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# Integrating Values Education into STEM Curriculum: A Case Study on Cultivating Professional Ethics and Social Responsibility in 'Radiation Physics and Protection'

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## Abstract

**In an era of rapid technological advancement, equipping STEM students with not only technical skills but also professional ethics and a strong sense of social responsibility has become a critical challenge for higher education worldwide. To address this, this study presents a case study of a pedagogical reform in 'Radiation Physics and Protection,' a core course for medical imaging technology majors. Based on two years of teaching practice with 540 undergraduate students at a university in China, this study uses a qualitative analysis to examine three teaching cases designed to enhance students' comprehensive competencies: "Cultivating a Sense of Professional Mission Through Historical Narrative," "Fostering Professional Ethics Through the History of Science and Hands-on Practice," and "Developing Critical Thinking Through Debates on Socioscientific Issues." The findings indicate that by adhering to the design principles of "Goal Alignment, Seamless Integration, Student-Centered Approach, and Value-Oriented Guidance," abstract values can be successfully internalized within a professional curriculum. Based on these findings, this paper proposes a generalizable "Tri-element Fusion" pedagogical model (Knowledge Domain, Value Domain, and Pedagogical Practice Domain), offering a practical framework for ethics and values education in other STEM courses globally.**

## Keywords

**Values Education; STEM Education; Professional Ethics; Social Responsibility; Case Study; Pedagogical Model.**

## 1. Introduction: A Global Challenge and a Local Practice

It is now widely recognized in global higher education that merely imparting cutting-edge scientific and technological knowledge is insufficient. Faced with increasingly complex global issues, such as public health crises, climate change, environmental pollution, and ethical controversies surrounding technologies like artificial intelligence and gene editing, future scientists and engineers must possess sound ethical judgment and a strong sense of social responsibility. Therefore, seamlessly integrating values and ethics education into the Science, Technology, Engineering, and Mathematics (STEM) curriculum has become a pressing international agenda, with many scholars emphasizing the importance of cultivating the humanistic dimension in STEM education (Gaudelli, 2021) [3].

As a local response to this global challenge, China has recently promoted a nationwide educational reform aimed at "Cultivating Virtue Through Education", which emphasizes the comprehensive integration of values into all courses. Research shows that this ethics education practice, centered on curriculum reform, has made positive progress in higher education (Tang & Chen, 2022) [5]. Against this backdrop, our study focuses on the highly specialized course, 'Radiation Physics and Protection.' This course is crucial for training future medical imaging

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technology specialists, as its content involves not only complex physical principles and operational techniques but also significant ethical issues related to patient safety, occupational protection, and public health. However, in practice, combining abstract values with highly technical course content presents universal difficulties, including a disconnect between theory and practice, a lack of diverse teaching methods, and low student engagement.

This study aims to answer the following question: How can we systematically design and implement pedagogical activities within a technical course to effectively cultivate students' professional ethics and social responsibility? To answer this, we use a case study methodology to conduct an in-depth analysis of a series of teaching interventions developed and validated over the past two years. The goal is to distill pedagogical strategies and models that have universal reference value beyond any specific cultural context.

## 2. Overall Design Principles for the Pedagogical Intervention

To build a meaningful connection between technical knowledge instruction and values cultivation, all our teaching case designs adhere to the following four fundamental principles:

### 2.1. Goal Alignment

All teaching activities must simultaneously serve the course's knowledge objectives (e.g., mastering physical principles) and its values-based goals (e.g., enhancing ethical awareness), ensuring they are consistent and coordinated rather than contradictory. This means that in designing teaching modules, we always start from a core knowledge point and look for intrinsically linked ethical or social issues, ensuring that knowledge transmission and value guidance are two sides of the same coin.

### 2.2. Seamless Integration

Values elements (such as scientific spirit, historical mission, and ethical dilemmas) are treated as an organic part of the professional knowledge being taught, rather than as a detached add-on, striving for a natural and deep fusion. We avoid setting up separate "moral lectures" in the course and instead integrate values education into the explanation of every knowledge point, every practical lab session, and every problem discussion (Ahmad & Khan, 2022) [1].

### 2.3. Student-Centered Approach

We replace traditional one-way lecturing with active learning methods such as case studies, group debates, and role-playing to create a learning environment that stimulates students' thinking, participation, and reflection. This approach aims to transform students from passive knowledge recipients into active knowledge constructors and value explorers.

### 2.4. Value-Oriented Guidance

Through carefully selected teaching materials and guiding questions, we actively lead students to think prudently and lean towards making responsible value judgments when faced with complex professional and ethical issues. The role of the teacher shifts from a traditional "knowledge transmitter" to a "catalyst for thought," stimulating students' moral reasoning by asking questions rather than providing ready-made answers.

## 3. In-depth Analysis of Teaching Cases

The following three cases are representative teaching interventions that have been proven through multiple rounds of practice to be effective in stimulating student interest and promoting their comprehensive competencies.

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## 3.1. Case 1: Cultivating a Sense of Professional Mission Through Historical Narrative

### 3.1.1. Instructional Goal

To foster students' professional pride and their sense of mission to serve society.

### 3.1.2. Knowledge Domain

The "Fundamentals of Nuclear Physics" chapter in the course.

### 3.1.3. Pedagogical Implementation

When teaching nuclear physics, we no longer just focus on abstract formulas and theories. We introduce the historical narrative of China's major breakthroughs in nuclear technology during the 20th century to achieve scientific and technological self-reliance. By showing historical video clips and telling the personal stories of key scientists (such as Yu Min and Qian Xuesen), we guide students to discuss how, under specific historical conditions, scientists' professional pursuits were closely linked to national development and destiny. The core of the discussion is not political propaganda but a deeper exploration of the question: "As a science and technology professional, to what extent can one's personal professional efforts contribute to social progress?"

### 3.1.4. Pedagogical Reflection

This historical narrative successfully provides students with an empathetic role-model framework. It concretizes grand societal contributions into individual professional pursuits and relentless efforts, effectively transforming an external, historical sense of achievement into students' internal sense of mission for their future careers and motivation for learning.

## 3.2. Case 2: Fostering Professional Ethics Through the History of Science and Hands-on Practice

### 3.2.1. Instructional Goal

To cultivate a rigorous scientific spirit and reinforce the ethical norms that must be observed in professional practice.

### 3.2.2. Knowledge Domain

"The Discovery of X-rays," "The History of MRI Technology," and "Radiation Protection Operating Procedures."

### 3.2.3. Pedagogical Implementation

First, through vivid storytelling, we recount the story of how Wilhelm Röntgen discovered X-rays through meticulous experimental observation and perseverance, and how Paul Lauterbur and Peter Mansfield co-developed MRI technology through innovative thinking and rigorous research. Subsequently, the focus of the class shifts from "scientific discovery" to "technological application." By presenting real medical accident cases caused by improper radiation protection and having students practice how to correctly wear and test personal dosimeters, we emphasize that complying with operating procedures is not just a technical requirement, but a fundamental ethical principle of being responsible for the lives and health of patients and oneself. This method of combining abstract concepts with concrete practice has been proven to be an effective way to cultivate ethical awareness (Kahn & Van Wynsberghe, 2023) [4].

## 3.3. Case 3: Developing Critical Thinking Through Debates on Socioscientific Issues

### 3.3.1. Instructional Goal

To develop students' multi-perspective, critical thinking skills and sense of social responsibility when facing complex technological and ethical issues.

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#### 3.3.2. Knowledge Domain

"Peaceful Use of Nuclear Energy" and "Prevention and Control of Radioactive Pollution."

#### 3.3.3. Pedagogical Implementation

We organize the class into a debate on the "application of nuclear technology," a typical Socio-Scientific Issue (SSI). The instructor first introduces the immense contributions of nuclear technology in fields like energy and medicine, as well as its potential risks and global controversies in areas like weapons applications and nuclear waste disposal. Students are divided into groups to research and debate topics such as, "From the perspective of global sustainable development, should humanity continue to develop or restrict nuclear technology?" The instructor acts as a neutral facilitator, encouraging students to consider the perspectives of different stakeholders (e.g., governments, scientists, the public, environmental organizations). This SSI-based debate model has been shown to effectively enhance students' critical thinking and civic responsibility (van der Riet & Ng, 2021) [6].

#### 3.3.4. Pedagogical Reflection

The SSI debate model greatly stimulates student engagement. By tackling a real-world problem with no simple answer, students are pushed to move beyond a purely technical perspective and begin to consider issues from multiple dimensions, including ethical, social, economic, and environmental. This not only deepens their understanding of the professional knowledge but, more importantly, hones the prudent and responsible critical thinking skills necessary for them as future professionals and global citizens.

## 4. Discussion and Conclusion

This case study demonstrates that systematically integrating values education into STEM courses is both feasible and effective. The key lies in moving beyond a simple "knowledge + values" addition to achieve an organic fusion of the two. Based on this, we propose a universally applicable "Tri-element Fusion" pedagogical model, which emphasizes that instructional design must simultaneously consider and integrate the following three dimensions:

Knowledge Domain: The professional theories, techniques, and facts that the course aims to impart.

Value Domain: The professionally relevant ethical norms, social responsibilities, scientific spirit, and humanistic concerns that students are expected to internalize.

Pedagogical Practice Domain: The specific teaching activities, methods, and tools designed to connect knowledge and values, such as case studies, project-based learning, role-playing, and debates.

### 4.1. Implications for International Higher Education

The experience from this study suggests that, regardless of the cultural and educational system, the fundamental path to enhancing the humanistic dimension of STEM education is to return to the curriculum itself. It involves deeply mining the rich resources for values education embedded in the history of science and technology, engineering ethics codes, and cutting-edge scientific controversies. This aligns with the "responsible research and innovation" framework advocated by many scholars (Børsen & Klyve, 2020) [2]. The role of the educator needs to shift from that of a traditional "knowledge transmitter" to a "facilitator of students' intellectual and character development."

### 4.2. Limitations and Future Research

As a qualitative case study, the generalizability of this study's conclusions requires validation through larger-scale empirical testing. In the future, we plan to develop more quantitative assessment tools to more accurately measure the impact of such teaching interventions on

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students' values and critical thinking skills. We will also test and refine the "Tri-element Fusion" model in a wider variety of STEM courses.

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