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From "Not Following" to "Can Judge": A Teaching Reconstruction of Principles of Steel Structure in the Context of Digital-Intelligence Education

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Abstract: Principles of Steel Structure is an extension of mechanics of materials at the member level, and its teaching effectiveness depends far less on what the course covers than on what students bring to the classroom. Classroom observation shows a marked mismatch between students' preparation in mechanics and the information density of the course, and their engagement degrades from following derivations to copying conclusions. Meanwhile, generative artificial intelligence and short instructional videos have brought the cost of obtaining a solution close to zero, so that the gap between where answers come from and whether students can judge them is widening rapidly. This paper diagnoses the phenomenon as two breaks: the knowledge interface between mechanics of materials and steel structure, and the absence of judgment training once answers are freely available. Four measures are proposed accordingly: pre-course diagnosis and compensation of the interface, deliberate gaps left in in-class derivations, review-style assignments built on flawed model answers, and an evidence-based assessment reform. The role of the teacher's own model literacy in this reconstruction is also discussed. The practice remains empirical and still lacks controlled data.

Keywords: Principles of Steel Structure; Mechanics of Materials; Digital-intelligence Education; Engineering Judgment; Teaching Reform.

1. Where the Problem Comes From

Principles of Steel Structure occupies an unusual position in the curriculum: it is not a self-contained theory course but the engineering realization of mechanics of materials. The overall stability of an axially loaded compression member, the plastic development of a beam section, the eccentric shear of a bolt group — the textbook offers ready-made formulas for all of them, yet behind every formula sit the concepts of internal force, state of stress, compatibility of deformation and stability that mechanics of materials established. Without that foundation, each formula in class can only be a conclusion to be memorized, never an inference that can be traced. [1]

In recent years the author has repeatedly met the same situation: the more carefully a topic is explained, the fewer students follow. In one lecture on the overall stability of a solid-web axially loaded compression member, the argument ran from the additional bending moment caused by initial curvature and residual stress to the edge-yield criterion and then to the stability coefficient; the blackboard work took nearly twenty minutes. After class a student admitted that the first ten-odd minutes had looked like an unintelligible script, and only when a formula appeared that could be plugged in did it feel "finally useful". The teacher believed he was transmitting an argument; the students treated the classroom as a counter where formulas are handed out.

The other half of the problem lies outside the classroom. Students paste an exercise into a large model, obtain within seconds a solution with complete steps and tidy formatting, copy it out and submit it, while most of them cannot judge whether it is right: they do not see whether the model has taken the effective length factor wrongly, whether it has assumed something convenient about the plastic development coefficient, or whether it has treated a stability problem as a strength problem. Instructional videos work in the same way: the explanation is orderly and the student understands it, yet hardly anyone works the derivation out alongside. Between understanding and reproducing there is a step, and internalization happens precisely in crossing it — a step that is now skipped.

A self-reinforcing loop follows. A weak foundation makes the lecture unintelligible; unintelligibility makes attention withdraw; withdrawal makes students outsource their learning to models and videos; outsourcing stops derivation and judgment from growing; and the lack of growth makes the next round of lectures even harder to follow. Figure 1 sets out this chain. It is drawn not to place the blame on students, but to locate the breaks where something can actually be done.

2. Two Breaks

2.1. The Knowledge Interface

Mechanics of materials deals with stress, steel structure with resistance; between them lies one conversion, from a state to a capacity. The conversion itself is not difficult; what is difficult is that it assumes the earlier knowledge to be solid. Column stability shows this most clearly. Mechanics of materials gives the Euler critical load, which concerns the bifurcation of an ideal straight bar; steel structure has to deal with initial curvature, residual stress and end restraint, and therefore introduces a stability coefficient that folds the imperfections in. A student who has memorized only the table of coefficient values cannot understand why the coefficient falls so fast as slenderness grows; a student who knows the premises under which the Euler formula holds can see that this is a problem of reduction for imperfections. The bending of a beam requires the plastic development coefficient, and its premise is knowledge of stress redistribution; joints and connections require the load path through a bolt group, and its

premise is the ability to draw the internal-force components under eccentric shear. Once the interface breaks, everything that follows degenerates into table look-up. [2]

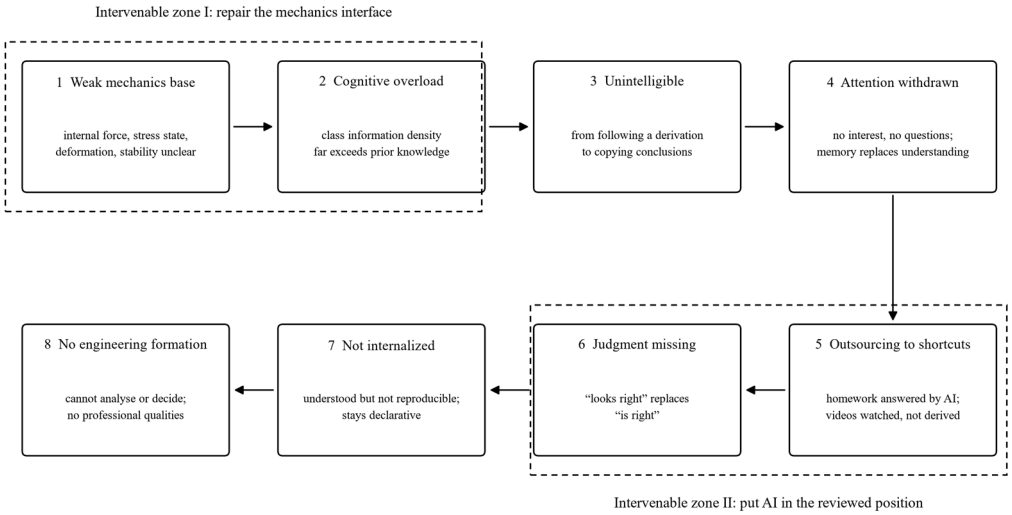

Figure 1. Transmission chain of the learning difficulty in the steel structure course and the two intervenable zones

2.2. The judgment

Answers now cost almost nothing, yet the training of judgment has not been adjusted accordingly. Half the teaching value of the traditional assignment lay in the search for the answer, which forced the student to work the derivation once; with that half removed, only copying remains. Worse, the errors of the models usually look right: units are complete, steps are coherent, standard clauses are even cited — only applied in the wrong place. Such errors are the most deceptive, because they match what students expect a standard answer to look like. Students therefore substitute "does it look right" for "is it right", and this is precisely the substitution that engineering judgment can least afford.

2.3. Internalization

Understanding is not reproduction, and reproduction is not application. The viewing experience of an instructional video is smooth because the explainer has already removed the detours; what the student sees is a pruned reasoning path, and the hesitation, trial and error and back-checking that internalization actually requires are absent from the screen. Students therefore readily form the illusion of having learned it, and cannot start once the parameters or the load case change. Knowledge stays at the level of declarative memory and cannot be called upon when a design problem requires a trade-off.

3. Where Digital-intelligence Education Can Act

By digital-intelligence education I do not mean inviting artificial intelligence into the classroom as a new lecturer, but using its availability to bring back in front of students the thinking steps that used to be bypassed. Figure 2 shows the arrangement the author tried out over one semester; the four links turn around a single goal — to make students take responsibility for judging their own answers.

3.1. Before Class: Repair The Interface, Not Reteach the Whole Book

A short diagnostic test before the course opens locates the breaks, and it asks only four things: given the bending moment on a section, can the student state the position of the neutral axis and the stress distribution; can the student judge convexity and concavity from the differential relation of the deflection curve; on what quantities does the critical load of a column depend, and why does it not depend on the strength of the material; under combined deformation, how is the critical point located. The results sort the breaks into three classes, each matched with a micro-lecture of about ten minutes — not systematic coverage, only the break repaired. In class the same bar serves as the contrast: a simply supported beam, whose normal stress and deflection are computed in mechanics of materials, and whose plastic development, local stability and web buckling must be checked in steel structure. One bar, two languages — and the position of the interface becomes visible.

3.2. In Class: Expose The Derivation and Leave a Gap

Key derivations are worked on the spot; at a certain point the teacher stops and hands the next step to the class: two minutes of explanation to a neighbour, then a randomly chosen student restates it. The teacher does not rush to give the correct answer, but lets the error appear first and corrects it on the spot. The price is contact hours — about one third less content per session; the return is that attention comes back to the derivation, because the next step may fall to anyone. Nor should the board be wiped too quickly: the traces of the derivation stay on the board, and only then can students see where the reasoning turns.

3.3. After Class: Put the Model in The Position of Being Reviewed

The assignment changes its form: the teacher generates a number of solutions with a large model, keeps or deliberately injects typical errors, and asks students to write a review

answering three questions — which step is wrong, on which section of the textbook or clause of the code the judgment rests, and what the correct procedure is. The marking looks at three things: accurate location, verifiable basis and feasible correction. Video tasks work in the same way: after watching an explanation, the student writes out which step of the derivation it omitted and supplies that step. The model thus moves from supplier of answers to supplier of errors, and the student's task moves from obtaining an answer to bearing judgment; what the change of form alters is really the student's position in the learning chain.

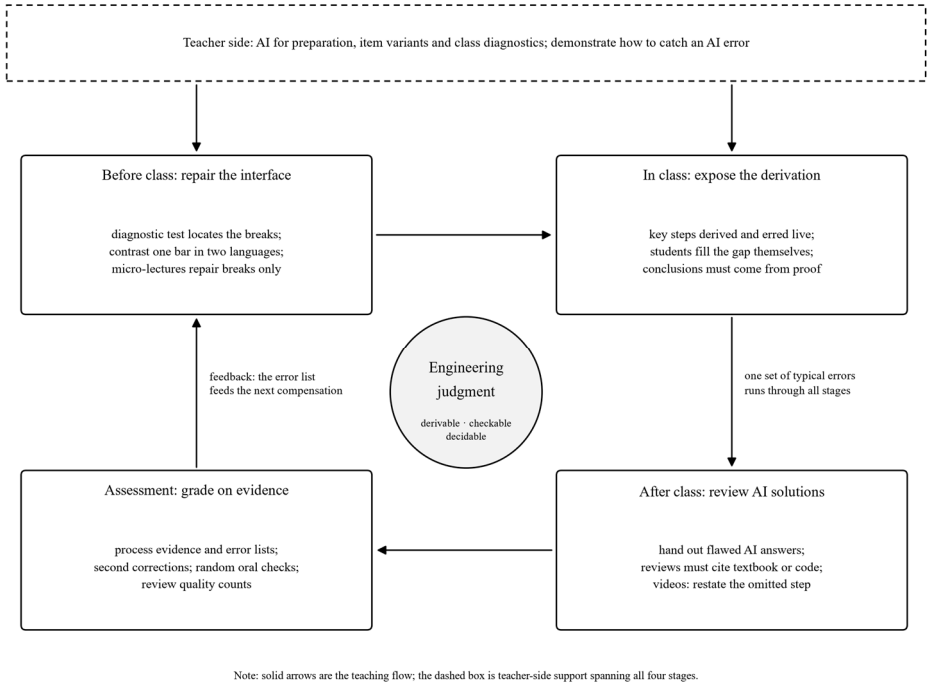

Figure 2. The four-stage teaching loop centred on engineering judgment

3.4. Assessment: Grade on Evidence

Assessment must change with it, otherwise the reform will be dissolved by perfunctory compliance. Three measures: raise the weight of continuous assessment; in every session draw three to five students at random to give a two-minute oral account of one step from the previous session, treating an unclear account as not mastered; allow assignments to be corrected a second time, provided the reason for the change is written down, since a changed result alone earns no marks. Grading on evidence means that whether the answer is right accounts for only part, while whether the student can say clearly why it is right or wrong accounts for the main part.

4. The Teacher's Position

Frankly, this reform forced the author to learn to use the model first. At the preparation stage it generates variants of the same problem with different parameters, writes erroneous solutions according to common errors on request, and digests a semester's record of questions into high-frequency breaks; it did save a good deal of work. The more valuable gain is this: when you have to judge whether the solution the model gives is correct, your own knowledge is genuinely put to the test. That experience of being tested is isomorphic with the students' review assignment, and it is how the teacher comes to know where the students' difficulty really lies, instead of assuming that something so simple could not possibly be misunderstood.

So the author deliberately voices his own judging process: this solution looks fine, but taking the effective length factor as 1.0 is wrong, because the column is not hinged at both ends; this plastic development coefficient is too large, because the flange is not a compact section. Demonstrating how to doubt has more teaching value than demonstrating how to obtain an answer; a teacher who does not act as a reviewer of the model can hardly ask students to become reviewers. [3]

5. Trial and Open Questions

The arrangement above was tried in two teaching groups over one semester; only qualitative observations can be offered here, and no controlled data yet. Three changes are visible: expressions such as "the error is located here" have markedly increased in assignment texts, with judgments as concrete as "here the stability problem was computed as a strength problem"; questions in class have shifted from "where does this step come from" to "why can this coefficient be taken here"; and in the oral checks, students able to restate a whole derivation chain are still few, but they are no longer a rarity.

Problems must also be admitted. Contact hours are the most direct constraint, and reducing the amount of lecturing is not easy within the current teaching plan; as class size grows, the cost of oral checks and assignment marking rises quickly; errors generated by the model are not always valuable errors, since some are so clumsy that students see through them at a glance; and marking review reports is fairly subjective, so the credibility of the assessment remains to be tested. Cross-cohort comparison and coded analysis of assignment texts will be needed before any reasonably reliable judgment of the effect can be made.

6. Conclusion

The centre of gravity of digital-intelligence education need

not lie in bringing new technology into the classroom, but in putting "why" back at the centre of teaching once answers are within easy reach. Principles of Steel Structure is well suited to this task: behind every formula there is a traceable load path, and right and wrong never depend on resemblance but on whether the derivation holds. If students acquire, in such training, the habit of doubting first, checking second and concluding last, the formation of an engineer's qualities will have a real starting point.

References

[1] Wang, J. (2026). Exploration of teaching reform driven by dual engines of "BIM+AI" in the course Principles of Steel Structure Design for the intelligent construction major. Journal of Intelligent Manufacturing Research and Application, 2(9), 148–150. (in Chinese)

[2] Zhang, N. (2026). Teaching reform of civil engineering courses under the background of new engineering: Taking the course Principles of Steel Structure Design as an example. Education and Teaching Forum, 10, 71–74. (in Chinese)

[3] Zeng, C. (2025). Research on the teaching reform of steel structure course empowered by AI: Exploration of the constructivism teaching mode based on intelligent cognition. Journal of Higher Education, 11(31), 1–4. (in Chinese)