

Research Literacy Development in Higher Vocational Traditional Chinese Medicine Programs: A Science-Education Integration Perspective

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Abstract

Science-education integration is an emerging direction in modern vocational education. To address weak research-education objectives, separation between research and professional curricula, limited student participation, and narrow assessment in higher vocational TCM-related programs, this paper uses an authentic acupuncture project on exercise-induced fatigue to propose a "one core, four dimensions, five chains" framework for research literacy. The core is an authentic research question; the four dimensions are question-and-evidence awareness, research design and methods, data analysis and communication, and ethical compliance and collaboration; the five chains are problem, task, resource, mentoring, and assessment chains. Research activities are converted into tiered curricular tasks in proposal development, literature retrieval, experimental design, public-data analysis, interpretation, and academic communication. Implementation pathways include curriculum embedding, platform coordination, faculty collaboration, process-based assessment, and ethical governance to support evidence-based, innovative, and standardized professional practice.

Keywords

Science-Education Integration; Higher Vocational Education; TCM-Related Programs; Research Literacy

1. Introduction

The report to the 20th National Congress of the Communist Party of China called for coordinated innovation across vocational education, higher education, and continuing education, and for advancing the integration of vocational and general education, industry and education, and science and education [1]. The Opinions on

Deepening the Reform of the Modern Vocational Education System, issued in 2022, further established science-education integration as a new direction for building the modern vocational education system and called for the timely incorporation of new methods, technologies, processes, and standards into educational practice [2]. The Outline for Building a Leading Country in Education (2024-2035) emphasized developing models of science-education integration that combine talent cultivation, scientific research, and technology transfer [3]. In 2026, the Ministry of Education's opinion on reforming key elements of vocational education and teaching further called for a shift in talent cultivation from the transmission of isolated knowledge to the development of comprehensive capabilities [4]. These policy signals indicate that "science" in vocational education should not be reduced to faculty publication output, nor should "education" be confined to repetitive training in established skills.

Higher vocational traditional Chinese medicine (TCM)-related programs are strongly practice-oriented. Students must master meridian and acupoint knowledge, Chinese materia medica, rehabilitation assessment, and technical procedures, while also developing the ability to judge evidence quality, interpret clinical phenomena, identify risks, and continue learning. As evidence-based medicine, molecular biology, health big data, and artificial intelligence enter TCM research and service settings, reliance solely on rote memorization and imitation of procedures can no longer meet the demands of occupational mobility and career development. Research literacy does not mean requiring every student to publish a paper; rather, it refers to the ability to formulate researchable questions, retrieve and evaluate evidence, understand basic study designs, record and analyze data in a standardized manner, and communicate conclusions honestly and clearly.

Undergraduate research experiences can promote active learning, professional identity, and interest in research careers [8], while inquiry-based, problem-based, and project-based learning situates knowledge in authentic problems and encourages students to construct understanding through problem solving [6-7]. However, higher vocational TCM education cannot simply replicate the laboratory training model of research universities. Given constraints related to program duration, students' academic foundations, faculty structure, and laboratory conditions, there is a greater need to transform existing faculty research projects into learning tasks that are appropriately challenging, can be embedded in courses, and can be assessed. Using an "acupuncture intervention for exercise-induced fatigue" project as an example, this paper proposes a research literacy development framework for all students.

2. The Rationale for Science-Education Integration and Research Literacy Development

2.1. From Showcasing Research Outputs to Educating through the Research Process

The relationship between research and teaching encompasses at least several levels: bringing research findings into teaching, incorporating research methods into courses, engaging students in inquiry, and using research evidence to improve teaching [6,9]. If a classroom merely presents what papers a teacher has published, students remain passive recipients. Only when students are entrusted with formulating questions, comparing study plans, making judgments from data, and reflecting and revising does the research process genuinely become an educational process. The key to science-education integration is not to add an abstract standalone "research course," but to reorganize the knowledge, skills, and evidence in professional courses around authentic problems.

2.2. From Participation by a Select Few to Tiered Development for All Students

Traditional student research often involves teachers selecting a small number of high-performing students to join research teams. This model can generate competition awards or publications but is difficult to extend to the majority of students. Higher vocational education is better suited to tiered tasks: at the foundational level, students conduct literature searches, explain terminology, and interpret data figures; at the intermediate level, they compare research designs, perform statistical analyses, and prepare research reports; and at the advanced level, they participate in experimental procedures, database analysis, or innovation projects. Within a shared problem context, students can gain research experiences at different depths, avoiding the misconception that an inability to conduct complex experiments is equivalent to lacking research literacy.

2.3. From a Publication-Oriented Approach to a Professional-Competency-Oriented Approach

Research literacy and professional competence are not parallel tracks. Standardized documentation of experimental procedures corresponds to the quality of clinical records; identifying confounding factors corresponds to risk assessment; evaluating published evidence corresponds to clinical decision-making; and interpreting statistical charts corresponds to health communication. The habits of evidence verification, error awareness, and ethical awareness developed through research training can improve the standardization of technical practice and the ability to learn when encountering new technologies. The Vocational Education Law's emphasis on cultivating both ethics and technical competence also requires students to comply with relevant standards when using data, animals, human information, and artificial intelligence tools [5].

3. Practical Barriers to Research Literacy Development among Higher Vocational TCM Students

3.1. Narrowly Defined Training Objectives Leave Research Literacy at

the Curriculum Periphery

In some program training plans, research competence is subsumed broadly under "innovation capability" or "capacity for sustainable development," without corresponding courses, instructional hours, or assessment indicators. Professional courses focus on knowledge points and procedural steps, while research-methods courses concentrate on abstract concepts; the two share few common tasks. Students often encounter research questions for the first time only during graduation projects or innovation and entrepreneurship competitions, making it difficult to build research competence cumulatively.

3.2. Research Resources Exist but Have Not Been Converted into Teaching Resources

Faculty members undertake government-funded projects, commissioned projects, or clinical studies, yet these projects often operate separately from classroom teaching. Project proposals are lengthy and terminology-dense, animal experiments and molecular assays have high entry barriers, and raw data cannot be used directly as student materials. Without pedagogical transformation, research projects remain individual faculty achievements and are difficult to convert into cases, tasks, figures, and assessment resources.

3.3. Differences in Student Foundations Are Poorly Matched to the Difficulty of Research Tasks

Higher vocational students vary substantially in English reading, statistical foundations, computer skills, and scientific writing. Assigning a complete research project directly can lead to a few students doing most of the work while others merely observe; lowering the difficulty too much can reduce research training to information copying. Task design therefore needs scaffolding, exemplars, explicit outputs, and opportunities for students to participate through different roles.

3.4. Outcome-Heavy Assessment Neglects Process Quality and Research Ethics

Using papers, patents, and competition awards as the sole assessment criteria can encourage overly ambitious topics, rushed data collection, and irregular authorship practices. Research literacy development should assess whether search strategies are appropriate, variables are clearly defined, data records are complete, conclusions remain within the evidence, and team members fulfill their assigned responsibilities. For TCM-related projects, attention should also be paid to laboratory animal welfare, protection of human information, appropriate representation of traditional knowledge, and research reproducibility.

4. The "One Core, Four Dimensions, and Five Chains" Training Framework

4.1. One Core: Authentic Research Questions

Authentic questions can connect fragmented curricular knowledge. Taking "Can acupuncture alleviate exercise-induced fatigue by regulating lactate metabolism?" as the core question links TCM understandings of fatigue, the rationale for selecting acupoints such as Zusanli, exercise physiology, animal models, lactate measurement, molecular pathways, statistical analysis, and research ethics. Core questions should be professionally relevant, open to examination through evidence, and decomposable into tasks; the full technical difficulty of a faculty research project should not simply be transferred to students.

4.2. Four Dimensions: Defining Observable Research Literacy Outcomes

First, awareness of questions and evidence. Students should be able to transform clinical or everyday phenomena into answerable questions and distinguish experiential judgments, theoretical explanations, and empirical evidence. Second, research design and methods. Students should be able to identify study subjects, interventions, controls, outcome measures, and major confounding factors, and understand randomization, blinding, replication, and quality control. Third, data analysis and communication. Students should be able to read basic statistical charts, understand the interpretive limits of differences, variability, and correlations, and produce clearly structured abstracts, posters, or reports. Fourth, ethical compliance and collaboration. Students should be able to comply with requirements for data integrity, informed consent, animal welfare, authorship, and conflicts of interest, while undertaking traceable responsibilities within a team.

4.3. Five Chains: Converting Research Projects into a Teaching Delivery Mechanism

The problem chain progresses from "Why does fatigue occur after exercise?" to "How is lactate produced and transported in different cells?" and "At which points might acupuncture exert an effect?"; the task chain includes retrieval, appraisal, design, observation, analysis, communication, and reflection; the resource chain converts project proposals, experimental flowcharts, de-identified data, public databases, and representative literature into teaching materials; the mentor chain brings together course instructors, principal investigators, laboratory technical staff, and part-time clinical instructors; and the assessment chain links diagnostic assessment, process records, staged outputs, peer assessment, and final presentation. These five chains support one another and prevent research tasks from becoming isolated activities.

5. Implementation Pathways Using an Exercise-Induced Fatigue Research Project as the Vehicle

5.1. Embed Research Questions in Professional Courses Rather Than Add Extracurricular Burdens

Project content can be distributed across courses such as Meridian and Acupoint Studies, Acupuncture Treatment Techniques, TCM Rehabilitation Techniques, Exercise Therapy Techniques, and Medical Statistics. The meridian and acupoint course can focus on acupoint selection and theoretical rationale; the acupuncture techniques course can emphasize procedural standards and risk control; the exercise rehabilitation course can address fatigue assessment and exercise-load planning; and the statistics course can use data from the same project to train students in figure and chart interpretation. By advancing progressively around the same question across courses, unnecessary repetition is reduced and students can see the connections among different areas of knowledge.

5.2. Break a Complete Research Project into Progressive Task Packages

Task packages can be organized at three levels. Foundational tasks for all students include concept mapping, keyword searches, explaining the rationale for acupoint selection, and sequencing experimental procedures; intermediate tasks are completed in groups and include control-group design, redrawing result figures, analyzing sources of error, and abstract writing; advanced tasks for interested and prepared students include observing animal experiments, learning ELISA or PCR procedures, reanalyzing public databases, and applying for innovation projects. Movement between levels should remain possible, and participation should not be determined by a single examination score.

5.3. Use Public Data to Lower Barriers to Research Participation

Because animal experiments are constrained by ethics, equipment, and cost, they should not be mandatory for all students. Teachers can select skeletal-muscle expression data before and after exercise from public databases such as GEO and provide de-identified and simplified expression matrices, UMAP plots, and target-gene lists. Beginners can focus on reading figures and charts, while more advanced students use visualization tools to compare changes in genes such as SLC16A1, SLC16A3, or PPARGC1A. Public-data tasks can train information retrieval and data awareness while making one principle explicit: secondary analyses must cite the data source and may not be described as sequencing conducted by the students' own team.

5.4. Build a Cross-Curricular, Cross-Role Mentoring Community

No single teacher can simultaneously cover TCM theory, acupuncture procedures, exercise physiology, molecular experiments, and statistical analysis. Schools can establish small project-based mentoring communities: professional instructors are responsible for problem design and curricular alignment; laboratory staff ensure

methodological standardization; clinical or rehabilitation instructors provide authentic application scenarios; and information-technology instructors support data processing. Such communities need not add numerous meetings; collaboration can be supported through shared task sheets, resource packages, and assessment rubrics.

5.5. Adopt Assessment Based on "Process Evidence + Performance of Outputs + Reflective Improvement"

Assessment should not be based on whether positive results are obtained. A suggested weighting is 60% for process assessment, including search records, protocol iterations, raw records, within-group contributions, and ethical compliance; 30% for output assessment, including the logic of reports, accuracy of figures and tables, and oral presentation; and 10% for reflection, focusing on whether students can identify study limitations and propose next-step improvements. Assessors should include instructors, group peers, and students themselves. When generative artificial intelligence is used for literature searching or writing, students should be required to retain prompts, verification records, and revision notes so that tool outputs are not directly treated as research conclusions.

6. Evaluation Approach and Expected Outcomes

Evaluation of the framework should focus on whether students develop transferable research behaviors rather than merely on satisfaction surveys. Implementation effects can be judged from four types of evidence: (1) changes in question quality and search strategies between pre- and post-tasks; (2) the completeness of research plans in variable definition, control setting, and risk identification; (3) whether figures and conclusions are aligned and whether students can proactively explain sample size, bias, and the limits of causal inference; and (4) whether raw records, authorship responsibilities, and ethical requirements are properly implemented. Where conditions permit, a quasi-experimental design comparing different classes within the same grade can be used. Where no control condition is feasible, a longitudinal portfolio of student work should be retained and combined with rubric scoring and interviews to generate multiple sources of evidence.

In terms of expected outcomes, authentic projects may improve the contextualization of professional knowledge, helping students understand the relationships among acupuncture prescriptions, exercise physiology, and modern experimental methods; tiered tasks may broaden participation in research; public data and visualization tasks may lower equipment barriers; and ethical and reflective assessment may help correct the misconception that "success simply means obtaining positive results." These effects, however, need to be validated with data from subsequent teaching implementation; this paper does not substitute theoretical inference for evidence of actual effectiveness.

7. Conclusion

Science-education integration is neither a matter of simply moving research outputs into the classroom nor a requirement that all higher vocational students become academic researchers. Its core is to transform authentic research projects into learning experiences that promote professional growth. The "one core, four dimensions, and five chains" framework built around an exercise-induced fatigue project can organize TCM theory, acupuncture skills, experimental methods, data analysis, and research ethics within a single problem chain, enabling students with different starting points to engage in inquiry at an appropriate level. The next step is to evaluate implementation in specific courses and classes, revise task difficulty based on student work, process records, and interview feedback, and gradually develop replicable and shareable research-oriented educational resources for higher vocational TCM programs.

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