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Challenges and Strategies in Cultivating Scientific Literacy Among Students in Technical Universities

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Abstract: This paper examines the challenges faced by technical universities in cultivating scientific literacy among their students and proposes targeted strategies for improvement. Drawing on international practices and domestic research, it highlights four key obstacles: insufficient practical teaching resources, inadequate emphasis on innovation, limited proficiency in modern technology tools, and a lack of interdisciplinary collaboration. Corresponding solutions are proposed, including infrastructure enhancement, curriculum redesign, integration of digital competencies, and the establishment of interdisciplinary learning platforms. The study underscores the importance of a holistic and systemic approach to scientific literacy education in technical universities. By addressing these challenges through strategic interventions, technical institutions can better prepare students for the demands of contemporary and future professional landscapes.

Keywords: Scientific literacy; Technical universities; Interdisciplinary collaboration; Innovation capacity

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1. Introduction

In the rapidly evolving landscape of technological advancement and social demand for high-quality skilled professionals, scientific literacy has emerged as a pivotal component of the core competencies for students at technical universities [1]. Scientific literacy encompasses an individual's understanding of scientific knowledge, methods, and spirit, forming an essential part of modern society's required comprehensive quality and laying the foundation for lifelong learning and development. Internationally, scientific literacy is commonly divided into three aspects: knowledge of science, understanding of the research process and methodologies, and awareness of the impacts of science and technology on society and individuals [2]. This paper aims to delve into the challenges and strategies in fostering scientific literacy among students at technical universities, providing theoretical support for optimizing educational systems and enhancing students' scientific literacy.

The significance of scientific literacy is magnified in the era of globalization and information, where it becomes not only a critical skill for students to adapt to future career developments but also a driving force for societal innovation and technological progress [3]. Technical universities, as crucial grounds for nurturing highly skilled talents, shoulder the responsibility of delivering competent professionals equipped with solid specialized skills and high levels of scientific literacy [4]. Drawing from international experiences, such as Germany's dual education system that integrates theoretical teaching with practical operations through school-enterprise cooperation, focusing on cultivating students' scientific thinking and innovative abilities, or the diverse curriculum settings and flexible teaching methods adopted by American community colleges, these examples demonstrate that the cultivation of scientific literacy requires not only systematic theoretical instruction but also the organic integration of practical teaching and scientific research activities [5–7].

Despite significant attention from domestic scholars towards the cultivation of students' scientific literacy, several deficiencies remain within China's technical universities regarding scientific literacy training [8]. Issues such as limited practical teaching resources, inadequate emphasis on innovation ability cultivation, and insufficient opportunities for students to participate in scientific research activities and academic exchanges significantly impede the enhancement of students' scientific literacy and their future career development and innovation capabilities. Consequently, exploring suitable models and measurement methods for fostering scientific literacy among students at technical universities holds substantial practical and theoretical value. This exploration not only contributes to improving the quality of education in technical universities but also provides valuable references for reforming vocational education in China.

2. Problems encountered

2.1. Insufficient practical teaching resources for enhancing students' scientific literacy

Practical teaching plays a crucial role in the cultivation of scientific literacy; however, technical universities often fall short in investing in practical resources. Many institutions are equipped with outdated laboratory facilities that fail to meet students' needs for practicing with cutting-edge technologies. Furthermore, practical teaching tends to focus more on imitative operations rather than being supported by open experiments and research projects, leaving students with little opportunity to experience the entire process of scientific inquiry. The depth of school-enterprise cooperation is also lacking, resulting in the inefficient integration of enterprise resources into the practical teaching system and limiting students' participation in real-world research projects and skill competitions. Such resource scarcity not only hinders the enhancement of students' scientific literacy but also directly affects the cultivation of their innovation capabilities and professional competitiveness.

2.2. Inadequate emphasis on innovation ability cultivation

Technical universities tend to prioritize developing students' standardized operational skills over fostering innovation abilities. There is a notable absence of specific training for innovative thinking and practice in course designs, leading to low student participation in innovative activities such as patent applications, academic paper writing, and skill contests. For instance, some institutions have yet to establish systematic incentive mechanisms for innovation, leaving students without adequate policy support and resource guarantees when engaging in research activities. Additionally, there is insufficient guidance from teachers on innovative methods, with teaching approaches still predominantly lecture-based, thereby depriving students of opportunities for autonomous exploration and teamwork. Consequently, the cultivation of innovation capabilities and scientific spirit remains superficial.

2.3. Weak application abilities of modern technology tools

With the rapid advancements in artificial intelligence, big data, IoT, and other modern technologies, the application of tech tools has become an integral aspect of scientific literacy. However, students at technical universities generally exhibit lower proficiency in these areas. The curriculum lacks targeted training in modern technology tools, resulting in inadequate skills in data processing and intelligent algorithm applications. For example, many students lack a fundamental understanding of AI principles, hindering their ability to solve real-world problems. Moreover, their capabilities in using statistical software and visualization tools for data analysis are relatively weak. These deficiencies not only restrict the improvement of students' scientific literacy but also place them at a disadvantage in future career competition.

2.4. Lack of interdisciplinary collaboration skills

Course designs at technical universities often center around single disciplines, lacking modules that integrate interdisciplinary elements. This deficiency makes it challenging for students to apply multidisciplinary knowledge when addressing complex issues. Engineering students, for example, may lack systematic learning about humanities and social sciences, making it difficult for them to comprehend the societal implications of technological applications. Conversely, humanities and social science students might struggle with mastering technical tools, preventing them from participating in interdisciplinary innovative practices. Furthermore, schools often lack platforms and mechanisms for interdisciplinary collaboration, resulting in evident deficiencies in students' teamwork and communication skills. This lack of comprehensive capabilities not only impedes the holistic development of students' scientific literacy but also limits their overall competitiveness in future professional scenarios.

3. Strategies for improvement

3.1. Enhancing practical teaching resources to support scientific literacy development

To address the current shortage of practical teaching resources, technical universities should prioritize upgrading laboratory infrastructure and integrating advanced technologies into hands-on learning environments. Investment in modern equipment and simulation tools can provide students with access to real-world technological scenarios and foster deeper engagement in scientific inquiry. Moreover, schools should strengthen collaboration with industry partners by establishing structured internship programs, joint research projects, and co-developed practical courses. These partnerships not only enrich the practical curriculum but also expose students to authentic problem-solving experiences. Additionally, incorporating open-ended experiments and project-based learning into the syllabus can encourage student autonomy and creativity, thereby enhancing both scientific literacy and innovation capabilities.

3.2. Strengthening innovation capacity building through curriculum and institutional reform

In order to shift from a focus on standardized operations to a more innovation-oriented educational model, technical universities must redesign their curricula to include dedicated modules on creative thinking, design thinking, and applied research methods. Establishing innovation incubators, makerspaces, and patent development centers within campuses can offer students institutional support and mentorship for translating ideas into tangible outcomes. Furthermore, introducing incentive mechanisms—such as innovation credits, research grants, and recognition awards—can motivate student participation in academic writing, skill competitions, and intellectual property creation. Faculty development programs that emphasize innovative pedagogy will also ensure that instructors are equipped to guide students through exploratory and collaborative learning processes, thus reinforcing the integration of scientific spirit and innovation capacity into everyday teaching practices.

3.3. Integrating modern technology tools into the curriculum to improve digital competence

Given the increasing importance of digital skills in scientific literacy, technical universities must systematically incorporate modern technology tools such as artificial intelligence, data analytics, and Internet of Things (IoT) platforms into their curricula. Offering foundational and advanced courses in programming, machine learning, and data visualization will equip students with the necessary competencies to analyze complex systems and develop technology-driven solutions. Additionally, embedding digital tools across disciplines—not just in engineering but also in social sciences and humanities—ensures that all students gain exposure to computational thinking and its applications. Partnering with tech companies to deliver certification programs or workshops can further enhance students' familiarity with industry-standard software and hardware. This integration not only elevates students' technological proficiency but also aligns their skill sets with the evolving demands of the labor market.

3.4. Promoting interdisciplinary collaboration through integrated learning platforms

To overcome the limitations imposed by siloed disciplinary structures, technical universities should establish interdisciplinary education frameworks that encourage cross-departmental course offerings, joint degree programs, and team-based capstone projects. Creating interdisciplinary research labs and thematic learning communities can facilitate knowledge exchange between students from different fields and promote holistic problem-solving approaches. Moreover, implementing communication and teamwork training as core components of the curriculum will help students articulate ideas effectively and collaborate across domains. Institutions can also host interdisciplinary competitions, hackathons, and symposiums to stimulate intellectual synergy and innovation. By fostering an educational ecosystem that values diverse perspectives and collaborative inquiry, technical universities can significantly enhance students' ability to integrate scientific, technical, and societal insights—thereby cultivating well-rounded professionals prepared for complex global challenges.

4. Future perspectives

The future will see a continuous evolution of the requirements for scientific literacy among technical university students. With the rapid advancement of emerging technologies such as quantum computing, biotechnology, and advanced materials science, students will need to develop a deeper understanding of these cutting-edge fields and their interdisciplinary implications. The scientific literacy of the future will not only encompass traditional scientific knowledge and methodologies but also require students to be adept at navigating a complex landscape of rapidly changing information and technological paradigms. They must be capable of critically assessing new scientific theories and technologies, understanding their potential benefits and risks, and making informed decisions in both professional and societal contexts.

Looking ahead, the integration of advanced technologies in the cultivation of scientific literacy will become increasingly significant. Virtual reality (VR) and augmented reality (AR) technologies will offer immersive learning experiences, enabling students to virtually participate in scientific experiments and research projects that would otherwise be inaccessible due to limitations in physical resources or safety concerns. Artificial intelligence-assisted education platforms will provide personalized learning paths for students, adapting to their individual learning paces and styles to enhance the effectiveness of scientific literacy education. Additionally, the IoT will facilitate the creation of smart learning environments where students can collect and analyze real-time data, thereby developing their data-driven scientific thinking and problem-solving abilities.

5. Conclusions

This study identifies key challenges in the development of scientific literacy among students at technical universities and proposes corresponding strategies for improvement. The main issues—insufficient practical teaching resources, limited emphasis on innovation, weak technology tool application skills, and a lack of interdisciplinary collaboration—are critical barriers to holistic student development. By enhancing hands-on learning environments, integrating innovation-focused curricula, embedding modern digital tools, and promoting interdisciplinary cooperation, technical universities can significantly strengthen students' scientific capabilities. These strategic interventions not only support the cultivation of scientific literacy but also align educational outcomes with the evolving demands of the knowledge-based economy. Ultimately, a comprehensive and integrated approach is essential for equipping technical university students with the competencies needed to thrive in future professional and societal contexts.

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