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Reform and Practice of LEEPEE Experiential Teaching in "Embedded Device Driver Software" under the Emerging Engineering Education Paradigm

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Abstract: To advance the educational quality of applied undergraduate institutions, which play a critical role in supporting regional socioeconomic development, and to cultivate highly skilled applied undergraduate talent under the emerging paradigm of engineering education-characterized by the integration of theory and practice, and the convergence of learning, application, and innovation-this study explores pedagogical reforms in embedded systems education. Specifically, it addresses the limitations inherent in traditional teaching models for embedded technology courses, which often overemphasize theoretical instruction while neglecting practical application and experiential learning. In response, this study implemented a reformed teaching approach for the course Embedded Device Driver Software, grounded in experiential learning theory. The approach follows a structured "Project Lead(L)-Demonstration and Explanation(E)-Imitation Exercise(E)-Classroom Practice(P)-Check and Feedback(E)-Expansion and Enhancement(E)" experiential teaching model. Each stage is designed to progressively deepen students' understanding: beginning with guided project initiation, followed by step-by-step demonstration and explanation, hands-on imitation exercises, structured classroom practice, systematic feedback checks, and culminating in opportunities for independent expansion and enhancement of skills. Implementation of this model in classroom practice demonstrates multiple benefits. Students not only achieve a stronger grasp of theoretical knowledge and its practical applications, but also exhibit significantly increased motivation, engagement, and problem-solving ability. Furthermore, the model fosters creativity and the capacity for independent innovation, aligning with the core objectives of applied undergraduate education under the emerging engineering paradigm. These findings offer practical insights for the reform of other practical and application-oriented courses, providing a scalable framework for enhancing student learning outcomes and bridging the gap between theory and practice in higher education.

Published: 26 October 2025



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Keywords: emerging engineering education; LEEPEE experiential teaching; embedded device driver software; reform and practice

1. Introduction

1.1. Background and Motivation

With the ongoing development of emerging engineering education, the demand structure for computer-embedded systems talent in the industry has undergone significant changes [1]. Rapid advancements in fields such as smart vehicles, the Internet of Things, and industrial automation have heightened expectations for university-trained embedded professionals. These sectors now require graduates who not only possess a solid theoretical foundation but also demonstrate strong practical skills, problem-solving abilities, and innovative thinking. Traditional teaching models, however, have gradually

revealed limitations in curriculum updates, depth and breadth of practical instruction, and the cultivation of students' comprehensive capabilities, making it increasingly difficult to keep pace with the rapid evolution of industrial requirements.

1.2. The LEEPEE Experiential Teaching Model

To address these challenges, the LEEPEE experiential teaching model provides a structured and progressive approach to teaching embedded systems, as illustrated in Figure 1. Within this framework, the teaching process is divided into distinct phases:

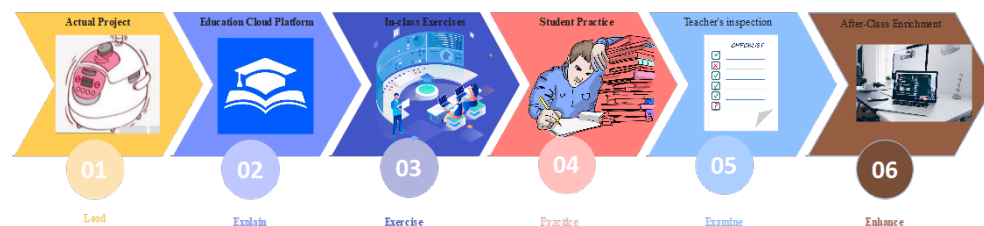


Figure 1. Implementation approach for the LEEPEE experiential teaching method.

- 1) Project Introduction (L): Integrates real-world industrial projects into the classroom, exposing students to cutting-edge technologies and engineering case studies to stimulate curiosity and engagement [2].
- 2) Demonstration and Explanation (E): Utilizes digital tools and online resources to deliver complex theoretical knowledge with clarity, overcoming the constraints of traditional lecture-based instruction.
- 3) Imitation Practice and Classroom Practice (E & P): Emphasizes student agency through hands-on exercises and group collaboration, strengthening practical skills, teamwork, and problem-solving capabilities.
- 4) Assessment and Feedback (E): Implements a multidimensional evaluation system that provides real-time guidance, helping students refine learning strategies and improve outcomes.
- 5) Extension and Enhancement (E): Encourages students to undertake challenging tasks independently, promoting creativity and innovative thinking.

This structured approach enables a seamless integration of theory and practice, providing students with continuous reinforcement and application opportunities throughout the course (see Figure 1).

1.3. Institutional Implementation and Educational Impact

As an applied university in Foshan City, the Electronic Information Engineering program at the School of Computer Science has consistently aligned its talent cultivation goals with regional economic and social development. The curriculum is designed to match local industrial needs while anticipating future technological advancements [3]. Under the Ministry of Education's Emerging Engineering Education initiative, the institution has actively pursued pedagogical reforms centred on the LEEPEE experiential teaching model. These reforms include optimising teaching strategies, integrating high-quality educational resources, enhancing specialised course instruction and experimental facilities, and strengthening faculty engineering competencies [4].

The practical implementation of LEEPEE not only enhances students' hands-on abilities and innovative thinking but also contributes to the preparation of highly qualified embedded technology professionals to support local economic development. This teaching model exemplifies the principles of emerging engineering education and provides a replicable framework and valuable reference for pedagogical reform in applied undergraduate institutions.

2. Content and Implementation Methods of the Curriculum Reform Plan

In the early stages of teaching *Embedded Device Driver Software*, the LEEPEE experiential teaching method was initially explored. However, practical application revealed that the original model did not fully achieve the intended learning outcomes. To address key shortcomings, we repositioned the roles of teachers and students, emphasizing the establishment of a collaborative learning community. The reform focused on optimizing core components of the LEEPEE methodology, including project selection, demonstration and explanation, classroom motivation, assessment and feedback, and expansion and enhancement.

2.1. Selecting High-Quality Projects to Strengthen the Foundation of Teaching

Teachers carefully select or develop high-quality projects, which are essential for the success of the LEEPEE experiential approach. Effective projects align with students' interests, connect to green development and real-world industrial applications, and integrate fundamental theories, interdisciplinary elements, and practical relevance. Instructors survey job roles and competency requirements within modern embedded driver-related enterprises to ensure projects address real industrial demands. Partner enterprises are also encouraged to recommend projects, increasing industry participation and aligning the curriculum with the latest skill requirements for professionals, thus serving regional economic development.

Using projects as a central thread, each knowledge point is embedded within multi-level sub-projects, allowing students to systematically master the fundamental theories and development methods of embedded Linux driver development. For the *Embedded Device Driver Software* course, comprehensive multi-level project scenarios were designed, including 10 Level 5 projects, 4 Level 4 projects, and 1 Level 3 project, as illustrated in Figure 2. This tiered design addresses limitations of traditional single-project courses and ensures thorough assimilation of each knowledge point, reinforcing the foundational teaching strategy of the LEEPEE experiential process.

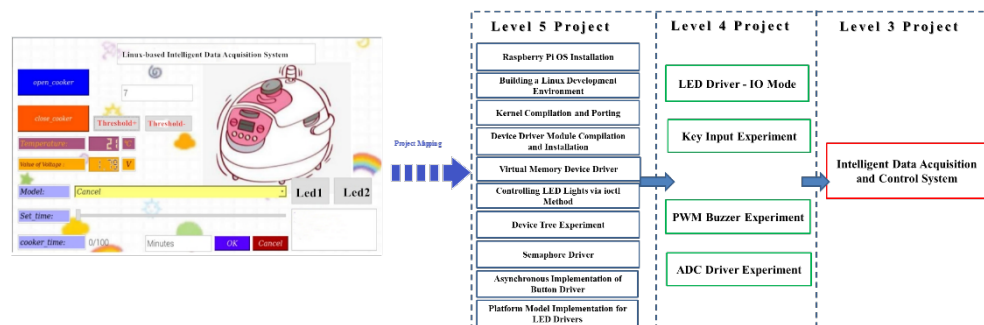


Figure 2. Multi-level course projects.

2.2. Skillfully Utilizing Information Technology to Support Explanations and Demonstrations

Instructional demonstrations are designed considering students' learning abilities, comprehension levels, and adaptability. Given the breadth of embedded systems content and limited teaching hours, it is impractical to cover all technologies exhaustively. Yet, industry demands graduates who can directly apply their skills in real-world scenarios.

To bridge this gap, the Neusoft Smart Education Cloud Platform is employed to publish lab guides, manage lab projects, and categorize tasks by difficulty. All practical projects adhere to hierarchical, progressive, and systematic principles, supporting both the project introduction and advanced enhancement phases of the LEEPEE methodology [5]. Additionally, online resources provide access to cutting-edge enterprise materials, enhancing students' immersion and practical skills during demonstration-based learning.

2.3. Designing Effective Incentive Mechanisms to Invigorate Classroom Practice

oriented engagement. Clear learning objectives, evaluation mechanisms, and emotional motivation through teacher-student trust and respect further encourage participation [6].

Assessment methods integrate online discussions, offline practical exercises, group experiments, and classroom performance into formative evaluation, complemented by summative assessments of major projects and short papers. As shown in Figure 3, formative assessment contributes 50% of the total grade, while summative assessment accounts for the remaining 50%. This multi-faceted approach effectively stimulates proactive learning and enhances comprehension of Linux device drivers.

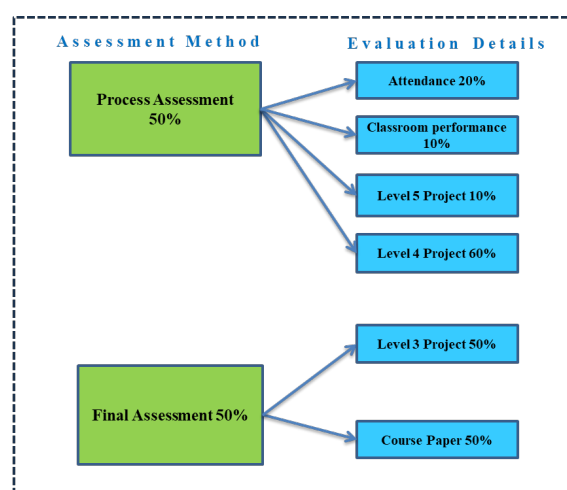


Figure 3. Evaluation criteria.

2.4. Appropriately Checking Feedback to Reinforce Learning Objectives

Assessment feedback is delivered through two complementary mechanisms, each serving distinct but interconnected purposes [7]. The first mechanism, in-class feedback during practical sessions, provides immediate, context-sensitive guidance. Instructors observe students' hands-on performance, identify errors or misconceptions in real time, and offer targeted interventions without undermining student autonomy. This flexible feedback encourages active problem-solving, reinforces key theoretical and practical concepts, and cultivates adaptive thinking by prompting students to reflect and adjust their approaches during the learning process.

The second mechanism, comprehensive post-activity feedback, occurs after the completion of all extension and enhancement activities. This form of feedback emphasizes a holistic review of students' work, including project design, technical analysis, and applied problem-solving strategies. By synthesizing insights from independent study, classroom exercises, and extracurricular research, post-activity feedback helps students integrate fragmented knowledge, identify strengths and areas for improvement, and develop higher-order cognitive skills such as critical thinking, system-level analysis, and creative solution generation.

To reinforce these feedback processes, the course has restructured its experimental system to go beyond traditional theoretical instruction, emphasizing collaborative, project-based learning. Group-based project collaboration is organized through a multi-tiered system, including five levels of on-site project acceptance, four levels of group presentations, and three levels of group defenses. Instructors provide synthesis and critique at each stage, offering guidance on technical accuracy, methodology, and innovation while encouraging peer evaluation and discussion. This structured feedback loop, illustrated in Figure 4, not only consolidates learning outcomes but also strengthens teamwork, communication, and project management skills, ensuring that students

develop comprehensive applied competencies essential for embedded system engineering.

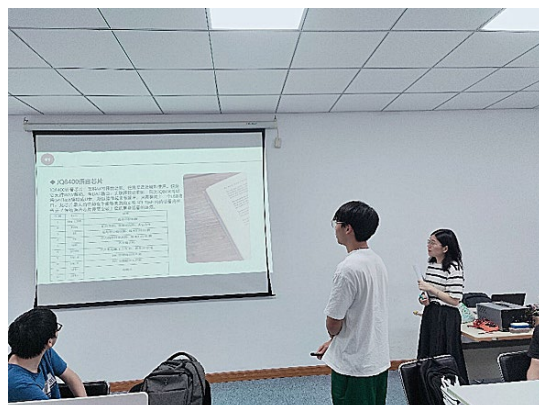


Figure 4. Group presentation.

2.5. Expansion and Enhancement to Improve Competence

The expansion and enhancement phase has traditionally been the weakest link in the LEEPEE experiential teaching methodology, often receiving less emphasis compared to project introduction and hands-on practice. In the optimized model, this phase is strategically leveraged to maximize students' innovative abilities and independent problem-solving skills. Central to this approach is the incorporation of student-driven thesis or capstone-style projects into final assessments. These projects are designed to allow students to select topics aligned with their professional interests, prior knowledge, and long-term career goals, fostering intrinsic motivation and personal ownership of learning outcomes.

During this phase, students are encouraged to explore complex, open-ended problems that extend beyond the standard curriculum. They are tasked with integrating multiple knowledge domains, applying theoretical principles to practical challenges, and proposing novel solutions or optimizations for real-world embedded systems. The process emphasizes iterative development, critical reflection, and continuous improvement, ensuring that students engage deeply with both technical content and methodological approaches.

Moreover, this phase cultivates essential academic and professional skills beyond technical expertise. Students refine their scientific writing, project documentation, and presentation abilities, learning to communicate complex ideas clearly and persuasively. Collaborative elements, such as peer review and group consultation sessions, further enhance teamwork, critical evaluation, and adaptive learning. By the conclusion of the expansion and enhancement phase, students not only demonstrate improved mastery of embedded system concepts but also exhibit enhanced creativity, analytical thinking, and self-directed learning capacities. This comprehensive integration of higher-order cognitive, technical, and communication skills effectively completes the LEEPEE experiential learning cycle, ensuring that graduates are better prepared to meet the challenges of modern industrial and technological environments.

3. Effectiveness of Curriculum Reform

3.1. Improving Classroom Teaching Quality

The implementation of the LEEPEE experiential teaching model, combined with carefully designed incentive mechanisms, has substantially improved the overall quality and effectiveness of classroom instruction. First, students demonstrate markedly higher engagement in project-based learning activities, actively participating in both individual and collaborative tasks. Platform data indicate that overall participation rates increased

from 65% before the reform to 92% after the adoption of the new teaching model, reflecting a significant boost in student motivation. Observations during class reveal a livelier, more interactive atmosphere in group discussions, peer-to-peer problem solving, and cross-team collaboration, which fosters a culture of active learning and critical inquiry.

Second, the integration of digital teaching tools and the Neusoft Smart Education Cloud Platform for hierarchical project management and online publication of lab tasks has provided students with a clearer understanding of learning objectives, task progression, and assessment criteria. These tools enable students to monitor their own progress, manage deadlines, and access supplemental learning resources anytime, which helps reinforce self-directed learning. In particular, completion rates for four Tier-4 collaborative projects reached 95%, with average project scores improving by 15% compared to pre-reform levels. This structured, technology-supported approach not only streamlines project implementation but also enhances students' ability to apply theoretical knowledge in practical contexts, increasing overall learning efficiency.

Finally, measurable improvements in teaching outcomes demonstrate the model's effectiveness in consolidating knowledge and enhancing applied skills. Data from final assessments show an average score of 83.6 for Level 3 projects, with the proportion of students achieving excellence (scores above 85) rising from 35% to 50%. Beyond quantitative improvements, qualitative observations indicate that students have developed stronger analytical thinking, problem-solving abilities, and collaborative skills. They are more confident in tackling complex tasks, proposing innovative solutions, and integrating multi-disciplinary knowledge into their projects. Collectively, these outcomes suggest that the LEEPEE experiential teaching reform has not only strengthened comprehension and practical application but also cultivated a proactive, motivated, and innovation-oriented learning environment within the classroom.

3.2. Enhancement of Students' Core Professional Competencies

A primary objective of the curriculum reform is to systematically cultivate students' practical skills and core professional competencies, ensuring they are well-prepared for both academic advancement and industry demands. Through carefully selected and progressively structured experiential projects, students gain hands-on experience in embedded device driver software development, bridging the gap between theoretical knowledge and real-world application. Data indicate that 95% of students can successfully complete foundational tasks, including environment setup, kernel configuration, and porting, while 85% demonstrate proficiency in developing character and block device drivers. Additionally, 78% of students are capable of independently analyzing and resolving complex driver-related problems, illustrating the effectiveness of the hands-on, project-based approach in developing technical autonomy and problem-solving skills.

In the advanced enhancement phase, students undertake more challenging, open-ended projects that require integration of multiple knowledge domains, critical thinking, and innovative solution design. These projects not only test technical competence but also foster creativity, analytical reasoning, and adaptive thinking, as students must consider real-world constraints and propose feasible, optimized solutions. Moreover, the reform has had a notable impact on students' participation in academic and professional competitions. Following the curriculum overhaul, the number of awards in provincial-level and higher competitions increased from 5 to 15, including five provincial first prizes, demonstrating tangible recognition of students' technical skill and innovation potential.

Beyond quantifiable outcomes, qualitative observations indicate that students have become more confident in applying theoretical concepts, collaborating effectively in teams, and independently exploring advanced topics. They exhibit stronger problem-solving strategies, project management skills, and the ability to synthesize cross-disciplinary knowledge. Collectively, these achievements confirm that the LEEPEE experiential teaching model not only enhances students' technical abilities but also cultivates their

creativity, innovation potential, and preparedness for future professional or research pursuits, thereby fulfilling the core goals of applied engineering education reform.

3.3. Enhancement of Teachers' Instructional Competence

Teachers played a central role in the curriculum reform by actively participating in the design of teaching projects, the development of experimental modules, and the supplementation of instructional resources. Through these efforts, instructors enhanced their mastery of both course content and pedagogical methods, enabling more effective guidance of students in complex, project-based learning activities. Regular interactions with students provided continuous insights into learners' comprehension levels, challenges, and problem-solving approaches, allowing teachers to adapt instructional strategies dynamically, tailor guidance to individual or group needs, and optimize the pace and structure of classroom activities.

The reform process also fostered professional growth among faculty members, as they collaborated on project planning, coordinated cross-disciplinary resources, and integrated real-world industry applications into course content. Teachers refined their ability to design multi-level experiential projects, implement effective feedback mechanisms, and incorporate digital tools for project management and assessment. These efforts directly contributed to improving teaching effectiveness and aligning instruction with emerging engineering education principles.

In recognition of their contributions, faculty members achieved significant professional accolades, including the Second Prize in the National Educational Teaching Innovation Competition and the First Prize in the National Experimental Teaching Case Competition for computer-related courses. Such achievements not only enhance individual and institutional reputation but also provide practical models and benchmarks for ongoing teaching reform initiatives. Additionally, the process of participating in these reforms strengthened teachers' reflective practice, collaborative skills, and capacity for instructional innovation, ensuring that the benefits of the curriculum reform extend beyond immediate student outcomes to long-term improvements in educational quality and faculty development.

4. Conclusion

This teaching reform initiative implemented a comprehensive set of strategies centred on the LEEPEE experiential teaching methodology for the *Embedded Device Driver Software* course, achieving significant improvements in both student learning outcomes and instructional quality. By carefully selecting high-quality, industry-relevant projects, integrating advanced digital teaching tools, designing effective incentive mechanisms, providing timely and structured assessment feedback, and expanding opportunities for student-led skill enhancement, the reform created a richer, more engaging, and practically oriented learning environment. These measures effectively strengthened students' core professional competencies, fostered innovative thinking, enhanced collaborative and problem-solving skills, and promoted the integration of theoretical knowledge with real-world application.

The reform also produced measurable improvements in student performance and engagement. Higher participation rates, improved project completion rates, and increased achievement in both coursework and competitions demonstrate that the LEEPEE model successfully cultivates applied technical skills and innovation capabilities. At the same time, the initiative enhanced teachers' instructional competence, promoting reflective practice, resource optimization, and curriculum innovation, which collectively contributed to a more dynamic and responsive educational ecosystem.

Looking forward, further reform efforts could focus on deepening industry collaboration by incorporating more authentic, real-world projects, ensuring that curriculum content remains closely aligned with the evolving needs of industry.

Additionally, exploring diversified and multidimensional assessment mechanisms-such as project portfolios, peer evaluations, and real-time performance analytics-would allow for a more comprehensive evaluation of students' learning outcomes, professional competencies, and creative capacities.

Overall, the continuous application of experiential teaching, supported by targeted reforms and technological integration, provides a scalable and effective approach to cultivating applied undergraduate talent under the emerging engineering education paradigm. By fostering practical skills, innovative thinking, and industry readiness, this teaching model not only benefits students but also contributes to the broader objectives of regional economic and social development, establishing a sustainable framework for future curriculum innovations in applied engineering education.

Funding: 2024 National Higher Education Computer Education Project: "Reform and Practice of LEEPEE Experiential Teaching in 'Embedded Device Driver Software' under the Emerging engineering education Paradigm" (CERACU2024R09); Guangdong Neusoft Institute 2023 Institutional Quality Engineering Project: "Reform and Practice of LEEPEE Experiential Teaching in 'Embedded Device Driver Software' under the Emerging engineering education Paradigm"; First Batch of National Higher Education Smart Course Teaching Reform Research Projects (BLDXZHKCYJ153); 2025 National Higher Education Computer Fundamentals Education Research Association Teaching Research Project (2025AFCEC336); Guangdong College Student Innovation and Technology Cultivation Special Fund (pdjh2024a469).

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