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Problem posing in university mathematics education: A study informed by deep learning theory

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ABSTRACT

Problem posing is increasingly recognized as a key instructional strategy for promoting deep learning in college mathematics education; however, its effective implementation largely depends on teachers' pedagogical understanding and classroom practices. This study adopts a mixed-methods approach to examine university mathematics teachers' understanding of deep learning and whether their classroom questioning aligns with deep learning principles. Quantitative data were collected through questionnaires administered to 102 mathematics teachers, while qualitative data were obtained from classroom observations of three advanced mathematics courses and semi-structured interviews with four teachers. The findings indicate that although teachers generally value positive teacher–student relationships and diversified learning forms, their understanding of deep learning remains limited, particularly with regard to critical thinking and meta-cognitive development. Classroom observations show that reasoning-based questions dominate instructional practice, whereas critical, creative, and modeling-oriented questions are relatively scarce. In addition, teachers mainly rely on direct questioning and evaluative feedback, with limited use of dialogic, inquiry-based, or scaffolded questioning to support deeper exploration. Interview data further reveal that teachers' questioning practices are largely influenced by textbooks and examination requirements rather than being consciously guided by deep learning theories. In response, this study proposes a professional development framework integrating theoretical learning, contextualized problem design, progressive questioning sequences, student exploration support, and diversified feedback strategies. Overall, the findings reveal a gap between deep learning theory and classroom practice in college mathematics teaching and provide practical guidance for fostering students' conceptual understanding, creativity, and reflective thinking.

Contribution/Originality: This study promotes research on in-depth learning of higher mathematics by highlighting teachers' question shortcomings in real classrooms and proposing targeted training strategies. It offers new insights on effectively promoting students' in-depth cognitive participation and learning outcomes through problem design and inquiry guidance.

1. INTRODUCTION

With the rapid development of globalization and science and technology, the global requirements for the higher education system are increasing. We hope to cultivate students with complex cognitive skills, strong problem-solving ability, and innovative thinking. In terms of college mathematics education, these expectations bring challenges and opportunities because mathematics learning requires a deep understanding of concepts, logical cognition, and the ability to migrate across situations. Relevant scholars in the field of mathematics education have also long realized

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that superficial learning relying on rote memorization and procedural exercises is not enough to adapt students to today's world (Kovač, Nome, Jensen, & Skreland, 2025; Wang & Abdullah, 2024). For this reason, a teaching method that emphasizes deep learning has gradually emerged in higher education, emphasizing meaningful knowledge construction, comprehensive thinking, and positive feedback participation (Fawzia & Karim, 2024).

From the perspective of pedagogy, deep learning in mathematics refers to students' ability to integrate concepts, establish interdisciplinary connections, and think critically about mathematical problems (Orhani, 2024). In college mathematics classes, promoting deep learning requires shifting the teaching model from content-centered to inquiry, reasoning, and judgment-centered thinking. A crucial pedagogical tool is encouraging students to tackle new kinds of problems known as problem posing, which involves presenting students with new questions related to mathematics, reformulating existing questions, or offering alternative pathways for solutions. These have been recognized as key to fostering higher-order thinking and creativity in mathematics (Lim, Yoon, Bae, & Kwon, 2023), yet similarly to an ethics education context, where nuanced judgment, multi-viewpoint Thinking and problem posing rely on students' deep conceptual understanding and capacities to navigate uncertainty and complexity.

Despite the significant role problem posing plays in higher education, research shows university mathematics instruction still follows teacher-centered pedagogies in which problems are predetermined, closed-ended, and procedural in nature (Vale & Barbosa, 2023), which restricts the possibility of students to authentically deploy reasoning or consider multiple solution modes. More critically, problem posing is yet to be effectively implemented in universities or often executed superficially, largely due to most university mathematics lecturers receiving limited pedagogical training in the context of deep-learning-oriented approaches (Maass, Swan, & Aldorf, 2017). This means students' cognitive and metacognitive capacities are inadequate to develop higher-stage mathematical thinking.

Moreover, literature has revealed problem posing as not solely a mental ability but as a thinking process that requires students to scrutinize hypotheses, consider alternative portrayals, and communicate their justifications. Indeed, these skills are similar to other thinking processes explored in many disciplines, including ethics education (Demircioglu, Karakus, & Ucar, 2023). Similar to the debate in ethical reasoning, which facilitates ethical thinking by guiding learners toward argumentation, problem posing could be utilized in higher education to promote mathematical inquiry and deeper learning. However, research based on using deep-learning theory to support problem posing in mathematics in higher education remains underdocumented globally.

In response to these limitations, the present study is conducted with the goal of exploring university mathematics instructors' understanding of deep-learning theory and evaluating the alignment between their problem-posing practices and deep-learning principles. Examining current curricular practices, this study will attempt to propose an array of deep-learning-oriented pedagogical approaches to design and execute problem-posing activities in the context of the university mathematics classroom. The findings will contribute to mathematics education reform worldwide through pragmatic tips on how educators can optimize students' higher-order thinking, creativity, and deep conceptual understanding.

2. LITERATURE REVIEW

Deep learning developed rapidly in the past decade and has become one of the key technologies actively propagating advances in artificial intelligence. In recent years, in line with deep neural networks' continual breakthroughs in computer vision, natural language processing, speech recognition, and multimodal understanding, the frameworks and theories behind its design and development continue to become more sophisticated. ResNets, Transformers, GANs, GNNs, diffusion models, and cross-modal models these theoretical models and conceptual frameworks have changed the landscapes of feature representation learning, reasoning abilities, and generative performance, allowing deep models to formulate complex hierarchical diagrams from enormous data. However, at the same time, deep learning still faces several system-level challenges: high computational costs, unstable training, heavy reliance on large data sizes, weak interpretability, and so on (Mienye & Swart, 2024; Qing & Yan, 2024). Moreover,

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recent research trends seek to sustain previous performance superiority and minimize costs of resources and Human Controllerability (Hajamydeen & Kumar, 2025), which will not only foster the development of Artificial Intelligence models but also provide technical bases in education to combine intelligent resources into adaptive learning systems.

As a crucial cognitive activity and pedagogical strategy, problem posing (PP) has been identified as a way of gaining deep learning in mathematics education. The consensus for researchers is that problem posing does not solely refer to the act of constructing new problems before problems are solved but also encompasses the much more complicated reasoning activity that can advance conceptual comprehension, promotes mathematical invention, augments meta cognition, and is importantly, strongly and positively associated with the quality of problem solving (Calabrese, Capraro, & Thompson, 2022; Liljedahl & Cai, 2021). Over the past five years, the research efforts of problem posing have also greatly diversified in the areas of instructional interventions, instructional contexts, teacher education, and assessing problem posing. Structured lessons have led to significant improvements in the quality and variety of student-constructor problems (Zhang, Stylianides, & Stylianides, 2025), and learners' depth of thinking was heavily affected by instructional characteristics like openness, organization, and realism. The research on problem posing is continuing to make significant theoretical contributions to improve teaching practices (Baumanns, 2022). However, in actual schools, the practice is restrained due to certain issues.

These problems include teachers' lack of sufficient professional knowledge and specialized training, lack of standardized assessment methods, and limited time to raise high-quality and meaningful questions (Cai & Hwang, 2020; Lee, 2021). These restrictions also restrict the large-scale and effective application of problem posing methods in college mathematics classrooms.

In recent years, with the rise of generative artificial intelligence, there are more and more cross-field problem-setting research (including automatic generation problems and the use of large-scale language models to construct artificial intelligence-assisted problems) and deep learning. Recent research shows that artificial intelligence has great potential in generating mathematical problems, controlling the difficulty of problems, and generating multimodal projects. For instance, the "Learning to Ask" model proposed by Wei, Zhao, Shen, Chen, and Cheng (2025) designs problem templates by chaining-of-thought prompting and leverages feedback from solver solutions for reinforcement learning, paving the way for adaptive problem solving and more high-quality math problems. Similarly, QueST, suggested by Wei et al. (2025), is capable of generating highly difficult programming problems by using difficulty-controllable Sampling mechanisms to augment the reasoning capabilities.

Furthermore, the utilization of multimodal models such as COMET has facilitated the creation of complex math problems in multidisciplinary contexts beyond traditional text by introducing graphical information into problem presentation formats, thus extending the scope of traditional problem presentation (Huang & Chen, 2024). In the realm of instruction, problem causing technologies are seen as facilitators to guide students through problem construction routines and provide problem structure, feedback, and support during learning sessions (Ofda & Topcu, 2025). However, to-date, this novel intersectional domain is relatively nascent, face difficulties related to evaluation quality, generative content controllability, biases and ethical issues, and seamless integration into instructional proceedings.

In sum, the fusion of deep learning with problem posing proposes new avenues for mathematics instruction. Recent works are mostly centered on theories of modeling, problem-solving infrastructures, or the performance of AI systems, with fewer reports on the on-the-ground translation of ideas to real classroom workflows. Specifically, existing investigations have failed to address how the outcomes of problem-causing technologies satisfy instructional goals, match students' cognitive load, or how to provide sustainable instructional designs during teaching. To explain these gaps, the author's work intends to tackle how to navigate deep learning technologies into practice for problem posing within a college mathematics classroom, thereby stretching the line between theoretical conceptual innovation and its translational application to pedagogical practice and producing useful steps forward for the integration of deep learning in mathematics schooling.

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3. METHOD

3.1. Research Design

The study employed a mixed-methods approach to explore mathematics teachers' knowledge of deep learning theory and how problem-posing practice manifests in college mathematics classrooms. Quantitative data were gathered through a questionnaire; qualitative data were captured from classroom observation and a semi-structured interview. The integration of these two approaches contributed to triangulation, increasing the credibility of the findings, and yielded a more holistic understanding of teachers' instructional beliefs and classroom practice.

3.2. Participants

The participants were divided into three groups. A total of 105 questionnaires were mailed to math teachers at WEIFANG Vocational College of Industry and Commerce, Shandong Province, and 102 questionnaires (see Table 1) were returned with valid answers, resulting in a response rate of 97.14%. Second, classroom observations were conducted in three sections of college mathematics courses taught at the same university. Third, four teachers who also participated in the questionnaire survey were invited to join semi-structured interviews. All participants were informed of the study's purpose and voluntarily agreed to participate.

Table 1. Questionnaire sample information.

Item 1	Item 2	Number	Percentage
Gender	Male	53	52%
	Female	49	48%
Age	Under 30 years old	12	11.8%
	30-40	34	33.3%
	40-50	49	48%
	Over 50 years old	7	6.9%
Professional title	Level 1	47	46%
	Level 2	43	42.2%
	Senior teacher	12	11.8%

3.3. Instruments

3.3.1. Questionnaire

A questionnaire was developed to measure mathematics teachers' instructional beliefs and their understanding of deep learning theory. The selection of dimensions was informed by prior research on teachers' pedagogical beliefs by Cui (2019) and Zhong (2022), focusing on teacher & student relationships, learning formats, and thinking patterns. The design further incorporated items from teacher questionnaires developed in previous studies by Wu (2018) and Wang (2021).

The final questionnaire consisted of 11 items. Items 1-2 collected basic demographic information. Items 3-11 were constructed using a five-point Likert scale, ranging from "Strongly Agree" to "Strongly Disagree." Higher scores indicated a stronger alignment with deep learning-oriented instructional beliefs. Detailed questionnaire items are provided in Table 2.

Table 2. Questionnaire details.

Teachers' pedagogical beliefs	Item
Teacher & student relationship	Q3-Q5
Learning format	Q6-Q8
Thinking patterns	Q9-Q11

Only Items 3-11 were subjected to reliability analysis because the first two items were demographic questions. Using SPSS 24.0, the internal consistency reliability was examined, and the Cronbach's alpha coefficient exceeded

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0.80, indicating high reliability. Construct validity was assessed using the KMO test and Bartlett's Test of Sphericity. The questionnaire achieved a KMO value of 0.760, exceeding the recommended threshold of 0.70, and Bartlett's test was significant ($p < 0.05$). These results indicate that the data demonstrated acceptable validity.

3.3.2. Classroom Observation Protocol

To investigate how problem-posing practices are carried out in praxis, a classroom observation rubric was derived from existing frameworks.

The model was constructed based on the Gu (2025) questionnaire model, the dimensions expanded by Lu and Hong (2010), and observational indicators by Ye and Zhou (2012). 4 dimensions were chosen for the current researcher's study.

The full observation checklist is delivered in Table 3.

Table 3. Classroom observation dimensions.

First-level dimension	Second-level dimension
Types of questions	Management, memory, reasoning, critical, creative
Questioning approaches	Direct questioning, heuristic elicitation, situational questioning, reverse questioning
Types of student responses	No response, mechanical yes/No, memory-based response, reasoning-based response, creative/Evaluative response
Teacher feedback behaviors	Ignoring, interruption, direct feedback, repetition, explanation, praise, probing.

3.3.3. Interview Protocol

This study adopted semi-structured interviews to gain a deeper understanding of teachers' knowledge about deep learning, their views on its role in learning mathematics, their guidelines for constructing questions in class, and the connection between question practices and deep learning. The interview guide comprised four principal questions (Table 4) adapted from Paşca-Tuşa and Ciascai (2021).

Table 4. Interview outline.

Question	Content
Q1	Are you familiar with deep learning theory?
Q2	What benefits do you think deep learning can bring to students?
Q3	How do you design classroom questions? What are the criteria for your selection?
Q4	How do you think the formulation of questions in high school mathematics classrooms reflects deep learning?

4. RESULT

Our sample included teachers with varying lengths of experience. As outlined in Table 5, nearly half of the respondents had 5-15 years of experience (47.08%), followed by less than 5 years and 16-25 years of experience (21.59% each). Teachers with 25 or more years of experience contributed 9.74% of the sample. Regarding professional development, 22.53% of respondents reported attending teacher training frequently, while 77.47% attended occasionally.

Read Table 6 for the descriptive statistics of teachers' instructional philosophies. The dimension of teacher-student relationship (Q3-Q5) generated the highest mean score ($M = 3.96$, $SD = 0.79$), followed by learning format (Q6-Q8). The learning format scored moderately ($M = 3.32$, $SD = 0.85$). Thinking patterns (Q9-Q11) demonstrated the lowest mean ($M = 2.31$, $SD = 0.99$).

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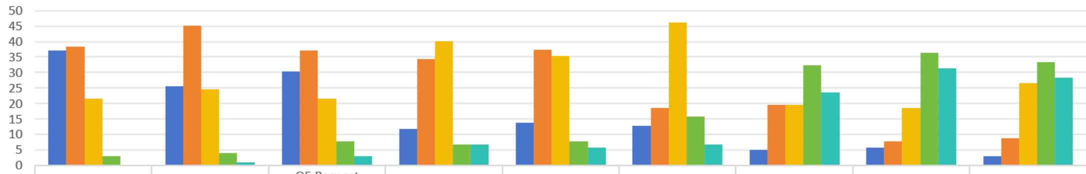
Table 5. Sample characteristics (Q1-Q2).

Characteristics	Items	N(%)
Teaching experience	Less than 5 years	21.59
	5-15 years	47.08
	16-25 years	21.59
	25 years or more	9.74
Frequency of attending teacher training	Often	22.53
	Occasionally	77.47

Table 6. Descriptive statistics.

Teaching philosophy	Question number	Sample size	Mean	Standard deviation
Teacher & student relationship	3-5	102	3.96	0.79
Learning format	6-8	102	3.32	0.85
Thinking patterns	9-11	102	2.31	0.99

Figure 1 illustrates teachers' responses to items Q3-Q11. Items related to teacher-student relationships showed generally positive agreement. For example, 75% of respondents completely or somewhat agreed that mathematics classes should be student-centered (Q3). Similar trends were observed in Q4 and Q5. For the learning format dimension (Q6-Q8), responses were more evenly distributed, with relatively high neutrality, particularly for Q6 and Q8. In the thinking patterns dimension (Q9-Q11), the responses showed lower agreement. For Q9, only 24.51% of teachers expressed agreement, while 55.88% disagreed to varying degrees. A similar pattern appeared in Q10 and Q11, where disagreement outweighed agreement, suggesting that fewer teachers perceived a strong emphasis on cultivating critical, innovative, or reflective thinking in their classrooms.



	Q3：Mathematics classes should be student-centered	Q4:A good teacher-student relationship and a democratic classroom atmosphere should be established in mathematics classrooms.	Q5:Respect students' ideas and opinions, encourage their active participation in class discussions, and allow students to fully play a leading role in the classroom.	Q6:Create teaching scenarios to stimulate students' interest in learning mathematics.	Q7:Let students do more exercises to master the content they have learned.	Q8:Provide experiential activities to help students understand the learning content.	Q9:Classroom teaching emphasizes the cultivation of students' critical thinking.	Q10:Classroom teaching emphasizes students' innovative thinking and their ability to apply knowledge.	Q11:The classroom guided students to reflect on and question the knowledge they learned, thus cultivating their ability to think independently.
Completely agree	37.24	25.47	30.41	11.76	13.73	12.75	4.9	5.88	2.94
Somewhat agree	38.25	45.08	37.24	34.31	37.25	18.63	19.61	7.84	8.82
Neutral	21.59	24.53	21.55	40.21	35.30	46.08	19.61	18.63	26.47
Disagree	2.92	3.94	7.86	6.86	7.84	15.68	32.35	36.27	33.33
Completely disagree	0	0.98	2.94	6.86	5.88	6.86	23.53	31.38	28.44

Figure 1. Questionnaire result (Q3-Q11).

The classroom observations of three university-level Advanced Mathematics lessons revealed distinct patterns in teachers' questioning practices, student response types, and feedback behaviors. As shown in Table 7, reasoning questions were the most frequently used, accounting for 66.7% of all questions. These questions were commonly employed to guide students in deriving mathematical conclusions or performing multi-step logical analysis, such as prompting students to infer general rules from specific function properties. Critical questions constituted 16.5%, often used to encourage students to compare different problem-solving approaches or evaluate the applicability of mathematical theorems. When examining the type of questions asked, we observed that questions about memory amounted to 9.5% of the total question inventory, mainly serving as efficient recollections of prerequisite information. Meanwhile, inquiries surrounding management were exceedingly scarce (4.8%), signifying mostly orderly classroom surroundings. Questions related to creativity were scarcely present, constituting a meager 2.5% of the total, indicating a paucity of emphasis on the inclusion of open-ended or exploratory styles of mathematical thinking.

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Looking into the question, we noted direct questioning as predominant (66.7%), allowing the instructor to swiftly gauge the pupil's comprehension of central ideas, such as limits, derivatives, and conditions of theorem conditions. Only mildly scattered, situational questioning (14.3%) surfaced, often at the moment of the teachers giving tangible realities to a theoretical case analysis, for instance, an optimization predicament, intending to make the lesson more applicable. The heuristic elicitation accounted for 9.5%, whereas reverse questioning captured the same amount of (9.5%), signifying that the teachers have employed both styles to teach their students to think higher in higher analytical realms. Heuristic questioning helped educate the pupils to follow a complicated proof step by step via hints and questions. Conversely, reverse questioning allowed students to visualize a scenario where some rules and conditions, such as a given assumption, are no longer valid, subsequently leading the students to think higher in analytical reasoning. As far as students' responses are concerned, reasoning-based responses dominated (47.8%), signifying that pupils often performed the teachers' logical processes as depicted. Memory-based answers and mechanical yes/no answers accounted for 19% each, reflecting instances where students recalled definitions or rendered simple judgments, still not engaging in serious processing. Creative or evaluative answers were scant (9.5%), and only 4.7% of the responses recorded involved student participation.

Regarding teacher feedback behaviors, direct feedback, which included immediate confirmation or correction of student responses, comprised 33.3% of all instances. This behavior occurred frequently, typically when students provided incorrect answers or when answers were ambiguous. Teachers' repetition and explanation, responsible for 28.6% of the feedback, usually involved restating or elaborating students' responses to reinforce critical concepts or clarify misunderstandings. Probing follow-up questions (19%) came as an essential type of behavior and were used to extend students' thinking, especially during multistep reasoning tasks. Irrelevance was shown in 14.3% of cases, whereas interruption in 0 cases was not observed. Praise, though, was used in only 4.8% of instances and tended to be general instead of specific.

Table 7. Observation result.

First-level dimension	Second-level dimension	N(%)
Types of questions	Management	4.8
	Memory	9.5
	Reasoning	66.7
	Critical	16.5
	Creative	2.5
Questioning approaches	Direct questioning	66.7
	Heuristic elicitation	9.5
	Situational questioning	14.3
	Reverse questioning	9.5
Types of student responses	No response	4.7
	Mechanical yes/No	19
	Memory-based response	19
	Reasoning-based response	47.8
	Creative/Evaluative response	9.5
Teacher feedback behaviors	Ignoring	14.3
	Interruption	0
	Direct feedback	33.3
	Repetition and explanation	28.6
	Praise	4.8
	Probing	19

The interview data revealed considerable variation in teachers' understanding and application of deep learning theory. According to the results in Table 8, teachers' knowledge of deep learning ranged from only knowing it by dictionary or surface-level, to complete ignorance, and only a few respondents reported previous professional training. For the perceived role of deep learning, most teachers believed that deep learning contributes to students' deepening

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understanding, provides autonomy in learning, promotes reflection, and develops students' mathematical thinking skills. Regarding how to design questions, most teachers reported drawing from various sources, such as content in their textbooks, examination requirements, students' learning levels, and instructional purposes, with some following a progression from recall to application when designing questions. When asked how deep learning is represented in the question-posing process, teachers described several options, such as guiding students to compare strategies, providing meaningful contexts, using scaffolded sequences of questions, and designing questions that involve mathematical modeling.

Table 8. Interview result.

Theme	Code	Description	Example Quote
Q1	DL-Knowledge-Basic	Teacher has only general or surface-level understanding of deep learning theory.	"I only know that deep learning emphasizes meaningful understanding instead of memorization." (T1)
	DL-Knowledge-Limited	Teacher has vague or incomplete knowledge; lacks systematic study.	"I have seen some articles online, but my understanding is vague." (T2)
	DL-Knowledge-Trained	Teacher has received professional training related to deep learning.	"I attended relevant training sessions and know it develops critical thinking." (T3)
	DL-Knowledge-Absent	Teacher has little or no awareness of deep learning theory.	"I am not familiar with deep learning theory." (T4)
Q2	DL-Role-Conceptual Understanding	Deep learning deepens students' understanding of mathematical concepts.	"It helps students understand concepts more clearly and comprehensively." (T1)
	DL-Role-Autonomous Learning	Deep learning enhances students' active engagement and self-regulation.	"It encourages students to explore knowledge proactively." (T2)
	DL-Role-Reflection & problem solving	Promotes reflection and improves problem-solving skills.	"It helps students identify and solve problems through reflection." (T3)
	DL-Role-Mathematical Thinking	Enhances mathematical thinking and core competencies.	"It strengthens mathematical thinking and improves performance." (T4)
Q3	CQ-Design-Textbook-Based	Questions designed mainly based on textbook content and course objectives.	"I design questions around the textbook and course objectives." (T1)
	CQ-Design-Exam-Oriented	Questions influenced by exam requirements or past papers.	"I refer to past exam questions when designing problems." (T2)
	CQ-Design-Student-Level	Questions constructed based on students' learning progress and classroom response.	"I consider students' learning status and reactions in class." (T2)
	CQ-Design-Cognitive Progression	Questions structured progressively, from recall to application.	"I start with recall questions and move to conceptual and applied ones." (T3)
	CQ-Design-Goal-Aligned	Questions aligned with specific instructional goals.	"Questions must be aligned with the instructional goals." (T4)
Q4	DL-QP-Strategy Comparison	Encourages method comparison to promote deep thinking.	"Why choose substitution over integration by parts here?" (T1)
	DL-QP-Context Creation	Realistic or meaningful contexts stimulate deep thinking.	"Creating meaningful contexts stimulates critical thinking." (T2)
	DL-QP-Progressive Scaffolding	Multi-level questioning promotes step-by-step deeper understanding.	"A series of progressively deeper questions leads to flexible thinking." (T3)
	DL-QP-Model Building	Questions require constructing or applying mathematical models.	"Questions requiring mathematical modeling reflect deep learning." (T4)

5. DISCUSSION

This research uncovers some essential findings on higher mathematics teachers' knowledge of deep learning theory and their questioning practices in the classroom. Teachers' general attitude toward teacher-student

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relationships and learning models tended to be positive, but their recognition of thinking dimensions showed limitations in deep thinking and, specifically, critical thinking. This resemblance aligns with previous studies that have found teachers are aware of the need to develop higher-order thinking, but many still lack an adequate theoretical foundation to incorporate teaching practices favoring deep learning (Huang & Iksan, 2019). Questionnaire findings indicated teachers who routinely receive professional development training experience higher levels of understanding, whereas a high proportion of teachers reported they participate occasionally. This result is consistent with many studies, which point out that insufficient teacher training is one of the main challenges in applying the concept of deep learning to classroom practice.

Classroom observation further confirmed this conclusion. Although reasoning questions are very common, only one of the questions raised in the classroom involves critical or creative thinking, which shows a disconnect between teachers' theoretical cognition and classroom practice. Previous studies have also recorded this problem. Teachers are often limited by test-based education requirements and continue to use traditional teaching strategies, reducing students' opportunities for in-depth thinking (Umardiyah & Rohmah, 2021). Interview evidence also confirmed this view. Most teachers said that their understanding of deep learning was superficial or vague, and only one teacher said that they deliberately designed problem situations in teaching to encourage deep learning. Researchers believe that this conceptual ambiguity hinders teachers' ability to integrate deep learning into classroom problem design practice, resulting in superficial or procedural questions, which in turn burdens teachers and students, creating a vicious circle.

Another important finding is that teachers are inadequate in creating meaningful problem situations. Contextual creation is crucial to guiding students to participate in real and complex problem solving, but more than half of the interviewed teachers said that there were difficulties in designing such situational problems. Observation data shows that situation-based questions account for less than 20% of all questions, and they usually come directly from examples in textbooks. Previous studies have also found that teachers lack experience in designing open, challenging, and realistic problem situations, which are crucial to cultivating students' in-depth understanding of mathematics (González-Pérez & Ramírez-Montoya, 2022). The lack of real situations in mathematics classrooms limits students' ability to connect mathematical concepts with real-world applications, which ultimately affects the development of deep learning ability.

In addition, the research results show that teachers' question design needs to be improved, especially in promoting students' critical thinking. Although teachers strive to design questions based on textbooks, learning objectives, student levels, and examination requirements, they rarely prioritize deeper cognitive abilities. Research shows that teachers pay too much attention to low-level questions, and their questions tend to focus more on procedurality and fluency than on meaning construction and reflective reasoning (Wahyuddin, Ernawati, Satriani, & Nursakiah, 2022). In addition, the single and direct feedback model prevalent in the classroom may also limit students' ability to reflect and explore openly. Diversified and effective feedback is often a key element to support students' development of deep learning (Sánchez, Font, & Breda, 2022); however, there are relatively few such practices and cases in the observed classroom.

Overall, quantitative and qualitative data show that college mathematics teachers face many key challenges in understanding deep learning theory, situational construction, problem design, critical thinking cultivation, and lack of diversity in classroom feedback methods. These results highlight the necessity of mathematics teachers to carry out structured and continuous professional development. In order to solve these problems, this study proposes a comprehensive training method, which integrates theoretical learning, situation-based problem design, progressive questions, student question guidance, and teachers' diversified feedback methods. For further details, please refer to Figure 2. By integrating these elements, educators can create better high-quality sequences of classroom questions that promote conceptual understanding, critical reflection, and substantive mathematical engagement among students. This, in turn, will contribute to their deep learning experience.

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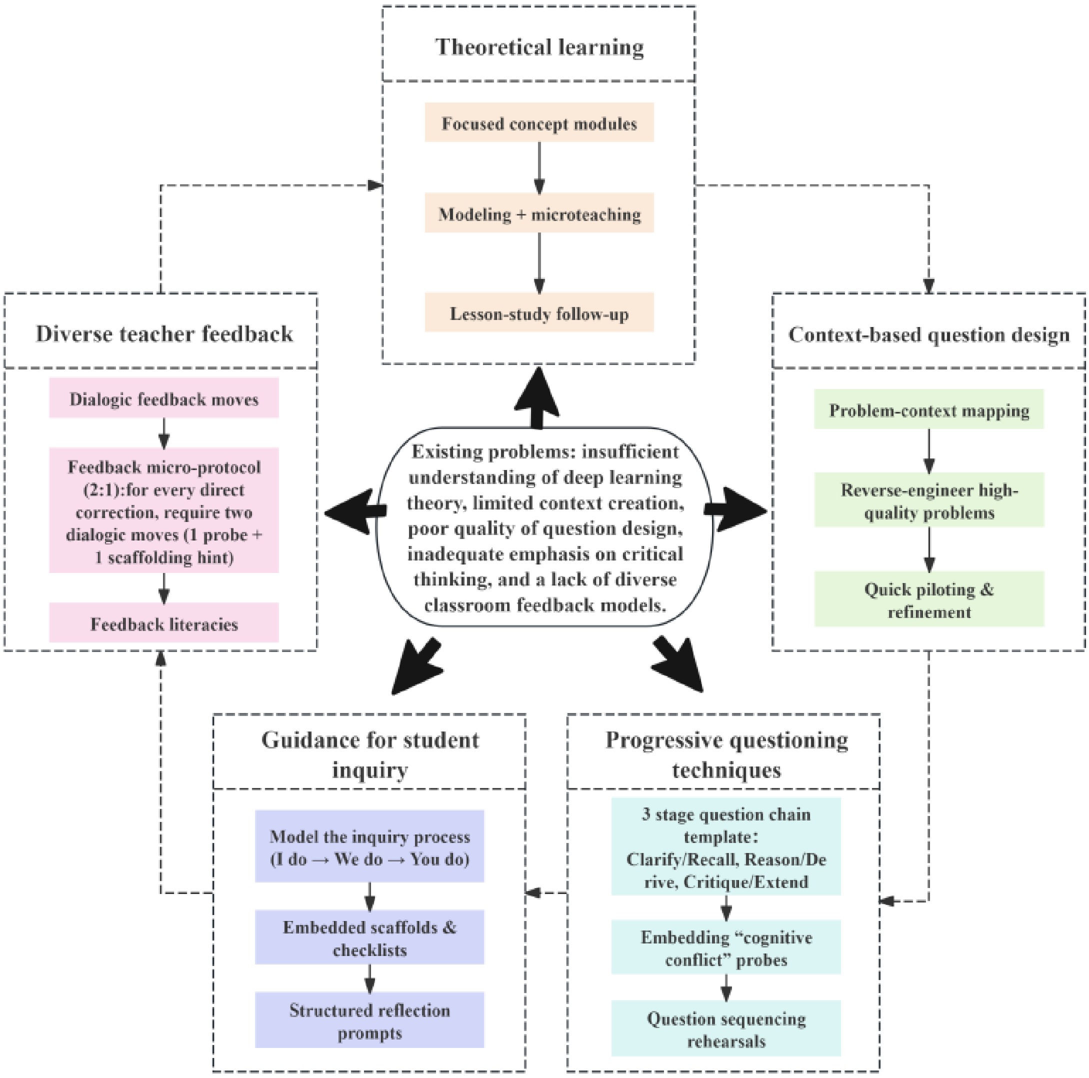

Figure 2. Comprehensive training strategy.

6. CONCLUSION

This paper explored three fundamental questions regarding deep learning in university advanced mathematics instruction: Do instructors know their deep learning theory, have their classroom questioning practices aligned with deep-learning intentions, and what are effective practices for fostering deep-learning-focused question posing.

This study also revealed that classroom questioning practices only partially support deep learning in advanced mathematics classrooms. Reasoning-based questions prevailed in teachers' instructional practice, while critical, creative, and model-based questions, those that best align with deep-learning theory, were seen sparingly. While direct questioning was most frequent, other types of questioning such as heuristic, contextual, and reverse were used only minimally and, as a consequence, afforded constrained opportunities for cognitive conflict and deep inquiry. Similarly, teacher feedback was largely limited to direct evaluation, rather than probing or guided questioning, and student responses were rarely evaluative or creative. These results suggest that, while instructors appreciate logical reasoning, their existing questioning practices would not fully employ the higher-order thinking processes inherent to deep learning.

In light of these limitations, this paper suggests several possibilities for promoting deep-learning-focused question pose in university mathematics classrooms, from enhancing instructors' professional learning in deep learning theory to designing meaningful real-world contexts for mathematical inquiry, constructing progressive chains of questions to scaffold higher-order thinking, encouraging students to raise questions and engage in dialogic

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reasoning, and moving towards other types of more varied and interactive feedback such as probing and directed encouragement. Overall, these possibilities provide an effective way for higher mathematics teaching to shift from surface learning to deep learning.

Although this study has made some contributions, there are still limitations. First of all, the sample size of classroom observations and interviews is relatively small, which may limit the universal applicability of research results. Secondly, this study only focuses on the higher mathematics courses of universities in a specific regional context, and does not examine the differences in institutions, disciplines, or teaching cultures in different contexts. Third, although this study puts forward strategies to improve the problem, it is not tested in vertical practical classroom intervention. Future research should make up for these shortcomings by expanding the sample size, conducting cross-regional and cross-institution comparisons, and carrying out longitudinal intervention research. In vertical intervention research, it should be tested whether the design of training strategies can really affect students' high-level thinking, problem-solving ability, and emotional input. If we want to build a more detailed theoretical and practical framework for deep learning teaching methods in higher mathematics education, these studies need to be further implemented.

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Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Competing Interests: The authors declare that they have no competing interests.
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REFERENCES

Baumanns, L. (2022). Rethinking problem-posing situations: A review. In Mathematical problem posing. In (pp. 87–121). Singapore: Springer.

Cai, J., & Hwang, S. (2020). Learning to teach through mathematical problem posing: Theoretical considerations, methodology, and directions for future research. *International Journal of Educational Research, 102*, 101391. https://doi.org/10.1016/j.ijer.2019.01.001

Calabrese, J. E., Capraro, M. M., & Thompson, C. G. (2022). The relationship between problem posing and problem solving: A systematic review. *International Education Studies, 15*(4), 1–8. https://doi.org/10.5539/ies.v15n4p1

Cui, Y. X. (2019). Deep learning based on the cultivation of core literacy. *Curriculum, Teaching Material and Method, 39*(2), 66–71.

Demircioglu, T., Karakus, M., & Ucar, S. (2023). Developing students' critical thinking skills and argumentation abilities through augmented reality–based argumentation activities in science classes. *Science & Education, 32*(4), 1165-1195. https://doi.org/10.1007/s11191-022-00369-5

Fawzia, S., & Karim, A. (2024). Exploring the connection between deep learning and learning assessments: A cross-disciplinary engineering education perspective. *Humanities and Social Sciences Communications, 11*(1), 29. https://doi.org/10.1057/s41599-023-02542-9

González-Pérez, L. I., & Ramírez-Montoya, M. S. (2022). Components of education 4.0 in 21st century skills frameworks: Systematic review. *Sustainability, 14*(3), 1493. https://doi.org/10.3390/su14031493

Gu, L. Y. (2025). Breaking teacher inertia and promoting educational reform: A review of research on teacher Inertia and its intervention strategies in educational reform. *Educational Review, 14*(3), 2–18.

Hajamydeen, A. I., & Kumar, S. (2025). *A survey of deep learning techniques: Applications across industries and ethical considerations.* United States: Preprints.org.

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Huang, J. X., & Iksan, Z. (2019). Understanding of teacher in Pekan district on 21st century learning. *International Journal of Modern Education*, *1*(2), 1-12.

Huang, Z., & Chen, G. (2024). COMET: "Cone of experience" enhanced large multimodal model for mathematical problem generation. *Journal of Educational Data Mining*, *16*(1), 45–67.

Kovač, V. B., Nome, D. Ø., Jensen, A. R., & Skreland, L. Lj. (2025). The why, what and how of deep learning: Critical analysis and additional concerns. *Education Inquiry*, *16*(2), 237-253. https://doi.org/10.1080/20004508.2023.2194502

Lee, S.-Y. (2021). Research status of mathematical problem posing in mathematics education journals. *International Journal of Science and Mathematics Education*, *19*(8), 1677-1693. https://doi.org/10.1007/s10763-020-10128-z

Liljedahl, P., & Cai, J. (2021). Empirical research on problem solving and problem posing: A look at the state of the art. *ZDM–Mathematics Education*, *53*(4), 723-735. https://doi.org/10.1007/s11858-021-01291-w

Lim, W., Yoon, H., Bae, Y., & Kwon, O. N. (2023). The development of sociomathematical norms in the transition to tertiary exam-oriented individualistic mathematics education in an East Asian context. *Educational Studies in Mathematics*, *113*(1), 57-78. https://doi.org/10.1007/s10649-022-10203-y

Lu, Z. Z., & Hong, S. Z. (2010). Effective classroom questioning by teachers: Value orientation and standards construction. *Educational Research*, *31*(4), 65–70.

Maass, K., Swan, M., & Aldorf, A.-M. (2017). Mathematics teachers' beliefs about inquiry-based learning after a professional development course-an international study. *Journal of Education and Training Studies*, *5*(9), 1-17. https://doi.org/10.11114/jets.v5i9.2556

Mienye, I. D., & Swart, T. G. (2024). A comprehensive review of deep learning: Architectures, recent advances, and applications. *Information*, *15*(12), 755. https://doi.org/10.3390/info15120755

Ofda, M., & Topcu, T. G. (2025). Problem-causing technologies in education: Frameworks for problem construction, feedback, and generative support. *Journal of Educational Technology and Artificial Intelligence*, *11*(1), 112–130.

Orhani, S. (2024). Deep learning in math education. *International Journal of Research and Innovation in Social Science*, *8*(4), 270-278. https://doi.org/10.47772/IJRISS.2024.804022

Paşca-Tuşa, A., & Ciascai, L. (2021). Teachers' opinion about deep learning. In I. Albulescu & N. Stan (Eds.), Education, Reflection, Development – ERD 2020. In (Vol. 104, pp. 105–112). Romania: European Publisher.

Qing, L. T. S., & Yan, Y. S. (2024). A decade of deep learning: A survey on the magnificent seven. *Journal of Artificial Intelligence Research*, *79*, 1–45.

Sánchez, A., Font, V., & Breda, A. (2022). Significance of creativity and its development in mathematics classes for preservice teachers who are not trained to develop students' creativity. *Mathematics Education Research Journal*, *34*(4), 863-885. https://doi.org/10.1007/s13394-021-00367-w

Umardiyah, F., & Rohmah, Z. (2021). Development of teaching materials on geometry materials to develop students' critical thinking skills according to the criteria for critical thinking 4C's. *Application: Applied Science in Learning Research*, *1*(2), 71-76. https://doi.org/10.32764/application.v1i2.1666

Vale, I., & Barbosa, A. (2023). Active learning strategies for an effective mathematics teaching and learning. *European Journal of Science and Mathematics Education*, *11*(3), 573–588. https://doi.org/10.30935/scimath/13135

Wahyuddin, W., Ernawati, E., Satriani, S., & Nursakiah, N. (2022). The application of collaborative learning model to improve students' 4Cs skills. *Anatolian Journal of Education*, *7*(1), 93–102. https://doi.org/10.29333/aje.2022.718a

Wang, Q., & Abdullah, A. H. (2024). Enhancing students' critical thinking through mathematics in higher education: A systemic review. *Sage Open*, *14*(3), 21582440241275651. https://doi.org/10.1177/21582440241275651

Wang, S. (2021). A survey on the current situation of senior high school mathematics teachers' value orientation of teaching. Master's Thesis, Hebei Normal University.

Wei, Y., Zhao, Y., Shen, L., Chen, X., & Cheng, R. (2025). QueST: Incentivizing LLMs to generate difficult problems. *Journal of Artificial Intelligence Research*, *84*, 1–28.

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Wei, Y., Zhao, Y., Shen, L., Chen, X., Cheng, R., Du, S., . . . Li, D. (2025). Learning to pose problems: Reasoning-driven and solver-adaptive data synthesis for large reasoning models. *arXiv preprint arXiv:2511.09907*. https://doi.org/10.48550/arXiv.2511.09907

Wu, H. (2018). Research on deep teaching in primary school mathematics. Doctoral Dissertation, Central China Normal University.

Ye, L. J., & Zhou, F. L. (2012). A study on teachers' questioning approaches based on video analysis. *Theory and Practice of Education*, *32*(5), 52–54.

Zhang, L., Stylianides, A. J., & Stylianides, G. J. (2025). Approaches to supporting and measuring mathematical problem posing: A systematic review of interventions in mathematics education. *International Journal of Science and Mathematics Education*, *23*(7), 2225–2254. https://doi.org/10.1007/s10763-025-10542-1

Zhong, Q. Q. (2022). Deep learning. *Global Education Outlook*, *51*(1), 129–145.

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