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Impact of Practical Teaching for the Professional Identity Development of Engineering Students*

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Professional identity education is a primary goal of university courses. While existing studies on the cultivation of professional identity have focused on theoretical education and didactic teaching by case models, this study explores the influence of practical teaching on the professional identity development of engineering students using primary data from a questionnaire survey. The study randomly selected 378 freshmen majoring in electrical engineering at a Chinese university and evaluated their professional identity after participating in social practice teaching courses using existing questionnaires, of which 367 were valid. To clarify the benefits and effects of practical teaching, this study also investigates practice effectiveness and practical teaching with a self-administered questionnaire. Finally, a data model is constructed to explore the mechanism of the role of social practice teaching methods on professional identity. The results show that (1) the social practice teaching method has a significant positive enhancing effect on the professional identity of engineering students; and (2) social practice teaching effectiveness has a significant positive mediating effect on professional identity through the mediating variables task drive, hands-on ability, and character function, while effect feedback shows a weak positive effect.

Keywords: engineering students; professional identity; social practice teaching; mediating effect

1. Introduction

Over the past 20 years, research concerned with professional identity has grown. Researchers have defined the connotation of professional identity and have clarified its measurement dimensions [1, 2], which has laid the theoretical foundation for subsequent studies to explore the factors influencing professional identity. Personal, relational, and practical factors can be outlined [3], and researchers suggest that developing and enhancing professional identity should promote students' interaction with professionals in practice [4]. However, despite researchers' emphasis on the importance of practice in fostering professional identity among engineering students, teachers remain focused on classroom lectures and lack attention to students' practical experiences in course instruction. Conversely, the effectiveness of practical teaching is rarely verified in the empirical research. This gap in the academic literature can guide future research in the field of professional identity. It is unclear whether practical teaching can develop professional identity; and if it can, introducing practical elements while teaching engineering students should be considered. Social practice provides a method for practical teaching; thus, our research perspective is social practice.

This study surveyed first-year electrical engineering and automation majors in a Fundamentals of Electrical Engineering class at a top-10 ranking university in China to investigate the structural characteristics and change mechanisms of students' professional identity following a social practice teaching approach. Fundamentals of Electrical Engineering is a prerequisite class for engineering students, which provides a systematic introduction to the major and is an important course for cultivating students' sense of professional identity. Although an Introduction to Electrical Engineering course is offered for electrical engineering majors in almost all universities, this university is unique in that it offers additional two weeks of "social practice hours" after the theoretical lecture. Students accumulate experience in the electrical engineering industry through on-site visits and practice during the additional 30 hours of coursework. It is worth mentioning that social practice teaching refers to, on the basis of theoretical learning, students' personal involvement in the front-line work of the profession through concrete hands-on practice, which is different from the general employment-oriented internship. This approach is in line with Hunter et al.'s suggestion in 2007 to promote students' socialization through practical behaviors to develop their professional identity[4]. This study explores the changes in students' professional identity by surveying students who completed this course, thus providing evidence that the social practice teaching method can enhance professional identity and analyzing

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the mechanism of the influence of social practice on professional identity.

2. Theoretical Frameworks

2.1 The Connotation and Dimensions of Professional Identity

Researchers have defined professional identity according to varying specialized occupations, thus yielding different expressions in different fields and studies. For example, in 1993, Higgs defined the professional identity of health professionals as the development of "attitudes, beliefs, and standards which support the practitioner's role and the development of an identity as a member of the profession with a clear understanding of the responsibilities of being a health professional [1]". In the field of teaching, Welmond defined teachers' professional identity as the ability to be energetic, competitive, professionally well-developed, able to construct possible contradictions between interests and ideologies, willing to pursue academic truth and responsibility, and able to understand success and achievement in different ways [5].

Higgs and Welmond define professional identity in terms of cognitive and emotional aspects, while Paterson et al. extend the definition. Paterson et al. recognize professional identity as a sense of adequacy and satisfaction, but state that the acquisition of these traits lies in the individual's development of "values and behavior patterns consistent with society's expectations of members of the profession. [6]" This requires students to not only excel in their academic work but also form and develop the behavioral patterns needed for their future careers.

According to research on professional identity, there is commonality among the division of the dimensions of professional identity. Most researchers point to three dimensions (cognition, affectivity, and behavior). For example, Van Dick et al. argue that professional identity can be divided into cognitive evaluation, emotion and behavior [2].

In addition to theoretical support from sociology and psychology, Ben-Eliyahu et al. performed a rigorous data study on the interrelationship of the three dimensions of professional identity in 2018 [7]. They compared several measurement models, namely, the one-dimensional model for direct measurement, the A-B-C type, and the A-BC type, concluding that the A-B-C type model had a better fit.

In a comprehensive manner, this study also divided professional identity into three dimensions for measurement and analysis, namely, professional cognition, professional affectivity, and professional behavioral tendency. Professional cognition is the degree of students' understanding of their majors, including their understanding of professional training, the curriculum, and professional value. Professional affectivity is the emotional connection between students and their majors, including professional interest, sense of professional acquisition, and professional enthusiasm. Professional behavioral tendency is the positive professional learning behaviors based on cognition and emotion, including learning commitment.

Inspired by Ben-Eliyahu et al., we conducted a cross-sectional comparison of the various measurement models of professional identity [7].

2.2 The Influencing Factors of Professional Identity

The dimension division of professional identity provides rigorous theoretical support for scientific measurement, while the strength of professional identity present in individuals guides research observations of the factors that influence professional identity. Most consider a specific professional group as the research object and explore the antecedent variables which influence professional identity. These influencing factors can be roughly summarized as personal factors, relationship factors, and practical factors. Scholars have carried out research on these three aspects according to their research interests [8–10], while research on practical factors is of particular interest to this study.

Practical factors refer to students' socialization awareness and ability in practice, which not only emphasizes the result of their work but also the process. Lamote and Engels believe that the work difficulties faced by college students in practice and the experience of solving these difficulties through a knowledge exchange affects their professional identity [3]. This conclusion is supported by Volkmann and Anderson, and Samuel and Stephens, who found that first-hand experience and difficult practice experiences, such as the tension between expectations and reality, have a significant impact on the professional identity of practicing teachers [11, 12].

As the study demonstrates, technical skills and interpersonal skills in practice courses do not ensure the development of professional identity [6], because "identity formation is a dynamic process achieved through socialization" [8]. Accordingly, the socialization of students' professional practice should be considered in the course design [13]. And students should participate in professional experiences and interact with qualified professionals [14]. These approaches echo this study's attempt to enhance students' professional identity through social practice. The approach to developing professional identity should focus more on actions and behaviors, rather than theories and concepts [4].

Regrettably, most of these studies propose strategies at the level of theoretical discussion or empirical summary and do not validate these strategies in subsequent pedagogical practice. However, the researchers' emphases on practice prompted this study to introduce practice elements in the university introductory course and provided ideas to verify whether social practice can enhance students' professional identity.

3. Methodology

3.1 Curriculum Background and Research Questions

The current research on professional identity is mostly focused on medical students and teachers, with few studies focusing on engineering students. Furthermore, research on development strategies of professional identity is more paper-based, with few validation studies on the effectiveness of practical strategies, such as social practice teaching. Accordingly, we selected electrical and automation students from a top 10 university in China as participants for our survey. The chosen survey course was Fundamentals of Electrical Engineering, which is the first major course students complete and is designed to provide a systematic introduction to the major. The course exposes students to the areas encompassed by their major, the knowledge required for their major, and the future career paths and uses of their major. The course involves a vast body of specialized knowledge and the specific application of this knowledge, which leads many students to "feel the intense difficulty of their major [15]" and a "level of tedium [16]" when studying, which affects the formation of their professional identity.

To explore an effective approach to developing professional identity, we improved the teaching design of this course; in addition to the "theoretical class," there is an additional "practical class." The theoretical class is 60 hours and 1 credit, and the practical class is 30 hours and 0.5 credit. In the practical class, students apply their knowledge of the major through observation and social practice. For example, students visit the Museum of Electricity Development, the hydroelectric power station, the power supply company, and experience maintenance work. The course content in social practice teaching comprises the social situation of electrical engineering, the practical application of professional knowledge, and the realistic connection between the electrical engineering industry and national social development, which allows students a concrete experience of the electrical engineering profession. We expect students to enhance their professional identity through this teaching method. This is in line with a special issue of *IEEE Transactions on Education* entitled, "Using Inquiry and Design-Based Learning to Promote Cognition and Identity Development in Engineering Students" [17]. The practical teaching in this study aims to cultivate students' professional identity through various means, including social observation, hands-on design, etc. The purpose of this paper is to explore four questions through survey research and model construction:

(1) What are the characteristics of the dimensions of engineering students' professional identity and the relationships among them?
(2) How can we prove the validity of the professional identity measurement scale for engineering students? Can social practice teaching enhance the professional identity of engineering students?
(3) How do social practice programs influence the development of electrical engineering students' professional identity through the mediating effect of practical effectiveness?
(4) How can we improve the social practice teaching in an Introduction to Electrical Engineering university course?

3.2 Survey Objects and Methods

In this study, a questionnaire was administered during the summer school term in the first academic year of the students' enrollment. The summer school semester is a specialized time for the students to complete an internship. To analyze the characteristics of students' professional identity and the mechanism of practical teaching on professional identity, a survey was conducted upon students' completion of the course. In total, 378 questionnaires were distributed to all students in this major's 2021 class, and 367 valid questionnaires were collected. The total number of students surveyed qualified for a fourfold mediated effects model ($\geq$300) [18]. Among them, 281 (76.6%) were male students, and 86 (23.4%) were female students. The independent samples t-test of SPSS showed that the Sig was 0.391 (>0.05) representing the difference between male and female students' professional identity, with 95% certainty that the effect of gender was not significant. Thus, we can assume that gender does not have a significant effect on professional identity.

3.3 Measurement Tools

3.3.1 Professional Identity Questionnaire

This study refers to the Professional Identity Questionnaire for College Students compiled by Dr. Panbo Qin [19]. This questionnaire is a measure of college students' professional identity

Table 1 Professional identity measurement table

Professional Identity (J)	Professional Cognition (A)
	Professional Affectivity (B)
	Professional Behavioral Tendency (C)

and meets psychometric standards through item analysis, factor analysis, and reliability testing by conducting a statistical analysis. This questionnaire has been widely accepted and used in China; it is the most used scale in current research on professional identity among Chinese college students (cited 622 times at the time of our adoption). Much of the literature using the scale has been published in journals, such as *Studies of Psychology* and *Behavior and Psychological Development and Education*, which are leading Chinese journals in the field.

The questionnaire comprised three dimensions: professional cognition, professional affectivity, and professional behavioral tendency (Table 1). We adapted the questions appropriately to accommodate the characteristics of engineering students. The questionnaire included 36 questions, yielding 12 for each dimension. The questionnaire items were measured on a 5-point scale (totally disagree, relatively disagree, average, relatively agree, and totally agree) using a Lister rating. The questions for Professional Cognition were numbered sequentially as 1q1, 1q2...1q12. Professional Affective questions were established with the numbers 2q1, 2q2...2q12. The question numbers for Professional Behavioral Tendencies were 3q1, 3q2...3q12.

The internal consistency coefficients were tested to be 0.959, 0.952, and 0.946. The results of the validation factor analysis showed x^2=80.091, $p < 0.001$, $df = 24$, $RMSEA = 0.080$, $CFI = 0.965$, $TLI = 0.947$, $SRMR = 0.039$. Combining the model fit index criteria indicates that the questionnaire has good structural validity [20]. Thus, the questionnaire has good reliability and validity.

3.3.2 Practice Effectiveness Questionnaire

An important purpose of social practice teaching (hereafter referred to as practice teaching) is to provide students with practice effectiveness to teach professional knowledge more efficiently and promote the development of their professional identity [21]. Therefore, we constructed a mediating model of practice teaching and professional identity from the perspective of practice effectiveness.

Practice effectiveness is the effectiveness internalized by students through practice teaching. We summarized several possible dimensions of practice effectiveness based on previous studies; four aspects were highlighted: (1) task drive, which is a realistic and necessary task that reflects the purpose and nature of practice teaching and is a macroscopic anchor; (2) character function, which reflects the possible characters of individuals in the task, as well as the collaboration and division of labor between individuals and others; (3) hands-on ability, which refers to the ability to perform hands-on work when faced with specific problems, as well as the ability to apply theory in specific contexts; and (4) effect feedback, which is the evaluation and reflection of the completion of practical projects.

In this study, the practice effectiveness questionnaire consisted of four sub-questionnaires, each containing three questions yielding a total of 12 questions. A 5-point scale was used, and the internal consistency coefficients were 0.865, 0.852, 0.913, and 0.812; the results of the validation factors were: $x^2 = 112.737$, $p < 0.001$, $df = 48$, $RMSEA = 0.087$, $CFI = 0.994$, $TLI = 0.992$, $SRMR = 0.038$. Combined with the model fit index criteria, it is indicated that the questionnaire has good structural validity. Expressly, the questionnaire has good reliability and validity.

3.3.3 Practical Teaching Questionnaire

To develop a practical teaching questionnaire and investigate different pedagogical perspectives, we referred to research on teaching engineering courses. For example, in 2014, Freeman et al. compared the active learning of students in traditional classroom teaching versus effective practical teaching. The study focused on the impact of hands-on teaching on subsequent academic performance and showed that undergraduate students performed better in STEM courses following hands-on teaching [22]. According to Truct, improving practice teaching leads to better professional skills among engineering students. ''It is important for higher education institutions to continuously strive for innovative curriculum and prepare their students adequately for industry'' [23].

Defining the dimensions of practical teaching must consider the elements of practical teaching. In addition to the basic scientific-practical basis acquired in the laboratory, corresponding practical theory is needed. Practical theory is a component of practical teaching, and good practical theory informs the teaching of specific social practices. For this reason, our scale divides practical teaching into three parts: experimental engineering teaching, practical theory teaching, and social practice teaching, with six questions for each variable using a five-point scale. The internal consistency coefficient is 0.867, and the results of the validation factors are: $x^2 = 97.614$, $p < 0.001$, $df = 25$, $RMSEA = 0.084$, $CFI = 0.904$, $TLI = 0.912$, $SRMR = 0.034$. This indicates that the model has good reliability and validity.

4. Results

4.1 Analysis of the Professional Identity Measurement Model

Different methods were used to construct a measurement model of professional identity by using Mplus 8.3. We then compared the models. Although previous research has classified professional identity into three dimensions, namely, professional cognition, professional affectivity, and professional behavioral tendency, few studies confirm this division. Thus, we used Confirmatory Factor Analysis, a technique often applied in psychometric assessments to determine the basic structure of a scale, to test this hypothetical division of dimensions.

While we hypothesized that engagement is multidimensional (the Multidimensional Hypothesis), we first considered the possibility that engagement is a unidimensional construct. This unidimensional model was then contrasted with several possible multidimensional models. Table 2 summarizes the fitted data.

As shown in Table 2, the A-B-C model fit indices are: $x^2 = 96.954$, $p < 0.001$, $df = 24$, $RMSEA = 0.091$, $CFI = 0.964$, $TLI = 0.945$, $SRMR = 0.039$. The best fit compared to other models was consistent with Ben-Eliyahu et al. [7]; we then used the bias-corrected non-parametric percentile Bootstrap method, repeated the put-back sampling 1000 times, and constructed a measurement model using "by" statements. We found that the contribution of each dimension to overall professional identity was greatest for professional behavioral tendency and least for professional cognition.

Accordingly, we conclude that professional behavioral tendencies are the most significant contributor to professional identity, followed by professional affectivity, while professional cognition contributes the least. Fig. 1 summarizes the comparison of the models.

4.2 Correlation Analysis of Practical Teaching, Practice Effectiveness, and Professional Identity

We used SPSS26 to conduct the correlation analysis of practice teaching, practice effectiveness, and professional identity. As shown in Table 3, there are significant positive correlations between practice teaching and practice effectiveness of task drive, character function, and hands-on ability, and there are significant positive correlations between practice teaching and professional identity. Additionally, excluding the significant low correlation between effect feedback and professional identity, the three mediating variables of task drive, character function, and hands-on ability all have significant positive correlations with professional identity.

4.3 Analysis of Multiple Mediating Effects

A model was constructed to test for mediating effects using experimental teaching as the independent variable, task drive, character function, hands-on ability, and effect feedback (marked as v, o, t, and m) as the mediating variables, and professional identity as the dependent variable.

First, the direct effect of experimental teaching on professional identity was tested. The measurement model for each characteristic was constructed, and then the structural model was constructed. The results showed that the model fit index was: $x^2 = 152.168$, $p < 0.001$, $df = 50$, $RMSEA = 0.075$, $CFI = 0.959$, $TLI = 0.946$, $SRMR = 0.043$. This indicates that the model fits well, and there is a significant positive effect of experimental teaching on professional identity.

Second, the relationship between experimental teaching, practical effectiveness, and professional identity was analyzed as a path analysis. Practical teaching was a predictor variable; professional identity was an outcome variable; and task drive, character function, hands-on ability, and effect feedback were mediating variables. The results are shown in Fig. 2, and the model fit index was: $x^2 = 660.364$, $p < 0.001$, $df = 240$, $RMSEA = 0.069$, $CFI = 0.916$, $TLI = 0.904$, $SRMR = 0.069$. This indicates that the model has a good fit.

Finally, as indicated in the partial codes list in the Appendix, the bias-corrected non-parametric percentile Bootstrap method was used to repeat the put-back sampling 1000 times using Mplus to calculate the 95% confidence interval of the mediated effect value. If the confidence interval does not include 0, the mediated effect is inferred to be significant. We constructed the measurement model of each indicator with the "by" statement, and then constructed the path relationship between each indicator with the "by" statement. In addition,

Table 2 Summary of fitting indices of different models

MODEL	χ^2	*df*	*TLI*	*CFI*	*SRMR*	*RMSEA* (90% CI)
One-dimensional model	276.218**	27	0.834	0.875	0.050	0.159(0.142, 0.176)
A-B-C	96.954***	24	0.945	0.964	0.039	0.091(0.073, 0.110)
AB-C	134.492**	25	0.841	0.885	0.047	0.155(0.138, 0.173)
A-BC	127.506**	26	0.930	0.949	0.040	0.103(0.086, 0.121)
AC-B	225.129*	26	0.862	0.900	0.048	0.144(0.127, 0.162)

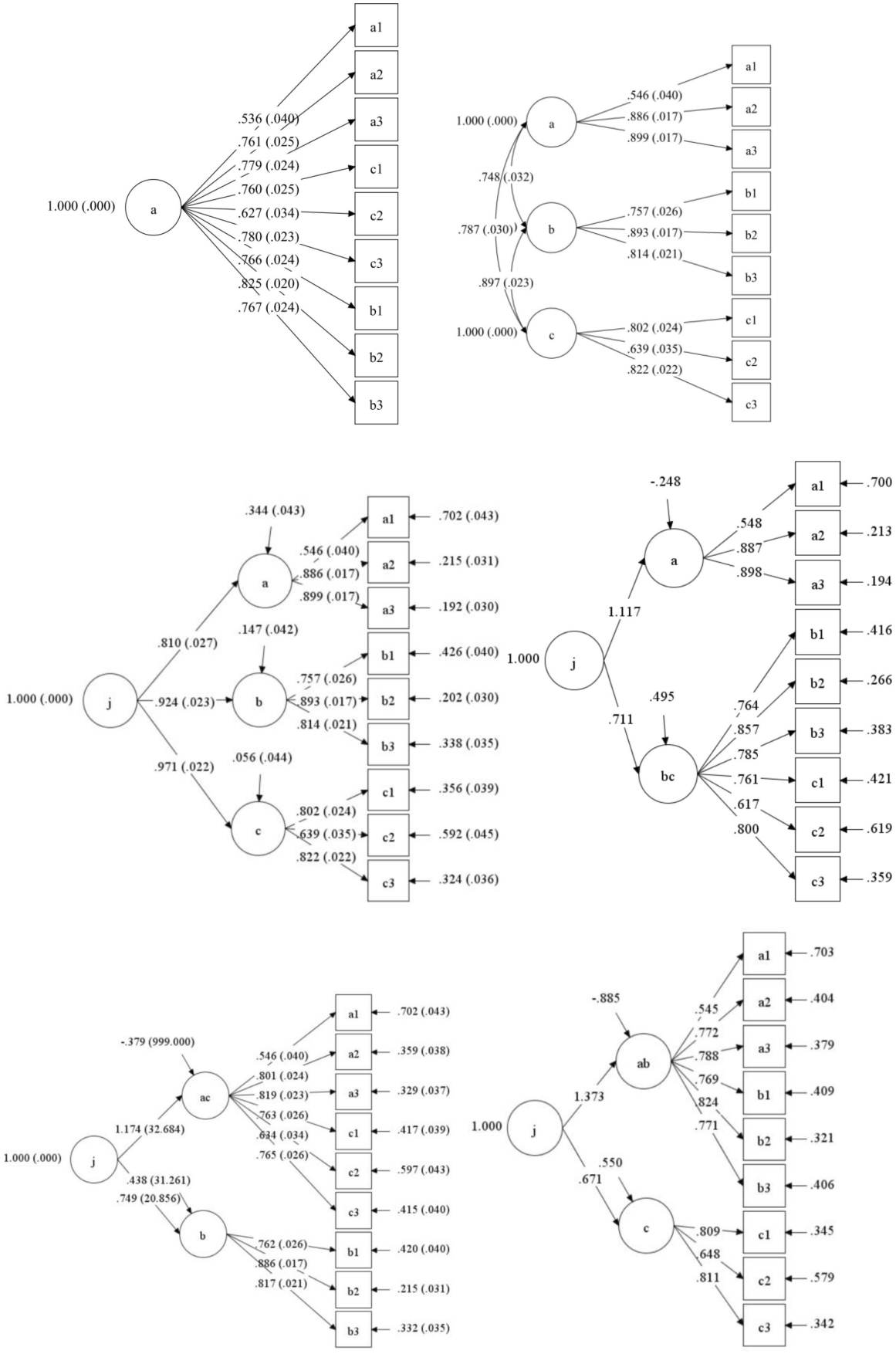

Fig. 1. Measurement models of professional identity.

Table 3 Correlation analysis of practical teaching, practical effectiveness, and professional identity

Variable	M	SD	1	2	3	4	5	6
Practical teaching	3.863	0.489	–					
Character function	3.966	0.625	0.574**	–				
Task drive	3.994	0.580	0.507**	0.629**	–			
Effect feedback	2.164	0.853	0.147**	–0.179*	–0.213*	–		
Hands-on ability	4.333	0.542	0.559**	0.418**	0.396**	0.179**	–	
Professional identity	3.595	0.457	0.646**	0.711**	0.690***	0.045***	0.392***	–

Note: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.005$, (same below).

we calculated the percentage of each path within the whole path; we found the difference of the path coefficients to determine whether there is a significant difference by observing its p-value.

The results show that the total effect accounts for 0.510 and the confidence intervals for all four paths do not include 0, indicating that each path is significant. Specifically, path o had a mediated effect value of 0.098 with a confidence interval of [0.004, 0.016], accounting for 11.2% of the total effect; path m had a mediated effect value of 0.030 with a confidence interval of [0.046, 0.004], accounting for 3.5% of the total effect; path v had a mediated effect value of 0.304 with a confidence interval of [0.093, 0.287], accounting for 34.6% of the total effect; path t had a mediated effect value of 0.094 with a confidence interval of [0.120, 0.016], accounting for 10.7% of the total effect.

The difference between the values of each path effect is significant for each effect. Only the difference between the mediating variables m and t was not significant (diff = 0.037, $p = 0.158$). The maximum difference between t and v was diff = 0.231, $p < 0.001$.

The above data fully demonstrate that: (1) practical teaching can significantly enhance professional identity; and (2) there is a mediating effect between practice teaching and professional identity. Among them, task drive has a significant positive mediating effect between practical teaching and professional identity and accounts for the largest proportion of the total effect; hands-on ability has a significant positive mediating effect between practical teaching and professional identity; character function also has a significant positive mediating effect between practical teaching and professional identity; the mediating effect of effect feedback is weak.

5. Discussion

In this study, we use an Introduction to Electrical Engineering university course to investigate the influence of the social practice teaching method on the professional identity of engineering students. Our study findings are divided into two parts.

First, we found that social practice teaching can indeed enhance engineering students' sense of professional identity. This is consistent with Yufang's conclusion that participation in career-related social practice activities is beneficial to the develop-

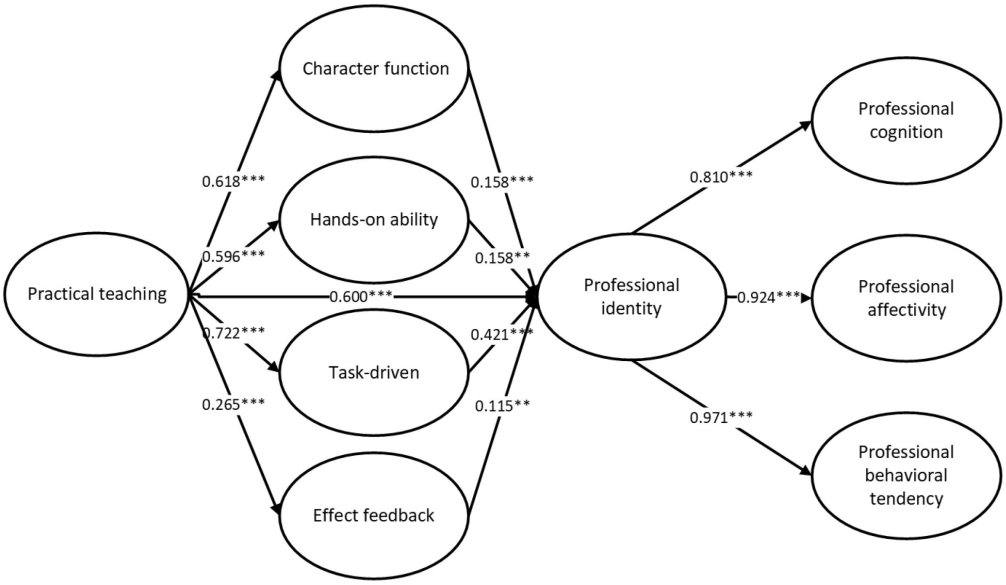

Fig. 2. Mediation model of professional identity and the mediating effects of practical teaching.

ment of students' professional identity [24]. However, relatively few studies verify that social practice teaching methods enhance professional identity through empirical research data. Our study enriches and expands the research object of professional identity, shifting from doctors and nurses to include engineering students. Additionally, we innovate the research method, not only highlighting empirical research, but also adopting a longitudinal research approach, focusing on changes in the same group of students to analyze the influence mechanism of social practice teaching on professional identity.

Second, we explored the mediating effects of the process of social practice teaching to enhance professional identity using task drive, hands-on ability, character function, and effect feedback of practice benefits as mediating variables. We found that task drive, hands-on ability, and character function all had significant positive mediating effects between practice teaching and professional identity, excluding the weak mediating effect of effect feedback, in which task drive had the largest share of the total effect. Furthermore, task drive, as a vehicle for students' realistic needs, is an anchor in students' professional development. According to self-determination theory, increasing task drive in practice teaching enhances students' intrinsic motivation for professional learning, and this intrinsic motivation keeps students actively engaged and enthusiastic about their profession, thus enhancing their professional identity [25]. This explains why the positive mediating effect of task drive is the largest contributor in social practice teaching that enhances professional identity. Character function and hands-on skills also played a significant positive mediating role, which echoes Benjamin et al.'s view in 2023 that important social relationships and interactions are influential factors in the integration of engineers into the workplace and for their professional recognition [26]. This result is also consistent with Rasmussen et al.'s study that used qualitative interviews to conclude that hands-on skills and hands-on experiences enhance students' professional identity [10]. In this study, the mediating role of effect feedback between practice teaching and professional identity was relatively weak, possibly due to the implicit nature of reflection on practice teaching and the lack of direct and timely evaluation feedback.

Although this study expands the research on enhancing professional identity, areas needing improvement remain, such as insufficient sample size, failure to conduct controlled experiments with control variables, and follow-up studies on subsequent effects. Follow-up studies can build upon this foundation by further expanding the breadth and length of research and by conducting stability validation.

6. Conclusion

There is consensus in the research community that practical factors contribute to enhancing professional identity; however, the specific mechanisms of this process are still unknown. In this study, we constructed a mediating effects model to clarify the dimensions of engineering students' professional identity and determined that social practice teaching enhances students' professional identity through practice effectiveness.

In STEM programs, students need to not only acquire theoretical knowledge but also develop creative and practical skills. As a pedagogical model, social practice teaching can provide students with practice effectiveness that enhances their professional identity, allowing them to further develop professionally.

Future teaching research in this and similar disciplines should pay more attention to real teaching contexts in addition to experimental contexts. While research on teaching does emphasize effective learning outcomes, it should also analyze the mechanisms of each influencing factor in the teaching process. Further, although social practice teaching is a teaching method that promotes students' practical experience, it is urgent that future research explore how other teaching methods focusing on students' embodied experience can be applied in engineering education.

Statements and Declarations

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Competing Interests – All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

Compliance with Ethical Standards – First, we presented the study plan in detail to the course authorities and the course instructors and obtained their approval. Second, consent was obtained from the students prior to each questionnaire's distribution and collection. Finally, the names and other information of the research subjects were anonymized to ensure that the information would not be disclosed.

Data, Materials, and/or Code Availability – Some or all data, models, or materials generated or used during the study are available from the corresponding author, (Ying Wang), upon reasonable request.

Author Contributions – All authors contributed to the study's conception and design. Material preparation, data collection, and analysis were performed by Fusheng Zhu, Hongjie Zheng, Ying Wang, and Fei Tang. The first draft of the manuscript was written by Hongjie Zheng and Yujia Huang, and the manuscript revision was completed by Fusheng Zhu and Ying Wang. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Appendix

Model analysis code (partial)

```
ANALYSIS:
  boot=1000;
MODEL:
  A By A1-A3;
  B By B1-B3;
  C By C1-C3;
```

```
  J By A B C;
  L By D1-D3;
  O By E1-E3;
  M By M1-M3;
  V By V1-V3;
  T By T6 T7 T8;
  O On L(a1);
  J On O(b1);
  J On L(c);
  J On M(b2);
  M On L(a2);
  V On L(a3);
  J On V(b3);
  J On T(b4);
  T On L(a4);
  MODEL CONSTRAINT:
  new(ind1 ind2 ind3 ind4 r4 r1 r2 r3 total diff1 diff2 diff3 diff4 diff5 diff6);
  ind1 = a1*b1;
  ind2 = a2*b2;
  ind3 = a3*b3;
  ind4 = a4*b4;
  total = ind1 + ind2 + ind3 + ind4 + c;
  r1 = ind1/total;
  r2 = ind2/total;
  r3 = ind3/total;
  r4 = ind4/total;
  diff1 = ind1 - ind2;
  diff2 = ind1 - ind3;
  diff3 = ind1 - ind4;
  diff4 = ind2 - ind3;
  diff5 = ind2 - ind4;
  diff6 = ind3 - ind4;
OUTPUT: stand cint(bcboot) tech4;
```

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