A Multi-Dimensional Evaluation Study on the Educational Effectiveness of Digitalization Empowering the Spirit of Craftsmanship in Ideological and Political Education of Higher Education Courses

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ABSTRACT To address the limitations of conventional educational assessment in capturing multi-dimensional learning outcomes, this study develops a digitalized evaluation framework for measuring the effectiveness of cultivating the craftsmanship spirit within higher education ideological and political education. Based on 698 valid samples, a multidimensional evaluation system encompassing cognitive internalization, behavioral performance, and value identification is established. Multiple regression analysis and analysis of variance are employed to quantify the contributions of digital teaching tools to educational outcomes. Results indicate that digital interventions significantly improve students' understanding of craftsmanship values, increase engagement in practical activities, and enhance positive value identification. Text sentiment analysis further reveals a positive sentiment score of 0.87 among participating students. The proposed framework provides a quantitative approach for educational effectiveness evaluation and offers methodological references for learning analytics, behavioral data mining, and intelligent educational information processing.

INDEX TERMS digital empowerment, craftsmanship spirit, learning analytics, behavioral data mining, intelligent information processing

I. INTRODUCTION

IN the new stage of high-quality higher education, deeply integrating the professional virtue and value pursuit of craftsmanship—exemplified by the precision of technical production and the structural integrity of advanced material engineering—into ideological and political education has become essential for cultivating outstanding talents. This integration utilizes the interwoven logic of industrial craftsmanship as a practical framework for fostering the dedication and technical excellence required in the new era. The qualities of craftsmanship resemble the value-ideas of the ideological and political education very much, including values such as striving for excellence, dedication, upholding integrity, through innovation. However, in actual teaching, how to objectively and scientifically measure the real educational effect of the introduction of craftsmanship in the ideological and political education process has always been a difficult problem for educators. Traditional evaluation methods frequently depend on subjective observation or summative evaluation and may not be capable of detecting subtle shifts in the cognitive, emotional, and behavioral dimensions of students.

With the rapid development of digital technologies such as big data, artificial intelligence, and virtual simulation, educational evaluation has transitioned from experience-based description to a data-driven paradigm

centered on the structural logic of technical production and high-performance material engineering. This evolution allows for the precise quantification of learning outcomes through the digital modeling of complex interwoven patterns, transforming traditional assessment into a multidimensional analysis of industrial craftsmanship and material science. Digital technologies allow learners full-trajectory data to be recorded, but also allows implicit qualities (like professional identity and focus) to be quantified with algorithmic models. Therefore, discussing the digital way to

thoroughly represent the effect of infusion of craftsmanship spirit in the curriculum in the ideological and political education and building a multi-dimensional, quantifiable evaluation system, generally has great significance on both theoretical and practical value in promoting curriculum-based ideological and political education from "soft indicators" to "hard constraints" and the precise education. The contributions of this study are mainly reflected in the following three aspects: First, in terms of theoretical dimensions, it breaks through the traditional single evaluation model and constructs a three-dimensional evaluation framework, which integrates the dimensions of cognitive internalization, behavioral performance and value recognition, more comprehensive covering of the inherent logic transformation of craftsmanship spirit from the knowledge, action and intention. Second, in terms of technical methods, it brings in digital

data collection and analysis methods (such as learning behavior log analysis, virtual simulation operation trajectory tracking, text mining of sentiment and so on), which realizes the transformation of the evaluation of educational effectiveness from outcome assessment to process tracking and from subjective description to data-driven empirical evidence. Third, in terms of empirical research, on the basis of the detailed data of 698 valid samples from three types of universities, quantitative research is conducted on the marginal contribution of the digital environment to the cultivation of craftsmanship spirit, and specific data support and practical roads for universities to deepen the reform of curriculum-based ideological and political education in the digital transformation environment.

The structure of this paper is as follows: The results of relevant researches on the integration of ideological and political education on courses with the spirit of craftsmanship is reviewed, clarifying the construction of multi-dimensional evaluation system, the design of data collection and the quantitative model, the results of data analysis of each dimension are presented and discussed, the research conclusions are summarized and some future prospects are proposed.

II. RELATED WORK

Ideological and political education in courses has been widely and deeply explored in the teaching of various majors in colleges and universities. SUN et al. [1] pointed out that in the context of engineering education in the new era, simply imparting professional knowledge can no longer meet the fundamental requirements of cultivating morality and talent. It is necessary to integrate value shaping, knowledge imparting and ability cultivation. Sun [2] took the professional course "Packaging Structure Design" in colleges and universities as an example to explore the practical application of ideological and political education in professional course teaching. Guomin [3] analyzed the problems existing in the current teaching of human resource management courses and proposed teaching strategies that integrate ideological and political elements from the aspects of setting teaching objectives and reconstructing teaching content. Zeng [4] indicated that integrating ideological and political education into song creation courses can guide students to create more excellent works that reflect the spirit of the times and promote the main theme . Liu [5] proposed a specific path for constructing an ideological and political education system for art major courses .

Lu [6] explored and practiced the application of immersive teaching method in curriculum ideological and political education. The construction of curriculum ideological and political education needs to be promoted systematically. Peng et al. [7] started from the teaching and research office level and studied the three-party collaborative mechanism of curriculum ideological and political education, accounting professional curriculum system and "Financial Accounting" course teaching. Sun et al. [8] practice showed that under the concept of engineering education certification, bilingual teaching and curriculum ideological and political education can promote each other. Jiayun [9] combined the characteristics of "International Economics" course and analyzed the particularity and challenges of implementing curriculum ideological and political education in international student teaching. The study believes that it is necessary and feasible to implement curriculum ideological and political education in international student professional courses. Guo [10] pointed out that from the perspective of curriculum ideological and political education, the integrity education of accounting major should be shifted from single course teaching to a comprehensive and whole-process education system. Existing research has verified the educational value of curriculum ideological and political education from the perspective of different disciplines. How to use digital means to build a scientific and comprehensive evaluation system for educational effectiveness and accurately depict the real effect of integrating craftsmanship spirit into college curriculum ideological and political education has become an urgent research topic. Based on this, this paper proposes a multi-dimensional evaluation study on the educational effectiveness of integrating digital intelligence empowerment of craftsmanship spirit into ideological and political education in college courses, aiming to provide theoretical support and practical path for the precise implementation and continuous improvement of ideological and political education in courses [11].

III. METHODS

A. CONSTRUCTION OF EVALUATION DIMENSIONS AND DESIGN OF DATA COLLECTION

In order to accurately measure the integration effect of craftsmanship spirit, this study first constructed a three-dimensional evaluation framework. This framework breaks through the traditional single knowledge assessment model and extends the evaluation focus to students' psychological cognition and behavioral externalization. Specifically, the three dimensions are: cognitive internalization dimension

(A), which mainly measures the depth of students' understanding of the historical origin, contemporary connotation and professional norms of craftsmanship spirit; behavioral performance dimension (B), which focuses on recording the focus, meticulousness and perseverance shown by students in experiments, practical training and daily learning tasks; and value identification dimension (C), which aims to assess the degree of students' inner acceptance of craftsmanship spirit and the transformation of their professional values [12,13]. Based on the above dimensions, this study selected three different types of universities (one science and engineering university, one comprehensive university, and one vocational teacher training university) as sample sources. The survey subjects included third- and fourth-year students from eight majors, including mechanical manufacturing, electronic information, and art design. The data collection period was one full semester (18 weeks). In terms of data collection methods, in addition to traditional pre- and post-test questionnaires, key digital data collection tools were introduced: students' online learning behavior logs (such as video viewing completion rate and task repetition frequency) were captured through a smart teaching platform; students' operational accuracy and time consumption were recorded using a virtual simulation experiment platform; and in course forums and reflection reports, the Jieba word segmentation library in Python combined with the SnowNLP sentiment analysis module was used to analyze the sentiment tendency of students' subjective texts. A total of 720 questionnaires were distributed, and 698 valid questionnaires were returned, with an effective response rate of 96.94%. The questionnaire design used a five-point Likert scale and cross-validated it with objective test items.

This study was approved by the Ethics Committee of Zhangzhou Institute and Technical College, and was performed in accordance with the principles of the Declaration of Helsinki. All eligible participants signed an informed consent form.

B. DATA FEATURE EXTRACTION AND PREPROCESSING IN A DIGITAL AND INTELLIGENT ENVIRONMENT

After obtaining the raw data, it is required to clean the data, and do feature engineering to get some important indices that can effectively represent the craftsmanship. For the cognitive internalization dimension, we created an "cognitive gain" indicator by comparing the accuracy of students in terms of understanding key terms attached to craftsmanship (e.g. "tolerance fit," "process optimization," and "quality control") in the first and final assessments of the course. For the behavioral performance dimension, from the digital training platform's log data we extracted two key behavioral features ("average focus time per task", and "number of backtracking corrections of operation steps"). For the value identification dimension, based on the sentiment analysis technology, we transformed over 400 learning reflections submitted by the students to the "positive sentiment values" with a range of 0-1 "frequency density of craftsmanship-related words".

In the data preprocessing stage, first, the removal of outliers was conducted. For example, during the collection process for focus duration data, to distinguish between deep cognitive engagement (such as reading complex structural diagrams) and actual inactivity, the system integrated mouse tracking with page material scrolling and active window duration. Data were only flagged as 'inactive' if no input or navigation occurred for more than 15 minutes, ensuring that reflective reading time was not erroneously excluded, which results in 683 cleaned data. Subsequently, Min-Max normalization processing was adopted to dimensionless processing for the data of each indicator in order to eliminate the effect of dimensional difference on the comprehensive evaluation. For example, the original focus duration data was observed to be in the range of 12 minutes to 147 minutes, whereas the normalized data is in the range of 0 to 10 to 1, which is very useful for making subsequent horizontal comparisons and calculations of weight later.

C. CONSTRUCTION OF A QUANTITATIVE MODEL FOR MULTI-DIMENSIONAL EVALUATION

To scientifically determine the weights of each evaluation indicator, this study adopted a combined weighting method using entropy weighting and analytic hierarchy process (AHP). AHP is used to reflect expert judgment, while entropy weighting objectively assigns weights based on the dispersion of the data itself. The combination of the two effectively avoids the bias of a single weighting method.

The specific operation steps are as follows: First, invite 8 experts engaged in curriculum ideological and political teaching research and front-line professional course teaching to compare the three primary indicators and their subordinate secondary indicators in pairs, construct a judgment matrix, and calculate the subjective weight vector W1 based on expert experience. Second, organize 698 sample data into an original data matrix according to the evaluation indicators, calculate the entropy value of each indicator through the entropy weight method, and then obtain the objective weight vector W2 based on data fluctuation. Finally, adopt the linear weighted combination method, set the preference coefficient α to 0.6 (reflecting experience orientation) and β to 0.4 (reflecting data orientation), and synthesize the final comprehensive weight W. According to the calculation, the weights of the three primary indicators are: cognitive internalization dimension 0.32, behavioral performance dimension 0.41, and value recognition dimension 0.27. The behavioral performance dimension has the highest weight, reflecting the advantages of digital intelligence in capturing explicit behavior, and also confirming the essential characteristics of the craftsman spirit of "learning by doing" [14].

IV. RESULTS AND DISCUSSION

A. EFFECTIVENESS ANALYSIS AND DATA COMPARISON OF THE COGNITIVE INTERNALIZATION DIMENSION

By comparing pre- and post-test data from the experimental group (using digitally-enabled teaching) and the control group (which utilized the same case studies and instructional content delivered via traditional classroom lectures without digital simulation tools), this study found that the digital delivery medium specifically significantly improved students' understanding of the connotation of craftsmanship. In the essay question on "the relationship between craftsmanship and modern industry," the experimental group had an average score of 86.5%, while the control group had a score of 72.3%. Detailed comparison of the test data is shown in Table 1.

TABLE 1. Comparison of Cognitive Internalization Dimension Test Scores

Test categories	Control group average score rate (%)	Average score rate of the experimental group (%)	Standard deviation difference (experimental group - control group)	T-value	Significance (P-value)
Basic concept memorization	78.4	91.2	-0.24	3.12	0.003
Case Study Application	69.7	84.3	-0.31	4.05	<0.001
Value connotation analysis	70.1	85.6	-0.19	2.98	0.004
Overall Average	72.7	87.0	-0.25	3.78	<0.001

As shown in Table 1, the experimental group scored significantly higher than the control group in all three subitems: basic concept memorization, case analysis application, and value connotation identification, with an overall average score 14.3 percentage points higher. Particularly noteworthy is the experimental group's most significant advantage in assessing higher-order cognitive abilities such as case analysis application, where the score difference reached 14.6%. This indicates that the introduction of real-world enterprise case studies and virtual simulation scenarios through digital technology effectively helps students understand the application value of craftsmanship in specific contexts, rather than simply memorizing concepts. The negative standard deviations indicate that the skill differences within the experimental group were smaller than those in the control group. Digital teaching helps narrow the cognitive gap among students, reflecting the fairness and inclusiveness of education.

B. DATA TRACKING AND PROCESS EVALUATION OF BEHAVIORAL PERFORMANCE DIMENSIONS

Behavioral performance is the focus of this study. Thanks to the full-process tracking provided by the digital platform, we obtained a large amount of objective process data. During the four-week "Precision Component Mapping" training project, we recorded students' behavioral indicators in real time. The data shows that the experimental group students' behavioral patterns when completing tasks differed significantly from those in traditional teaching methods; detailed data is shown in Table 2.

TABLE 2. Statistical Table of Key Indicators of Student Behavioral Performance on the Training Platform

Behavioral indicators	Control group (mean)	Experimental group (mean)	Mean difference (experimental group - control group)	Increase (%)
Single task focus duration (minutes)	24.5	57.1	32.6	133.1
Number of repetitions per task (times/item)	1.8	3.9	2.1	116.7
Number of violations of operating procedures (times/person)	5.2	2.1	-3.1	-59.6
Frequency of proactively seeking help and communicating (times/week)	2.1	4.8	2.7	128.6

Table 2 shows several key trends. First, the experimental group's average focus time per task reached 57.1 minutes, more than double that of the control group. While the inherent nature of the 'Precision Component Mapping' task and potential novelty effects of the platform may contribute to this engagement, the results suggest that the challenge-based task design and real-time feedback mechanism embedded in the digital environment effectively maintained students' attention. Second, students in the experimental group were willing to practice repeatedly to achieve higher precision, averaging 3.9 times per project, compared to only 1.8 times in the control group. This demonstrates that the "low cost of trial and error and immediate feedback" of the digital simulation environment inspired students to pursue excellence and refine their skills through meticulous practice. Furthermore, the significant decrease in violations of operational procedures indicates that the standard process demonstration before virtual simulation operations effectively strengthened students' awareness of standardization. The increased frequency of proactive communication suggests that the collaborative space provided by the digital platform facilitated discussions among students regarding technical details and quality standards, which is of great significance for the collective cultivation of craftsmanship.

C. EMOTIONAL MINING AND SCALE CONSTRUCTION FOR VALUE IDENTIFICATION DIMENSION

Value identification is the soul of craftsmanship and also the most difficult aspect to quantify and evaluate. This study used natural language processing technology to conduct sentiment mining and thematic analysis on over 400,000 words of reflection logs submitted by students on the course platform. The analysis results show that the experimental group students exhibited significantly more positive sentiments in their expressions and used craftsmanship-related vocabulary more frequently and in greater depth. Specific data from the sentiment analysis are shown in Table 3.

TABLE 3. Comparison of Emotional and Thematic Analysis Results of Student Reflection Logs

Analysis indicators	Control group (mean)	Experimental group (mean)	Trend of change
Positive sentiment score of the text (0-1)	0.62	0.87	Up 0.25
Frequency density of words related to craftsmanship (%)	3.2	7.8	Up 4.6 percentage points
Negative/Negative Emotions Percentage (%)	18.5	6.3	A decrease of 12.2 percentage points
Frequency of expressions related to professional mission (times per 100 articles)	12	31	Increased by 19 times

Table 3, presents the score of text sentiment positivity achieved by the students of the experimental group with 0.87, arriving in the interval of the very positive and the control interview group with a score of 0.62, which is in the neutral section. In terms of word frequency density, the text of the experimental group had a significantly higher degree of words related to craftsmanship, such as "rigorous", "standard", "responsibility", and "inheritance". More notably, the expression related to professional mission was found 31 times in 100 logs that were written by the experimental group, which is more than double the number of logs from the control group. For example, one student in the experimental group wrote: ‘’It really is the process of adjusting parameters repeatedly in the virtual simulation that made me to really understand what ‘a small error can lead to a huge mistake’ means.‘’ In my future career, I will have to be responsible for all data that comes into my hands. This sense of professional responsibility based on concrete operational experience is a direct manifestation of internalization of value recognition. Research data proves that digital empowerment not only increases the attractiveness of teaching, but more importantly, through recording, feedback, and incentives, digital empowerment makes the abstract spirit of craftsmanship visible as observable and evaluable concrete behaviors and attitudes, indeed making the educational effectiveness explicit.

V. CONCLUSION

This study evaluates the effectiveness of digital technology in ideological and political education by focusing on the development of craftsmanship spirit through the precision of high-performance technical production and advanced material structural engineering. By utilizing virtual simulations of complex interwoven industrial patterns, the research demonstrates how digital tools cultivate technical dedication and professional ethics within the framework of modern science. It develops an evaluation system with 3 dimensions: cognitive internalization, behavioural performance and value identification and tests it empirically. The results show that the application of digital technology has significant improvement in educational effect: primarily at the behavioral level, where digital tracking revealed a doubling of focus and practice frequency; and secondary at the cognitive level, where the accuracy of student understanding and applying craftsmanship spirit is significantly improved; in terms of behavior aspect, the behavioral indicators that represent the craftsmanship behavior, such as the focus intensity and repetition frequency in the practical training task of students are greatly improved; in terms of value aspect, the reflective text of students has a more positive emotional inclination and a stronger sense of professional mission. The multi-dimensional evaluation scale built and key data gained in this paper have provided high support for the transition from "qualitative description" to "quantitative evaluation" of ideological and political education in courses in colleges. Future research should expand the sample scope and cross-institutional data comparisons while incorporating long-term tracking to verify the sustainability of educational effectiveness in mastering high-performance technical textile weaving and complex fiber-reinforced structural logic. By analyzing the longitudinal mastery of advanced industrial textile engineering, researchers can better assess how these pedagogical models support the enduring development of professional craftsmanship and technical innovation.

AUTHOR CONTRIBUTIONS

Conceptualization –Alian Ye and Wenchun Wu; methodology – Alian Ye and Wenchun Wu; investigation – Alian Ye and Wenchun Wu; writing-original draft preparation – Alian Ye and Wenchun Wu. All authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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