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LEARNING GAPS IN STRUCTURE AND CONSTRUCTION EDUCATION IN ARCHITECTURAL PROGRAMS: A STUDY OF STUDENT AND TUTOR PERCEPTIONS

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Abstract

Structure and construction form part of the technical backbone of any architecture degree, yet students consistently find them one of the hardest areas to engage with – particularly when they are expected to apply structural knowledge at the same time as they are still developing a design project in a parallel studio. This paper reports on a qualitative study conducted in Structure Studio III, a third-semester course at a private university in Bandung, Indonesia, that runs alongside Design Studio III. We collected open-ended questionnaire responses from 117 undergraduate students and 8 studio tutors, then analysed them using thematic analysis supported by frequency counts. Four recurring patterns emerged from the data: inadequate mastery of basic structural concepts (raised by 76.1% of students; confirmed by all tutors), persistent difficulties with technical drawing (70.1%; all tutors), the challenge of running a technical course in parallel with a design studio (63.2%; 87.5% of tutors), and a range of organisational constraints that limit how much learning can actually happen in a session (60.7%; 75% of tutors). Tutor responses also drew attention to something the existing literature has not examined: a significant step-up in demand between Structure Studio II and Structure Studio III that students are not adequately prepared for. Taken together, the findings point not to students lacking aptitude but to a series of structural misalignments in how the curriculum is sequenced and coordinated. We conclude with a proposed framework for staging competency development across the three structure courses and coordinating more deliberately with the design studio.

INTRODUCTION

Ask most architecture students to describe what structure courses feel like, and a familiar picture tends to emerge: the subject seems to belong to a different world from the one they came in through. Where design studio rewards speculation, inventiveness, and a willingness to pursue an idea even when its outcomes are uncertain, structure and construction ask students to commit to numbers, to accept that some answers are simply wrong, and to reason from physical constraints rather than aesthetic intentions. That tension is not new (MacDonald, 2001; Charleson, 2008), but it remains one of the more persistent problems in architectural education.

Part of what makes it difficult is that students are rarely blank slates when they arrive in a structure course. They carry months or years of studio conditioning – habits of thought shaped around possibility and expression rather than load and constraint. Schon (1987) described these as the tacit competencies of practice, and noted that shifting from one mode of professional knowing to another is rarely smooth. Stevens (1998) made a related observation from a sociological angle: the culture of architecture tends to position technical knowledge as subordinate to design, so students may already have absorbed, implicitly, the idea that structure is someone else's problem. Docherty (2017) found that this tendency to underrate structural relevance often persists until students experience its consequences directly.

There is no shortage of proposals for how to teach structure better in architecture programmers. Problem-based approaches have been tried (Salama, 2016); so have attempts to weave structural logic into design briefs from the outset (Oxman, 2008), to use physical models as a way of building intuitive structural understanding (Webster, 2008), and to bring digital simulation tools into studio practice (Holzer, 2015). Each of these responds to a real aspect of the problem. Moreover, existing studies often address curriculum design from a top-down or theoretical perspective rather than from the standpoint of what students and tutors actually experience in the studio. There remains a lack of empirical studies that document learning gaps as they are perceived by the people who live them – from the ground up. This study addresses the gaps by drawing directly on the language of students and tutors engaged in Structure Studio III at a private university in Bandung, Indonesia. What remains harder to find in the literature is a ground-level empirical account – one that starts not from what educator's think should help, but from what students report actually getting in the way (Groat & Wang, 2013).

The study reported here was prompted by a practical concern. As course coordinator for Structure Studio III – a third-semester studio at a private university in Bandung, Indonesia – the first author had observed, over repeated cycles of the course, that students were arriving with competencies significantly below what the course assumes. Some of the gaps were predictable: weak structural mechanics, unfamiliarity with calculation. Others were less anticipated, particularly the difficulty around technical drawing, and the degree to which the simultaneous demands of Design Studio III were creating conditions that made learning in both courses harder than they needed to be. Figure 1 maps the two course sequences side by side.

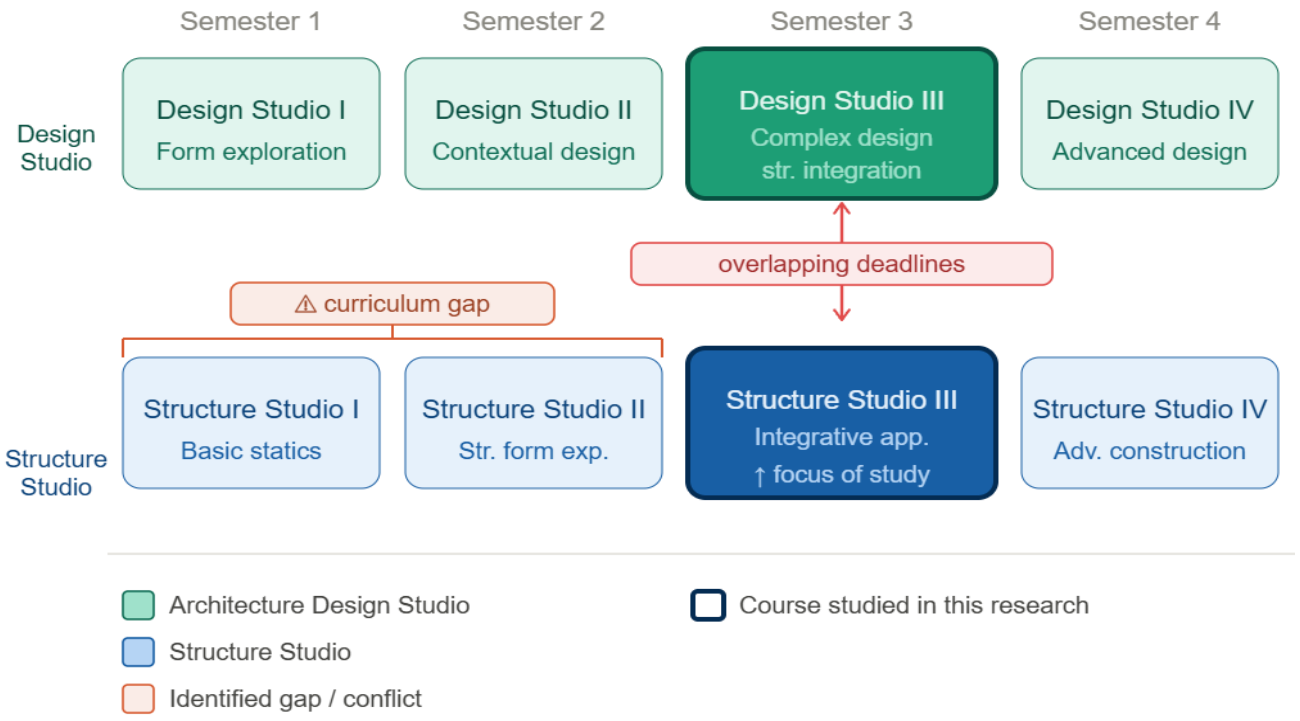

Figure 1. Curriculum map showing the Architecture Design Studio and Structure Studio pathways running in parallel from Semester 1 to Semester 5. Conflict markers indicate where the two courses impose competing demands in Semester 3.

The study has three aims: to document the learning gaps as students and tutors actually experience them; to understand what conditions produce or deepen those gaps; and to propose practical adjustments to how the course sequence is structured. The questionnaire data came from 117 students and 8 tutors, all of whom were directly involved in Structure Studio III during the 2025–2026 odd semester.

What this study adds to existing scholarship is a bottom-up perspective grounded in student and tutor language rather than curriculum design theory. It also names something that has not appeared before in the international literature on structure education in architecture: a specific and largely unacknowledged step-change in difficulty between Structure Studio II and Structure Studio III that the curriculum does not yet account for.

METHODS

We used a qualitative descriptive design — an approach chosen because the questions we were trying to answer were fundamentally about meaning and experience (Creswell & Poth, 2018; Groat & Wang, 2013). Numbers alone cannot tell us why students find structural calculation confusing, or what it feels like to sit in a studio session without yet having the drawing skills the task requires. A descriptive rather than interpretive orientation meant staying close to what people actually said, without imposing a theoretical framework in advance (Sandelowski, 2000).

Research Setting

Structure Studio III runs every Thursday at this institution. The format consists of a two-hour plenary lecture in the morning, followed by six hours of supervised studio work. It runs concurrently with Design Studio III, which is the third of a sequence of architecture design studios that form the core of the programme. Three structure courses precede or accompany the design studios in the curriculum: Structure Studio I covers basic statics in Semester 1; Structure Studio II focuses on simple building structures in Semester 2; and Structure Studio III, the course at the centre of this study, is where students are first expected to apply structural thinking directly to their own architectural designs. That transition – from the relatively contained exercises of Structure Studio II to the full complexity of applying structural reasoning to a live design project – turned out to be more significant than the curriculum had anticipated.

Participants

Two groups took part. The larger was 117 undergraduate students who had completed Structure Studio III simultaneously with Design Studio III in the odd semester of the 2025–2026 academic year. We invited the entire enrolled cohort and received responses from all 117. The second group consisted of 8 studio tutors, one per teaching group, drawn from across the three parallel classes that made up the course. Including tutors was important because the perspective of someone guiding thirty students through a studio session is qualitatively different from the perspective of a student sitting in that session – tutors see patterns across the cohort that individual students cannot. Both groups participated voluntarily, and all responses were collected anonymously.

Questionnaire Design

Each group received a separate questionnaire, delivered digitally through Google Forms near the end of the semester. Both instruments used only open-ended questions, since the study's aim was to understand experience rather than measure outcomes against pre-set categories. Students answered nine questions; tutors answered twelve. Table 1 lists all items.

Table 1. Questionnaire items administered to students (n=117) and tutors (n=8).

No.	Student Questionnaire (n=117)	Tutor Questionnaire (n=8)
Q1	What part of this course do you find most challenging to understand or complete? Please explain why.	How would you describe students' general level of preparedness when they first enter Structure Studio III?
Q2	When did you first start to feel that you were struggling to keep up with the material or complete the tasks?	Which areas of foundational knowledge or skill do you notice are most clearly underdeveloped when students arrive?
Q3	What are the main obstacles you have run into when trying to complete assignments or understand the course content?	In your view, how well do students manage to connect basic structural and material concepts with what they are doing in Design Studio?
Q4	Are there any core concepts or skills you feel you lacked going into this course that made things harder for you?	What obstacles do you encounter most often when guiding students through studio tasks?
Q5	Were there any topics or abilities you wished you had been better prepared in before taking this course?	Which topics or concepts do you find yourself explaining again and again — things students should already know?
Q6	Which part of the assignments — individual or group — did you find hardest to do, and why?	How would you characterise the quality of students' academic discussion when making decisions about structure and materials?
Q7	What do you usually do when you hit a wall with a task or do not understand something?	Are there competencies you believe students should have coming in that are consistently missing in practice?

Q8	What do you think would most help students arrive in this course better prepared?	What do you typically do to work around students' limited prior knowledge during studio?
Q9	What suggestions would you make to improve how this course is taught going forward?	Does the readiness — or lack of it — of the students affect how deeply you can go into the material or how the studio runs?
Q10	—	What do you see as the main reasons students struggle in Structure Studio III?
Q11	—	What would you recommend to help students arrive better prepared academically?
Q12	—	Any other thoughts on how Structure Studio III could be improved?

Analysis

All responses – student and tutor – went through the same six-phase thematic analysis procedure described by Braun and Clarke (2006). We read everything several times before starting to code, then worked through the data line by line, labelling segments that expressed something meaningful about difficulty, obstacles, or perceived gaps. Initial codes were grouped into candidate themes and then refined iteratively; boundaries between themes shifted as the analysis developed. The four themes we report are the ones that proved genuinely robust across the full dataset. Although the themes were developed inductively across all questionnaire items, the primary sources for each theme can be identified. Theme 1 (Gaps in Fundamental Structural Competencies) drew most heavily on student Q1, Q3, and Q4, and tutor Q1, Q2, and Q5 – items that asked directly about what students found most challenging and what prior knowledge was missing. Theme 2 (Difficulties in Technical Drawing and Documentation) emerged primarily from student Q1, Q4, and Q5, and tutor Q2 and Q7 – items focused on specific skills lacking upon entry and areas requiring repeated re-explanation. Theme 3 (Challenges Integrating Structure with Design Studios) was anchored in student Q3 and Q6, and tutor Q3, Q4, and Q9 – items addressing obstacles to completing tasks and the relationship between the two concurrent studios. Theme 4 (Instructional and Organisational Constraints) drew on student Q3 and Q6, and tutor Q4, Q8, and Q9 – items about what got in the way during studio sessions and how tutors managed limited conditions. The Coping Strategies section was derived directly from student Q7, which asked what students do when they hit a wall.

We also counted how many student responses addressed each theme, across all nine questionnaire items. One response could address multiple themes. These frequency counts, reported throughout the results, serve the purpose Maxwell (2010) identifies for numbers in qualitative analysis: they communicate magnitude, helping the reader gauge how widespread a pattern is rather than whether it existed at all. A second author who had not been involved in the original coding reviewed all theme assignments; the few disagreements were settled through discussion.

RESULTS

The analysis produced four themes that appeared with consistency across student responses and were corroborated, with varying degrees of emphasis, by tutors. Table 2 summarises the themes, the proportion of students and tutors whose responses addressed each, and what we take to be the most direct pedagogical implication of each finding. Figure 2 shows the frequency distribution.

Table 2. The four dominant themes, frequency of occurrence, and primary pedagogical implication.

Dominant Theme	Students (n=117)	Tutors (n=8)	Pedagogical Implication
1. Gaps in Fundamental Structural Competencies	89 (76.1%)	8/8 (100%)	Reinforce structural prerequisites; stage exercises progressively before integrative design tasks
2. Difficulties in Technical Drawing and Documentation	82 (70.1%)	8/8 (100%)	Introduce technical drawing systematically from Semester 1 and sustain it across all studio courses
3. Challenges Integrating Structure with Design Studios	74 (63.2%)	7/8 (87.5%)	Establish formal coordination between studios; directly address the Structure Studio II–III transition
4. Instructional and Organizational Constraints	71 (60.7%)	6/8 (75.0%)	Reconsider same-day submission policy; move toward a 1:1 tutor-to-group ratio; expand tutorial access

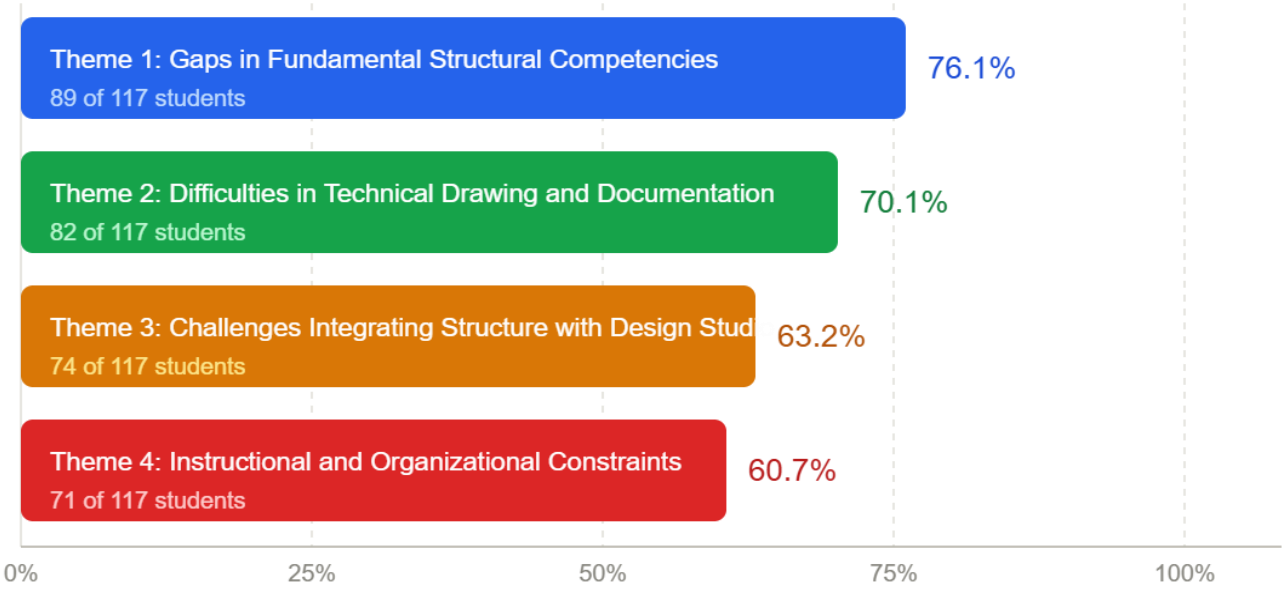

Figure 2. Proportion of student responses (n=117) addressing each of the four dominant themes. A single response could address more than one theme.

Theme 1: Gaps in Fundamental Structural Competencies

Seventy-six point one percent of students – 89 out of 117 – described some form of difficulty with the structural content itself, making this the most widely reported theme. Dimensionering was at the heart of it: 78 students (66.7%) mentioned calculating structural dimensions as the hardest part of the course. What was striking, reading through the responses, was that the difficulty often went deeper than simply not knowing the right formula. Students described being stuck before they even reached the calculation stage – not knowing where to begin, not knowing how to read a design in structural terms, not knowing what a reasonable answer would look like.

> *"Belum terbiasa menggunakan rumus untuk menentukan dimensi kolom, sehingga banyak trial and error yang terjadi selama proses pembelajaran" [I'm not used to working with the formulas for column sizing, so there's been a lot of trial and error throughout]*
>
> *"Materi yang paling sulit adalah dimensioneering, khususnya penentuan daya topang kolom dan pondasi, karena harus menghitung beban total bangunan" [The hardest material is dimensionering — particularly figuring out how much load the columns and foundations have to carry, because that requires calculating the total building load]*

Forty-three point six percent of students (51 responses) made an explicit point of mentioning prior knowledge that had not been in place – not that they had forgotten things, but that the concepts had never fully settled. Tutors described seeing the same thing from the front of the studio:

> *[Tutor] "Pemahaman Struktur secara feeling berdasarkan logika anak-anak bisa memahami bagaimana struktur bekerja, namun pemahaman secara teknis dan penjelasan terkait kekuatan, kekakuan, dll masih tidak memahami" [Intuitively, based on logic, students can follow how structure works — but once you get into the technical side, strength, stiffness and so on, they're lost]*
>
> *[Tutor] "Hampir semua materi struktur sederhana tidak dipahami, anak seolah-olah ngeblank tentang struktur paling sederhana" [For almost all the material, they go blank — even the simplest structural concepts]*

What tutors were describing was not students who had missed a few lectures. It was students who had arrived without the conceptual floor the course was built on. The result – as the data make clear – was that tutors spent significant studio time revisiting material that ought to have been established in earlier courses, rather than building on it.

Theme 2: Difficulties in Technical Drawings and Documentation Standards

Eighty-two students (70.1%) raised technical drawing as a significant problem, and all eight tutors confirmed it. The core issue is fairly specific: students in this programme spend their first two semesters learning to draw architecturally – to communicate design intentions spatially, aesthetically, persuasively. Then they arrive in Structure Studio III and discover that structural and construction drawing operates by entirely different conventions. Sixty-one students (52.1%) said directly that technical drawing had not been taught to them before, or had been covered only briefly and superficially.

> *"Banyak waktu dipakai untuk merevisi gambar yang terlalu 'arsitektural' yang dituntut untuk menjadi lebih teknikal" [A lot of time went into revising drawings that were too 'architectural' — they needed to become technical drawings instead]*
>
> *"Gambar teknik baru diajarkan di tengah semester" [Technical drawing only got properly introduced halfway through the semester]*

For tutors, this was not just a skills problem – it was a communication problem with direct consequences for what feedback they could give. If a student cannot represent what they are thinking in a way that conveys structural intent, the tutor has very little to respond to. Several tutors put this plainly:

> *[Tutor] "Percuma pengetahuan struktur tapi tidak dapat menyajikan dengan informatif" [Structural knowledge is worthless if you can't present it informatively]*
>
> *[Tutor] "Karena tidak dapat mengkomunikasikan desain mereka dengan baik (gambar teknik) dan belum mempunyai kesadaran elemen struktur dasar, otomatis pada saat asistensi feedback dari instruktur terbatas" [When students can't communicate their design through technical drawing, and have no awareness of basic structural elements, the feedback I can give during a session is automatically limited]*

The two things compound each other. A student who is not sure about the structural logic and also cannot draw it in a way that makes the logic legible ends up in a loop of revision that is more about learning to draw than learning to think structurally. Tutors described spending tutorial sessions that should have been about structural reasoning on notation and line conventions instead.

Theme 3: Challenges in Integrating Structure and Construction with Design Studios

Sixty-three-point two percent of students (74 responses) described challenges that arose specifically from the fact that Structure Studio III and Design Studio III run at the same time. Three distinct problems showed up in the data, each worth treating separately.

The first is a timing problem. Fifty-eight students (49.6%) described situations where Design Studio had already moved on to a stage that required structural knowledge Structure Studio had not yet reached. The sequence of material in the two courses was not coordinated, so students sometimes found themselves being asked to draw a foundation in Design Studio before foundations had been covered in Structure Studio.

> *"Ketika Studio Desain Arsitektur sudah selesai opzet, Studio Struktur III baru mulai pembelajaran lebih dalam sehingga agak menyusahkan" [By the time Design Studio had finished its opzet phase, Structure Studio III was only just getting into the deeper material — which made things difficult*]

The second problem is a deadline problem. Sixty-three students (53.8%) described the combined weekly workload as unmanageable — not because either course was unreasonable on its own, but because both required significant output on overlapping days. Several described working through the night to keep up with both.

The third is a complexity problem. Forty-one students (35.0%) found that their Design Studio projects were structurally complex in ways that fell outside what Structure Studio was designed to handle. The course teaches structural reasoning for orthogonal, geometrically simple buildings; many Design Studio projects in this cohort were circular, irregular, or parametric.

> *"Struktur yang dijelaskan lebih kepada bentuk geometris sederhana, sedangkan tugas Studio Desain Arsitektur saya berbentuk lingkaran" [The structural systems we're taught are for simple geometric forms, but my Design Studio project is circular]*

Figure 3 illustrates the underlying logic problem. Design Studio and Structure Studio do not just have a scheduling conflict – they operate in opposite directions. Design Studio moves from form to structure to foundation; sound structural reasoning moves from foundation to structure to form. Running them simultaneously without coordinating their conceptual flow compounds the cognitive demand rather than relieving it.

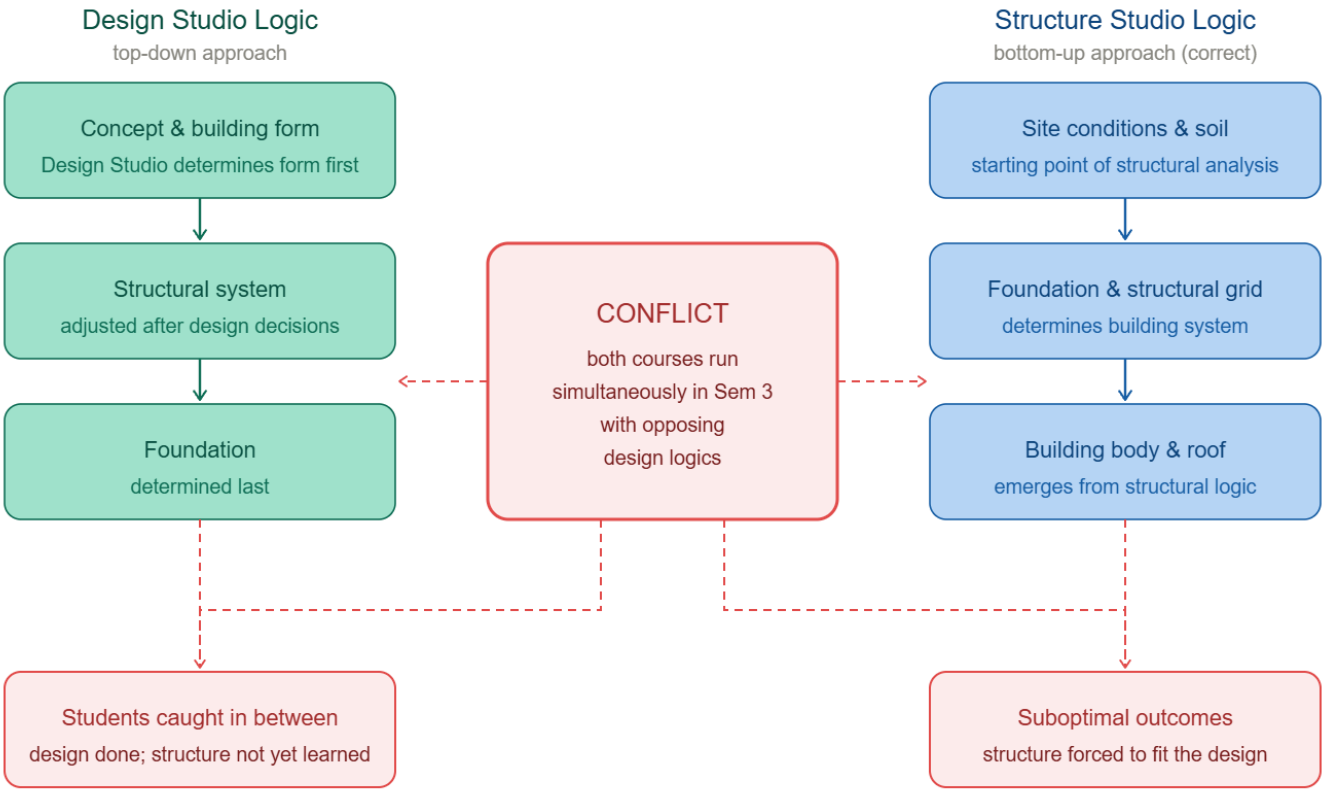

Figure 3. Opposing pedagogical logics in Semester 3. Design Studio proceeds top-down from form to foundation; rigorous structural thinking proceeds bottom-up from foundation to form. Operating both simultaneously, without alignment, creates a conceptual conflict for students.

Sub-theme: The Gap Between Structure Studio II and Structure Studio III

Something the pre-existing literature has not discussed directly emerged from both student and tutor data: a step-change in demand between Structure Studio II and Structure Studio III that the curriculum has not explicitly prepared students for. Twenty-nine students (24.8%) and five of the eight tutors (62.5%) described this transition as a source of unpreparedness that was distinct from simply finding Structure Studio III hard. Their concern was with what the previous course had and had not delivered. Figure 4 shows the gap and what a revised Structure Studio II might look like.

> *"pada mata kuliah Studio Struktur II dulu kami lebih banyak mengeksplor bentuk/desain struktur daripada menguasai dan mengerjakan gambar teknikal dan basic understanding terhadap struktur satu bangunan" [In Structure Studio II we spent most of our time exploring structural forms and designs, rather than actually getting on top of technical drawing or building any real understanding of how a building's structure works as a whole]*
> *"gambar teknik dasar di Studio Struktur II konsep terus, di Studio Struktur III tugasnya gambar semua, jadi sempat kagok" [Basic technical drawing — in Structure Studio II it was all concepts, then suddenly in Structure Studio III everything is drawing, so there was a real jolt]*

Tutors echoed this from the other side of the relationship:

> *[Tutor] "Ada lompatan materi dan skala tugas yang terlalu jauh dari sebelumnya sehingga perlu minat besar dan waktu yang lebih banyak" [There's a jump in content and task scale that's too large a step from what came before — it demands a lot of motivation and much more time than students typically have]*
> *[Tutor] "Faktor utama adalah harus diperjelasnya kompetensi apa yang ingin dicapai dan benang merahnya harus disiapkan dari semester awal sampai akhir agar pemahaman baik di studio perancangan dan studio struktur bisa sejalan beriringan" [The main issue is that the competencies expected need to be made explicit, and the thread connecting them needs to be drawn from the very first semester — only then can understanding in both the design and structure studios develop in step]*

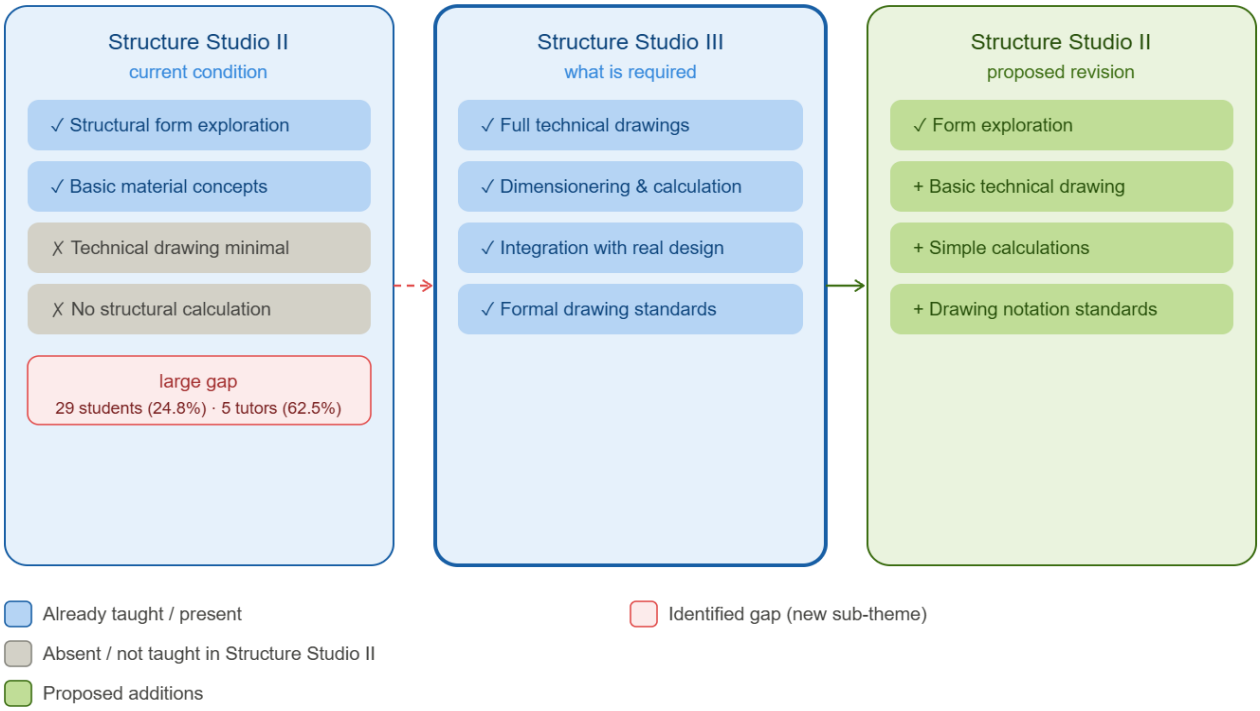

Figure 4. The curriculum gap between Structure Studio II and Structure Studio III. Structure Studio II as currently delivered focuses on structural form exploration but does not develop the technical drawing competency or structural calculation that Structure Studio III requires from the outset. The right column shows what a revised Structure Studio II could add.

Theme 4: Instructional and Organisational Constraints

Seventy-one students (60.7%) and six tutors (75.0%) pointed to aspects of how the studio is organised – rather than what is taught in it – as a significant barrier to learning. The issue that came up most often (65 students, 55.6%) was the same-day submission policy: students receive new material in the morning lecture and are expected to submit a completed structural drawing before the end of that same day's session. There is, in effect, no time between learning something and having to demonstrate it.

> *"tidak ada waktu yang cukup untuk benar-benar memahami materi sebelum langsung mengerjakan tugas dan tugas dikumpul pada hari itu juga sehingga banyak terjadi kesalahan yang bisa dihindari jika diberi waktu lebih banyak" [There's just not enough time to really understand the material before you have to start working on the assignment, and then it's collected the same day – so there are a lot of avoidable mistakes that would disappear if we had more time]*

Thirty-eight students (32.5%) raised the tutor ratio specifically – one tutor managing two groups simultaneously, which means a significant portion of each studio session is spent waiting rather than working. Forty-two students (35.9%) described tutorial time as insufficient more broadly, and 58 students (49.6%) noted that Design Studio workload was making it hard to give full attention to Structure Studio.

> *[Tutor] "tidak cukup waktu mempelajari bahan, atau terlalu banyak bahan/informasi yang diharapkan masuk dalam waktu yang singkat – rasio pembimbing-siswa yang sangat tidak imbang" [There isn't enough time to work through the material, or there's simply too much packed into too short a window – and the tutor-to-student ratio is severely out of balance]*

Coping Strategies

When asked what they do when they hit a wall (Q7), students described a set of informal strategies that reveal something about the gap between what the formal structure provides and what students actually need. Table 3 summarizes the responses.

Table 3. How students respond when they encounter difficulty (Q7, n=117).

Coping Strategy	Students (n=117)	Percentage (%)
Peer discussion with classmates	89	76.1
Tutorial consultation with studio tutor	71	60.7
Independent online search (Google, YouTube)	68	58.1
Help from senior students	23	19.7
AI tools (e.g., ChatGPT)	19	16.2

Three quarters of students (76.1%) turn first to peers. This is not surprising in a studio environment, but it does suggest that peer discussion is carrying some of the weight that formal tutorials are not. Just over half (60.7%) consult the tutor when they can get access. Nineteen students (16.2%) mentioned using AI tools.

Table 4. Sub-theme frequency breakdown within each dominant theme.

Sub-theme	Student Responses (n=117)	%	Tutor Confirmation (n=8)
Theme 1: Gaps in Fundamental Structural Competencies (89 students, 76.1%)			
Dimensionering / structural sizing difficulty	78	66.7%	8/8 (100%)
Insufficient prior structural knowledge	51	43.6%	8/8 (100%)
Foundation design problems	45	38.5%	8/8 (100%)
Steel structure calculation difficulty	22	18.8%	6/8 (75%)
Theme 2: Difficulties in Technical Drawing and Documentation (82 students, 70.1%)			
Insufficient technical drawing skills	72	61.5%	8/8 (100%)
Not taught adequately before Structure Studio III	61	52.1%	8/8 (100%)
Confusion about drawing standards and notation	48	41.0%	7/8 (88%)
Difficulty meeting formal drawing requirements	23	19.7%	5/8 (63%)
Theme 3: Challenges Integrating Structure with Design Studios (74 students, 63.2%)			
Overlapping deadlines with Design Studio	63	53.8%	7/8 (88%)
Misaligned course timelines	58	49.6%	7/8 (88%)
Design complexity beyond what Structure Studio teaches	41	35.0%	6/8 (75%)
Structure Studio II–III curriculum gap (NEW)	29	24.8%	5/8 (63%)
Theme 4: Instructional and Organizational Constraints (71 students, 60.7%)			
Same-day submission deadline for weekly tasks	65	55.6%	6/8 (75%)
Concurrent workload pressure from Design Studio	58	49.6%	6/8 (75%)
Too little time for tutorial sessions	42	35.9%	6/8 (75%)
Tutor-to-group ratio (1 tutor: 2 groups)	38	32.5%	6/8 (75%)

DISCUSSION

Reading the data as a whole, what strikes us is not those students are weak or unmotivated – the responses do not read that way. What they describe is a curriculum that has accumulated incompatibilities over time: between what Structure Studio II develops and what Structure Studio III assumes, between the way Design Studio and Structure Studio are sequenced, and between the intensity of what is asked of students in a session and the conditions under which they are asked to do it. The four themes point not to a single problem but to a set of interacting pressures, each of which would be manageable on its own but becomes something harder to navigate when they occur simultaneously.

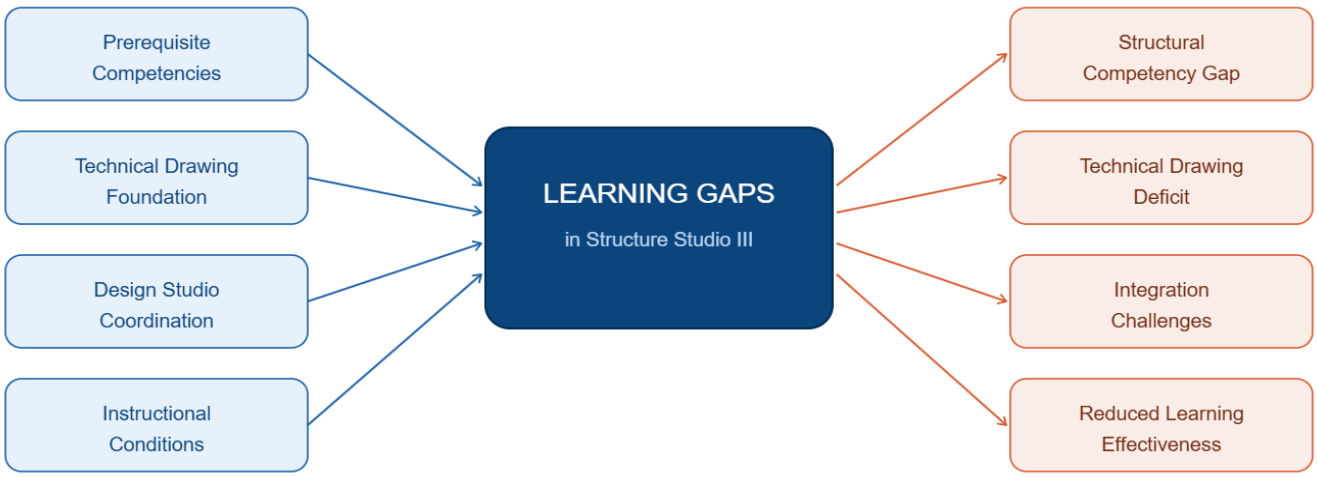

Figure 5. Conceptual model showing how four systemic conditions – inadequate prerequisite competencies, insufficient technical drawing preparation, misaligned course coordination, and constrained instructional conditions – converge to produce the learning gaps documented in this study.

Why Structural Competency Gaps Are Harder Than They Look

The difficulty with structural calculation that 76.1% of students described is not simply a matter of students needing more formula practice. Several responses suggested a more fundamental problem: students who can execute a calculation correctly in isolation but have no framework for knowing whether the answer they got is physically reasonable, or for knowing which formula applies to the situation in front of them. This is what transfer researchers mean when they distinguish surface learning from deep learning (Bransford, Brown, & Cocking, 2000). Formula fluency without conceptual grounding does not transfer when the conditions change.

Tutors confirmed this from their vantage point. The time they described spending on foundational explanations – load paths, the difference between axial and bending forces, basic material properties – was time the curriculum assumed had already been covered. The implication is that the remedial function has migrated into Structure Studio III without being officially acknowledged there. Under cognitive load theory (Sweller, Ayres, & Kalyuga, 2011), asking students to remediate conceptual gaps while simultaneously learning new material and applying it to a live design is likely to push working memory past its effective limit. The trial-and-error approach students described is a predictable response to exactly that situation.

Technical Drawings as a Barrier to Structural Understanding

Difficulties related to technical drawings and documentation standards further intensify learning gaps. Students' confusion regarding drawing conventions, notation systems, and levels of detail – reflected in statements such as "we were confused about what the correct drawing standards should be" – indicates that drawings are not consistently taught as instruments of technical communication.

In architectural education, drawing is often emphasized as a representational and conceptual medium, while its role in conveying structural intent and construction logic receives less explicit attention (Pérez-Gómez & Pelletier, 2000; Allen & Zalewski, 2010; Ching, 2015). Without clear and consistent documentation standards, students struggle to translate structural concepts into precise technical drawings. This results in repeated revisions, uncertainty during tutorials, and reduced efficiency in the learning process.

The Technical Drawing Problem Is Curricular, Not Individual

The fact that all eight tutors identified technical drawing as a critical gap – and that more than half of students said it had not been adequately taught before – is harder to explain as individual variation than as a curriculum design issue. Allen and Zalewski (2010) and Ching (2015) have argued that technical drawing in structural contexts is fundamentally a communication medium: it is the mechanism through which a structural intention becomes legible to someone else, whether that is a tutor, a structural engineer, or a builder. Teaching students to draw architecturally for two semesters and then expecting them to switch modes without explicit instruction is asking a lot. Nicol and Pilling (2000) made essentially this argument over two decades ago: the technical and representational aspects of architectural education need to develop together, not in sequence.

The practical consequence tutors identified – that drawing limitations constrain what feedback they can give – matters beyond the inconvenience it creates. Studio learning in architecture depends to a significant degree on the quality of the student–tutor dialogue around a drawing in progress (Salama, 2016; Schon, 1987). When the drawing is not informative enough to sustain that dialogue, the session reverts to instruction, and the learning that comes from iterative feedback is lost.

Three Problems Inside the Integration Theme

The integration theme is harder to summaries than the others because it contains three distinct problems that each require a different response. The timeline problem – structural material arriving after Design Studio has already needed it – is a coordination failure. It does not require either course to change its content; it requires the two course teams to talk to each other at the semester planning stage and align their delivery sequences. The deadline problem is partly structural (how many tasks are set, when they fall) and partly a resourcing question (would more tutorial capacity allow students to manage the load differently). The complexity problem is the most pedagogically interesting. Design Studio III in this cohort was producing geometrically complex projects that fell outside what Structure Studio III teaches. That mismatch is not obviously anyone's fault, but it does point to a need for a shared protocol between the two studios for handling projects that structural instruction cannot adequately address.

The sub-theme about the Structure Studio II–III transition is, in our view, the finding in this paper most likely to be new to readers working in architectural education elsewhere. The gap between what Structure Studio II develops (structural form exploration, conceptual vocabulary, basic material awareness) and what Structure Studio III requires from day one (technical drawing, structural calculation, full integration with a design project) is large enough that many students arrive underprepared in ways that are not simply about motivation or prior academic performance. The course sequence has a vertical coherence problem that needs to be addressed at the curriculum design level, not managed by individual students or tutors.

On Instructional Conditions and What They Make Possible

The instructional constraints theme is the most directly actionable of the four. Constructive alignment (Biggs & Tang, 2011) is not just a pedagogical ideal – it is a practical framework for asking whether the conditions under which students are asked to perform make the expected performance genuinely possible. When 55.6% of students say the same-day deadline does not give them enough time to understand what they have just been taught before they have to demonstrate it, and tutors confirm they cannot reach all students before the session ends, the basic conditions for learning are not being met. Students learn to produce output under pressure; that is not the same as learning to reason structurally, and it is not what this course is trying to achieve.

A Staged Framework for the Structure Course Sequence

We draw on the patterns in the data, and on what students and tutors recommended in response to Q8, Q9, Q11, and Q12, to propose the following staged framework. It is a proposal rather than a finding – its effectiveness would need to be tested through a deliberate intervention study.

The framework rests on a simple principle: each course in the structure sequence should develop the competencies that the following course will depend on. Structure Studio I build the conceptual foundation – understanding how structures work, what loads are, how they transfer. Structure Studio II, in the revised form the framework proposes, builds technical drawing competency and introduces basic structural calculation for simple buildings. Students would leave Structure Studio II able to communicate structural ideas through drawing and to make simple sizing decisions – the two things that most frequently trip them up on arrival in Structure Studio III. Structure Studio III can then focus on what it is actually designed for: applying structural reasoning in full to a live, complex architectural design.

Alongside this vertical resequencing, the framework calls for a formal coordination mechanism between the structure studios and Design Studio. This does not need to be complex – it could be as straightforward as a shared planning document at the start of each semester that aligns when particular material is covered in Structure Studio with when Design Studio projects will need students to have that material. A shared protocol for handling geometrically complex student designs would also reduce the frequency of the mismatch problem described in Theme 3. At the instructional level within Structure Studio III itself, we propose reconsidering the same-day submission model (or at minimum extending the deadline to allow overnight reflection), moving toward a 1:1 tutor-to-group ratio, and introducing structured peer critique as a way of multiplying feedback opportunities when tutor access is limited.

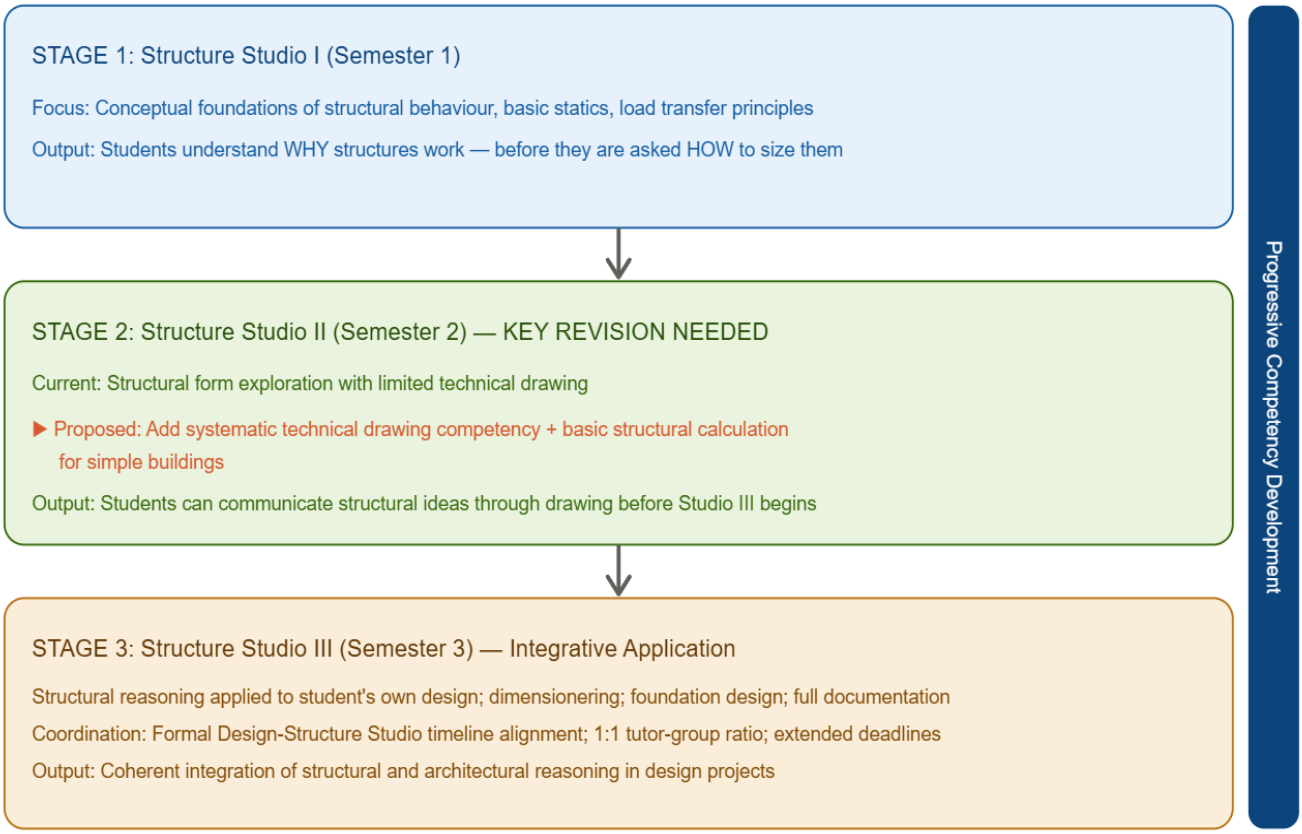

Figure 6. Proposed staged framework for structure and construction education. The key revision is to Structure Studio II, which would take on explicit responsibility for developing technical drawing competency and basic structural calculation – competencies currently expected of students arriving in Structure Studio III but not systematically built in the preceding course.

Limitation and Scope

This study has several limitations that should be stated clearly. The data come from one institution, and the course sequence described here – Structure Studio I, II, III, running alongside Design Studio I through V – reflects this particular programmer's structure. Readers at institutions with different arrangements may find some findings more or less applicable than others. The student sample is a single cohort; whether the same patterns would appear in other years, or under different teaching arrangements, we cannot say. The tutor group of eight is small by any quantitative measure, and should be treated as informative rather than generalizable.

CONCLUSION

Structure and construction courses in architecture are harder to teach well than they might appear, partly because the students who most need them are also the ones who have been most successfully trained to think in ways that make them difficult. This study documented what that difficulty looks like from the inside, drawing on responses from 117 students and 8 tutors at a private university in Bandung, Indonesia. Four themes emerged consistently: inadequate structural competencies on arrival (76.1% of students; all tutors); insufficient technical drawing preparation (70.1%; all tutors); the friction of running a technical course in parallel with a design studio (63.2%; 87.5% of tutors); and organizational conditions that limit what learning can actually occur in a session (60.7%; 75% of tutors). A sub-theme that does not appear in the existing international literature – the step-change between Structure Studio II and Structure Studio III – emerged from both datasets as a source of unpreparedness that the curriculum needs to address directly.

The proposed staged framework is our attempt to translate these findings into something actionable. Its central recommendation is not to make Structure Studio III easier, but to make Structure Studio II do more of the preparation work that Structure Studio III is currently having to do itself. Whether that rebalancing produces the outcomes we anticipate is something that only a properly designed follow-up study could test. What the current data do establish is that the problem is not primarily one of student aptitude – it is one of curriculum design.

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