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Reconstructing Classroom Learning Engagement in Engineering Mechanics at Applied Undergraduate Institutions: A Three-Loop "Suspense–Interaction–Achievement" Instructional Design

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Abstract: *Applied undergraduate education requires Engineering Mechanics to move from transmitting knowledge to developing competence that students can call upon in real engineering situations. Classroom observation at the author's institution shows that students' behavioral, emotional and cognitive engagement are weakened to different degrees. This study analyzes the causes from five angles: the translation between engineering phenomena and mechanical models breaks down; learning motivation is unsupported; cognitive scaffolding is in short supply; interaction fails to form a feedback loop; and assessment does not reach classroom engagement. On this basis a three-loop "suspense–interaction–achievement" instructional design is proposed: a real engineering question arouses curiosity, multi-party dialogue drives inquiry, and visible progress sustains confidence. The design logic and the implementation points of the three loops are set out, and a worked example from the chapter on column stability is given, as a reference for classroom reform in basic engineering courses at applied undergraduate institutions.*

Keywords: *Engineering Mechanics; Classroom learning engagement; Suspense–interaction–achievement; Instructional design; Applied undergraduate education*

1. Introduction

1.1 The Engineering Mechanics course

Engineering Mechanics is a compulsory basic course for engineering majors. Its content rests mainly on statics and mechanics of materials, and some textbooks extend to structural mechanics. Statics deals with the analysis of forces acting on a body and the conditions for equilibrium; mechanics of materials addresses the strength, stiffness and stability of members. As a basic professional course, it serves a large number of majors and students, yet the contact hours allotted to it are relatively tight. Its dense theoretical derivations and the long-standing lecture-and-blackboard format also limit its appeal, and teaching outcomes do not always meet expectations.

1.2 New demands on the Engineering Mechanics classroom under the transition to applied undergraduate education

In 2017 the Ministry of Education of China issued the Opinions on the Establishment of Higher Education Institutions during the *13th* Five-Year Plan Period[1], which classified higher education institutions into three types: research-oriented, applied, and vocational. Applied undergraduate institutions thus acquired an explicit policy status. Their central task is to redirect institutional orientation from academic pursuit toward serving local economic and social development, and to cultivate application-oriented talent with practical ability[2]: students who not only hold knowledge but have formed the capacity to use it in real engineering situations. Engineering Mechanics as traditionally taught stresses the completeness of its theoretical system and the manipulation of formulas, which sits at some distance from what the cultivation of applied talent requires. Many teachers have already responded to that gap. Chu et al.[3] took Hefei University as a case and, in the light of the characteristics of

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environmental engineering, sorted out the salient problems in teaching Engineering Mechanics and proposed a model in which students are the subject and innovation and practical ability are foregrounded. Li et al.[4] carried out course reform for programs such as engineering cost and strengthened the analysis of engineering cases in order to improve students' capacity to analyze and solve practical problems. Zhou et al. [5] discussed the coordinated construction of engineering courses against the background of the "Double First-Class" and Emerging Engineering Education initiatives, using the Engineering Mechanics course at Tarim University as an example. These efforts inform the present study, but their focus falls mainly on adjusting teaching content and course resources; how classroom phases should be organized, and how students can genuinely engage in class, have received less attention.

1.3 The reality: the "three lows" of classroom learning engagement

1.3.1 Superficial behavioral engagement

Engineering Mechanics is usually assessed through continuous assessment during the term combined with a final written examination. In the author's teaching practice, many students attend class in order to earn full attendance marks, but their attention is not on the lesson: scrolling on phones and dozing off occur from time to time, and a reminder from the teacher brings them back only briefly. When questions are put to the class, most students respond slowly and few answers of their own accord. Patterns of this kind are common in basic engineering courses and recur across the classes the author has taught.

1.3.2 Weakening emotional engagement

Engineering Mechanics is dominated by calculation, with dense and abstract formulas; difficulty in learning has long been a salient problem for this course and a focus of teaching reform[6]. Some students even develop a psychological aversion to calculation-based courses and problems, from which a reluctance to study follows. Conversations with students also show that some are not interested in the major they entered, and because their applications to change major were unsuccessful, their initiative keeps declining; sustaining steady emotional engagement with the course then becomes difficult.

1.3.3 Shallow cognitive engagement

Classroom feedback shows that students usually understand a single knowledge point without difficulty, yet once several points converge in one comprehensive problem their reasoning tends to break down. If the geometry is changed or the loading situation altered, they find it still harder to transfer what they know. On the whole their learning stays at the level of memorizing isolated conclusions, and the connections between topics are missing. This is precisely the difficulty that reform of mechanics courses has sought to break[7].

Against this background, the present study takes the applied undergraduate Engineering Mechanics classroom as its object and, addressing the practical problem of weak learning engagement, attempts to construct a three-loop "suspense–interaction–achievement" instructional design. The design logic, instructional aims and workable classroom strategies of each loop are explained, and the implementation is presented through one specific chapter.

2. Causes of the classroom problems in applied undergraduate Engineering Mechanics

(1) A breakdown in knowledge translation. Most students have little contact with specific engineering situations in daily life, and the link between abstract mechanics theory and concrete engineering objects is missing, so what they learn stays on the surface. Teaching also rarely arranges training in translating an engineering phenomenon into a mechanical model, or the reverse, and students therefore struggle to establish a correspondence between the two representations.

(2) Learning motivation is unsupported. Some students have no plan for their future career and discover only after enrolment that the major does not match their expectations; their goal then narrows to passing examinations and obtaining a diploma. Others doubt that the content will be useful in their future work and are accordingly unwilling to invest effort. When the immediate purpose of learning is no more than assessment, there is no basis on which competence can be built.

(3) Cognitive scaffolding is in short supply. Contact hours have been compressed in recent years while the content to be covered has not shrunk correspondingly, so teachers can only accelerate the pace of lecturing, and the time left for students to practice and digest is very limited. Knowledge points are presented one after another in fragments; tasks that progress from easy to difficult, and that connect with

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engineering situations, are absent, and higher-order thinking is therefore hard to generate.

(4) Interaction fails to form a feedback loop. Constrained by contact hours the classroom remains predominantly one-way lecturing, and interactive segments, even when retained, are often curtailed when time runs short. Teachers can hardly give immediate feedback, let alone guidance suited to individual differences; students' confusion cannot be resolved in class and simply accumulates.

(5) Assessment does not play its directing role. Courses of this calculation-based kind generally rely on examination as the main means of assessment: the overall grade consists of a continuous assessment component and a final examination component, and the former is usually determined by attendance and after-class assignments. Little is designed for students' behavioral, emotional and cognitive engagement in class, so the "baton" of assessment can hardly guide students toward deeper learning.

3. Construction of the three-loop instructional design

The three-loop design can be summarized in three points of emphasis: attention is drawn by a question, participation is driven by collaboration, and confidence is sustained by progress. A class opens with an unresolved question, so that students enter inquiry carrying a doubt and their attention is drawn by curiosity; the question is then handed to group discussion, where students revise their thinking through mutual questioning and challenge, so that participation is no longer the formalized exchange of "teacher asks, student answers"; and each advance made during inquiry is noticed and recorded in time, which becomes the reason for further investment. The three loops are not independent steps arranged one after another; they drive and feed back into one another around the development of engineering modeling ability. The suspense loop supplies the motive force: it provides the engineering problem as an anchor, fixes the topic of discussion and gives the dialogue that follows its task. The interaction loop is the vehicle of the process: it takes up the suspense and opens multi-party dialogue, and the mechanical models, lines of analysis and typical misconceptions it produces become the material that the achievement loop assesses. The achievement loop regulates: it feeds the results of continuous assessment back, so that students see their own progress and become more willing to join the next round of suspense-driven inquiry, while the teacher uses the same information to judge how the class is doing and to adjust the difficulty of the next main suspense question and the level of follow-up questioning.

3.1 The suspense loop: starting the class with a question

Suspense material comes from roughly five sources. The first is engineering design cases, which point to problems of engineering configuration, section selection and member layout, such as why I-beams are made in the shape of an "I" rather than as solid rectangular sections. The second is engineering accident cases such as bridge fracture, tower crane overturning and scaffold collapse, where a real failure event arouses alertness: a steel sling ruptured suddenly at a load far below the tensile strength of the material — why? The third is phenomena from daily life, taking mechanics problems from things, students know well: a slender drinking straw bends sideways under vertical compression well before it is crushed, whereas a short and thick one does not. The fourth is material that creates cognitive conflict, using the tension between everyday intuition and mechanics to provoke thought. If a hole in a beam is assumed harmless so long as its area is small, which is more dangerous: a hole at the upper or lower edge, or one at the neutral layer? The fifth is demonstration and simulation, which presents deformation and failure directly through small classroom experiments or numerical simulation: for two compressed bars of identical cross-section, changing only the end restraints changes the critical load by a wide margin, and buckling can be demonstrated on the spot. When preparing a lesson, the teacher selects one or two core suspense questions based on the session's knowledge points to thread through the entire class. The teacher generally prefers to use design and accident cases as the source, from which three or four sub-questions are derived. These sub-questions integrate real-life phenomena, cognitive conflicts, and experimental or simulation materials, enabling students to progress from simple to complex and accomplish the bidirectional conversion between engineering phenomena and mechanical models. As for timing, the main suspense question is best raised within the first five minutes of the class, and a question pointing to the next session may be left in the last five minutes.

3.2 The interaction loop: building the class through dialogue

Once the suspense question has been raised, the class moves into group discussion. Dialogue between teacher and students and among students forms the main mode of interaction, while the smart teaching

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platform carries a third layer of interaction as its medium; one-way lecturing gives way to inquiry in which several parties take part, and the abstraction of mechanical models, the weighing of alternative solutions and the clash of ideas all take place in dialogue.

Dialogue between teacher and students works mainly through follow-up questioning. Rather than giving conclusions directly, the teacher poses layered questions around the suspense. When students' analysis stalls or their simplification of the model goes astray, scaffolded questioning leads them to check for themselves the key links (forces, boundary conditions and failure modes) so that repeated attempts build an analytical path for dealing with complex engineering problems. In this process the teacher also acts as moderator, keeping the pace of discussion, correcting direction when necessary, and helping students distinguish among failure types such as strength, stiffness and stability.

Horizontal exchange among students matters as much. Grouping follows a differentiated strategy: each group is given one outgoing and articulate student to set the tone of discussion, together with one student with a solid foundation and quick understanding to organize the line of reasoning and tackle the difficult parts. Within a group, sound lines of thought may be borrowed from one another, and mistaken assumptions and flawed models may be displayed openly; by exposing the gaps in their own understanding, students gradually clarify mechanics concepts, and correcting errors is no longer the teacher's task alone.

The third layer of interaction is mediated by the smart teaching platform. Groups discuss in the platform's discussion area, online and offline at the same time, and the views, free-body sketches and preliminary calculation ideas they form can be uploaded and shared. Students can read other groups' solutions and take part in cross-group peer review, which broadens their analytical perspective and takes discussion beyond their own group.

Throughout the interaction loop the teacher plays several roles at once: proposer of the suspense, moderator of the discussion, and respondent when students are stuck. One role is particularly distinctive: "magnifying errors". The teacher deliberately picks up representative mistaken models and intuitive misconceptions, places them before the whole class, and guides everyone to examine the source of the error together, so that the error itself becomes an opportunity to understand mechanics principles. After the discussion, groups report their results in turn, laying the ground for the model building and theoretical derivation that follow.

3.3 The achievement loop: making learning visible

After group discussion the class enters the achievement loop. What this loop does is make visible the thinking, views and interim results students produce during inquiry, so that the sense of gain has something concrete to attach to. The teacher has to catch students' output as discussion proceeds: when a student offers a sound mechanics judgment, a correct free-body model, or steps outside the habitual line of thought and explains the engineering suspense from a new angle, the teacher responds promptly with verbal recognition and classroom appreciation. Recognition tends to strengthen students' identification with the course, and their subsequent investment becomes more willing.

Classroom achievement is recorded in several ways: classroom performance counts toward classroom points, the continuous assessment grade and the student's growth portfolio, forming a traceable record of learning; beyond the quantitative credit incentive, staged awards may be set up, such as selecting and displaying the best modeling sketch, the best problem analysis, or the most inventive thinking. It should be noted that achievement assessment does not look only at whether an answer is correct: process counts as much: whether the student can translate an engineering phenomenon into a mechanical model, whether they identify failure modes on their own initiative, whether they dare to question, and what specific work they took on within the group.

Table 1: Scoring rubric for the achievement loop (per class, cumulative for the individual).

Observation dimension	Observable indicator (behavior that can be judged)	Scoring rule	Retained evidence	Maximum per class
Mechanical modeling	Can abstract an engineering phenomenon into a mechanical model, with a correct free-body diagram and correct boundary	2 points if completed independently; 1 point if corrected by the student after follow-up questioning	Free-body sketch (photographed and uploaded to the	2 points

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	conditions, and can state the basis for the simplification		platform)	
Failure mode identification	Can identify the dominant failure mode and distinguish strength failure from instability failure	2 points if raised on the student's own initiative before the teacher gives the conclusion; 1 point if raised after	Record of classroom analysis (entered by the recorder)	2 points
Questioning and innovation	Raises a substantiated doubt about a textbook conclusion, a problem statement or an engineering phenomenon, points out an omission, or offers a new angle of analysis	1 point if substantiated, regardless of whether the conclusion is right; up to 2 points when the teacher records the reason in writing	Platform question posts and teacher annotations	2 points
Disclosing errors	Publicly discloses one's own mistaken assumption or failed solution and has it taken up in the class analysis	2 points, once per class	Original derivation or experimental record (revision marks kept)	2 points, combined with the row above
Collaboration and peer review	Takes on a specific task within the group and takes part in cross-group peer review	Anonymous within-group peer review graded A/B/C, worth 2, 1.5 and 1 points respectively; the comment counts only if it names one specific strength and one point for improvement	Within-group peer review form	2 points
Classroom participation	Speaks up, asks questions, or reports for the group; continues to ask questions or uploads supplementary calculations on the platform after class	1 point each time	Recorder's log; platform interaction record	2 points
Total	—	—	—	10 points

Four points about Table 1 should be noted. First, a combined ceiling: "disclosing errors" and "questioning and innovation" share the 2-point ceiling, and both require the teacher to record the reason in writing. Second, a distribution constraint: in a single class the number of students in band A (8 points or above) does not exceed one third of the group, and once a student has reached the maximum in a given dimension for three consecutive classes, that dimension no longer earns repeated points from the fourth class onward, the excess not being counted, so that the student is directed toward weaker dimensions. Third, recording and review: the group recorder enters the points on the spot and the teacher checks and signs after class; the points are published at the end of each class and students may raise objections and have them reviewed before the next class, with the retained evidence governing where there is an objection. Fourth, conversion: at the end of the term the classroom achievement points are totaled and weighted at 20% in the overall course grade (the continuous assessment grade consists of attendance, after-class assignments and classroom achievement points), and a personal growth portfolio curve is generated so that students can see the trajectory of their own engagement.

The point of the achievement loop is that students see the value of their own thinking and the process of their growth, rather than receiving knowledge passively. This positive feedback in turn supports the suspense and interaction loops, so that "raised suspense – inquiry through dialogue – gained recognition" runs repeatedly through the classroom.

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4. Teaching implementation: the chapter on column stability

The following uses the chapter on column stability to illustrate how the design is put into practice. The chapter deals with the critical load at which an axially compressed member buckles laterally, how the various parameters affect it, and how the stability of a member is checked; it combines theoretical derivation with a rich engineering background, which makes it a suitable example for the three-loop design.

4.1 Design of the suspense loop

The main suspense question is built around the collapse of the vertical posts of a scaffold on a construction site: the steel of the posts passed inspection and satisfied the safety requirement when checked against axial compressive strength, and the actual load was far below the compressive strength limit of the material, yet the posts suddenly bent sideways and brought the whole structure down (the bending in Fig. 1(a) is assumed). The members were not crushed, but failed early — why?

Sub-question 1: two compressed bars of exactly the same cross-sectional area, one with a solid circular section and one with a hollow circular section (Fig. 1(b)), of the same material, length and support conditions — which buckles more easily? Why are steel columns mostly made with hollow sections?

Sub-question 2: the same wooden ruler, standing vertically on the desk, bends sideways under light pressure at the top; laid horizontally as a simply supported beam under a vertical load, its failure mode is quite different. What is the essential difference between the failure mechanisms of the two cases?

Sub-question 3: an A4 sheet stood upright bends sideways at a light touch, but rolled into a tube and compressed vertically it carries noticeably more load. With almost no change in material or weight, why does its resistance to instability rise so much?

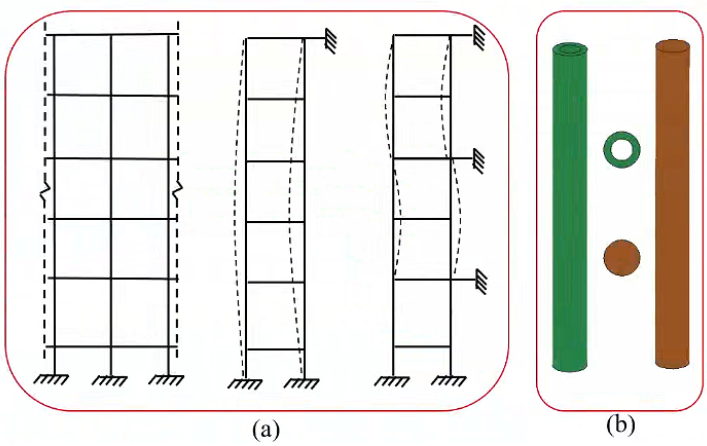


Fig. 1 Schematic of column stability: the dashed line in (a) indicates the lateral buckling curve of the post after instability, and (b) compares compressed bars with solid and hollow circular sections of equal cross-sectional area.

4.2 Implementation of the interaction loop

The main suspense question is presented together with Fig. 1(a), and the teacher guides group discussion along three directions: simplification of the force model, identification of the failure mode, and boundary conditions. Through scaffolded questioning, students first abstract the scaffold post as a centrally compressed straight bar, then distinguish strength crushing from lateral buckling as two different failure mechanisms, and then, using the buckling shapes under different lateral support conditions in the figure, consider how lateral restraint and effective length affect the critical load. After the discussion, the fixed belief that “a member fails because the strength of the material is insufficient” has been broken.

Sub-question 1 is developed from Fig. 1(b). Two compressed bars of equal cross-sectional area, the same material and the same restraints, one solid and one hollow — which buckles more easily? The discussion compares the geometric characteristics of the two sections: students have to translate the actual

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member into a mechanical model of a compressed bar and examine how the distribution of material within the section affects the radius of gyration and the critical load.

Sub-question 2 uses a classroom experiment together with follow-up questioning. Each group is given a ruler and completes two comparative trials: first, the ruler stands vertically on the desk and is loaded slowly at the top, so that lateral buckling can be observed; second, the ruler is simply supported at both ends and loaded vertically at mid-span, so that bending deformation can be observed. The teacher then asks, layer by layer: how do the deformation characteristics of the two trials differ? Has the material reached its ultimate strength when the ruler is pressed vertically? What mechanical model does each case correspond to? How do the criteria for strength failure and for instability failure differ? Which members in engineering practice require a stability check, and which need only a strength check?

Sub-question 3 also centers on experiment. Groups make specimens of different sections from A4 paper (flat sheet, tube, square tube and W-shaped folded plate), stand them upright and load them slowly at the top, comparing the buckling loads and the deformation patterns of the specimens. The teacher then asks: when the paper is rolled into a tube, with material and weight unchanged, which geometric parameter has actually changed? As material moves away from the centroid of the section, how do the moment of inertia, the radius of gyration and the critical load change? Of the tube, the square tube and the folded plate, which resists instability best? What does this experimental result suggest for the design of steel tube scaffolds and steel columns?

4.3 Implementation of the achievement loop

During group discussion and hands-on experiment, the teacher carries out continuous assessment at the same time. When students can abstract the mechanical model of the member, distinguish strength failure from buckling instability, or discover a deformation pattern in the ruler and A4 experiments and put forward a new idea, the teacher gives verbal recognition. Assessment is not limited to whether the answer is correct: mechanical modeling, experimental operation, group collaboration and engineering judgment all count, and the relevant performance is recorded in classroom points, the continuous assessment grade and the growth portfolio. Students or groups that correctly analyze the failure mechanism of a compressed bar, draw a sketch of the buckling deformation, or derive from experiment how section and restraint affect the critical load receive bonus points; outstanding experimental records and free-body sketches are uploaded to the smart teaching platform for public display. Through this loop the lines of inquiry students previously kept implicit become visible results, and their sense of gain grows; this positive feedback then supports the design of the following suspense question and the discussion that goes with it, so that the cycle "pose a suspense question – discuss through dialogue – feed back achievement" continues.

5. Conclusion

This study addresses the problem of weak learning engagement in the applied undergraduate Engineering Mechanics classroom. It analyzes the causes in five respects: knowledge translation, learning motivation, cognitive scaffolding, interactive feedback and assessment. On this basis it proposes a three-loop "suspense–interaction–achievement" instructional design, illustrating its implementation through the chapter on column stability. In terms of design, the suspense loop draws on engineering designs, engineering accidents, everyday phenomena, cognitive conflict and simulation demonstrations, using engineering questions to hold students' attention; the interaction loop, through dialogue between teacher and students, among students, and in a third layer mediated by the platform, hands the class over to inquiry in which several parties take part; the achievement loop records the results of inquiry through classroom points, the continuous assessment grade and the growth portfolio, and feeds assessment information back to the first two loops. The three loops advance in sequence, link information in turn, and share the same goal of engineering modeling ability, forming an inquiry structure that can run repeatedly in the classroom. It should be noted that the design makes considerable demands on the teacher's preparation time, classroom organization and the support conditions of the teaching platform; its applicability across different programs and classes, and its long-term effect on students' learning engagement, remain to be examined in further teaching practice.

References

[1] Ministry of Education of the People's Republic of China. Opinions on the establishment of higher

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education institutions during the 13th Five-Year Plan period: Jiao Fa [2017] No. 3[EB/OL]. (2017-02-04). (in Chinese)
[2] Wu Zhongjiang, Huang Chengliang. The connotation of applied talent and the cultivation of applied undergraduate talent[J]. Research in Higher Education of Engineering, 2014(2): 66-70. (in Chinese)
[3] Chu Zhuding, Liu Xiaowei. Teaching exploration of the Engineering Mechanics course for environmental engineering at applied undergraduate institutions: the case of Hefei University[J]. Journal of Chifeng University (Natural Science Edition), 2023, 39(7): 103-106. (in Chinese)
[4] Li Xiaoying, Hong Jianren. Research on teaching reform of the Engineering Mechanics course at applied undergraduate institutions[J]. Journal of Jilin Agricultural Science and Technology University, 2019, 28(3): 94-96+123. (in Chinese)
[5] Zhou Ling, Wang Dewei, Liu Jia. Coordinated construction of engineering courses under the "Double First-Class" and Emerging Engineering Education initiatives: the case of the Engineering Mechanics course at Tarim University[J]. Higher Education Journal, 2024, 10(22): 35-39. (in Chinese)
[6] Liu Juan, Shen Huoming, Li Xiangyu, Gao Fangqing, Kan Qianhua. Construction and practice of a blended teaching model for Engineering Mechanics empowered by digital intelligence[J]. Mechanics in Engineering, 2026, 48(3): 558-566. (in Chinese)
[7] Wang Rui, Zhang Xuejian, Zhao Hui, Yang Huiwei. Breaking the dilemma of traditional mechanics teaching: joint teaching reform of Mechanics of Materials and Structural Mechanics under Emerging Engineering Education[J]. Higher Education Journal, 2026, 12(3): 1-4. (in Chinese)