ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 2617-9415 (Online)
CODEN: ESSDAX

Education, Sustainability & Society (ESS)

DOI: http://doi.org/10.26480/ess.01.2024.17.20

RESEARCH ARTICLE

CONSTRUCTION OF THREE-DIMENSIONAL DIGITAL TEACHING MATERIAL FOR METALWORKING INTERNSHIP

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ARTICLE DETAILS

Article History:

Received 16 August 2023
Revised 19 September 2023
Accepted 22 October 2023
Available online 08 November 2023

ABSTRACT

This paper focuses on exploring and practicing the construction of three-dimensional digital teaching materials to address the problems in the teaching of metalworking internships. Through research and analysis in relevant fields and in combination with actual teaching needs, this study designs and develops a set of comprehensive teaching resources that are closely aligned with metalworking internships, with three-dimensional digital teaching materials as the core. These teaching materials not only include detailed interpretations of theoretical knowledge but also integrate innovative features such as real-time demonstrations of practical operations, 3D simulations, and immersive experiences. In the implementation process, case analysis and interactive teaching activities are adopted to improve the effectiveness and quality of students' learning in metalworking internships. The results of the study show that the digital teaching materials can enhance students' interest, initiative, and efficiency in learning, achieving significant teaching effects. The development of this study is of great significance for promoting the innovation of metalworking internship teaching models and the development of digital education.

KEYWORDS

metalworking internship; three-dimensional digital teaching materials; teaching resources; simulation and experience; teaching effectiveness

1. INTRODUCTION

The three-dimensional digital teaching materials go beyond the content of traditional printed teaching materials by incorporating teaching resources such as educational images, videos, audios, animations, online courses, and electronic information, leading readers into a realm of "autonomous, exploratory, collaborative, interactive, and ubiquitous" learning. This transformation aims to address the shortcomings of traditional paper-based books, which primarily focus on knowledge transmission, lack interaction, and fail to ensure learning quality (Chen and Li, 2019; Wang, 2022a). As a fundamental course in the discipline of metalworking, the hands-on practicum plays a crucial role in nurturing engineering thinking methodologies. However, the conventional paper-based materials merely mechanically explain relevant principles and construction knowledge, lacking theoretical guidance for practical applications. In contrast, the three-dimensional digital teaching materials offer abundant teaching resources and employ advanced information technology, embodying the concept of "integrating theory with practice" in instruction and providing robust support for educational reform (Liu et al., 2022).

2. ANALYSIS ON THE CURRENT STATUS OF METALWORKING INTERNSHIP TEACHING AND TEACHING MATERIALS

2.1 Analysis on the Current Situation of Teaching

Currently, the teaching content and methods in metalworking internship courses are somewhat outdated, and the main focus of the courses remains limited to validating the principles and techniques taught in mechanical manufacturing engineering courses. As depicted in Figure 1, the content framework is primarily built upon the inheritance of knowledge in lathe, clamp, and welding practices accumulated over the years. Students follow the teacher's demonstrations of mechanical operations, which foster an awareness and capability for engineering practices. However, the curriculum lacks elements of independent innovative practice and comprehensive skill training. The design of the content lacks distinctive and innovative knowledge, leading to a significant gap between the curriculum and the actual demands of talent development. As a result, students may initially show enthusiasm, but the teaching effectiveness is ultimately compromised (Song et al., 2022).

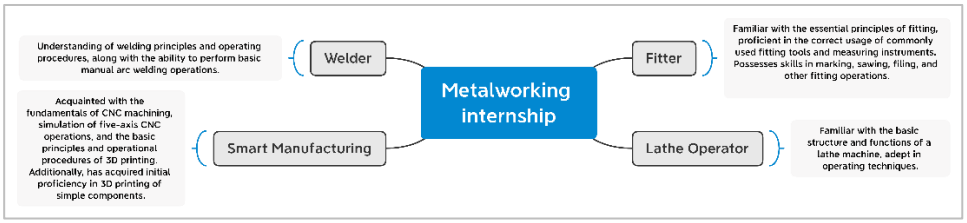

Figure 1: Content of metalworking internship system.

Quick Response Code	Access this article online	
	Website: www.educationsustability.com	**DOI:** 10.26480/ess.01.2024.17.20

Cite The Article: Chao Ma, Liu Xu, Xia Xie, Xiaoli Zhang (2024). Construction of Three-Dimensional Digital Teaching Material for Metalworking Internship. *Education, Sustainability & Society, 7(1): 17-20.*

2.1 Analysis on the Current Situation of Teaching Materials

2.1.1 Limited Content

Currently, most metalworking internship teaching materials mainly focus on introducing traditional machining processes, while lacking the introduction and discussion of advanced manufacturing technologies such as Industry 4.0. The content is relatively limited, failing to meet students' needs for new technologies.

2.1.2 Disconnection from Practice

Some metalworking internship teaching materials lack integration with practical applications. They emphasize theoretical knowledge but fail to provide effective guidance and assistance for actual operations. As a result, when students encounter problems during practical activities, they cannot find helpful guidance from the teaching materials (Yu, 2019).

2.1.3 Lack of Engagement

Metalworking internship teaching materials often lack excitement in their presentation, lacking vivid and interesting cases and practical stories. This makes it challenging to capture students' interest and attention. Furthermore, some teaching materials lack real-life application examples, failing to inspire students' enthusiasm for practical learning.

2.1.4 Incompatibility with Modern Teaching Methods and Approaches

Modern teaching emphasizes diversification, interactivity, and personalization. However, some metalworking internship teaching materials have not adapted to these changes and lack integration with modern teaching methods and approaches. This makes it difficult for teachers to effectively guide students in their learning, and students struggle to engage in self-directed learning through the teaching materials (Lu et al., 2020).

3. Characteristics and Ideas of Traditional Digital Teaching Materials

3.1 Advantages of Traditional Digital Teaching Materials

Considering the domestic and international situations, traditional digital teaching materials have the following advantages:

3.1.1 Ease of Reading

Traditional digital teaching materials are easily accessible on various devices, including computers, smartphones, and tablets. For students, this means they can access their materials anytime, anywhere, without being constrained by time or location. Additionally, traditional digital teaching materials support functionalities such as zooming, copying, and searching, which facilitate reading and note-taking.

3.1.2 Portability

Traditional digital teaching materials are lightweight and easy to carry or transmit. Students can conveniently carry a large amount of teaching materials with them, enabling them to study and review whenever they want.

3.1.3 Relatively Lower Cost

Compared to printed teaching materials, traditional digital teaching materials often come at a lower price. This can reduce the learning costs for students, particularly those in economically disadvantaged areas, and enhance educational equity.

3.2 Shortcomings of Traditional Digital Teaching Materials

Taking into account domestic and international contexts, traditional digital teaching materials have the following shortcomings:

3.2.1 High Technical Requirements

Traditional digital teaching materials are easily accessible on various devices, including computers, smartphones, and tablets. For students, this means they can access their materials anytime, anywhere, without being constrained by time or location. Additionally, traditional digital teaching materials support functionalities such as zooming, copying, and searching, which facilitate reading and note-taking (Zhou, 2021; Gu et al., 2020).

3.2.2 Limited Communication and Interaction

Traditional digital teaching materials may reduce direct communication and interaction between students and teachers. In traditional teaching methods, teachers can promptly identify and address students' learning problems through face-to-face interaction and observation. However, digital materials often only provide one-way knowledge transfer, reducing opportunities for interaction between students and teachers and impacting the effectiveness of instruction (Liu, 2020; Wang, 2022b).

3.2.3 Copyright Issues

Traditional digital teaching materials are typically distributed and shared through the internet, raising concerns regarding copyright. In the absence of clear legal regulations and management mechanisms, the rights of authors or copyright owners may be violated, which can hinder the promotion and application of digital materials. Additionally, there are variations in copyright protection and digital learning culture between different countries and regions. In some foreign countries, copyright protection regulations are well-established, and digital learning culture is more prevalent, resulting in fewer copyright issues related to digital materials. However, in certain domestic regions, where copyright awareness and digital learning culture have not fully developed, copyright problems regarding digital teaching materials may be more prominent.

3.2.4 Poor Learning Experience

Traditional digital teaching materials often have a limited presentation format, lacking in interactivity and appeal to engage students' interest in learning. Additionally, digital materials are often not designed to cater to students' personalized needs, failing to meet the diverse learning requirements of different students, resulting in a relatively subpar learning experience. The introduction of original foreign digital teaching materials may also face challenges due to differences in educational models and content between countries and regions, affecting the suitability of digital materials. In countries and regions where education is more flexible and emphasizes student autonomy, the use of digital materials may be more suitable. However, in countries and regions that follow more traditional educational approaches with an emphasis on teacher-centered instruction, there may be limitations on the use of digital teaching materials.

4. Construction of Three-Dimensional Digital Teaching Materials for Metalworking Internship

To address these issues, the internship course in metalworking has adopted a new teaching philosophy based on digitalization, drawing inspiration from the spirit of craftsmanship exhibited by leading industrial nations. As a starting point, the course emphasizes the renewal and upgrading of metalworking internship materials, ensuring they incorporate introductions to new technologies and practical applications, thus enhancing their readability and usefulness. Furthermore, it is crucial to encourage and support teachers in developing teaching materials that meet modern instructional needs, enabling the integration of materials with teaching methods and approaches to elevate the quality of metalworking internships. In addition, schools can establish practical training sites and introduce advanced equipment to enhance students' perception and practical skills in using new technologies, thereby fostering further upgrades and optimizations of metalworking internship materials. The development of teaching materials could be focused on the following three aspects:

4.1 Three-Dimensional Content Design

To achieve the three-dimensional design of the metalworking internship digital materials, the process involves refining and integrating the content, adopting effective teaching methods and technology, as well as designing interactive components and assessment formats. Firstly, during the refinement and integration phase of the content, it is important to extract relevant knowledge points and skill requirements from actual metalworking internship activities and consolidate them into a systematic curriculum. Throughout this process, it is crucial to maintain the scientific, systematic, and practical nature of the content, ensuring comprehensive coverage of all aspects of metalworking internships.

Next, during the stage of adopting teaching methods and technology, it is essential to choose appropriate teaching approaches and technology based on the characteristics of metalworking internships and the students' learning needs. For instance, utilizing actual metalworking internship cases in teaching can be effective. By combining traditional course content with practical vehicle maintenance, a curriculum system that integrates "traditional craftsmanship + emergency repairs" can be developed. For example, in welding internships, a seminar-style teaching approach can be employed, comparing and discussing the advantages and disadvantages of

traditional electric welding and non-electric welding techniques when working with the same metal sheet.

Furthermore, practical teaching cases can be expanded to include topics like rapid bonding, sealing, and repairing broken casings. In machining internships, after covering the basics of fundamental machining operations such as sawing and filing, practical teaching content can be extended to include techniques for quick repair of damaged threads and extraction of broken screws. This enhances students' abilities to perform rapid repairs. By creating simulated practical environments, students can experience immersive learning and practice. Additionally, modern digital technologies like virtual reality and augmented reality can be leveraged to provide more vivid and intuitive learning resources, stimulating students' interest and engagement in the learning process.

During the design phase of interactive components and assessment formats, it is crucial to prioritize students' active participation and practical application. By incorporating a variety of interactive elements such as discussions, group collaborations, and experiments, students' critical thinking skills and innovative mindset can be stimulated, leading to enhanced learning outcomes. Additionally, when designing assessment formats, emphasis should be placed on assessing students' practical abilities. Methods such as hands-on tasks and practical reports can be employed to comprehensively evaluate students' proficiency in metalworking internships.

4.2 Technologically-Integrated Teaching Methods

The adoption of teaching methods and technology is a crucial aspect in the development of a three-dimensional digital teaching material for metalworking internships. The selection of teaching methods should align with the characteristics of metalworking internships and the learning needs of students in order to enhance teaching effectiveness and students' practical operational abilities. To begin, the primary teaching approach can be centered around hands-on instruction. The nature of metalworking internships requires students to personally engage in metalworking operations, thus necessitating the cultivation and improvement of their practical skills through actual practice. In the process of developing three-dimensional digital teaching materials, it is essential to combine the advantages of traditional digital resources with internet technology.

This integration can include micro-lessons, PowerPoint presentations, images, animations, and other digital teaching resources within the materials. Following the principle of "sufficient theory, highlighting practical training", the writing should incorporate interactive questionnaires and instructional videos to emphasize the interactive nature of the materials. By doing so, students can engage in interactive learning experiences that allow them to experience the process and techniques of actual operations. Furthermore, real-time guidance and corrections based on students' operational performance can be provided, thereby enhancing their practical abilities. It is important to remain updated with the latest developments in the field of metalworking internships, facilitating the organization and implementation of interactive and self-directed teaching methods.

Furthermore, the utilization of teaching technology is crucial for the development of technologically-integrated, three-dimensional digital teaching materials for metalworking internships. Within the digital materials, multimedia technologies such as images and animations can be employed to demonstrate the specific operational steps and techniques involved in metalworking internships. This approach allows for a more intuitive presentation of the process and essentials of practical operations, enhancing students' understanding and operational skills in metalworking internships. Moreover, with the aid of teaching software like virtual laboratories, students can engage in simulated experiments and practice metalworking techniques on computers. This facilitates familiarity with operational procedures and allows for repeated practice to consolidate the acquired knowledge.

Lastly, the adoption of teaching methods and technology should also prioritize the experiential aspect and interactivity of practical operations. Metalworking internships require hands-on experience and actual operations, thus digital teaching materials should strive to replicate the process and environment of practical operations as authentically as possible. Utilizing 3D technology and virtual reality techniques can allow students to immerse themselves in realistic scenarios of actual operations, enabling real-time interaction with the virtual environment. This approach enhances student engagement and learning effectiveness through active participation.

4.3 Interactive Assessment Components

The design of interactive assessment components is crucial for the development of technologically-integrated, three-dimensional digital teaching materials for metalworking internships. Interactive components refer to the segments in the teaching process where students engage in communication and collaboration with the teaching materials, teachers, and their peers. Assessment methods, on the other hand, refer to the ways and approaches used to evaluate students' grasp of metalworking internship knowledge and skills.

When designing interactive components, various approaches can be employed, such as group discussions and presentations, practical hands-on exercises, and case analysis. Through group discussions and presentations, students can exchange ideas and experiences within their teams, leveraging individual strengths and enhancing problem-solving abilities. Practical hands-on exercises are vital for cultivating students' actual operational skills, allowing them to gain a better mastery of metalworking internship techniques through hands-on practice. Case analysis, on the other hand, facilitates the development of students' analytical and problem-solving skills by examining real-life cases.

In the design of assessment methods, a combination of comprehensive assessment and practical assessment can be utilized. Comprehensive assessment primarily includes a written test on metalworking internship knowledge and a practical assessment of operational skills. This type of assessment allows for a comprehensive evaluation of students' grasp of both knowledge and skills. Practical assessment, on the other hand, involves evaluating students' operational skills and their ability to address challenges through hands-on practice.

Simultaneously, when designing interactive components and assessment methods, it is crucial to take into account the individual differences and learning needs of students, ensuring that each student can actively participate and attain corresponding outcomes. Moreover, teachers can incorporate technological tools, such as virtual laboratories and online interactive platforms, to offer additional learning resources and opportunities for communication, thereby enhancing students' engagement.

5. Teaching Effectiveness of Three-Dimensional Digital Teaching Materials for Metalworking Internship

The evaluation of the effectiveness of three-dimensional digital teaching materials for metalworking internships is a significant criterion for assessing the quality of teaching materials. By conducting comparative and analytical assessments of the teaching effectiveness of such materials, it is possible to gain a comprehensive understanding of their strengths and weaknesses. This knowledge can serve as a valuable reference for making improvements to teaching methods and materials.

Initially, the teaching effectiveness of three-dimensional digital teaching materials for metalworking internships is manifested in students' mastery of metalworking knowledge and skills. The digital materials utilize multimedia formats, including rich visual and textual materials, as well as animated videos, allowing students to gain a more intuitive understanding of the specific work contents and operational procedures involved in metalworking internships. The inclusion of case studies in the materials also helps students integrate theoretical knowledge with practical applications, thereby enhancing their learning interest and outcomes.

Furthermore, the teaching effectiveness of three-dimensional digital teaching materials for metalworking internships is also evident in students' practical operational abilities. Through the digital materials, students can engage in practical hands-on training in a virtual environment, overcoming the limitations of equipment and materials typically encountered in traditional internships. This approach enhances the flexibility and opportunities for practical operations. Additionally, the digital materials can record students' operational steps in real-time, facilitating subsequent analysis and evaluation by instructors. This real-time feedback enables students to promptly identify and correct errors during actual operations, thereby enhancing their practical operational skills.

Moreover, the teaching effectiveness of three-dimensional digital teaching materials for metalworking internships also cultivates students' practical abilities and fosters innovative thinking. In comparison to traditional teaching materials, the digital materials place greater emphasis on students' active participation and interactive learning. Various interactive elements, such as interactive questions and discussion forums, are incorporated into the materials to encourage students to engage actively and engage in thoughtful deliberation. This interactive learning approach helps cultivate students' practical abilities and fosters their innovative thinking, stimulating their interest and initiative in the learning process.

6. Conclusions

Through an in-depth analysis and investigation of the issues present in metalworking internships, this study has proposed an exploration and practice of constructing three-dimensional digital teaching materials. In combination with thorough research and analysis in the relevant field, and considering the practical teaching needs, this study has designed and developed a comprehensive set of metalworking internship three-dimensional digital teaching materials. The utilization of these materials has demonstrated a significant enhancement in students' practical abilities and professional qualities. The design and development process of the teaching materials have received positive feedback and evaluations, validating their practical application value and instructional effectiveness in metalworking internships.

In conclusion, the construction of three-dimensional digital teaching materials for metalworking internships represents an innovative educational practice that holds significant importance in promoting innovation in the teaching model of metalworking internships and the development of digital education. The teaching design concept and development experience proposed in this study can serve as a reference for the instructional reform of other internship courses. It is hoped that this research will have a positive impact on the optimization and enhancement of the metalworking internship teaching model, contributing to the cultivation of highly skilled professionals who are adaptable to the needs of industrial development.

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