A Study on the Formation Path of Secondary School Physics Teachers' Professional Identity Based on fsQCA

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Abstract. In order to clarify the pathway for the formation of the professional identity of secondary school physics teachers, a model of factors influencing the professional identity of secondary school physics teachers based on social identity theory and social network theory was constructed by selecting the sense of professional mission, work-family gain, psychological capital, occupational stress and other demographic variables and using them to design a questionnaire. The data obtained were pre-processed and imported into fsqca 3.0 for qualitative comparative analysis of fuzzy sets, and the results showed that there were five paths of formation for the professional identity of secondary school physics teachers, and their overall consistency was good.

Keywords: Professional identity · fsQCA · Formation pathways · Physics teachers

1 Introduction

The study of secondary school physics teachers' professional identity can help to enhance teachers' motivation and work efficiency and improve the teaching quality of secondary school physics subjects in China. Most of the existing studies on teachers' professional identity are case studies of teachers and studies on the influencing factors of teachers' professional identity using structural equations, and there is a lack of path studies based on the idea of histories. Therefore, this study uses the fuzzy set qualitative comparative analysis method commonly used in management and social science research to investigate the pathways of forming secondary school physics teachers' professional identity.

2 Overview of Professional Identity

Professional identity is part of a variety of identities. While professional identity includes both personal and environmental dimensions, teachers' professional identity also consists of coordinated subsystems, which means that professional identity does not consist

of a stable or even fixed number of dimensions, but is constantly changing as society and research evolve. [1] Professional identity is part of a variety of identities. While professional identity includes both personal and environmental dimensions, teachers' professional identity also consists of coordinated subsystems, which means that professional identity does not consist of a stable or even fixed number of dimensions, but is constantly changing as society and research evolve. [2] Similar to other identities, some researchers have argued that the professional identity of teachers is an evolving process that needs to adapt to new demands and activities in society. [3] Previous research has also shown that teachers' professional identities are related to the teaching environment, social expectations and the reality of teaching, and that the paths by which professional identities are constructed are not uniform across teachers. [4] Drawing on previous literature and research, this paper argues that the professional identity of a group of teachers is an evolving process of assigning oneself to a group of teachers based on social demands and self-referential needs, and that the paths of generating professional identity for teachers may differ between contexts and practices.

There are different ways of expressing the word 'professional' in the context of professional identity, ranging from career, profession and domain, which are vocational and industrial terms, to major and specialty, which encompass the profession that one is studying. As a result, research on professional identity abroad often mixes it with occupational identity, and there are few studies that focus solely on the profession in the learning process. Since the present study is focused on secondary school physics teachers, professional identity that is biased towards the learning process is not analyzed in this case.

3 Theoretical Foundations and Research Model

3.1 Theoretical Foundations

This study of the pathways of professional identity formation for secondary school physics teachers is based on social identity theory and social network theory. Social Identity Theory (SIT) suggests that social identity is established by social-categorization, social comparison and the principle of positive distinctiveness. [5] In social identity theory, group members' delineation of self-identity subordination is often based on comparisons with out-group members, while cutting into the social environment and thus creating social status for the self. [6] Based on Tajfel H's social identity theory, Ellemers N et al. found that the emotional and value significance of being in a group, the individual's assessment of self in the group, and the status and group self-esteem that the group brings to the individual affect the individual's identification with the group. [7] It is clear that identification is not a unilateral attachment of the individual to the group, but more of a two-way process of influence. The individual's assessment of self and emotional situation in the group, as well as the positive and negative impact of the group on the individual, can influence the formation of the individual's identity with the group.

Social network theory and its subordinate strong and weak relationship theories analyse the impact of strong relationships within a group and weak relationships outside the group on individuals. [8] Weak relationships of low intimacy, voluntariness and

diversity provide better connections between different social contexts, and they usually connect different people in society, thus taking on the job of exchanging information and resources. [9] For strong relationships, the more in-group members such as friends, neighbours and colleagues, in addition to relatives, come into contact with individuals, the more conducive to the construction of relevant relationships and the interchange of support and resources between members. [10].

Given that the secondary school physics teacher is in a group of teachers, which involves a dual relationship of individual to group and group to individual, and that the teacher's assessment of self and his or her personal emotions and feelings, as well as the group's influence on him or her personally, affect the secondary school physics teacher's professional identity, this study chose social identity theory and social network theory as the theoretical basis.

3.2 Research Model

There has been much research on the factors influencing career identity. According to Duffy et al.'s WCT (the Work as Calling Theory), a sense of purpose is a 'double-edged sword', as it may cause burnout for individuals who are emotionally unstable, low in affinity and low in self-control. For those who are emotionally unstable, low in affinity and low in self-control, a sense of purpose may lead to burnout, while for those who are emotionally stable, high in affinity and high in self-control, a sense of purpose may increase job satisfaction and career identity. [11] The Hirschi study found that a sense of professional mission positively predicted professional identity. [12] Shuhua Wei et al. examine how work-to-family gain affects professional identity and conclude that it has a mediating effect on primary and secondary school teachers' job satisfaction. [13] Shaorong Chen et al. found that psychological capital had a positive predictive effect on young teachers' professional identity. [14] Another researcher examined the impact of occupational stress on the professional identity of primary school teachers. [15] Combining social identity theory and social network theory, this study constructs
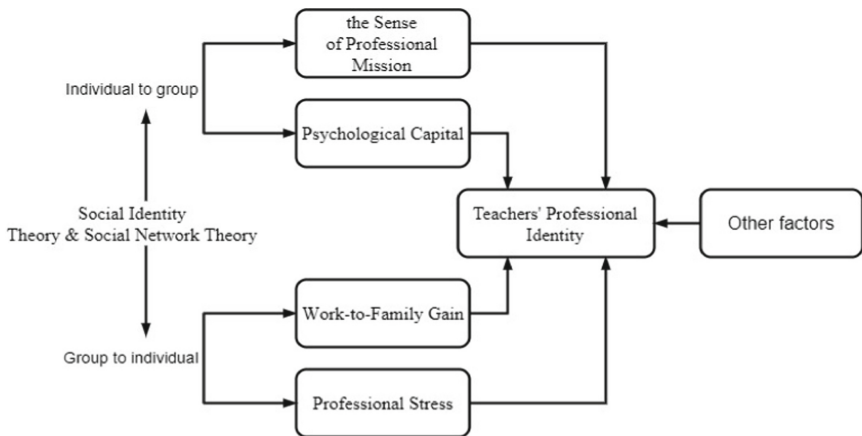

Fig. 1. A model of the relevant influences on professional identity

Table 1. Examples of Questionnaire Questions

Variables	Examples of Questionnaire Questions
The sense of professional mission	Q9: Compared to other professions, I think I deserve to be in the one I am in.
	Q10: The value of my life depends to a large extent on the career I pursue.
	Q11: I am in a profession that benefits others and meets the needs of society.
	Q12: I am willing to work extremely hard for my career.
	Q13: I am willing to work extremely hard for my career.
	Q14: I feel destined to pursue my current career.

a model of factors influencing the professional identity of secondary school physics teachers, as shown in Fig. 1.

4 Questionnaire Design and Administration

4.1 Design of the Questionnaire

Referring to existing studies, the Sense of Professional Mission, Psychological Capital, Work-to-Family Gain, Professional Stress and Professional Identity scales were developed for secondary school physics teachers. The above questionnaire has been modified to meet the needs of the study, and the questions on professional mission are presented as examples in Table 1. The questionnaire consists of six sections: Q1 to Q9 are measures of demographic variables; Q9 to Q14 are measures of the sense of professional mission; Q15 to Q20 are measures of work-to-family gain; Q21 to Q26 are measures of psychological capital; Q27 to Q32 are measures of Professional Stress; and Q33 to Q38 are measures of professional identity. The questionnaire is based on a 6-point Likert scale with options ranging from 'strongly disagree' to 'strongly agree'.

4.2 Measurement Results and Pre-analysis of Data

In this study, 122 data were collected through an online questionnaire and 119 data were collected after removing those who did not select "strongly disagree" for the test question. Based on the research hypothesis and model, whether the school was in an urban area and whether the school was a middle or high school were chosen as variables for analysis. The data were imported into SPSS 26 for reliability testing and common method bias testing and the results are shown in Table 2.

Table 2. Harman's single-factor test

Total Variance Explained						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	9.762	32.539	32.539	9.762	32.539	32.539
2	5.112	17.039	49.577	5.112	17.039	49.577
3	4.923	16.410	65.987	4.923	16.410	65.987
4	3.636	12.120	78.108	3.636	12.120	78.108
5	1.612	5.374	83.481	1.612	5.374	83.481
6	0.948	3.159	86.641			
Extraction Method: Principal Component Analysis.						

The Cronbach's alpha for the 30 questionnaire questions was 0.901, which shows that the questionnaire has good reliability. The KMO was 0.841, which indicates that the questionnaire has good validity and is suitable for principal component analysis. Q09 to Q38 were subjected to factor analysis and according to the results, five factors with eigenvalues greater than one were analysed, and these factors explained a total of 83.481% of the total variance, with the first factor explaining 32.539% of the variance, not more than half of the total variance explained, so there was no serious problem of common method bias in this study.

Questions Q9 to Q38 were subjected to factor analysis, with the maximum variance method selected and values below 0.40 set to prohibit display. One value of Q23 was less than 0.40 and one value of Q25 did not meet the theoretical hypothesis, so these two were removed from the analysis. A Hermann's one-way test analysis after removing the two questions Q23 and Q25 still produced five components and the first of these had 34.246% of the variance explained, which was not more than half of the total variance explained of 86.536% and passed the common method deviation test. The Cronbach's Alpha for the remaining 28 questions was 0.919, indicating good reliability for the remaining questions. The KMO was 0.838, indicating good validity for the remaining questions, while there was no change in the results of the component matrix for the remaining questions after rotation. The questions were divided into five categories according to the results of factor analysis and put into SPSS 26 for principal component analysis to calculate the indicator weights. Five new variables were obtained by calculating the scores of the five groups based on the weights. The values of the five variables were analysed for descriptive statistics and the results are shown in Table 3.

Table 3. Descriptive statistics results

		the Sense of Professional Mission	Work-to-Family Gain	Psychological Capital	Professional Stress	Professional Identity
N cases		119	119	119	119	119
Mean		4.3253	4.2840	4.3518	3.6690	4.7239
Median		4.8330	4.6690	4.5170	3.8400	5.0090
SD		1.54373	1.45436	1.51948	1.49033	1.26622
Percentile	25	3.1670	3.1580	3.2530	2.3320	3.9910
	50	4.8330	4.6690	4.5170	3.8400	5.0090
	75	5.8330	5.6680	5.7590	4.8440	5.8330

5   Method of Analysis and Research Process

5.1   Method of Analysis

Qualitative Comparative Analysis (QCA), created by Charles C. Ragin based on the methods of aggregation and Boolean algebra, combines the strengths of quantitative and qualitative analysis, focusing on 'concurrent causality' across cases, the diversity of causal relationships, the parsimony and generalisability of results, and the ability to expressing the effects of different combinations of variables. [16] The regression-based statistical methods commonly used in actual empirical research emphasise non-linearity, synergy and equivalence, but the process of applying these methods tends to imply more linearity, additive effects and infinity, a situation where variables compete with each other in a way that differs from the theoretical assumptions, so Fiss uses Boolean algebra-based set theory to explore combinations and cooperation between variables. [17].

Fuzzy sets use fuzzy affiliation scores to pinpoint the degree of affiliation of cases in a collection between complete inclusion and complete exclusion, as a way to provide a more fine-grained representation of the diverse and fuzzy categories in social science research. [18] The product of the combination of fuzzy ideas and qualitative comparative analysis methods is the fuzzy set qualitative comparative analysis method (fsQCA).

As the variables in this study were measured using a 6-point Likert scale and there was no objective data to judge the degree of affiliation of the cases, the fsQCA method and fsqca 3.0 software were used in this paper to analyse the formation pathways of secondary school physics teachers' professional identity.

5.2   Research Process

Data Blurring
In this paper, the calibrate function that comes with the fsqca 3.0 software was used to fuzzify the data. As there is no established external standard for this study, the quartiles of each variable were chosen as the anchor point for data calibration.

Table 4. The result of necessary condition testing

Factor	consistency	coverage
urban school	0.565	0.801
middle school	0.563	0.505
the sense of professional mission	0.757	0.711
work-to-family gain	0.696	0.660
psychological capital	0.694	0.696
low professional stress	0.685	0.655

Necessary Condition Testing

The results of the one-way necessity test conducted prior to the study are shown in Table 4. As seen from the results of the necessity test, the consistency of all six condition variables was less than 0.9 and did not constitute a necessity.

Construction of Truth Tables

In fsqca3.0 software, the Truth Table Algorithm requires the setting of a case number cutoff and a consistency cutoff. Considering the sample size of 119 in this study, which is a large sample in qualitative comparative analysis, the frequency cutoff was set to 2 and the consistency cutoff was set to 0.8 in this study, taking into account the data.

The QCA analysis produces Complex solution, Parsimonious solution and Intermediate solution. As there may be logical residuals in the combination of conditions that may exist in the study but are not collected in reality, the Intermediate solution, which is based on real cases with partial logical residuals, is generally used as the result of the QCA study, while the Parsimonious solution, which contains all logical residuals, is generally used to determine core and edge conditions.In the analysis, consistency can be used to assess the extent to which the theoretical model agrees with the pooled theoretical relationships analysed using the case data, while coverage can demonstrate the proportion of members of the outcome explained by the solution term as a proportion of the overall sample, hence the need for fsQCA analysis to report on consistency and coverage across pathways. [19] The construction of a truth table is carried out based on the values set and three solutions for this study are derived.

5.3 Sensitivity Analysis

In this paper, sensitivity analysis was conducted using adjusted consistency cut-off values. Adjusting the consistency cut-off values from 0.8 to 0.82 and 0.78 resulted in paths similar to the original paths.

6 Results

6.1 Results of the Configuration Analysis

According to the analysis results of fsqca3.0, the formation path of secondary school physics teachers' professional identity was analysed by combining the intermediate and

Table 5. Results of the configuration analysis

Factor	1a	2a	3a	4	5	6	7
urban school	●	●	○		●	●	●
middle school	○	○	○	●	●	○	●
the sense of professional mission	●		○	●	●		●
work-to-family gain		○	○	●		●	●
psychological capital		●	○	●	●	●	
low professional stress	●	●	●	●		○	○
Raw coverage	0.176	0.113	0.038	0.156	0.233	0.127	0.124
Unique coverage	0.080	0.023	0.038	0.049	0.073	0.088	0.021
Consistency	0.917	0.910	0.895	0.944	0.875	0.870	0.780
Solution coverage	0.632						
Solution consistency	0.864						

Note: ● indicates the presence of a condition and ○ indicates its absence. Large circles indicate core conditions. Small circles indicate peripheral conditions. Blank spaces indicate that the condition is indifferent

parsimonious solutions, and the results of the group analysis and the core and edge conditions are shown in Table 5.

The consistency of the results was greater than 0.80 for all pathways except path 7, with an overall consistency of 0.864 greater than 0.85, indicating a strong explanatory power and range of analysis. Paths 1 to 3 share the core condition of low Professional Stress in high school* and therefore these three paths are grouped together. Path 3 consistency was higher than 0.80 but coverage was only 0.038, indicating that only a few cases reached professional identity through this path.

6.2 An Analysis of the Pathways of Professional Identity Formation for Secondary School Physics Teachers

Based on the results of the histological analysis, the four types of pathways for forming the professional identity of secondary school physics teachers can be identified by combining pathways 1, 2 and 3 with the same core conditions.

Category 1
Path 4 is middle school * professional vocation * work-to-family gain * psychological capital * low Professional Stress. Teachers who are under low Professional Stress are more likely to identify with the teaching profession when they are in a better psychological capital situation while gaining work-to-family benefits at work. This pathway suggests that whether or not a school is located in an urban area is relatively irrelevant when the three elements of a secondary physics teacher's professional vocation, work-family gains and psychological capital are all present. [20] If teachers have a

sense of purpose and recognise their professional aspirations, a less stressful working environment will be more conducive to the development of a professional identity.

Category 2
Path 4 is middle school * professional vocation * work-to-family gain * psychological capital * low Professional Stress. Teachers who are under low Professional Stress are more likely to identify with the teaching profession when they are in a better psychological capital situation while gaining work-to-family benefits at work. This pathway suggests that whether or not a school is located in an urban area is relatively irrelevant when the three elements of a secondary physics teacher's professional vocation, work-family gains and psychological capital are all present.

Category 3
Pathway 5 is urban school * junior high school * sense of professional mission * psychological capital. This pathway suggests that for physics teachers working in urban junior high schools, Professional Stress is irrelevant in relation to the teachers' own sense of professional mission and psychological capital. The difference between urban teachers and rural teachers in terms of work processes and school facilities, such as information technology in education, is significant, as is the issue of treatment and career advancement in urban and rural areas. For physics teachers in urban middle schools, the core elements of professional identity are identification with the teaching profession and having a reasonable mindset.

Category 4
Path 6 is urban school *high school *job gain to family *psychological capital* ~low Professional Stress. Unlike paths 1 and 2, path 6 indicates that high school physics teachers in urban schools are able to achieve teacher professional identity despite the presence of both work-to-family gains, psychological capital and high Professional Stress. This pathway suggests that high school physics teachers in urban high schools who have a high level of psychological capital and positive family gains from work can identify with the teaching profession in spite of high Professional Stress. It is suggested that the positive effects between work and family lead to a joint increase in the effectiveness of both arenas, resulting in a win-win situation for both work and family.

7   Conclusion

This study used questionnaires to collect data from six areas: demographic variables, sense of career vocation, work-to-family gain, psychological capital, Professional Stress, and professional identity, and used fuzzy set qualitative comparative analysis with fsqca.0 software to derive four types of pathways for forming the professional identity of secondary school physics teachers. Analysis of the core and borderline conditions showed that the combination of middle school and low Professional Stress can form the professional identity of secondary school physics teachers, while the combination of occupational vocation, work-to-family gain, and psychological capital can also form professional identity in certain pathways.

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