experiments in the region focus on heritage conservation, tropical climate-responsive design, or community-based participatory methods, leaving a gap in the literature concerning radical urban speculation as a pedagogical tool. This study addresses that gap directly.

Theoretical Foundations: Bruner, Frampton, and Ecological Urbanism

Three theoretical frameworks inform the pedagogical design of the studio and the interpretation of its outcomes.

First, Bruner's (1960) concept of the Spiral Curriculum provides the structural logic for the three-year iterative design. Bruner proposed that any subject can be taught effectively in some intellectually honest form to learners at any stage of development, provided that the curriculum returns to foundational concepts with increasing complexity and abstraction [23]. In the context of this studio, the recurring theme of the Vertical City functions as the spiral axis, with each annual cohort confronting the same conceptual territory at a progressively higher level of systemic complexity — from programmatic organization (Year 1), to specialized conceptual investigation (Year 2), to integrated systems synthesis (Year 3). Critically, Bruner's model is not merely applied as a rhetorical analogy in this study; it is operationalized through the deliberate incremental modification of studio briefs and the structured accumulation of evaluation criteria across cohorts.

Second, Frampton's (1995) concept of tectonics — the poetics of construction as an expression of structural and material logic — provides the theoretical basis for evaluating structural feasibility in student proposals [24]. Frampton argues that architectural integrity cannot be separated from the material and constructive reality of a building; speculative design that neglects tectonic grounding risks becoming scenographic rather than architectural. In this study, Frampton's framework is employed not to constrain student imagination but to identify the boundary between productive speculation and constructive implausibility — a boundary that, as the results indicate, students consistently struggled to negotiate across all three cohorts.

Third, Mostafavi and Doherty's (2010) framework of Ecological Urbanism informs the environmental dimension of the studio brief. Ecological Urbanism proposes that urban design must move beyond efficiency — reducing harm — toward regenerativity — actively restoring ecological functions. This framework directly shaped the Year 3 brief's emphasis on distributed renewable energy, closed-loop water and waste systems, and biophilic integration, and provides the conceptual language for interpreting the observed improvements in systems thinking across cohorts.

Research Gap and Originality

While vertical city design has been explored in competition contexts (eVolo, VCA) and in studios at globally prominent institutions, no documented study has examined a multi-year, iterative vertical city studio within a regional Southeast Asian university context using a structured longitudinal evaluation framework. Furthermore, existing pedagogical literature on speculative urban design studios does not offer a replicable evaluation rubric capable of quantitatively tracking competency development across the four dimensions identified in this study. This research therefore contributes an original, context-specific, and methodologically transferable pedagogical model to the existing literature.

3. RESEARCH DESIGN AND METHODOLOGY

Research Design

This study employs a longitudinal, quasi-experimental single-case research design, examining three successive cohorts of students enrolled in the Vertical City elective studio at the Faculty of Architecture, Khon Kaen University, over a period of three academic years. The case study approach is justified by the bounded, context-specific nature of the phenomenon under investigation [25] and by the absence of comparable documented precedents in the Thai architectural education context.

It is acknowledged that the single-case, single-instructor design introduces limitations regarding generalizability and the potential for observer bias. These limitations are addressed in Section 7 (Limitations and Future Research).

Participants and Context

Each cohort consisted of 12 fourth-year architecture students who voluntarily selected the Vertical City studio from among six available elective studio options. Selection was self-directed, with no formal pre-screening criteria applied; however, all participants had successfully completed the foundational three-year core curriculum, ensuring a comparable baseline level of design competency. Demographic data (age, gender, prior GPA) were recorded but are not reported here in order to protect participant anonymity in accordance with institutional ethical guidelines.

The studio was conducted over a 16-week semester, with five studio contact hours per week, supplemented by individual consultations and two formal review panels per semester. All participants provided written informed consent for the use of their work in this study. The research protocol was reviewed and approved by the Faculty of Architecture's internal academic review process prior to data collection.

Site Context: Khon Kaen as a Research Setting

Khon Kaen, the administrative and economic capital of northeastern Thailand, was selected as the primary site context for this study on the basis of three criteria: (1) its status as a rapidly growing secondary city confronting documented challenges of urban densification and agricultural land conversion [26]; (2) its geographic and cultural distance from Bangkok, which reduces students' tendency to replicate metropolitan typologies and encourages contextually grounded speculation; and (3) its institutional proximity to KKU, which affords students direct access to site documentation, municipal planning data, and community stakeholders.

In Year 1, students worked with real urban sites within Khon Kaen Municipality, selected through a structured site analysis exercise based on criteria including land availability, transportation access, and proximity to existing services. In Years 2 and 3, students were directed to a designated non-urban peripheral site in Khon Kaen Province, chosen to eliminate existing infrastructural constraints and maximize programmatic autonomy.

Studio Brief and Assignment Structure

Each year's brief was designed to build incrementally on the conceptual and technical demands of the previous cycle. The briefs shared a common core requirement — the design of a vertically organized, self-contained urban community — but differed in site context, programmatic emphasis, and systems integration requirements, as summarized in Table 1 below.

The assignment was structured in four sequential phases: (1) site and precedent analysis, (2) conceptual proposal and schematic design, (3) systems integration and technical development, and (4) final design presentation and formal review.

Data sources comprised: (a) student design portfolios (drawings, models, diagrams, and technical documentation) submitted at the end of each semester; (b) studio instructor field notes recorded during desk critiques and review sessions; and (c) brief post-review verbal reflections from students, summarized by the instructor. Portfolio data were analyzed.

4. RESULTS

Year 1: Programmatic Application on Urban Sites

In the first cycle, students were tasked with applying the Vertical City concept to real urban sites within Khon Kaen Municipality. Site selection was guided by a structured analysis exercise evaluating land availability, transportation connectivity, and proximity to existing municipal services. The studio brief required students to design a vertically organized community accommodating residential, retail, agricultural, public, and support functions.

Analysis of the Year 1 portfolios revealed that the predominant design strategy consisted of the vertical replication of conventional horizontal urban patterns. Programs were organized in recognizable configurations — retail at the lower levels, residential in the mid-section, and agricultural or public space at the upper levels — that closely mirrored standard mixed-use tower typologies.

The most significant finding of the Year 1 cycle was the near-complete absence of substantive engineering integration. Structural logic, mechanical services, and vertical circulation systems were either absent from proposals or represented only symbolically, without dimensional, material, or technical specificity. This observation suggests that fourth-year students, despite three years of foundational technical training, had not yet developed the cognitive frameworks necessary to translate structural and services knowledge into the context of a radical, large-scale speculative project.

Pedagogically, the Year 1 results indicated that the principal barrier to deeper design development was not lack of technical knowledge per se, but an insufficient conceptual framework for understanding the Vertical City as a systemic entity rather than a stacked collection of conventional programs. This finding directly shaped the modified brief for Year 2.

Figure 3. The students' works, 1st year

Year 2: Specialized Conceptual Innovation on Non-Urban Sites

In response to the Year 1 findings, the Year 2 brief introduced two significant modifications: (1) the site was relocated to a non-urban peripheral area of Khon Kaen Province, eliminating existing infrastructural constraints; and (2) students were organized into thematic interest groups and asked to design a cluster of functionally specialized Vertical Cities that together would constitute a self-sufficient community.

The resulting proposals represented a marked expansion of conceptual ambition. Distinct thematic clusters emerged organically from students' self-selected interests: (a) residential-focused vertical communities emphasizing social cohesion and shared space; (b) agriculturally-focused towers centered on vertical farming and food sovereignty; (c) energy-producing structures organized around renewable generation systems; (d) a vertical Buddhist temple community integrating contemplative space with sustainable living; and (e) air-purification-focused towers designed to address regional particulate matter challenges.

A notable secondary outcome of the Year 2 cycle was the significant social visibility of student proposals: several projects were shared widely across Thai social media and architectural online platforms, generating public interest in the speculative potential of vertical city design. While this visibility is not a formal research outcome, it suggests that the studio's speculative framework resonated with broader public curiosity about urban futures in the Thai context.

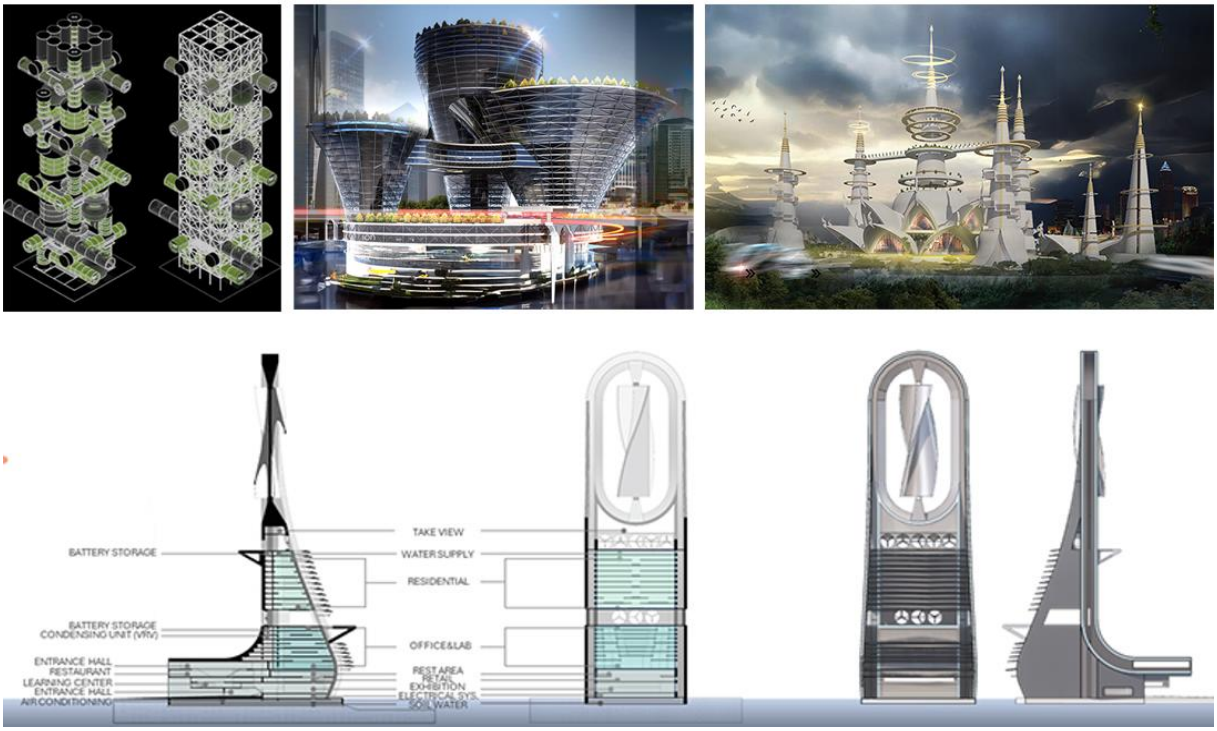

Figure 4. The students' works, 2nd year

Year 3: Integrated Systems Synthesis

The Year 3 brief retained the non-urban Khon Kaen Province site established in Year 2 and directed students toward the design of mixed-use Vertical Cities integrating residential and agricultural programs as primary functions. The critical modification was the explicit requirement for distributed, integrated engineering systems: renewable energy generation (solar, wind, and biogas) was to be embedded across the building

fabric rather than concentrated in a dedicated functional zone, and students were required to develop substantive technical diagrams for water recycling, climate control, and waste processing systems.

Portfolio analysis revealed the most substantive improvements recorded across the three-year study, particularly in systems thinking and engineering integration. Several proposals demonstrated genuine systemic interdependence — for example, projects in which biogas generated from composted food waste powered building mechanical systems, while grey water from residential units was treated and redistributed to vertical farming zones. These proposals moved meaningfully beyond diagrammatic representation toward technically informed systems logic, including preliminary calculations of energy demand, waste volumes, and water cycling capacity.

Creative thinking scores remained high, suggesting that the increased technical demands of the Year 3 brief did not suppress conceptual ambition. This finding is pedagogically significant, as it challenges the common assumption that technical rigor necessarily constrains creative exploration in design education. However, structural feasibility remained the most underdeveloped dimension. While Year 3 proposals demonstrated a more developed awareness of structural systems relative to previous cohorts, the translation of ambitious formal concepts into constructible structural solutions remained limited. Several proposals incorporated structurally implausible formal gestures without accompanying tectonic justification, confirming Frampton's (1995) observation that the tectonic dimension requires deliberate, sustained disciplinary attention that cannot be achieved through brief modification alone.

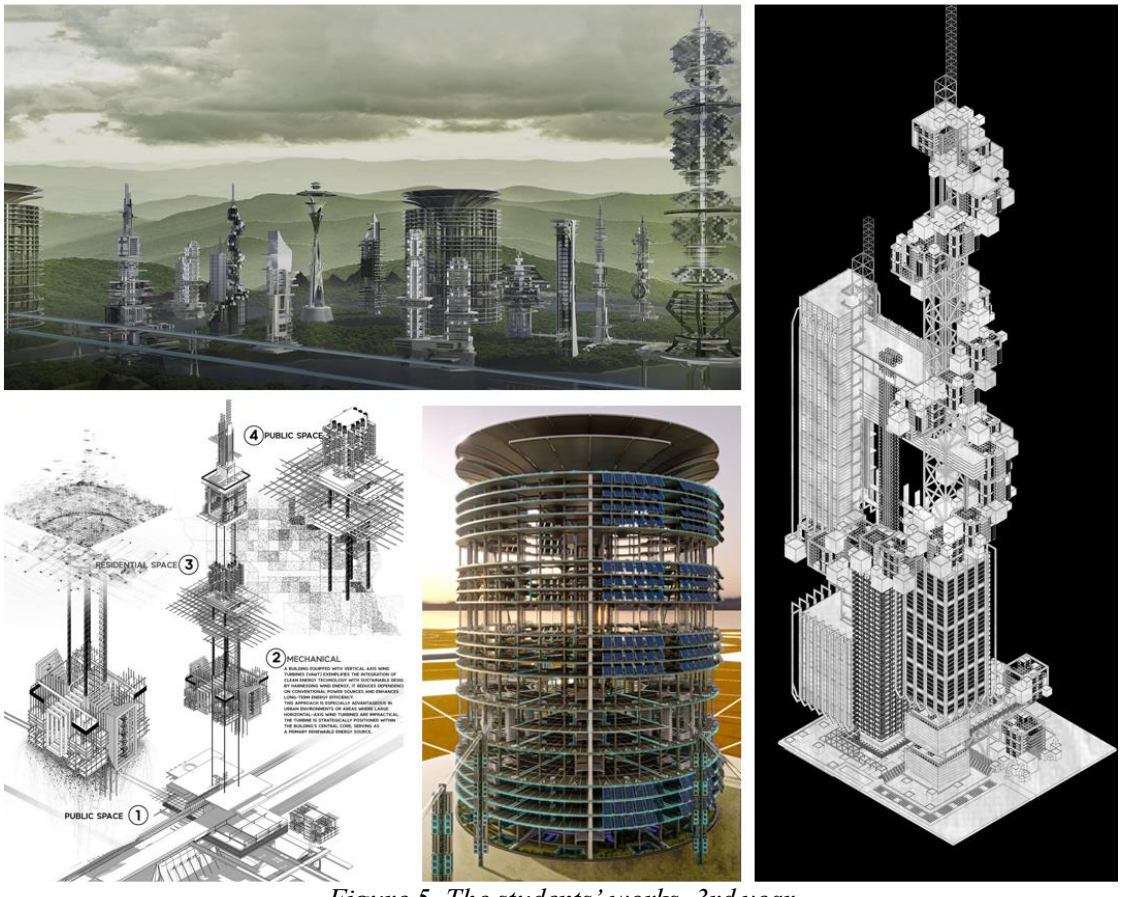

Figure 5. The students' works, 3rd year

Summary of Longitudinal Evaluation Results

From Table 1, the three-year trajectory of the Vertical City Studio demonstrates a clear maturation in student competency, moving from mimicry (Year 1) to innovation (Year 2) and finally to integration (Year 3).

Table 1. Three-Year Trajectory of the Vertical City Studio: Brief, Process, and Pedagogical Findings

Year	Site Context	Primary Brief Focus	Key Outcomes	Pedagogical Finding
Year 1	Urban sites, Khon Kaen Municipality	Application of vertical city concept to existing urban fabric	Programmatic competence; replication of conventional typologies; minimal engineering or systems integration	Breaking conventional typological thinking requires more explicit conceptual scaffolding; systems integration must be foregrounded from the outset
Year 2	Non-urban periphery, Khon Kaen Province	Specialized self-sufficient community as a cluster of thematically distinct Vertical Cities	Significant creative expansion; high conceptual ambition; engineering integration remained schematic	Specialization drives depth of conceptual investigation but may inhibit holistic systems thinking; the liberating constraint of a non-urban site is pedagogically generative
Year 3	Non-urban periphery, Khon Kaen Province (same site as Year 2)	Mixed-use Vertical City with integrated residential, agricultural, and engineering systems	Highest systems thinking and engineering integration scores; structural feasibility remained underdeveloped	Iterative brief refinement supports cumulative learning; technical integration is achievable without suppressing creative ambition; structural realism requires dedicated disciplinary reinforcement

5. DISCUSSION

The Iterative Studio as a Spiral Curriculum in Practice

The capacity for integrated, multidimensional design thinking is not fixed at entry to the fourth year but is developable through structured, cumulative engagement with increasing complexity. This trajectory corresponds directly to Bruner's (1960) spiral curriculum model: students encountered the same core conceptual territory — the self-contained vertical urban ecosystem — three times, each time with greater systemic complexity demanded by the brief and greater cognitive maturity brought by accumulated studio experience.

Importantly, this pattern holds at the cohort level, across three distinct groups of students, rather than tracking the same individuals longitudinally. This suggests that the progression observed reflects deliberate pedagogical design — specifically, the incremental modification of the brief — rather than individual maturation alone. The studio's recurring structure thus functions as an effective mechanism for institutionalizing cumulative learning within an elective studio context.

The Persistent Tension Between Imagination and Constructability

Despite the overall upward trajectory, structural feasibility remained the lowest-scoring criterion across all three cohorts. This finding resonates with Frampton's (1995) argument that tectonic integrity — the integration of material, constructive, and structural logic into the architectural proposition — represents a disciplinary commitment that cannot be achieved through conceptual or programmatic ambition alone.
The Year 3 data are particularly instructive in this regard: the simultaneous improvement in systems thinking and engineering integration scores alongside the continued underdevelopment of structural feasibility suggests that students can internalize systems logic at a diagrammatic level without necessarily developing the structural literacy required to translate those systems into constructible form. This distinction — between systems comprehension and tectonic competence — has not been clearly articulated in the existing literature on speculative design pedagogy and represents an original finding of this study. It implies that future studio iterations must address structural realism as a distinct disciplinary domain requiring dedicated pedagogical intervention, rather than assuming that general improvements in technical thinking will automatically extend to structural feasibility.

Systems-Based Thinking as a Transferable Competency

The marked improvement in systems thinking scores across cohorts, and the concurrent maintenance of high creative thinking scores in Year 3, challenges the common pedagogical assumption that technical and creative competencies exist in tension. The Year 3 results suggest that, when the studio brief is designed to frame engineering systems as creative material rather than as external constraints, students are capable of integrating technical complexity without sacrificing conceptual originality. This finding aligns with the broader pedagogical literature on design-integrated learning [27] and supports the proposition that environmental science, structural engineering, and social programming can be incorporated into a single design workflow without fragmenting the creative process.

This observation has direct implications for the broader debate about the balance between professional training and speculative education in architectural curricula. The Vertical City studio model suggests that speculative complexity and technical rigor are not mutually exclusive pedagogical goals, provided that the studio brief is carefully scaffolded to introduce each dimension of complexity at an appropriate moment in the design process.

Site Context as a Driver of Speculative Freedom

The shift from an urban site (Year 1) to a non-urban site (Years 2 and 3) had a measurable effect on creative thinking scores. This finding is consistent with the pedagogical concept of the "liberating constraint" [28]: by removing the immediate constraints of existing urban infrastructure, the non-urban site freed students to speculate beyond the boundaries of established typologies, while the geographic and ecological specificity of the Khon Kaen provincial context prevented the site from becoming a neutral or indeterminate tabula rasa.

However, it is worth noting that this creative expansion came at the expense of contextual grounding: Year 2 proposals, while conceptually ambitious, often engaged the site more schematically than the Year 1 proposals had engaged the urban context. The Year 3 brief's requirement for systemic integration partially addressed this issue by necessitating a more detailed engagement with site-specific environmental conditions (solar orientation, wind patterns, water availability) to support the design of distributed renewable energy and water management systems.

Limitations of the Current Pedagogical Model

Several limitations of the current studio model must be acknowledged. First, the absence of formal collaboration with engineering faculties means that students' engagement with structural and mechanical systems remained largely self-directed and, in consequence, often technically incomplete. Second, the reliance on architectural presentation softwares limited students' ability to test and validate performance claims against measurable simulation data. Third, the single-instructor design introduces the possibility of evaluative bias, which the inter-rater review protocol partially mitigates but does not fully eliminate.

6. CONCLUSION AND FUTURE DIRECTIONS

This three-year longitudinal pedagogical research project has examined the development of student competencies across four dimensions — creative thinking, systems thinking, engineering integration, and structural feasibility — within a recurring Vertical City design studio at Khon Kaen University. The study was conducted with 12 students per cohort, in a five-hour-per-week studio format, over three successive academic years.

The findings provide empirical support for three principal conclusions. First, iterative thematic studios designed according to a spiral curriculum logic are capable of fostering measurable, progressive improvements in students' capacity for systems thinking and engineering integration. Second, the tension between creative vision and constructive feasibility identified by Frampton (1995) is not resolved by brief modification alone; structural feasibility requires deliberate, focused disciplinary reinforcement that cannot be assumed to emerge organically from improvements in other technical dimensions. Third, in response to RQ3, the most significant pedagogical gaps in the current model are the absence of formal interdisciplinary collaboration with engineering faculties, the lack of digital performance simulation tools, and the insufficient depth of engagement with structural realism — all of which are addressable through the future directions proposed below.

These findings contribute to the literature on speculative design pedagogy in Southeast Asian architectural education by demonstrating that a regionally embedded, evidence-based studio model can produce measurable improvements in multidimensional design competency, while also identifying the specific pedagogical interventions required to address persistent gaps in structural literacy.

To build on these findings, future iterations of the Vertical City studio should pursue the following directions:

1) Formal Interdisciplinary Collaboration: Establishing structured collaboration with the Faculty of Engineering at KKU, incorporating joint reviews and co-taught technical workshops, to provide students with direct access to structural and mechanical engineering expertise.
2) Advanced Digital Performance Simulation: Integrating Building Information Modeling (BIM) and environmental performance simulation tools to enable students to validate energy, water, and structural performance claims against quantitative benchmarks.
3) Regenerative Systems Focus: Deepening the studio's engagement with ecological urbanism by framing the Vertical City explicitly as a regenerative rather than merely efficient system, with active ecological restoration as a design requirement.
4) Expanded Data Collection: Future research should incorporate structured student interviews, pre- and post-studio competency assessments, and comparison with a control cohort enrolled in a conventional large-scale building studio, to strengthen the evidentiary basis for the pedagogical claims advanced here.

Limitations and Future Research: This study is subject to limitations that constrain the generalizability of its findings. The single-site, single-instructor design prevents direct causal attribution of observed competency improvements to specific pedagogical interventions. The sample size (n = 12 per cohort) is sufficient for a longitudinal case study but too small to support statistical inference at a population level. Future research should replicate this studio model across multiple institutions and instructors, incorporate comparative cohort designs, and employ validated instruments for measuring design competency to enable broader generalization of the findings.

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