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Application of interdisciplinary teaching model in battery management system optimization education

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Abstract: A well-designed battery management system (BMS) is crucial for optimizing battery usage and lifecycle, ultimately enhancing the eco-friendliness and cost-effectiveness of energy systems. This paper explores the application of the interdisciplinary teaching model in optimizing the BMS. By integrating multidisciplinary knowledge and skills, interdisciplinary teaching cultivates students' critical thinking and innovation abilities, enhancing their capability to solve complex problems. In the optimization of BMS, the interdisciplinary teaching model promotes students' practical abilities and innovation by merging materials science with chemistry, combining industrial engineering with computer science, and analyzing real-world project cases. Further, this paper delves into strategies for enhancing teaching effectiveness through interdisciplinary collaboration, including teacher team cooperation, student team collaboration, production-study collaboration, and the introduction of practical application cases. The study shows that the interdisciplinary teaching model effectively enhances BMS education, thus supporting the advancement of the new energy industry.

Key words: battery management system; interdisciplinary teaching; multidisciplinary integration; teaching strategy

1 Introduction

With the rapid growth of global energy demand and increasing environmental issues, new energy battery technology, as a key renewable energy technology, has received extensive attention and research [1]. Electric vehicles (EVs), pivotal in diminishing reliance on fossil fuels and reducing greenhouse gas emissions, not only align with global initiatives to combat climate change but also foster innovations in energy storage and management systems. The battery management system (BMS) is critical in battery technology, essential for optimizing battery usage and lifecycle. It plays a crucial role in preventing overcharging, thermal imbalances, and premature battery degradation. This paper underlines the importance of BMS in maintaining the reliability and effectiveness of EVs and other battery-dependent technologies. An interdisciplinary educational approach is required for BMS education, incorporating principles of materials science, chemistry, industrial engineering, and computer science. To this end, traditional education models in specific disciplines often do not suffice due to the complexity and interdisciplinary demands of BMS optimization. Therefore, the interdisciplinary teaching model emerges as an innovative educational strategy. This model enhances the optimization of new energy battery technology by integrating knowledge and skills across multiple disciplines, offering fresh insights and innovative methods.

2 Overview of interdisciplinary teaching model

2.1 Definition and characteristics

The interdisciplinary teaching model is a teaching method aimed at solving complex problems by integrating knowledge and methods from different disciplines [2]. Its main characteristics include comprehensiveness, project orientation, collaboration, flexibility, and applicability. Comprehensiveness is reflected in the integration of multidisciplinary knowledge; project orientation emphasizes learning driven by actual projects; collaboration focuses on teamwork; flexibility allows for the adjustment of teaching content and methods based on specific situations; and applicability emphasizes the application of knowledge in real contexts.

2.2 Advantages of interdisciplinary teaching

The interdisciplinary teaching model can cultivate students' critical thinking and innovation abilities, enhancing their ability to solve real-world problems [3]. Through the comprehensive application of multidisciplinary knowledge, students can more thoroughly understand and apply what they have learned, increasing their interest and motivation. Additionally, the interdisciplinary teaching model promotes teamwork and communication among students, helping them better adapt to and cope with complex work environments in their future careers.

2.3 Examples of related teaching models

In practical education, the interdisciplinary teaching model has been widely applied in multiple fields. For example, STEM education (Science, Technology, Engineering, Mathematics) integrates multidisciplinary knowledge to cultivate students' comprehensive literacy and practical abilities [4]. Environmental education combines biology, geography, and chemistry to enhance students' environmental awareness and action capabilities. Humanities integration combines history, literature, and art to cultivate students' comprehensive literacy and humanistic spirit.

3 Overview of battery management system optimization

3.1 Introduction to battery management system

The battery management system (BMS) is essential in advanced battery technology [5]. Core functionalities of a BMS include cell monitoring, state of charge (SOC) estimation, state of health (SOH) monitoring, and thermal management, etc. The BMS plays a critical role in the efficient management of battery packs across varied applications. For example, in electric vehicles, a robust BMS can significantly influence the vehicle's range, reliability, and safety. Thus, a well-designed BMS is crucial for optimizing battery usage and lifecycle, ultimately enhancing the eco-friendliness and cost-effectiveness of energy systems.

3.2 Goals and significance of battery management system optimization

Developing advanced BMS is crucial for enhancing the performance, safety, longevity, and economic value of battery-operated systems across various applications [6]. Specifically, BMS optimization helps accurately assess and manage the state of charge (SOC) and state of health (SOH) of the batteries. This ensures optimal power delivery and range, maximizing efficiency and overall performance. Furthermore, optimizing the BMS enables appropriate actions--such as disconnecting the battery or controlling the charging process based on continuous monitoring of critical parameters, thereby ensuring user and environmental safety. Additionally, a well-optimized BMS extends battery life by maintaining operations within optimal temperature and charging parameters and by effectively balancing the charge across all cells. BMS optimization not only prolongs the life of batteries but also enhances charging processes and energy usage, potentially yielding substantial cost savings over time.

3.3 Current optimization strategies and challenges

Current BMS optimization strategies encompass advanced algorithms, optimized thermal management systems, intelligent management systems, and modular, scalable BMS architectures. Advanced algorithms enhance the accuracy of critical estimations such as SOC and SOH, improving both decision-making and performance management. The optimization of thermal management technologies facilitates stable battery performance across various conditions, essential for operational safety and longevity. Leveraging big data analytics provides insights that drive further optimization. Additionally, developing modular BMS architectures scalable to application-specific needs is crucial for broad applicability. These strategies address multiple facets such as hardware architecture, software algorithms, and data management techniques, all aimed at delivering improved performance, increased safety, and extended lifecycle of battery packs.

However, alongside these technical advances, several challenges persist. The development and implementation of sophisticated algorithms and systems increase BMS complexity and costs, necessitating a balance between advanced functionalities and cost-effectiveness. Batteries are sensitive to environmental conditions such as temperature and humidity; therefore, effective BMS optimization must accommodate these variations, complicating design and operational parameters. Maintaining BMS reliability over the lifespan of a battery pack, amidst continuous exposure to stress factors such as load changes, temperature fluctuations, and aging, requires robust design and frequent updates or recalibrations. Moreover, each application scenario presents unique performance requirements, demanding customized designs and optimizations to meet specific operational needs.

4 Application of interdisciplinary teaching model in the optimization of battery management system

4.1 Necessity of multidisciplinary integration

Battery management system (BMS) optimization involves knowledge and skills from multiple disciplines, including materials science, chemistry, industrial engineering, and computer science. Therefore, applying the interdisciplinary teaching model in the optimization of BMS is crucial. By integrating multiple disciplines, students can comprehensively understand and master various aspects of BMS optimization, enhancing their ability to solve complex problems.

4.2 Specific applications of the interdisciplinary teaching model in battery management system

Applying an interdisciplinary teaching model to the optimization of battery management systems (BMS) involves the integration of material science, chemistry, industrial engineering, and computer science. Integrating materials science and chemistry allows for the understanding of reaction mechanisms and the development of high-performance materials. Merging industrial engineering and computer science enables optimal battery production and simulations, and improves BMS operations. Analyzing actual project cases helps students grasp the latest advancements and applications, thereby enhancing their practical and innovative capabilities.

5 Subject integration and project-driven teaching methods

5.1 Interdisciplinary courses and collaborative projects

Interdisciplinary courses and collaborative project courses can be co-taught by faculty from materials science, chemistry, and industrial engineering, covering the intersection of these disciplines. Collaborative projects engage students from both fields in designing, simulating, and implementing BMS solutions.

(1) Integration of materials science and chemistry

In optimizing BMS, the integration of materials science with chemistry is particularly important. This combination equips students with a thorough understanding of electrochemical reaction mechanisms and battery material properties, vital for developing advanced electrode materials and electrolytes. For instance, by examining the electrochemical properties of high-nickel cathode materials, silicon-carbon anode materials, and electrolytes, students can enhance the energy density and life cycle of batteries.

(2) Integration of industrial engineering and computer science

Combining industrial engineering with computer science can markedly enhance system performance, efficiency, and innovation in BMS. This integration enables students to conduct real-time monitoring of critical battery parameters like voltage, temperature, and current. Such data is essential for optimizing charging and discharging processes, thereby improving battery efficiency and lifespan. Moreover, BMS involves data collection and analysis regarding battery performance and operation, which are instrumental in refining production processes, improving quality, and developing effective maintenance schedules. Predictive models using data analytics and machine learning forecast potential system failures or maintenance needs, shaping strategies that boost system longevity and reliability.

5.2 Analysis of actual project cases

By analyzing actual BMS optimization projects, students can understand and grasp the latest advancements and application cases of BMS, enhancing their practical abilities and innovative capabilities. For example, students can improve their practical abilities and innovation capabilities by studying optimization projects of electric vehicle battery technology, researching energy storage system configuration optimization, and improvement projects of portable device battery technology.

6 Enhancing teaching effectiveness through interdisciplinary collaboration

6.1 Interdisciplinary collaboration among teaching teams

Implementing the interdisciplinary teaching model requires interdisciplinary collaboration among teaching teams. By integrating knowledge and skills from different disciplines through teacher collaboration, comprehensive teaching support can be provided to students. For example, materials science and chemistry teachers can collaborate to teach the properties of battery materials and electrochemical reaction mechanisms. Industrial engineering and computer science teachers can collaborate to teach the development and application of battery management systems.

6.2 Multidisciplinary collaboration among student teams

The implementation of the interdisciplinary teaching model also requires multidisciplinary collaboration among student teams. By working together, student teams can develop teamwork and communication skills, enhancing their ability to solve complex problems. For example, in BMS optimization projects, student teams can consist of students from materials science, chemistry, industrial engineering, and computer science, working together to complete project tasks and improve their comprehensive abilities.

7 Conclusion

The interdisciplinary teaching model can effectively improve the educational outcomes in BMS optimization. By integrating multidisciplinary knowledge and skills, the interdisciplinary teaching model cultivates students' comprehensive abilities and innovative capabilities, enhancing their ability to solve complex problems. Throughout the BMS optimization process, the interdisciplinary teaching model guides students to study and practice through project-oriented, team-based, and problem-oriented learning methods, improving their practical abilities and innovative capabilities. Moving forward, the ongoing advancement and refinement of the interdisciplinary teaching model will continue to bolster the education and evolution of BMS, driving innovation and growth in the new energy sector.

Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Ke L. 2024. Exploration of interdisciplinary teaching reform in basic courses of Chinese universities under the background of new engineering. *Higher Education Exploration*, 3: 124-128.

[2] Wang Y, Jin Z, Ma C. 2024. Teaching reform of new energy battery professional courses under the background of new engineering. *Battery*, 54(02): 281-283.

[3] Guo Z. 2024. The disciplinary base color in interdisciplinary teaching: concealment phenomena and restoration pathways. *Contemporary Education Science*, 2: 45-51.

[4] Hu G. 2023. Technology innovation drives low-carbon development of new energy batteries. *Trade Practice*, 7: 63-64.

[5] Fu S. 2023. Optimization of thermal management technology for new energy vehicle power batteries. *Automotive Test Report* , 11: 85-87.

[6] Zeng X, Yu Q. 2023. Exploration of application paths of new energy battery technology in low-carbon tourism industry. *Energy Storage Science and Technology*, 12(04): 1304-1305.