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Practice of Classroom White Space in the Reform of PAD Teaching in "Biogas Engineering"

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Abstract: ***As a core elective in the Energy and Power Engineering major, the "Biogas Engineering" course covers essential knowledge that undergraduate students are expected to master proficiently. Under the traditional lecture-based teaching model, the commonly used "teacher question-student answer" approach often leads to multiple inefficiencies and reduced instructional effectiveness. To address these issues, the PAD (Presentation-Assimilation- Discussion) model encourages bilateral interaction between teaching and learning, enhancing student initiative and creativity, improving educational outcomes, and alleviating the teaching burden. Simultaneously, the application of "intentional silence" in classroom instruction often yields benefits that surpass expectations. It stimulates intrinsic learning motivation, fosters creative thinking, and promotes independent student character. The combined use of the Bipartite Classroom model and intentional silence transforms the learning process into a dynamic and constructive exchange.***

Keywords: Biogas Engineering, PAD, Classroom white space**.**

1. Introduction

"Biogas Engineering" is a highly practical professional course designed to teach core concepts such as the principles of anaerobic fermentation, characteristics of typical anaerobic processes, biogas purification and upgrading, as well as the design of large-and medium-scale biogas projects. The course enables students to understand the fundamental principles of engineering design, including construction models, process selection, basic parameter calculations, key equipment specification, and engineering drawing production. It emphasizes the application of theoretical knowledge, aiming to cultivate students' comprehensive analytical and hands-on practical skills. By becoming familiar with relevant design standards and codes, students are expected to perform preliminary designs for biogas projects based on typical feedstocks, laying a solid foundation for future work in related fields.

In the traditional lecture-based teaching model, the classroom is often dominated by the teacher, where teaching is largely unidirectional and student participation is passive [1]. In this model, the teacher delivers content and asks questions, while students are expected to listen and provide correct answers. This conventional "teacher asks–student answers" approach can lead to various challenges-teachers often complain of insufficient time for thorough instruction, and students may focus more on answering questions than on engaging deeply with the material.

2. Practice of PAD Model in "Biogas Engineering"

The PAD (Presentation-Assimilation- Discussion) model can effectively address the drawbacks of traditional classrooms. The concept of PAD was first proposed and promoted by Professor Zhang Xuexin from Fudan University [2]. The so-called PAD refers to dividing the classroom time equally, assigning half of the class time to teachers to teach knowledge and leaving the other half for students to absorb and discuss. The discussion time is staggered, allowing students to have one week after class to independently arrange their learning and engage in personalized internalization and absorption. During this period, process management is strengthened. The main idea is to combine teacher lectures with student discussions, thereby enhancing students' enthusiasm for self-directed learning and stimulating teachers' passion for teaching.

2.1 Significance of Applying the PAD Model in the "Biogas Engineering" Course

The PAD model is highly effective in addressing the limitations of traditional lecture-based instruction. It facilitates bilateral interaction between teaching and learning, emphasizes the central role of students, stimulates their initiative and creativity, and ultimately enhances teaching outcomes [3]. The pedagogical philosophy of the "Biogas Engineering" course aligns with the objectives of contemporary curriculum reform, making this model particularly relevant. It fosters dynamic and efficient engagement between instructors and students, reinvigorating classroom environments, encouraging authentic student participation, and supporting the development of learning capacity and innovative thinking-while also offering new perspectives and directions for educational practice and research.

This approach is particularly valuable for cultivating students' research-oriented and innovative thinking. The structure of the PAD allows students to thoroughly review, question, and absorb course content independently, and subsequently engage in collaborative discussions. This process deepens their understanding of fundamental concepts, strengthens connections among knowledge domains, facilitates meaningful knowledge transfer, and fosters divergent thinking and multi-perspective problem-solving skills.

Moreover, the PAD enhances interaction and communication among peers and between students and instructors. By shifting interactive elements into classroom time, students arrive prepared with questions and collaborate to find solutions. This active engagement fosters a vibrant academic

atmosphere both during and outside class sessions. Through discussion, students develop communication skills, learn to appreciate diverse viewpoints, inspire one another, and strengthen interpersonal relationships and camaraderie.

In terms of learning outcomes, the model offers clear benefits. Under this approach, students undergo four interconnected phases over the course of a week: classroom instruction, review and consolidation, independent assignments, and group discussions. Teachers concentrate on explaining key concepts and challenging topics during class, while students are responsible for pre-class preparation, identifying knowledge gaps, and deepening their understanding through post-class review. This structure promotes deeper internalization of course material and significantly enhances learning effectiveness.

Additionally, the model reduces teachers' workload and improves instructional quality. In traditional classrooms, instructors are burdened with planning, delivering, and summarizing content, requiring substantial preparation time. In contrast, the PAD allows teachers to focus on core concepts, thereby shortening lecture time and shifting from content delivery to learning facilitation. This change frees up time for instructors to enhance course design, conduct research, and improve their own pedagogical skills.

2.2 Implementation Plan of the PAD Model in the "Biogas Engineering" Course

2.2.1 Teaching Stage

This phase is primarily teacher-led. The instructor introduces the fundamental framework, key concepts, and theoretical logic of the course content, focusing particularly on complex and critical points without attempting to cover every detail of the slides. No more than 60% of class time is allocated to lecturing. During this time, students are expected to actively listen and take detailed notes. After class, the instructor assigns a discussion topic related to the lesson's key concepts. Students are required to form individual viewpoints and engage in analytical thinking. A designated student group is responsible for preparing a presentation in the form of a PowerPoint (PPT) to be delivered in the subsequent class.

2.2.2 Internalization and Absorption Stage

This stage encourages students to reflect independently on their learning. Each student is required to summarize their understanding in three parts:

1) The content that had the greatest personal impact or benefit.
2) The knowledge points they fully understood and believe may be challenging for others.
3) The concepts or sections they still find confusing.

This reflective process allows students to deepen their comprehension and identify both their strengths and knowledge gaps.

2.2.3 Discussion and Sharing Stage

This is the core of the PAD model and takes place during the next scheduled class. After having time for self-study and reflection, students bring their insights and questions to group discussions. Group members engage in active communication and knowledge exchange centered on the chapter content. Each group presents a PPT summarizing their learning outcomes. They may also quiz other students on well-understood concepts or pose questions on areas of confusion to encourage peer-to-peer teaching. This segment typically lasts around 20 minutes but can be flexibly adjusted depending on the classroom dynamics.

During the achievement-sharing phase, student representatives freely express their thoughts on behalf of the group. They may share their learning experiences or highlight any unresolved questions. This segment usually takes 10-20 minutes. The remaining 5-10 minutes of class are reserved for the instructor to address students' questions and provide supplementary insights and guidance based on the learning feedback collected during the session.

3. The Practice of the PAD Model in "Biogas Engineering" Course

In 1927, German psychologist Bluma Zeigarnik conducted an experiment in which 22 different tasks were assigned to 32 participants. Of these, 16 participants were allowed to complete their tasks, while the remaining 16 were deliberately interrupted before finishing. After the experiment, participants were asked to recall the tasks. Results showed that those whose tasks were interrupted recalled 68% of them, compared to only 43% recalled by those who had completed their tasks. This phenomenon—where unfinished tasks are remembered more vividly than completed ones—is known as the Zeigarnik Effect, or the "incompletion effect" [4].

The application of PAD in classroom teaching reflects the pedagogical value of this psychological mechanism. As an artistic technique, leaving blank space refers to the deliberate omission of certain elements to better highlight the subject matter [5]. In an educational context, it means withholding direct instruction and instead creating cognitive gaps through the design of thought-provoking questions (including rhetorical and critical inquiries), assigning exploratory tasks, and promoting in-class discussions. For students, attempting to "fill in the blanks" leads to greater engagement and discovery, often producing outcomes that exceed teachers' expectations.

First, PAD model in the classroom can effectively stimulate students' intrinsic motivation for learning. It fosters independent study habits and activates students' initiative, encouraging them to take ownership of their learning rather than passively absorbing information. For example, in the "Biogas Engineering" course, after teaching the core content of the biogas fermentation process, instructors can assign students semi-open research projects based on their personal interests. This "research-based learning" process might follow these steps: 1) Topic Selection: Students choose a specific process within the biogas production system that interests them (e.g., raw material pretreatment, microbial strain optimization, fermentation parameter tuning, or reactor design), and review relevant academic literature to deepen their understanding. 2) Problem Definition: Students refine

their research questions with guidance from the instructor, who assesses feasibility. 3) Independent Experimentation: Students conduct their own experiments and seek to identify optimal process parameters. 4) Results Communication: Students present and discuss their findings with peers and instructors. This structure allows students to pursue topics that resonate with them personally, seek solutions through self-directed inquiry, and design and execute experiments-thereby activating their subjective initiative. Throughout the semester, multiple such mini-projects can be integrated, with each one building logically on the previous, forming a coherent research-learning trajectory. As students encounter challenges, they are encouraged to explore literature and engage with outside resources, promoting deeper learning and a seamless integration between in-class and extracurricular study.

Secondly, PAD model in the classroom can foster the development of students' creative thinking. When teachers deliberately avoid exhaustive instruction and instead leave conceptual gaps-free from rigid frameworks or standard answers-it creates cognitive space that encourages originality and personal expression. For instance, a high school teacher once taught Qian Zhongshu's essay Reading Aesop's Fables. To help students grasp the text's spiritual essence and stylistic features, the teacher first asked them to preview the nine fables mentioned in the article and engage in discussion-based learning centered on the author's interpretations. Students were then invited to share their own views. While some aligned closely with the author's perspectives, others diverged significantly, offering novel, multi-angled interpretations of the fables. The teacher welcomed these unique insights-even those contrary to the author's views—and further enriched the discussion by quoting Rabindranath Tagore: "Who will read my poems a hundred years from now?" and posing the question: "Why are there a thousand Hamlets in the hearts of a thousand readers?" These reflections sparked deep contemplation about the interpretive nature of literary works. Inspired by the open-ended discussion, several students rewrote the fables from their own creative standpoints [6]. Subsequently, the teacher assigned a homework task to compose a new fable. Remarkably, even students who typically submitted careless or uninspired assignments managed to produce highly original stories.

This example highlights the pedagogical power of intentional silence. By refraining from over-structuring instruction, teachers invite students to engage more deeply, think independently, and explore creatively. Such an approach not only stimulates intellectual curiosity but also nurtures imagination. The seemingly incomplete nature of the classroom experience leaves untapped potential for post-class exploration—this is the essence and allure of intentional silence: a lesson that appears unfinished on the surface often enables wisdom to flourish across extended, open-ended time and space.

Finally, the use of blank space in the classroom also supports the development of students' independent personalities. As their subjectivity and creativity are activated, so too is their sense of individuality. In art, blank space is not merely a stylistic device but a technique that creates a profound aesthetic atmosphere, embodying the traditional Chinese wisdom of "creating something from nothing." Similarly, as a teaching strategy, intentional silence offers students opportunities to cultivate, explore, and apply their thoughts, emotions, perspectives, creative ideas, and problem-solving methods within a broader and more dynamic learning context.

Moreover, this approach exemplifies a student-centered educational philosophy. It bridges classroom and extracurricular learning, extends the reach of teaching beyond the lesson itself, and meaningfully engages students in active learning. Ultimately, it facilitates a creative, generative, and mutually constructive educational process between teacher and student.

4. Conclusion

As a core elective in the Energy and Power Engineering curriculum, Biogas Engineering is a subject in which undergraduate students are expected to attain proficiency. Under traditional classroom teaching models, the "teacher-asks, student-answers" approach often results in issues such as limited classroom interaction, student passivity, and teacher dissatisfaction with time constraints, ultimately leading to reduced teaching efficiency.

In response to these challenges, the classroom white space proves highly effective in fostering dynamic interaction between teaching and learning. This model emphasizes the central role of students, enhances their initiative and innovative capacity, and improves the overall quality of instruction. It also supports the cultivation of research-oriented and creative thinking, alleviates the instructional burden on educators, and elevates the quality of teaching. Simultaneously, the integration of the PAD strategy into classroom instruction often produces outcomes that exceed the teacher's expectations. By leaving purposeful PAD, this approach stimulates students' intrinsic motivation, encourages the development of creative thinking, and empowers students to express and refine their independent identities. The concept of PAD effectively bridges in-class and out-of-class learning, creating a seamless continuum of educational engagement. It transforms the classroom into a space for co-constructed, creative learning, where students actively participate in generating knowledge. Together, the classroom white space and PAD methodologies establish a vibrant, student-centered, and generative learning environment that fosters both academic and personal growth.

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