

The Underlying Logic of Teacher Professional Development: A Study on the Transmission Mechanism from Teacher Development to Improvement of Basic Education Quality

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ABSTRACT This study systematically investigates the transmission mechanism through which teacher professional development improves the quality of basic education. A multidimensional theoretical model is constructed to connect teacher professional knowledge, teaching ability, and professional belief with student cognitive development, non-cognitive ability, and academic achievement through classroom teaching practice and school organizational support. Using large-scale empirical survey data and structural equation modeling, the study tests the relationships among teacher competence, classroom behavior, school support environment, and student development outcomes. The findings indicate that teacher development does not improve education quality through a simple linear input-output path; instead, it operates through competency internalization, behavioral transformation, and environmental interaction. Classroom teaching practice plays a key mediating role, while school support strengthens the transformation of professional competence into effective practice. The study provides a data-driven model for educational quality evaluation and a transferable mechanism for analyzing complex information transmission in organizational systems.

INDEX TERMS teacher professional development, basic education quality, transmission mechanism, structural equation model, data-driven evaluation

I. INTRODUCTION

IMPROVING the quality of basic education around the world is a fundamental issue and challenge to education reform and development in every country. The quality of basic education directly affects not only the individual growth and development potential of hundreds of millions of students, but affects national quality, social equity, and national competitiveness at a macro level. Among various elements that make up the quality of education, the teachers will definitely be the most important and most dynamic as the core resource. Therefore, how to strengthen the teaching force and promote teacher professional development is taken as the most fundamental and effective lever in improving the quality of education. In recent years, “teacher professional development” has become a commonly used term, from planning of policies to academic research, and significant resources have gone into various types of teacher training, professional development, and support programs. However, a fundamental question has not been answered, how and along which routes does the professional capability of teachers ultimately translate in the development of their

students?

The essence of this mechanism of transmission is the underlying logic in teacher professional development. It transcends mere linear “input-output” thinking of how individual teachers internalize and re-construct newly acquired knowledge, skills and learning concepts through overcoming different constraints in real-world situations, and transform them into effective teaching behaviors in the classroom, including teacher-student interaction models. Simultaneously, however, this transformation process is inevitably influenced and regulated by such factors as the organizational culture of schools, leadership support, and peer communities, as well as the larger policies and evaluation environment of schooling. Failure to make this complex mechanism real and understandable may easily result in blind investment or formalized training or disconnection with classroom practice in terms of teacher development, which significantly reduces its expected positive effects for improving the quality of education. While existing research provides rich and localised knowledge based on multiple perspectives including the composition (teacher competency), training models and

school leadership, it does not provide an integrated framework to systematically depict the whole transmission chain and especially lacks models testing based on large scale empirical data.

In light of this, this study is aimed to analyze the “process” and “principle” in which it carries out influence.

This study: First, it constructs theoretical model on multi-level transmission mechanism, combining individual teacher qualities, teaching practices, school organizational environment and student development outcomes; second, based on empirical survey data, it examines the path relationship and influence strength between the variables in this model, which leads to understand key mediating linkage and moderating factors; third, based on the research findings, it explains the internal logic of the mechanism of teacher professional development impacts educational quality and proposes corresponding policy suggestions, which can be used to improve the precision and effectiveness of method policies for the development of teaching staff. This study hopes to provide more penetrating theoretical support and practical guidance for promoting high-quality development of basic education in the new era.

II. RELATED WORK

Research on teacher professional development increasingly focuses on the profound impact of multidimensional capacity building and systematic support on the quality of education. Shekhavtsova[1] integrates the teaching principles and competency-based concepts of contemporary pedagogy to explore the design and implementation of effective models and methods for cultivating team building skills in teacher education. FENG et al. [2] conducted an exploratory analysis on the current status, challenges and feasible paths of the construction of “dual-qualified” teacher teams in local applied universities. Isa et al. [3] proposed a management model for improving the quality of teacher professional development, emphasizing the key role of systematic planning, effective implementation and continuous evaluation in improving teacher competence and teaching effectiveness. Sahuddin et al. [4] revealed the key role of principals of special schools in promoting teacher professional learning, creating a supportive school atmosphere, integrating resources and promoting teaching innovation. Fauyan et al. [5] proposed management strategies for improving the quality of professional teacher education programs.

Rohbiyatun and Kusumaningsih[6] quantitatively analyzed the effects of three factors—academic supervision, learning community participation, and teacher motivation—on improving the quality of primary school teaching. Muhammad et al. [7] explored the direct or indirect relationship between visionary leadership, teacher creativity, and the improvement of teaching quality, and verified its path of action. Morgan et al. [8] adopted a combination of quality improvement model and researcher-teacher collaboration method, and through cross-team collaboration, jointly designed, implemented, and iteratively optimized cross-

professional learning activities. Prananda and Refraza[9] sorted out the relevant theories and practical experience on the composition of science teachers’ abilities, influencing factors, and improvement strategies. Nashrulloh et al. [10] emphasized the importance of targeted improvement of the professional abilities of special education teachers. Although existing research has explored the impact of teacher professional development on education quality from multiple perspectives such as teacher ability composition, training model, management strategy, and leadership, there is a lack of systematic theoretical construction and empirical revelation of the underlying logic of the complex transmission mechanism from teacher team building (ability improvement) to basic education quality (student development). This study aims to explore the underlying logic of teacher professional development, and to construct and test a transmission mechanism model from teacher development to the improvement of basic education quality, in order to provide more penetrating theoretical support and practical guidance for teacher development and high-quality development of basic education in the new era.

III. METHODS

A. RESEARCH FRAMEWORK AND VARIABLE MEASUREMENT

To examine the transmission mechanism of teachers’ professional development to the quality of basic education, this study constructed an integrated theoretical model (as shown in Figure 1, which is descriptive text and should be attached in actual research). The model contains four core latent variables:

(1) Teachers’ professional competence: as the starting point of the transmission mechanism, it is operationalized into three observation variables: subject teaching knowledge level (measured by the teacher self-assessment scale, using a Likert 5-point scale, from “very lacking” to “very rich”), teaching skills mastery (based on the self-efficacy scale of skills such as instructional design, classroom management, and differentiated teaching), and professional beliefs and sense of mission (measuring their recognition of educational value and willingness to continue to develop) [11,12].

(2) Classroom teaching practice: as a key mediating variable, it is operationalized into two observation variables: frequency of student-centered teaching behaviors (such as the frequency of implementation of inquiry-based learning, cooperative learning, and personalized guidance), and depth of teaching reflection and improvement (referring to the degree of conscious teaching analysis and adjustment of practice after class).

(3) School support environment: As a moderating and mediating variable, it is operationalized into three observation variables: the activity level of the professional learning community (the quality and frequency of teaching and research group and lesson preparation group activities), the support level of teaching leadership (the encouragement and resource provision of teaching innovation by the principal

and middle-level leaders), and the sense of institutional and cultural support (the tolerance and support of the evaluation system and work atmosphere for professional attempts perceived by teachers).

(4) Student development outcomes: As the end point of the transmission mechanism, that is, the core manifestation of the quality of basic education, it is operationalized into three observation variables: longitudinal student academic achievement (based on the standard score of the regional unified academic quality monitoring collected over a sustained period to account for the necessary time lag between pedagogical intervention and measurable academic shifts), student learning engagement (including questionnaire measurement of behavioral engagement, emotional engagement and cognitive engagement), and student comprehensive quality development (through a combination of independent third-party observations and standardized peer-assessment rubrics to minimize social desirability bias inherent in teachers' evaluation of students' progress in critical thinking, cooperation ability, social and emotional skills, etc.).

All scales have been tested and revised in the preliminary study. The Cronbach's α coefficient of the Teacher Professional Competence Scale is 0.92, the Classroom Teaching Practice Scale is 0.87, the School Support Environment Scale is 0.89, and the Student Development Outcomes Scale (Teacher Evaluation Section) is 0.88, all indicating good reliability. Confirmatory factor analysis showed that the fit indices of each scale (CFI=0.95, TLI=0.93, RMSEA=0.05, SRMR=0.04) met the psychometric standards, and the convergent validity and discriminant validity met the standards [13].

B. RESEARCH SUBJECTS AND DATA COLLECTION

This study used a stratified cluster sampling method to select two prefecture-level cities from each of the three regions of eastern, central and western China. Ten primary schools and ten junior high schools were randomly selected from each city, for a total of 60 schools. In each sample school, five teachers of the three main subjects of Chinese, mathematics and English were randomly selected (if there were not enough teachers of a certain subject, all teachers participated) and student data from one class they taught (randomly selected). In the end, 1482 teachers participated in the study effectively, and the student data of the corresponding classes were obtained by integrating teacher questionnaires, student questionnaires and regional academic performance databases [14,15].

Data collection was conducted through a combination of online and offline methods. The teacher questionnaire focused on measuring teachers' professional competence, classroom teaching practices, and perceived school support environment. The student questionnaire measured their learning engagement and self-assessment of overall competence. Simultaneously, while the homeroom teacher and main subject teachers of each class provided evaluation for student learning engagement and comprehensive compe-

tence through observation and questionnaires, the 'student academic achievement' indicator was derived exclusively from the regional unified academic performance database to maintain objective measurement and prevent subjective bias from confounding the latent variable. Regional academic performance data was provided by the local education administration department after anonymization. All data was anonymized and subjected to logical checks and missing value handling (using the full-information maximum likelihood estimation method).

C. DATA ANALYSIS METHODS

This study primarily employed structural equation modeling (SEM) for data analysis to simultaneously test both the measurement and structural models, and to effectively handle latent variables and their mediating effects. The analysis tool used was Mplus 8.3 software.

First, confirmatory factor analysis was conducted on the four core latent variables and their observed indicators to confirm the validity of the measurement model. Second, a structural equation model was constructed to test the transmission paths of the theoretical hypotheses. The basic hypotheses include: H1: Teachers' professional competence has a direct positive impact on classroom teaching practice; H2: Teachers' professional competence indirectly affects student development outcomes through the mediating role of classroom teaching practice; H3: The school support environment both directly and positively impacts classroom teaching practice and moderates the transformation process of teachers' professional competence into classroom teaching practice (i.e., the moderating effect); H4: The school support environment has a direct positive impact on student development outcomes and may have an indirect impact through supporting classroom teaching practice.

IV. RESULTS AND DISCUSSION

A. SAMPLE DESCRIPTION AND MEASUREMENT MODEL VALIDATION

Of the 1482 teachers participating in this study, the male-to-female ratio was 3:7; in terms of teaching experience, 28% had 5 years or less, 45% had 6-15 years, and 27% had 16 years or more; in terms of educational background, 82% held a bachelor's degree, 15% held a master's degree or higher, and 3% held an associate's degree. The sample covered urban schools (65%), county and town schools (25%), and rural schools (10%). While the distribution reflects general staffing patterns, the high concentration of urban participants and female teachers suggests that the identified 'transmission mechanism' may be particularly reflective of resource-rich environments; future stratified analysis is required to determine if the moderating role of the 'school support environment' functions differently in resource-constrained rural settings. The students involved were in grades four through nine. Descriptive statistics are shown in Table 1.

TABLE 1. Descriptive statistics and correlation matrix of core latent variables (N=1482)

Latent variables	M	SD	Teacher professional competence	Classroom teaching practice	School Support Environment	Student Development Outcomes
1. Teachers' professional competence	4.12	0.68	1			
2. Classroom Teaching Practice	3.95	0.72	0.63**	1		
3. School Support Environment	3.78	0.81	0.51**	0.59**	1	
4. Student Development Outcomes	3.88	0.65	0.45**	0.67**	0.55**	1

Note: ** $p < 0.01$; M = mean, SD = standard deviation.

As shown in Table 1, the means of each core latent variable are at a moderately high level, indicating that the sample teachers' professional competence, practical skills, perceived school support, and student development outcomes in their classes are generally good. Correlation analysis showed significant positive correlations among the four variables ($p < 0.01$), with the highest correlation between classroom teaching practice and student development outcomes ($r = 0.67$), which preliminarily supports the hypothesis that classroom teaching is a key mediator. Teacher professional competence also showed a high correlation with classroom teaching practice ($r = 0.63$). Confirmatory factor analysis results support the four-factor measurement model.

B. STRUCTURAL MODEL VERIFICATION OF THE TRANSMISSION MECHANISM

Structural equation modeling analysis shows that the overall goodness of fit of the theoretical model is good ($\chi^2/df = 3.02$, CFI = 0.94, TLI = 0.93, RMSEA = 0.06, SRMR = 0.05), and most of the assumed paths are supported. Specific standardized path coefficients and effect decompositions are shown in Table 2.

First, teachers' professional competence shows a strong and positive correlation with classroom teaching practice ($\beta = 0.48$), suggesting that teachers' intrinsic knowledge, skills, and beliefs are significant predictors associated with their improved teaching behavior (H1 holds true). Second, classroom teaching practice has a very significant impact on student development outcomes ($\beta = 0.52$), and its role as a mediating variable is crucial: the indirect effect of teachers' professional competence on student development outcomes through influencing classroom teaching practice is 0.25, while its direct effect is only 0.15. This means that over 60% of the effectiveness (0.25/0.40) of teachers' professional development outcomes must be transmitted to students through the crucial link of classroom teaching practice. This clearly reveals a core element of the transmission mechanism: if professional competence is not translated into effective classroom practice, its impact on the final quality of education will be significantly reduced (H2 holds true).

The role of the school support environment is equally significant. It not only directly promotes improvements in classroom teaching practice ($\beta = 0.34$) and student development outcomes ($\beta = 0.22$), but also generates additional indirect effects through supporting practice (0.18). More importantly, the significant interaction term ($\beta = 0.11$) indicates that the school support environment positively moderates the transformation of teachers' professional competence into classroom teaching practice. In a highly sup-

portive school environment, highly professionally competent teachers can more fully and effectively apply their abilities to teaching innovation; conversely, in a low-supportive environment, even if teachers possess high competence, the degree to which this transformation is applied is inhibited (H3 and H4 hold true).

C. INTEGRATED EXPLANATION AND DISCUSSION OF THE TRANSMISSION MECHANISM

Based on the above quantitative results, the transmission mechanism model constructed in this study has received empirical support, and its underlying logic has been preliminarily revealed. The transmission of teacher professional development to improve the quality of basic education is essentially an ecological process of interaction and hierarchical transmission among three elements: "competency-practice-environment." (See Table 3.)

As it has been illustrated in Table 3, transmission first takes place within the individual teacher (internalization layer) where external development activities result in positive changes in his/her professional knowledge, skills, and beliefs, representing the "potential energy" of transmission. However, this potential energy needs to be converted into "kinetic energy" which takes place at the behavioral transformation layer. This research showed that this transformation process is not automatic and there are significant dependencies on the ability of teachers to apply new competencies in the complex, contextualized classroom teaching, design and implementation of higher quality learning activities. This layer is the most vulnerable yet extremely crucial "choke point" of the transmission mechanism, where effectiveness of so many teacher development activities gets reduced and becomes weak.

The environmental interaction layer is the "field" that the transmission takes place in. A positive environment of school support, by providing spaces for professional dialogue, granting teaching autonomy and defining systems that encourage innovation, reduces positively the risks and costs for teachers for putting new ideas into practice, thus increasing the efficiency of translating professional competence into teaching behavior (moderating effect). Hunger et al (2014) neither stated simply, "(-) Simultaneously, the presence of a positive environment may itself motivate for improved teaching practices and create an environment that is favorable to student growth (direct and indirect effects)." Ultimately, in outcome realization layer, continually optimized teaching practices and supporting environment accumulate in a certain period of time (the limitation of cross-section data in this study is; however, data can show

TABLE 2. Path coefficients and effect analysis of structural equation model

Path Relationship	Standardized path coefficient (β)	Bootstrapping 95% CI	Is it significant?
Direct effects:			
Teacher professional competence → Classroom teaching practice	0.48	[0.41, 0.55]	yes
Classroom teaching practice → Student development outcomes	0.52	[0.45, 0.59]	yes
Teacher professional competence → Student development outcomes	0.15	[0.07, 0.23]	yes
School Support Environment → Classroom Teaching Practice	0.34	[0.27, 0.41]	yes
School Support Environment → Student Development Outcomes	0.22	[0.15, 0.29]	yes
Interactive items (competencies × environment) → Practice	0.11	[0.04, 0.18]	yes
Indirect effect (mediation effect):			
Teacher professional competence → Practice → Results	0.25	[0.19, 0.31]	yes
School support environment → Practice → Outcome	0.18	[0.12, 0.24]	yes
Total effect:			
Teacher professional competence → Student development outcomes	0.40	[0.33, 0.47]	-
School Support Environment → Student Development Outcomes	0.40	[0.33, 0.47]	-

TABLE 3. Key Pathways and Characteristics of the Transmission Mechanism

Conduction level	core links	Functional properties	Examples of influencing factors	The ways in which it affects the quality of education
Individual internalization layer	Improving teachers' professional competence	The starting point and energy source of conduction	Training content relevance, individual reflection and learning ability, career motivation	Laying the foundation for potential and providing possibilities and directions for improvement.
Behavioral conversion layer	Improvement of Classroom Teaching Practice	Core intermediaries and key hubs	Teaching autonomy, courage to experiment, opportunities for trial and error and reflection, and immediate feedback.	Transforming potential into concrete behaviors that directly influence students
Environmental Interaction Layer	The school supports environmental creation	Regulators, catalysts and direct support sources	Leadership philosophy, community culture, evaluation system, resource allocation	Accelerating or hindering transformation, providing the nutrients needed for practice.
Results Implementation Layer	Student development achievements are evident	The endpoint and effectiveness of transmission	Individual student differences, family background, class atmosphere, and the cumulative effect of time	Multidimensional developmental outcomes following the sustained effects of practical actions

a correlation) causes the development of the students in different aspects.

This mechanism shows that it is not possible to improve the quality of basic education simply by focusing on quantitative competency metrics. It is necessary to pay attention and strongly encourage the intermediate process of “translating competence into practice”, as well as to carefully develop the school organizational ecosystem that supports this transformation. Any policy or practice that isolates and focuses only on one aspect will have difficulties ensuring a smooth transmission mechanism. For instance, training that is alienated from the realities of schools and that is not followed by practical assistance may fail at the starting point; on the other hand, a permissive organizational climate will be insufficient if it is coupled by a lack of basic competence among the teachers and therefore may not have sufficient initial impetus for effective transmission.

V. CONCLUSION

This study, through the construction and the empirical testing of a multi-level transmission model, discovers, in a preliminary way, the underlying logic of how the professional development of the teachers influences the quality of the basic education. The core conclusions are as follows: First, what we can find is that the transmission from teacher development to educational quality improvement is

an indirect process and “classroom teaching practice” is the key hub. Over 60% of the overall impact of teacher professional competency on student development outcomes must be realized in enhanced classroom practice of teaching, indicating the extreme importance that be placed on the classroom and the promotion of changes in classroom teaching behaviors. Second, the success of the transmission mechanism requires the synergy of individuals, behaviors and the environment. Teacher professional competence is the basic energy source, classroom teaching practice is the basic converter, and the school support environment is an indispensable catalyst and regulator. The three constitute an interactive and interdependent ecological cycle system. Third, the school organizational environment is not only a direct contributor to educational quality but also plays a “leveraging” role while improving the efficiency of the transformation of teacher professional competence in teaching practice. In a highly supportive environment, the efficacy and long-term sustainability of teacher professional development outcomes are significantly enhanced.

On the basis of the above findings, the following implications are proposed for policies and practices with regard to teacher development and the strengthening of the quality of basic education: First, the design of teacher professional development programs and their evaluation

need to look beyond the one-dimensional focus on changing teacher's knowledge and beliefs, but rather need to focus on behavioral and transformational change, as well as on continuous improvement in real classroom practice, building a closed-loop support system of 'learning~practice~reflection~practice'. Second, schools should work to create strong professional learning communities and systems of distributed teaching leadership, in which there is a safe, supportive and resource-rich organizational context for teachers to engage in the experimentation of new practices, thereby overcoming the dilemma of "separation of knowledge and action." Finally, education management departments should establish an integrated evaluation and support framework, in the same time, simultaneously attend to the teacher competence, teaching practice, school environment and student development, identify the weak link in the transmission chain and conduct precise interventions and resourcefulness allocation to achieve systemic empowerment of the transmission mechanism in order to effectively promote the overall improvement of basic education quality.

The limitations of this study are the use of cross-sectional data, which poses some constraints in making causal inferences. Future research could use a longitudinal tracking design to better describe the time dynamics of transmission. Furthermore, the model focuses mainly on internal factors within the school; it would be possible for future studies to include family, community and wider policy contexts within the analytical framework to achieve a more comprehensive picture of transmission.

AUTHOR CONTRIBUTIONS

Yifan Xin designed, collected and analyzed the data, and drafted the manuscript. Yifan Xin conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. Yifan Xin participated fully in the work, take public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

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