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New Year Greetings from *Science Insights Education Frontiers*

Longjun Zhou

Division of Education and Economy, China Center, International Education Communication Agency, the BASE, USA

*“Education is not the filling of a pail, but the lighting of a fire.”
–William Butler Yeats*

THE YEAR of 2023 was supposed to be a year full of hopes and with the promise that everything would return to the right track. At the end of the year, however, we realized that the world was far away from the right track. Instead, it underwent a turbulent period, becoming more unstable, uncertain, and unpredictable: Geopolitical conflicts continued to escalate, and the humanitarian crises were deteriorating, with no signs of the Russian-Ukrainian war coming to an end or Palestinian-Israeli tension subsiding; The world economy was slowing down, facing the dual challenges of low growth and high inflation; Natural and climate change-induced disasters arose one after another, like the devastating earthquake in Turkey, once-in-a-century drought in the Amazon rainforest, and the raging floods in the Horn of Africa, to name a few.

On the other hand, the scientific and technological breakthroughs in 2023 brought us new hopes. The accelerated development of artificial intelligence resulted in a proliferation of AI applications. In the domain of health and care, advances in areas such as gene editing and stem cell research produced revolutionary outcomes. Further advancements of information technology such as the block chain technology provided new opportunities for human society, instigating innovations in a variety of sectors. We are fully confident that the year of 2024 will generate more opportunities.

To *SIEF*, 2023 was also a special and challenging year. *SIEF* transitioned from a bimonthly to monthly journal in 2023 and doubled the number of articles published, with two thirds of them being empirical research. It focused on emerging issues in the world community of education, encouraged in-depth discussions on educational topics of common concern, and continuously expanded research perspectives. The geographic diversity

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of its contributors and the quality of the articles have significantly improved. Some of the studies have sparked serious reactions and discussions among readers, and the number of views and downloads has seen a substantial increase. We hereby extend our sincere gratitude to all our contributors and readers who have been concerned with *SIEF*'s development. Your trust, support, and encouragement give sustaining impetus to our progress.

Facing prospective challenges, we continue to pursue our dreams. *SIEF* is committed to providing an open, inclusive, impartial, and scientific platform of academic exchanges for our global peers in the fields of education and teaching. In the New Year, the journal will carry on working to improve its academic level and focusing on the pressing issues in educational development, such as the impact of poverty on education, high-quality development of education through educational technology, effective application of educational theories in educational and instructional practice, and educational equity, especially in ethnic minority areas. In the meantime, *SIEF* will further expand the scope of discussion to include issues like preschool education, special education, social education, and more. We sincerely welcome educational researchers from all over the world to contribute to research on these issues. We also look forward to readers continuing to pay attention to *SIEF* and giving us your valuable feedback in order for us to further improve our publication.

Correspondence to:

Longjun Zhou

PhD

Division of Education and Economy

China Center

International Education Communication Agency

The BASE

USA

E-mail: 294437034@qq.com

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Teacher STEAM Education Supported by Professional Learning Communities: A Meaningful Practice of Teacher Professional Development

Alan C.K. Cheung

The Chinese University of Hong Kong, Hong Kong 999077, China

“All sorts of things can happen when you’re open to new ideas and playing around with things.”

–Stephanie Kwolek

STEAM education is a synergetic, interdisciplinary approach that conflate science, technology, engineering, arts and mathematics to foster creative, critical, and imaginative thinking and skills in students (Lamichhane, 2021). The core of STEAM is innovation and problem-solving. It places premiums on interdisciplinary skills, including inquiry, communication, collaboration, and self-management (Holbrook, 2020). In a world facing emerging challenges and complexities, STEAM education is instrumental in cultivating talents with abilities to integrate multiple-disciplinary knowledge, think critically and innovatively, solve problems voluntarily, and carry out effective collaboration.

Improving teachers’ STEAM literacy is crucial for a successful STEAM education in formal schooling. There are a variety of teacher STEAM literacy training practices including but not limited to curricular reconstruction, project-based training, maker education, and the professional learning community (PLC). Among them, the concept of PLC stands out in recent teacher development research as the infrastructure for supporting teacher-teacher and teacher-researcher collaboration to advance student learning. The PLC is an umbrella term, used to describe several forms of teacher collaboration, such as the “community of practice”, “teacher collaborative community”, “learning team”, “learning community”, “professional learning network”, “problem-solving team”, “collaborative teacher team”, and “inquiry community” (Olsson, 2019). There are commonalities among these practices. Generally, members of a PLC share one or several common goals that relate to educational outcomes and teacher professional development. PLCs encourage communication, collaboration, and mutual assistance from teachers to resolve practical is-

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sues. PLCs provide opportunities for teachers to access new educational notions, approaches, and strategies. Additionally, PLCs establish mechanisms for regular feedback and evaluation to inform teachers of the improvement they need to make as well as the progress they have made (Yao, 2023).

Melding PLCs with STEAM education is of vital significance for developing teachers' STEAM literacy. PLCs have the potential to increase teachers' theoretical and practical capacities for STEAM education by providing diverse educational resources and creating professional learning environments (Qiao, 2023). Under PLC programs, teachers collaboratively explore interdisciplinary learning projects that require students to apply concepts from science, technology, engineering, arts, and mathematics to solve problems. Such practice-based activities can constantly improve teachers' understanding and application of STEAM education ideas (Ma, 2021).

STEAM training in the form of PLC helps promote teachers' professional development and, in the meantime, contributes to the building of sufficiently competent teaching force for successful implementation of STEAM education (Chen, 2023). *Professional Learning Community (PLC) in STEAM Education: A Hands-on Workshops Sample* in this issue of the journal is an examination of the effects of the Istanbul DSW (Design Skill Workshops) Academy training program on participating teachers' perceptions of key 21st century skills teaching effectiveness, design self-efficacy, and perceptions of interdisciplinary teaching (Gülhan, 2024). Its research findings confirm that the use of professional learning communities like the hands-on workshop is an effective practice in STEAM education.

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Correspondence to:

Alan C.K. Cheung
PhD

Department of Educational Administration and Policy
The Chinese University of Hong Kong
Hong Kong 999077
China

E-mail: alancheung@cuhk.edu.hk

Conflict of Interests: None

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Break out of Career Plateaus for Long-range Career Development as Teachers

Ming Zhou

Jiangnan School, Zhenjiang 212008, Jiangsu, China

“Plenty of people miss their share of happiness, not because they never found it, but because they didn’t stop to enjoy it.”

–William Feather

HISTORICALLY, teacher professional growth has been a major determinant of educational development. For a nation, the moral and academic levels of teachers mark its own level of civilization. It was claimed in Mourshed et al.’s (2011) study that the education quality of any nation could not surpass the quality level of its teachers. Teacher development is the cornerstone of high-quality education.

In its broad sense, teacher development spans all efforts of the teaching staff to enhance their educational work throughout their career, representing the long-range changes in their professional qualities, competences, achievements, and titles (Li, 2014). In the narrower sense, it refers to the process of teacher professional development as well as the process of promoting teacher professional growth, in which teachers develop knowledge and skills necessary for successful practice at specific stages during their teaching careers (Hoyle, 2012). However, at certain points in their career, the teacher may feel that they have reached a ceiling of growth and cannot progress further, which is generally described as career plateauing.

The concept of career plateau was first advanced by Ference and his co-workers in their research in management to characterize the phenomenon that the managerial career could level off or plateau following a period of rapid upward mobility (Ference et al., 1977). Research on teacher career plateauing drew on the definition of career plateau in management. Zhang (2005) operationalized teacher career plateauing as the state that the teacher experiences stagnation or even degeneration in the career hierarchy due to the constraints of environmental or personal factors. Wang (2016) described preschool teacher career plateauing as the phenomenon that after reaching a certain professional level, the

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kindergarten teacher stops progressing in terms of promotion and mobility, knowledge and skill acquisition, opportunities for new responsibilities, ending up with behavioral and or psychological stagnation or even regression. Relevant research reveals that career plateauing is correlated with negative emotions, leading to low job satisfaction, reduced motivation for devotion, high job pressure, low-spiritedness, negative attitudes, and increased turnover intention in consequence of temporary or permanent stagnation of mobility.

Amid the accelerating development of early childhood education in China, the professionalization of preschool teaching staff has drawn wide attention. Research on preschool teacher professional development is of vital academic and social significance. Preschool teacher career plateauing is an emerging topic in teacher development research, which involves multiple disciplines and a variety of issues and necessitates in-depth investigations. *Career Plateauing among Chinese Kindergarten Teachers* in this issue conducted a nationwide survey on Chinese preschool teachers' career plateaus using a self-developed scale and constructed the kindergarten teacher career plateauing structural model based on the survey results (Wang, 2024). Its research results were built on a considerable sample size, legitimate research design, and thorough analysis of quantitative and qualitative data. The article has the potential to provide valuable implications for preschool teachers' long-range career planning and sustainable career advancement.

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Correspondence to:

Min Zhou
PhD
Jiangnan School
Zhenjiang 212008
Jiangsu
China
E-mail: 929883506@qq.com

Conflict of Interests: None

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Career Plateauing among Chinese Kindergarten Teachers

Yan Wang

Jiangsu Second Normal University, Nanjing 210013, Jiangsu, China

Abstract: *Teacher career plateaus hinder the high-quality development of teaching staff. Based on a nationwide questionnaire survey on Chinese kindergarten teachers' career plateaus, this study developed a kindergarten teacher career plateauing structural model. The research findings indicate that overall career plateauing among Chinese kindergarten teachers is at a moderate level. The kindergarten teacher career plateauing model is best represented by the second-order single-factor/first-order three-factor structure, which consists of three dimensions: professional development, hierarchical, and emotional plateauing. Among these dimensions, emotional plateauing is most intensively perceived by teachers. Telltale signs of kindergarten teacher career plateauing range from stagnation of professional progress to losses of senses of meaning in work, constrained promotion of professional titles, slim chances of promotion to higher positions, fading positive emotional engagement, and increased negative workplace emotions. Implications of the study for building a professionalized preschool teaching force include emphases on teachers' long-range career planning and their agency in career advancement. Special attention should be paid to their emotional needs.*

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About the Author: Yan Wang, School of Preschool Education, Jiangsu Second Normal University, Nanjing 210013, Jiangsu, China, E-mail: 12577351@qq.com

Correspondence to: Yan Wang at Jiangsu Second Normal University of China.

Conflict of Interests: None

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Raising the Question

THIS STUDY is an examination of career plateaus among Chinese kindergarten teachers. Career plateauing in preschool teachers refers to the phenomenon that at a certain point in their career, the kindergarten teacher stops progressing in terms of promotion and mobility, knowledge and skill acquisition, and opportunities for new responsibilities, ending up with behavioral and/or psychological stagnation or even regression. Career plateauing has the potential to instigate a wide variety of negative outcomes, including low career satisfaction (Nicholson, 1993), high job strain (McCleese et al., 2007), losses of enthusiasm (Peterson, 1993), negative attitudes (West et al., 1990), absence of professional aspirations (Locke et al., 1998), permanent career stagnation (Lemire et al., 1999), increased turnover intention (Heilmann et al., 2008), and more. Research on the characteristics and causes of kindergarten teachers' career plateauing is of vital significance for understanding the challenges in their professional development and identifying appropriate coping strategies for sustaining career development in them.

Career plateau research was initiated in the mid- and late-20th centuries. Ference et al. (1977) advanced a definition of career plateau from a management perspective, which was widely accepted (Harvey & Schultz, 1987) and later further expanded (Choy & Savery, 1998). The definition of career plateau in management has been drawn upon in studies of teacher career plateauing. Newman et al. (1980) and Krupp (1987) both paid attention to this phenomenon but did not provide sufficiently in-depth insights. Chinese researchers Kou and Zhang (2008) and Zhang (2017) studied the issue of career plateauing among Chinese teachers. Chen and Lian (2011), Li (2012), and Hu (2013) conducted more specific investigations of teacher career plateauing at differential education levels.

In existing research, there were two approaches to measuring career plateauing: objective and subjective. Chao (1990) found that a perceptually based measure of career plateaus was more appropriate than the objective measure based on job tenure and had greater explanatory power for outcomes. The measurement results in the literature included both single-dimension and multiple-dimension career plateauing models. Tremblay & Roger (1993) posited the single-dimension model from the perspective of promotions. The two-dimension model included individual plateauing (a lack of upward mobility ability and opportunities due to personal factors) and organizational plateauing (an inability to provide developmental needs and opportunities on the part of the organization) (Warren et al., 1977). The three-dimension model comprised structural plateauing (organizational structure-induced constraints on employee development), job content plateauing (little likelihood of the individual acquiring new knowledge and skills from

work or a lack of challenge in the job per se), and individual plateauing (a lack of enthusiasm for the job or developmental directions) (Bardwick, 1986). The four-dimension model incorporated structural, job content, personal choice, and job skill plateauing (Veiga, 1981). Foreign academics have contributed to the literature on career plateau theories, which is the focus of the majority of Chinese studies in this area (Xie & Long, 2005).

The bulk of career plateau research has concentrated in the field of management. Teacher career plateau research has expanded to the primary and secondary levels. However, there are only a small number of studies on pre-primary teacher career plateauing, which are mainly theoretical analyses with a lack of empirical research, let alone studies with appropriate research instruments. The present study is an endeavor to create a kindergarten teacher career plateauing scale that conforms to psychological assessment criteria and suits current Chinese social and cultural contexts. It is meant to be a useful tool for analyzing the status quo and main components of pre-school teacher career plateauing and exploring the causes of challenges in the professional development of this group.

Research Methodology

Research Participants

Participants in the Development of the Questionnaire: At the stage of establishing items, convenience sampling was adopted to include in the interview three principals and 24 teachers from different kindergartens who had graduated from the School of Preschool Education of N University, and 150 open-ended questionnaires were distributed via them. Three principals, 24 senior kindergarten teachers, and 70 preschool education majors at Y University conducted a thorough examination for the semantic analysis of the questionnaire items. To evaluate the unidimensionality, appropriateness of expression, and pertinence of the items, one professor, one associate professor, three doctors with questionnaire development experience, and one psychology researcher were involved in the expert evaluation.

Participants in the Questionnaire Survey: In the trial survey, convenience sampling and cluster sampling were employed to distribute questionnaires to 350 teachers from 10 kindergartens in northern, central, and southern Jiangsu Province. After excluding invalid questionnaires (with no answers, identical answers, omissions, or redundant answers), 312 valid questionnaires were gathered, with a validity rate of 89%. In the formal survey, stratified random sampling was adopted, with a sample frame based on the division of eight major regions and 43 areas in the “Report on the Characteristics of Regional

Socioeconomic Development in Mainland China” by the Development Strategy and Regional Economy Research Department of the State Council’s Center for Developmental Research. A total of 1,500 questionnaires were distributed, and 1,163 valid ones were finally collected, with a 77% validity rate.

Research Instruments

The Initial Development of the Questionnaire

The questionnaire items were derived from interviews and the open-ended questionnaire survey. Keywords were extracted from the survey results, semantic units were identified, and categories were established through level-by-level coding. Based on the foregoing processes and the literature analysis, a three-dimension structural construct was created, with each dimension being specifically defined. Subsequently, a semantic analysis questionnaire, an item evaluation form, and an expert evaluation questionnaire were developed, and relevant specialists were engaged to assess the appropriateness and pertinence of the items included. With their professional comments and other established scales taken into consideration, an initial questionnaire consisting of 59 items across three dimensions was developed. Due to career plateauing being a discrete variable, an interval scale and the Likert 5-point rating method (from 1 denoting “absolutely disagree” to 5 denoting “completely agree”) were used. The questionnaire subjectively measures career plateauing through a self-report format, including a title, questionnaire description, answer instructions, questionnaire items, and a conclusion.

The Questionnaire Optimization

Data from the trial survey was utilized in the item analysis to finalize the question items. The critical ratio was used to detect the Sig value, and the item with the smallest t-value was deleted. The item-total correlation was calculated to delete items that reached the level of statistical significance. The reliability of the item was tested, and items with a corrected item-total correlation lower than 0.4 were removed. The commonality and factor loading of items were tested to delete those with factor loadings less than 0.45. Finally, 27 items that met the criteria were retained and included in the questionnaire.

Reliability Analysis

The Cronbach’s coefficient alpha was 0.922 (above 0.800) for the questionnaire and 0.902, 0.791, and 0.791 (all above 0.50) for the three dimensions

Table 1. Cronbach's Coefficients of Alpha of the Kindergarten Teacher Career Plateauing Questionnaire.

Names	# of Items	Cronbach's Coefficients of Alpha
Overall Career Plateauing	20	0.922
Emotional Plateauing	10	0.902
Professional Development Plateauing	5	0.791
Hierarchical Plateauing	5	0.791

Table 2. Matrix of Inter-Dimension Correlations and Dimension-Total Correlations.

	Dimension One Emotional Plateauing	Dimension Two Professional Development Plateauing	Dimension Three Hierarchical Plateauing	Overall Career Plateauing
Dimension One	/	0.614**	0.640**	0.925***
Dimension Two	0.614**	/	0.554***	0.805***
Dimension Three	0.640**	0.554***	/	0.825***
Overall Career Plateauing	0.925***	0.805***	0.825***	/

Note: ** $p < 0.01$, *** $p < 0.001$

of the questionnaire, respectively, indicating high consistency among the items and good reliability of the questionnaire itself and its three dimensions (Table 1).

Validity Analysis

- (I) Content Validity: This study conducted logical analysis and judgment on the validity of the questionnaire using a two-way specification table. It created questionnaire items based on the literature review, interviews, the open-ended questionnaire, and existing scales. The evaluation and post-trial survey revision of the questionnaire effectively guaranteed its content validity.
- (II) Expert Validity: In the processes of semantic analysis, item evaluation, and expert evaluation, valuable comments were generated for the modification of question items in terms of unidimensionality, clarity of expression, pertinence, relevance, and appropriateness, resulting in a questionnaire with a considerable degree of expert validity.
- (III) Construct validity. The coefficients of correlation between dimensions range from 0.55 to 0.65, and there are relatively high dimension-total

correlations, indicating that the questionnaire has desirable construct validity (**Table 2**).

Research Procedures and Data Processing

First, a questionnaire survey was carried out, and quantitative data were gathered from respondents' self-reports. Personnel who executed the trial and the formal surveys received unified training to ensure the effectiveness of their results. The reliability analysis, validity analysis, and exploratory factor analysis were administered to half of the data collected using the software SPSS 17.0, and the other half went through confirmatory factor analysis under AMOSS 5.0. A model of kindergarten teacher plateauing was constructed and validated.

Furthermore, the phenomenological method was adopted to gather qualitative data through interviews, which were based on relevant ethics and principles of voluntariness, convenience, and confidentiality. The survey participants were fully aware of the purpose, content, and methods of the study before signing the statement of informed consent. Interview questions were well prepared, and interviewers were trained to obtain phenomenological interview techniques in advance. The interviews were face-to-face, in-depth conversations that were recorded. Interviewers were required to pay attention to the gestures and facial expressions of the interviewees. After the interview, audio tapes were repeatedly played, written records were examined, and meaningful statements were preliminarily grouped. Essential and individually definable elements were extracted, and duplicate ones were deleted or merged. Themes were generalized from key elements through the methods of excerption, elaboration, and summary (Van Manen, 1997). Individual statements were presented in the interviewees' own words and interpreted with phenomenological analysis devices.

Results of Statistical Analyses

Exploratory Factor Analysis of the Kindergarten Teacher Career Plateauing Model

Goodness-of-Fit Test

The KMO test of data from the questionnaire survey of kindergarten teacher career plateauing resulted in a value of 0.945, and the Bartlett sphericity test showed a Sig value of 0.000 (**Table 3**), indicating the existence of common

Table 3. KMO and Bartlett Sphericity Tests Results of the Kindergarten Teacher Career Plateauing Questionnaire.

KMO Measure		0.945
Bartlett sphericity test	Approx. Chi-Square	7737.015
	Degree of Freedom(df)	351
	Sig Value	0.000

Table 4. Exploratory Factor Analysis of the Kindergarten Teacher Career Plateauing Questionnaire.

Items	Components		
	Factor 1	Factor 2	Factor 3
a21 No active responses to superiors' initiatives	0.745		
a14 Having different working attitudes from superiors	0.738		
a16 No concern with job outcomes	0.701		
a17 Losses of enthusiasm for the job, which is taken as routinized labor	0.677		
a15 Perception of heavy job pressures	0.645		
a13 Feeling no positive reactions from the leadership to my complaints	0.645		
a12 Deliberately distancing myself from the leadership	0.623		
a18 A low sense of achievement from the current job	0.610		
a9 My dedication to the job being undervalued	0.594		
a23 Feeling underpaid	0.559		
a27 No aspirations for further professional development		0.759	
a24 No intention of participating in selection and contests		0.755	
a6 Feeling overburdened with miscellaneous duties		0.687	
a20 No deliberate reflection on career planning		0.595	
a22 No intention of engaging in educational research		0.521	
a2 No intention of outperforming colleagues			0.717
a1 Low desire of pursuing leadership positions			0.708
a5 A lack of motivation for higher professional titles			0.679
a3 Perceiving overwhelming uncertainties in the process of promotion			0.664
a4 Few opportunities for promotions			0.510

Table 5. Goodness-of-Fit Index Test Results.

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI	RMS EA	LO 90	HI 90	PCL OSE	PRA TIO	PN FI	PC FI
Default model	0.879	0.863	0.908	0.895	0.908	0.069	0.064	0.075	0.000	0.879	0.773	0.798
Saturated model	1.000	/	1.000	/	1.000	/	/	/	/	0.000	0.000	0.000
Independence model	0.000	0.000	0.000	0.000	0.000	0.214	0.209	0.219	0.000	1.000	0.000	0.000

Table 6. Comparison of Goodness-of-Fit Indexes in Various Structural Models of Kindergarten Teacher Career Plateauing.

Models	x2	x2/df	RMR	RMSE	CFI	NFI	GFI	AGFI	RFI	IFI	TLI	PNFI	PGFI	PCFI
Measures		1-3	<0.05	<0.10	>0.90	>0.90	>0.90	>0.90	>0.90	>0.90	>0.90	>0.50	>0.50	>0.50
M1	1282.425	7.544	0.397	0.106	0.781	0.756	0.824	0.783	0.727	0.781	0.755	0.677	0.667	0.698
M2	997.238	5.866	0.101	0.091	0.837	0.810	0.822	0.781	0.788	0.837	0.818	0.725	0.666	0.749
M3	633.784	3.795	0.081	0.069	0.908	0.879	0.897	0.871	0.863	0.908	0.895	0.773	0.714	0.798
M4	560.744	3.419	0.072	0.064	0.922	0.893	0.908	0.882	0.876	0.922	0.909	0.771	0.709	0.796
M5	524.650	3.279	0.078	0.063	0.928	0.900	0.914	0.887	0.882	0.928	0.915	0.758	0.697	0.782
M6	633.784	3.795	0.081	0.069	0.908	0.879	0.897	0.871	0.863	0.908	0.895	0.773	0.714	0.798

factors among the correlation matrices. This demonstrated that the scale in question met the requirements of exploratory factor analysis.

Factor Extraction

Principal component analysis (PCA) was applied to extract common factors and reach the unrotated factor loading matrix. After that, the rotated factor loading matrix was obtained through varimax rotation. Multiple experiments were conducted based on the screening principles until a clear framework of dimensions emerged.

A three-dimension construct was established after the removal of items with a less-than-0.45 factor loading, items that appeared concurrently in two dimensions, and factors with only two items (**Table 4**). The factor loading of each of the 20 items was above 0.5, and there was no cross-factor relationship between these items.

Naming of Factors

The extracted factors were named and described according to the rules of factor naming. Factor 1 included 10 items and was named “emotional plateauing” to characterize the situation in which the emotional engagement of the kindergarten teacher in the current job shows no signs of increase or decrease after reaching a certain level. Factor 2 covered five items and was named “professional development plateauing” to describe the situation where the professional development of the kindergarten teacher halts for the time being after they have accumulated certain scales of expertise and skills, or their current job no longer provides challenges or developmental opportunities. Factor 3 included five items and was named “hierarchical plateauing” to characterize the state in which the professional title and position of the kindergarten teacher exhibit no signs of change after reaching certain levels as a consequence of the restriction of organizational structure.

Confirmatory Factor Analysis of the Structural Model of Career Plateauing among Kindergarten Teachers

Confirmatory factor analysis was administered to the data from the remaining 581 questionnaires with the software Amos 21.0 to test the appropriateness and applicability of the model. **Table 5** shows that the key goodness-of-fit indexes meet the statistical requirements, indicating that the model is consistent with the theoretical construct and that the questionnaire displays a significant level of construct validity.

Testing and Adjusting the Structural Model of Kindergarten Teacher Career Plateauing

To test the goodness of fit of the model in question, competing models were created for comparison and further analysis. After consulting the literature, the items in the present questionnaire were arbitrarily categorized into different factors to establish five competing models for the comparison of goodness of fit: Model 1 (M1), a null model (**Figure 1**); Model 2 (M2), a first-order single-factor model (**Figure 2**); Model 4 (M4), a first-order four-factor model (**Figure 4**); Model 5 (M5), a first-order five-factor model (**Figure 5**); Model 6 (M6), a second-order single-factor/first-order three-factor model (**Figure 6**). Model 3 (M3), a first-order three-factor model (**Figure 3**), was the model under testing.

Table 6 shows the goodness-of-fit indexes of all models. The χ^2 , χ^2/df , RMR, CFI, NFI, GFI, AGFI, RFI, IFI, and TLI values of M2 exceed prescribed measures, indicating poor goodness of fit of the single-factor model. Therefore, a one-dimensional structure is unsuitable for the model in question. The goodness-of-fit indexes of M3, M4, and M5 are by far more

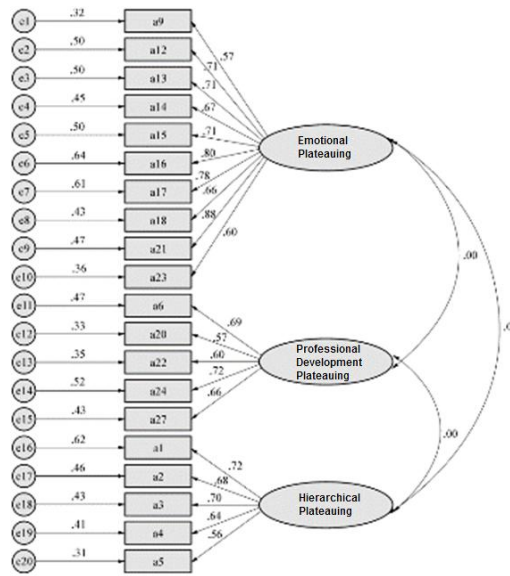


Figure 1. M1: A Null Model.

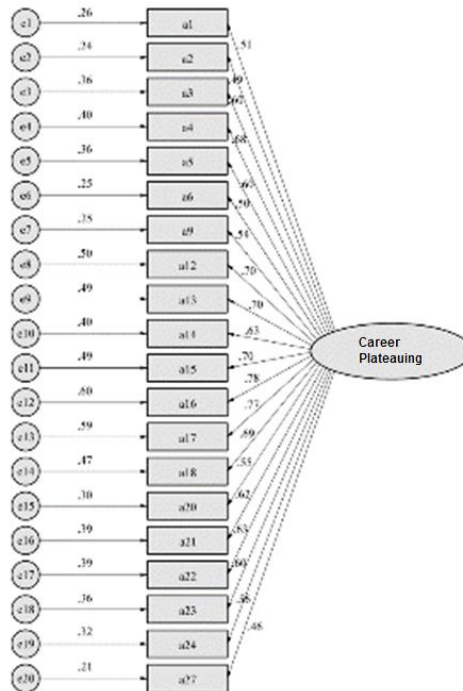


Figure 2. M2: A First-Order Single-Factor Model.

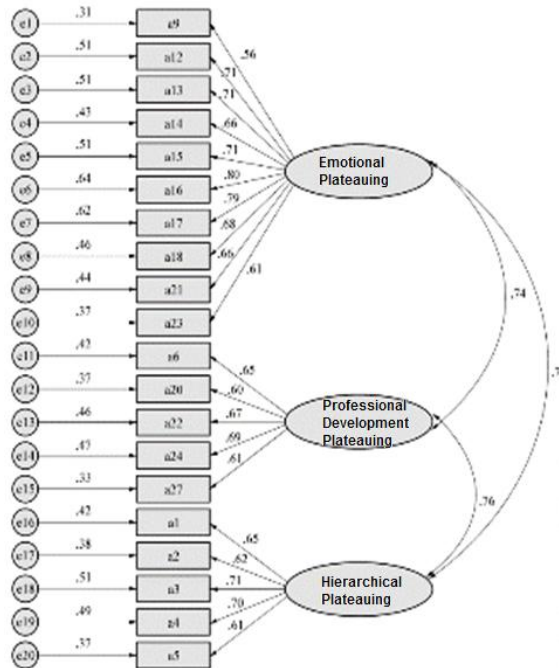


Figure 3. M3: A First-Order Three-Factor Model.

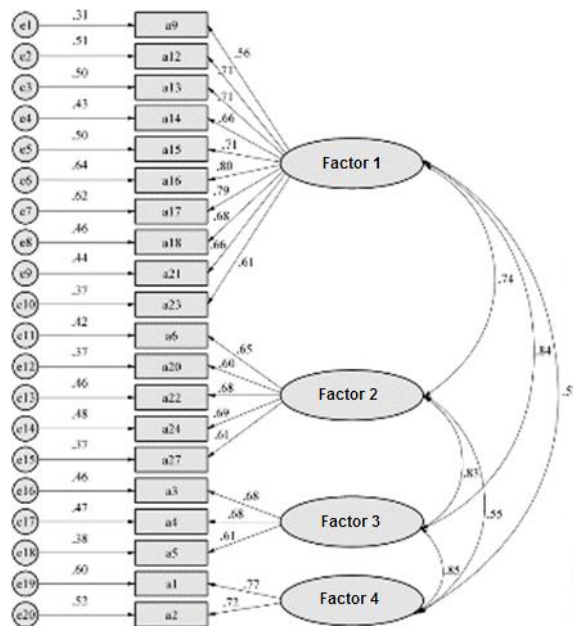


Figure 4. M4: A First-Order Four-Factor Model.

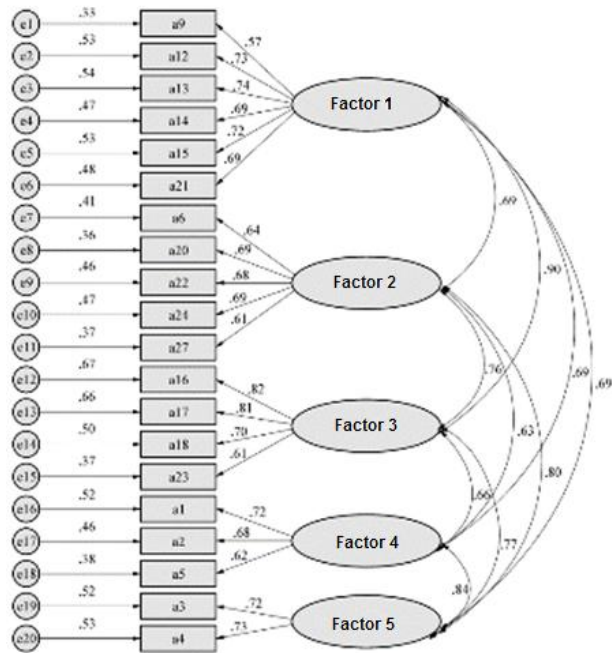


Figure 5. M5: A First-Order Five-Factor Model.

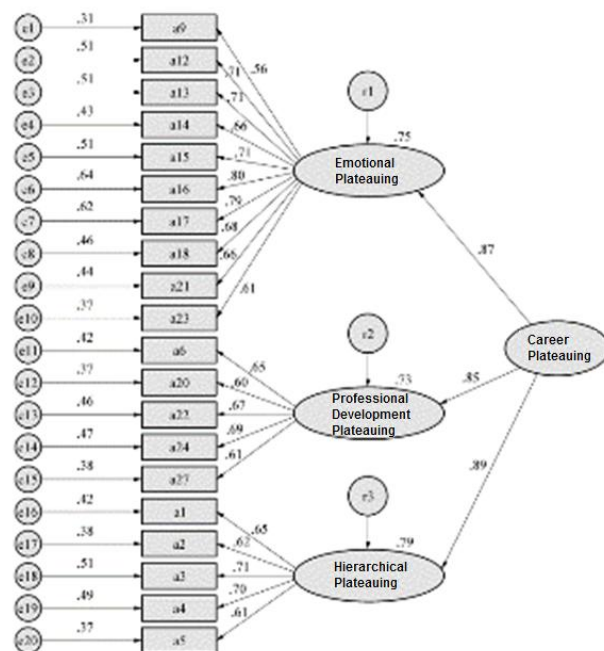


Figure 6. M6: A Second-Order Single-Factor/First-Order Three-Factor Model.

suitable than those of M1 and M2, showing the superiority of a multiple-dimension structural model. However, M4 and M5 both have dimensions with only two items after the process of clustering, so M4 and M5 were excluded. The goodness-of-fit indexes of M3 and M6 are identical. Nevertheless, the correlation coefficients between the three factors in M3 are above 0.74, indicating that these first-order factors are all influenced by a latent higher-order feature and that there is a higher-order structure that can explain the constructs of first-order factors. The factor loadings of the three first-order factors in M6 are 0.87, 0.85, and 0.89, all greater than 0.71, and their reliability index values are 0.75, 0.73, and 0.79, indicating the good quality of the model. In addition, the second-order structure's GFI and TLI values approximate 0.90, meeting the criteria of marginal interpolation. Therefore, M6 is superior to M3. As a result, the second-order single-factor/first-order three-factor structure (**Figure 6**) was selected as the structure for the kindergarten teacher career plateauing model.

Hence, based on the initial model of kindergarten teacher career plateauing, a final structural model with 20 items in three dimensions (**Figure 6**) was established after exploratory factor analysis, confirmatory factor analysis, and the comparison of competing models being conducted.

Results of Interviews

Experience of the Professional Development Plateau

Stagnation of Professional Progress

A Quotation from an Individual Statement: *I am presently experiencing a career plateau, feeling stuck between aspiration and reality and with a deep sense of emptiness. You aspire for education, but you are unsure of how to achieve them, or you know the right approach but find it difficult to apply in real-life situations. I accept those scientific notions of preschool education, but somehow, I have no chance to implement them or apply my professional expertise. For instance, at a demonstration class, an instructor may show us how to behave professionally when a child is looking for his personal stuff under the bed after the afternoon nap. In the actual classroom setting, however, a child's failure to get dressed up in time after the nap may result in missing snack time or causing a delay in the work of logistics staff. In this case, I have to stop them searching, even though I am fully aware that, professionally, I should be more patient with them. You do not know who you should turn to for issues like this; even those grade leaders or educational research team leaders cannot help too much. Also, the majority of training programs are based on the needs of performance evaluation, not on teachers'*

authentic needs for professional development. Research projects are often carried out in a superficial fashion, with few of them reaching meaningful outcomes. How can a serious project only last one or two years? Older teachers may have the chance to engage in longer-range research, whereas young teachers have no choice but to get involved in projects that come one after another. This is not favorable for their professional advancement.

Content Analysis: This interviewee is a teacher at a public kindergarten with over ten years of tenure. She stands out among the few teachers of her age in kindergarten who have been awarded senior professional titles, showcasing her dedication as a teacher. She has her own career ideals and aspirations and has been a front-line teacher for years. With her unique insights into early childhood education, she can look at events at the workplace from multiple perspectives. In her opinion, kindergarten events related to teacher professional development, such as in-service training, research projects, and regular teacher education activities, are typically treated as matters of form with a lack of effective implementation. Teachers cannot really benefit from them in terms of career progression. As for herself, she has gained a superior professional standing among her peers, and the current job is no longer challenging for her. However, poorly implemented research projects, which were intended to drive teacher professional development, have proven to be unhelpful for her career progress. She has been deeply perplexed by this issue, feeling that the workplace limitations have constrained her professional development and placed her on a career plateau.

Losses of Senses of Meaning in Work

A Quotation from an Individual Statement: *Being perfunctory is my current work attitude. I should do better at work and more for the children, but somehow, I cannot. Currently, multiple government departments are involved in the management of kindergartens. In addition to my teaching responsibilities, I have been assigned miscellaneous duties that make me feel overburdened but have no sense of meaning. I used to pay visits to my colleagues' classrooms and learn from what I thought were good practices. However, my colleagues were not happy about it. As a grade leader, I should collect lesson planning sheets from teachers in my grade. Once, we were assigned a lesson preparation task for a "theme-specific class-based activity." Teachers in other grades decided to submit one collective plan for each grade. However, I believed that since it was a "class-based activity," the content of lesson preparation should be tailored to each class. Therefore, I required teachers in my grade to submit an independent sheet for each class. As a result, teachers both in my grade and other grades opposed my proposal, claiming that I took the task in an unnecessarily serious way and would increase their workloads. I had to give up on my decision. Since then*

on, I no longer took my responsibility as the grade leader as seriously as before. I now just concentrate on finishing off my teaching duties and do not care much about other matters.

Content Analysis: This is a senior, responsible teacher from a kindergarten affiliated with the education bureau of X City, an economically prosperous city in southern Jiangsu Province. As an early childhood education experimental base, the kindergarten has undertaken a big variety of trial projects in early childhood care and education, teacher training, and curriculum reform and has received numerous visitors. Teachers here juggle a multitude of tasks. The requirements of leaders, parents of students, and the community are changeable and often contradictory with each other, which leaves teachers with no idea about the right way to follow them. Increased duties, temporarily added tasks, and constantly changing instructions from the leadership contribute to elevating tension and anxiety in teachers and distracting their attention from professional development. Making perfunctory efforts for all workloads is their coping response. She sees this work climate as the source of the career plateau she is experiencing. In the meantime, in the context of perfunctory “group attitudes,” her seriousness can make her colleagues’ carelessness more pronounced, resulting in her alienation from the collective. Under the influence of group behaviors, she has become less devoted to her job. In addition, there are no close connections between teachers from different classes. Collective activities for kindergarten teachers are mainly in the form of contests and selections. The lack of a cooperative atmosphere at the workplace is also unfavorable for their professional development.

Experience of Hierarchical Plateauing

Constrained Promotion of Professional Titles

A Quotation from an Individual Statement: *Among more than 50 teachers in this kindergarten, only 10% of them are working for a higher professional title; the majority of them intend to stay at the current levels of career plateaus. There are a very limited number of senior professional titles available to ordinary kindergarten teachers. Teachers with an education background like mine usually get a second-rank professional title after one year of service and a first-rank professional title after fulfilling the evaluation process. The senior professional title is the ceiling for most of them; only a few teachers and leaders strive for higher ranks. I don’t consider taking part in demonstration classes, publishing papers, or engaging in research projects anymore. At present, the demonstration class is typically a product of collective effort, and usually, the teacher with outstanding “star quality” is chosen to*

do the representation in order to make it impressive. It is not easy to get a paper published. The standards for papers are extremely high when you apply for a professional title above the senior rank. In the research project, it is assumed that the principal is the primary contributor, while the other participants are considered to play minor roles despite doing most of the work. I am currently holding the first-rank professional title, and I don't think it matters much to move ahead in professional title rating. It is too much trouble. Anyway, a professional title rating makes a difference in your pension after retirement, but with a minimal impact on your in-service compensation.

Content Analysis: The perception of this interviewee and her career trajectory are quite common among Chinese kindergarten teachers. The current criteria for kindergarten professional title rating are discouraging teachers from making further advancements after reaching a certain professional rank, and they are not sufficiently motivated to reach higher professional titles.

Slim Chances of Promotion to Higher Positions

A Quotation from an Individual Statement: I first encountered career plateaus 10 years ago. As a young teacher, I was selected as the grade leader. However, those teachers older than me were not happy about my promotion; you could feel jealousy and unfriendliness around you. At times, when selecting "excellent class teachers" and "excellent classes," I could not avoid offending some of my subordinates. If A was selected, B would be upset and spread humor about me. I could not do much except for transferring the instructions of my superiors to teachers in my grade. As a result, I chose to resign from the position of grade leader. Moreover, there was no higher position I could pursue after becoming a grade leader. Promoting a grade leader to deputy principal is challenging due to the high level of competence and experience required for all candidates. In many cases, the deputy principals of a public kindergarten are designated by the educational authorities. I often contemplate my future and question whether I will remain in my current position for the duration of my career.

Content Analysis: This interviewee is a male kindergarten teacher. In a female-dominated kindergarten setting, a male teacher appears somewhat like an intruder and has difficulty adapting to the communication styles of his female colleagues. Traditionally, men tend to be more ambitious than women in terms of career advancement. The flattening organizational structure of kindergartens provides slim opportunities for male preschool teachers to realize their career aspirations, therefore eliciting stronger senses of disappointment and helplessness in them. The interviewee has been in a state of career plateauing for a long time and has shifted his focus to part-time jobs. Shortly after the interview, he reportedly changed his profession.

Experience of Emotional Plateauing

Fading Positive Emotional Engagement

A Quotation from an Individual Statement: *To be a kindergarten teacher has been an aspiration of mine since I was young. I love children very much and love the profession of preschool education. I shared common notions of education with my co-workers from the previous class, and working there was very enjoyable. But in the current class, it's different. There is a divide in educational ideas between other teachers and me. Different educational ideas result in distinct educational attitudes, right? For example, should children be allowed to play with plastic building blocks during the last afternoon session before leaving kindergarten? Yes, since the game of building blocks is beneficial for them. In my view, children should be allowed time for spontaneous and low-control games. Nevertheless, my colleagues did not think it was a good idea because it would prolong students' stays at kindergarten. In the end, they agreed to my proposal on the condition that children must put away the toys before the parents come to fetch them. To complicate the issue, the childcare teacher raised the point that children must dismantle their "work" before leaving; otherwise, she would have to do it herself. As a result, the children had limited time for free play! I find my behaviors incompatible with the workplace environment and feel frustrated. In the past, I would leave aside the work that did not require immediate handling and do it at home so that I could spend more time with my students in the classroom. But now, whenever I can, I would rather keep myself away from them and occupy myself with other duties, for fear that I will get used to what is happening before my eyes, which is not the right interaction between preschool educators and young children.*

Content Analysis: This interviewee has a master's degree in preschool education, having developed a profound understanding of her profession and a substantial repertoire of early childhood education after seven years of undergraduate study and post-graduate program. As a novice teacher, she worked smoothly with those senior teachers whose educational ideas and methods were similar to hers. However, she cannot get along well with co-workers in the current new class; there is a huge gap in notions of preschool education between them. She is experiencing an unprecedented sense of distress, as she feels unrecognized, unaccepted, and isolated in the new environment. As a result, she faces a severe psychological crisis, doubting her self-worth and the significance of her career pursuit, which substantially compromises her emotional engagement in the present job.

Increased Negative Workplace Emotions

A Quotation from an Individual Statement: *People may say that children are a vulnerable group. So are teachers, indeed. For a while, I got so upset about workplace misunderstandings that I often complained tearfully to the principal. For example, once, a girl wet her pants after leaving kindergarten. It did not happen in the classroom, according to our final check. Anyway, her grandma filed a complaint against us, and our superiors criticized us. A child in my class told their parents at home that Z Teacher had stabbed him with a needle in the class, and they believed it and reported it to the principal, claiming that a three-year-old child would not lie. It happened that Z was off work that day, which could be testified by another teacher and me. If Z had been on duty that day, she would have been in trouble. In another case, a parent rang me up at night and asked me to go to her home immediately because her son said he was scratched by another child in kindergarten during the day. At that time, my child and I were running a fever, so my husband told me not to go out, but I decided to pay her a visit and check out. I also bought some fruits as gifts for the boy and managed to find his home, supported by my husband. Actually, there were no signs of scratches on the child's body, but his mother still threw tantrums, scolding me for not having watched her son closely. It was past ten o'clock when I got home. I was so upset that night that I considered ending my career as a kindergarten teacher. If I had one more insensible parent like her, I would choose to quit. Those years were a hurdle for me. To be honest, if there had been a better job available at that time, I would have left this position. I am an ordinary mortal, not a noble-minded person.*

Content Analysis: This teacher works at a private kindergarten and claims that she is going through a career plateau. She feels she is not being recognized and respected by the parents of her students. Amid ongoing conflicts with parents and surges in workloads, kindergarten teachers' grievances are accumulating. Kindergarten leaders and the public tend to think that kindergarten teachers should be patient with and tolerant of these illegitimate encounters and that dealing with home-kindergarten conflicts is among their job responsibilities. Little attention has been paid to the detrimental impacts of negative workplace emotions on preschool teachers' career development and the necessity of providing them with relevant psychological counseling. As a result, their emotional input in the job diminishes, which may even lead to the intention of leaving the job. The interviewee in the discussion spotted the shortcomings of teaching kindergarten when she compared it with other professions. However, there is no institutional mechanism in place to correct these shortcomings or organizational support and guidance available to her, resulting in her continuously accumulating negative emotional experiences at work.

Discussions and Analysis

The Structure of Kindergarten Teacher Career Plateauing

Research findings show that the structure of kindergarten teacher career plateauing is of multiple dimensions, comprising the first-order factor “career plateauing” and the second-order factors “emotional plateauing,” “professional development plateauing,” and “hierarchical plateauing.” There are commonalities and discrepancies in the results between this study and existing research. Since it was advanced by Bardwick, the construct of a three-dimensional career plateauing structure has been widely accepted, subsequently verified, and applied in many studies (Allen et al., 1998; Allen et al., 1999). The present study is a validation of this structure based on Chinese evidence. “Professional development plateauing” is basically identical with the job content plateauing in the literature, which refers to the stagnation of professional development of expertise, skills, and other aspects in the subjects (research participants). Professional development is one of the most important factors in the growth of kindergarten teachers. “Hierarchical plateauing” is also known as structural plateauing in the literature. Hierarchical development is a basic component of the initial definition of career plateauing as well as an essential consideration in career planning. “Emotional plateauing” describes the stagnation of the emotional input of the subject in the current job. To put forward this concept is to stress the importance of emotional development and its influencing factors for a career as a kindergarten teacher.

The commonalities in research results between the present study and the existing ones indicate the generality and stability of the structure of career plateauing in various professions. “Emotional plateauing,” which distinguishes this study from existing research, highlights the peculiarity of kindergarten teacher career plateauing and issues with emotional concern for kindergarten teachers.

The Kindergarten Teacher Career Plateauing Scale

The structural model of kindergarten teacher career plateauing was established on the basis of a literature review, interviews, expert evaluation, reliability and validity tests, and other processes. It meets the criteria of psychological testing and can be used as an assessment tool to evaluate the kindergarten teacher’s level of career plateauing. The self-developed “kindergarten teacher career plateauing questionnaire” can be utilized to gather statistical and demographic data for further dimension-specific research of kindergarten teacher career plateaus and to provide evidence for solving issues with career advancement in kindergarten teachers.

The Status Quo of Kindergarten Teacher Career Plateauing in China

The present study finds that the overall career plateauing of Chinese kindergarten teachers is at a moderate level, with nearly half of the teachers polled suffering from it. This indicates that kindergarten teacher career plateauing is relatively widespread under the current social and cultural backdrop and that factors related to teacher career plateaus are pervasive in our society.

Among the three dimensions, emotional plateauing is the most intensively perceived by Chinese kindergarten teachers as well as the most easily neglected issue. A considerable number of interviewees in this study complained that current preschool teacher education and training focused only on teachers' professional knowledge and behaviors, disregarding their emotional competence; that kindergarten management seldom praises or encourages teachers but instead frequently reprimands them even for minor problems; and that attention has been concentrated on high-performing teachers whereas those low-performing ones received no help. With heavy workloads and stressful pressures, kindergarten teachers need emotional support from relevant parties.

It is important to examine the plateauing professional development of kindergarten teachers within the context of the current initiative to professionalize preschool teaching staff. Despite the Teachers Law's provision that teachers are professionals specializing in educational and instructional responsibilities, the significance of preschool teachers' professionalism is less noticeable as the outcomes of early childhood education cannot be measured quantitatively in the short term, and as a result, the professional identity of the kindergarten teacher is not widely recognized by the public. Although the "Professional Standards of Kindergarten Teachers (Trial)" provide a framework of reference and direction for the professional development of this group, there are no concrete, operational stipulations in this government paper. How to promote the professional development of preschool teachers is an issue that deserves all stakeholders' attention.

Hierarchical plateauing is the earliest identified dimension in career plateau research. Nevertheless, it is a relatively less prominent issue among Chinese kindergarten teachers because the majority of this group is females, who have more conservative expectations of positional advancements due to their traditional family-centered roles. It also reflects the relatively flat organizational structure of preschool institutions. The organizational structure of a kindergarten is basically composed of three levels: ordinary teachers, middle-level management, and principals (including deputy principals). The principals are usually appointed by the local education authorities rather than being promoted to the top-level position from within the kindergarten. The

number of middle-level positions is limited, and promotion to this level largely depends on seniority. Therefore, promotion opportunities are scarce for ordinary teachers, and consequently, they have low expectations and little concern for positional changes. Regarding professional titles, far fewer kindergarten teachers can acquire them than their primary and secondary counterparts. The primary reason for this is the limited number of professional titles, particularly senior-rank titles, available for preschool staff. Moreover, the criterion of scientific research in professional title rating is also challenging for ordinary kindergarten teachers. Additionally, applying for professional titles is not encouraged in private kindergartens, and some of them are not even entitled to participate in professional title ratings. In sum, the majority of kindergarten teachers choose not to consider further hierarchical progress after reaching a certain professional level. This research result demonstrates the flattening organizational structure of kindergartens and the restricted paths of professional title elevation for preschool teachers.

Educational Implications

Strengthening Kindergarten Teachers' Career Planning

Teaching kindergarten is a specialized profession, requiring scientific, ongoing planning. It is important for preschool teachers to augment their career planning awareness and abilities. Career planning is the process of determining the action direction, timing, and plan for achieving career goals based on the individual planner's personal conditions and environmental factors. The notion of career planning originated from the early 20th century's career guiding movement in the United States, under the influence of theories of career development, whole-life development, and lifelong development. Kindergarten teachers should attach greater importance to career planning, recognize the significance of proactive planning in professional development, cultivate career planning and management habits, formulate development plans with clear goals and processes, and implement them through persevering efforts and effective measures. A well-crafted career plan significantly contributes to promoting the career progress of the preschool teacher, adjusting them to the development needs of kindergartens, and assisting them in overcoming career plateaus.

Encouraging Preschool Teachers' Use of Initiative in Professional Development

A plateaued teacher is a passive executor of assignments without initiative. Constrained by environmental factors, a plateaued kindergarten teacher can

only bury themselves in day-to-day chores, lose a sense of direction, and be unable to enjoy the charm and value of their profession. According to Schiller (1984), when a human is permanently bound to a separate fragment of a system, they gradually turn themselves into a fragment. What fills their ears is the monotonous noise of the machine wheels they are driving. In such a situation, they cannot develop a harmonious existence. Hence, it is important for kindergarten teachers to actively explore the meaning of their careers. They should keep themselves informed of the current dynamics of early childhood education development and increase their agency in shaping career trajectories. Self-construction is a precondition of free development. Through using their initiative and exercising autonomy, preschool teachers can extricate themselves from career plateaus and head for a broader career prospect.

Kindergarten Teachers' Career Development Is a Long-Term Course

The survey results of the study show that career plateauing experiences are common among preschool teachers, and their career plateaus are related to a wide variety of factors. Therefore, a reasonable understanding of career progression and realistic goal setting are crucial to kindergarten teachers' career planning. According to Bollnow (1999), it is impossible for an individual to develop with high momentum continuously and permanently. They often encounter burnout due to personal dispositions and burdens, falling into an undesirable state of degeneration. Teacher development is a long-term endeavor. Preschool teachers' lifelong learning is a practice aligned with the prevailing notion of lifelong education for all. The objective of lifelong education is to increase the individual's capacities to learn, which include the habit of persistent learning, self-renewal ability, and the capability to cope with ever-emerging challenges. Kindergarten teachers should prepare for a long course of active learning, continuously improving their understanding of the preschool profession, delving into its value, and, in the meantime, enjoying successes in their careers to circumvent career plateaus and achieve long-term development.

Conclusion

A substantial portion of kindergarten teachers can successfully transition from being novices to mature teachers but may encounter barriers to further career progress. Career plateauing among preschool teachers has become a grave issue involving a wide range of influencing factors, challenging the sustainability of their professional development. As a result of increased

public investment in early childhood education and expanded preschool teacher education, the shortage of kindergarten teacher supply has been significantly mitigated. Preschool teacher development will become the focus of attention in the ensuing period. Researchers can further explore the factors impacting the professional and cultural environment of kindergarten teachers or conduct finer-grained studies based on the present one to look into specific career plateauing issues faced by Chinese preschool teachers in different regions and at varied developmental levels and ascertain the support and assistance they need. In addition, due to the integration of care and education in early childhood education, career plateauing issues among kindergarten caregivers and health care providers also deserve specialized investigations.

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Professional Learning Community (PLC) in STEAM Education: A Hands-On Workshops Sample[¶]

Filiz Gülhan

Ministry of National Education, Turkey

Abstract: STEAM education puts professional learning communities on the agenda by requiring teacher collaboration along with disciplinary integrity. In this study, a professional learning community in STEAM education was investigated by observing 49 teachers from different disciplines working in different districts during 16 weeks of interdisciplinary training and their practice with students. Teachers' perceptions of skills teaching self-efficacy, design self-efficacy and perceptions of interdisciplinary teaching were assessed using pre-post tests. The research concluded that the STEAM professional learning community study positively improved teachers' perceptions of skill teaching self-efficacy and interdisciplinary teaching, but was not sufficient to develop design self-efficacy. It was found that teachers' views of practice were positive and that interdisciplinary collaboration contributed to this. In light of the research findings, it was suggested that the use of professional learning communities in STEAM education may be an effective example of the interdisciplinary functioning of hands-on workshops.

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About the Authors: Filiz Gülhan, Associate Professor, Dr., Ministry of National Education, Turkey, E-mail: flzgulhan@gmail.com, ORCID: <https://orcid.org/0000-0002-7915-6299>

Correspondence to: Filiz Gülhan at Ministry of National Education of Turkey.

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Note: Permission was obtained from the Istanbul Provincial Directorate of National Education with E-59090411-20-47554064 coded document to research these studies.

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Introduction

THE interdisciplinary nature of STEAM education brings teachers together as a professional learning community. For this purpose, STEAM education, professional learning communities and studies that combine the two concepts were reviewed. From the applications in the literature, the possible reflections on the applications in the hands-on workshops were explored.

STEM/STEAM Education

Interdisciplinary approaches enable the establishment of new connections and a creative perspective by providing a holistic approach to problems (Klein, 2005; Lederman & Niess, 1997; Yıldırım, 1996). STEM (Science, Technology, Engineering, Mathematics) education has become a highly regarded approach among interdisciplinary educational approaches worldwide and is frequently discussed as a research topic in education (Arslan & Arastaman, 2021; Bybee, 2013; Freeman, Marginson, & Tytler, 2019; Schomer & Hammond, 2020). According to Beers (2012), STEM education includes the 4Cs (critical thinking, creativity, communication and collaboration) skills that are essential for the 21st century.

With the addition of A (art) to related fields under the name of STEAM, STEM education has gained a structure in which creativity comes to light even more (Bequette & Bequette, 2012; Lewis, 2015; Watson & Watson, 2013; Wynn & Harris, 2012). STEAM, as an expanded concept of STEM, involves the creation of a new curriculum by merging more than one subject (Kwon, Nam, & Lee, 2011). In this respect, STEAM represents a more holistic model of education than STEM (Huser et al., 2020). Due to its multidimensional nature, STEAM education requires the collaboration of teachers from different fields and with different experiences, as well as emphasising the collaborative work of students.

Professional Learning Community (PLC)

Learning communities are social entities created by involving colleagues, students and professionals in a way that allows each member to learn from each other (Glaze-Crampes, 2020). Professional learning communities; it is defined as an environment that promotes professional development, collaboration and innovation among teachers (Brown, Horn, & King, 2018). The success of these applications; it shows that learning and teaching starts with the students, and the role of the teacher is to facilitate learning (Phusavat et al., 2018).

Although originally developed for the business world, PLCs were adopted by educational reformers as a component of the teaching profession in the mid-1990s (Irish, 2016). Educators and administrators, Richard DuFour & Mike Schmoker, pioneered change in the education field with the learning communities they created (Brown et al., 2018). Teachers working in strong learning communities have been found to be more satisfied with their careers and are successful educators who stay in teaching long enough (Fulton & Britton, 2011). Teachers who participate in professional learning community practices have been found to improve in the areas of curriculum, classroom management, learning, teacher role, and learning to teach (Kareemee et al., 2019).

Internationally, PLC practices are referred to in different ways. Lesson study in Japan, lesson group and research group in Shanghai, “teach less learn more” model in Singapore, problem solving group in Finland (problem solving group) (Wetwiriyaakun et al., 2021). Ansawi & Pang (2017) found that perceptions of professional learning communities were positively and highly correlated with lesson study. Lesson study is seen as a way to facilitate the practice of professional learning communities (Chichibu & Kihara, 2013).

In school practice it can be focused on these four points: planning, data collection, intervention and enrichment stages (Cansoy & Parlar, 2017). Altun (2020) found that teachers are motivated to develop, their self-awareness and their ability to collaborate develop in the study in which he examined the professional learning communities in two schools in action research. Aykan & Yıldırım (2021) reported that science teachers’ pedagogical knowledge and content knowledge improved in their research in which they integrated the lesson study model into distance STEM education.

Researches that Brings the STEM/STEAM Education and Professional Learning Communities (Plcs) Together

Communities of practice in STEM are a critical factor required by the interdisciplinary nature of the field (Han, Kelley, Mentzer, & Knowles, 2021). STEM/STEAM requires teachers from different disciplines to collaborate, which brings PLCs to the forefront (Blankenship, 2015; Bush et al., 2016; Irish, 2016; Öztekin, 2019). In STEM collaborative applications, team size, instructional goals, and the structure of collaboration between teachers have a significant impact on interdisciplinary success (Wang et al., 2020). In a systematic review of research on STEM communities of practice, Han et al. (2021) found that supporting collaborative learning and context-based learn-

ing contributes to student learning by increasing STEM teachers' collaboration, teaching skills and self-efficacy.

Studies on the close relationship between STEM/STEAM education and professional learning communities can be founded in the literature (Fulton & Britton, 2011; Glaze-Crampes (2020). Models developed for the combination of PLC and STEM are available in the literature (Kezar & Gehrke, 2017; Richmond et al., 2017).

The studies were conducted to emphasise the teacher collaboration in PLC applications: STEM professional development workshop (Khumwong et al., 2017; Phusavat et al., 2018; Woodruff, 2021), sustainable PLC system (Phusavat et al., 2017), out-of-school STEM (Kelley & Williams, 2013; Santaolalla et al., 2020; Suriel et al., 2018; Swanson Hoyle, 2017; Swanson, 2018), STEM in the preschool period (Brenneman, Lange & Nayfeld, 2019), online PLC STEM education (Kareemee et al., 2019), STEAM practices (Boice et al., 2021; Cook, Bush, Cox Jr & Edelen, 2020; Pollard, 2019), design and technology education (Vossen, Henze, De Vries & Van Driel, 2020), problem solving to socioscientific issues (Ekici et al., 2018; Thana, Siripun & Yuenyong, 2018).

Similar to professional learning communities, the number of applications of the model, which is called course research, in interdisciplinary curricula such as STEM is much lower in the literature (Gülhan, 2021a; Holden & Fotou, 2021). Therefore, there is a need for research that combines the concepts of STEM/STEAM education and professional learning communities/course research.

A Hands-On Workshops Sample: Design Skill Workshops (DSW)

Design Skill Workshops is an application included in the 2023 Vision Document of the Ministry of National Education of the Republic of Turkey. In this document, it is described as “an area to be established in all schools for the development of children's interests, talents and dispositions” (MoNE, 2018, p. 24). The design skills workshops are similar to the maker workshops in the global examples, but they are separated from the other global examples by the addition of sports and living spaces (Mısırlı, 2021). STEAM education encompasses many disciplines, it can gather all areas of science, arts, sports, culture and life in DSW under one roof. This brings to mind the necessity of applying interdisciplinary approaches in order to shape DSW with an educational structure.

In the survey conducted among school stakeholders in Istanbul regarding their expectations of DSW, it was found that DSW was viewed positively and hope, but teachers were the group most worried about the risks

that DSW might pose (Gülhan, 2021b). Considering that teachers are the key educational element, it can be concluded that one of the most important steps is teacher education.

In DSW, it is considered as the ideal element for collaborative and interdisciplinary teaching and where the most valuable equipment in its content is activities rather than space (Istanbul Provincial Directorate of National Education-IstMEM, Design skill workshops-application guide and interdisciplinary activity suggestions booklet, 2021). In this regard, studies have been conducted to transform DSW into a STEAM and professional learning community application specific to Turkey. The activities of the Istanbul DSW Academy, in which teachers from different branches and working in different districts apply by application, and the trainers are teachers with workshop experience, that has lasted throughout an educational period, were the subject of this research in 2021-2022 fall session.

In this research, the concepts of STEAM education and professional learning communities in the international literature were brought together under the roof of DSW in the sample of Turkey, and it aimed to provide an example of how to handle and maintain DSW with an interdisciplinary approach. For this purpose, the following questions were investigated in the research:

1. What is the effect of a STEAM professional learning community (PLC), on teachers' perceptions of their self-efficacy for teaching skills?
2. What is the effect of a STEAM professional learning community (PLC), on teachers' design self-efficacy?
3. What is the effect of a STEAM professional learning community (PLC), on teachers' perceptions of interdisciplinary teaching?
4. What are the opinions of the teachers who participated in the implementations, of the STEAM professional learning community (PLC)?

Methodology

The mixed method was used in this study. The mixed method has been; it is described as "a middle ground between empirical quantitative strategies and natural-qualitative strategies" (Patton, 2014). While the pretest-posttest single-group experimental design was used in the quantitative part of the research, the case study was used in the qualitative part. The findings obtained from the quantitative tests were supported by the findings obtained from the open-ended questions. Permission was obtained from the Istanbul Provincial Directorate of National Education to conduct these studies.

Participants

Table 1. Demographic Information of the Participants of the Research.

Gender (f)	Where They Work (f)	Professional Sceneries (f)	Educational Situations (f)	Branches (f)					
Woman	2	European Side	4	1-5 year	5	License	6	Primary school teacher	12
Man	7	Anatolian Side	5	6-10 year	15	Master	3	Technology-design	9
				11-20 year	20			Pre-school teacher	7
				20 above	9			Science	3
								Information technologies	3
								Mathematics	3
								English language	3
								Guidance and psychological counseling	3
								Special education	2
								Physical education	1
								Visual arts	1
								Music	1
								Geography	1

Maximum variation sampling, which is one of the purposive sampling methods, was used in the study. The aim of maximum diversity sampling is to reflect the diversity of individuals in a relatively small sample at the maximum level and to investigate the existence of common or shared phenomena in diverse situations (Yıldırım & Şimşek, 2008). In the research, in order to reach teachers from different branches working in different districts, applications were received via the link created through Google Forms. The application form asked about the district-school, the year of professional seniority, the branch, whether they had conducted workshops in their schools, the training they had previously received and the reasons for applying for this training. By examining the answers, teachers with different characteristics were selected. The study group of the research consisted of 49 teachers selected from among the teachers who applied to the Academy.

As can be seen in **Table 1**, 32 (65.31%) of the 49 participants are women. The professional seniority of most of the participants (40.82%) is between 11-20 years. Most of the participants (73.47%) are undergraduate graduates. Looking at the distribution by branches, it is seen that primary school teachers (24.49%), technology design teachers (18.37%) and pre-school teachers (14.28%) are in the majority, respectively.

The interview questions, which are the qualitative part of the research, were applied to 6 teachers selected from the study group with maximum diversity sampling. The teachers to whom the interview questions were applied; they are teachers who represent a wide spectrum in terms of group, gender,

branch and professional seniority. The teachers' answers of the teachers were evaluated by coding them as T1, T2, T3 etc. The descriptive characteristics of the interviewed teachers are as follows: T1 coded teacher is a female primary teacher with 15 years of seniority. T2 coded teacher is a female physical education teacher with 8 years of seniority and a master's degree. T3 coded teacher is a male information technology teacher with 7 years of seniority. T4 coded teacher is a female primary teacher with 21 years of seniority. T5 coded teacher is a male primary teacher with 25 years of seniority. T6 coded teacher is a female pre-school teacher with 14 years seniority and a master's degree. Interviews were conducted with these teachers, who had mixed characteristics and were selected with maximum diversity sampling.

Data Collection Tools

The characteristics of the data collection tools used in the research are explained under the headings.

Perception of Skill Teaching Efficiency Test

The Cronbach Alpha reliability coefficient of the scale, which was developed by Çelik and Çetin (2020) and whose validity and reliability studies were conducted, was found to be 0.95 and it was determined that the scale was suitable in terms of fit indices. Sub-dimensions of the scale; It covers 21st century skills consisting of collaboration (10 items), communication (8 items), creativity (7 items), problem solving (4 items) and critical thinking (3 items). The 5-point Likert-type test, consisting of 32 items, aims to measure teachers' perceptions of competence about the teaching of the specified skills.

Design Self-Efficacy Scale

The scale developed by Beeftink et al.d (2012) was adapted into Turkish by Atabek (2020), and it was determined that the Cronbach Alpha reliability coefficient of the scale was 0.87 and it had adequate psychometric properties. The 5-point Likert-type test, which consists of 8 items, aims to measure the perception of self-efficacy regarding the realisation of the design.

Perception of Interdisciplinary Teaching Test

The Turkish adaptation of the scale developed by Bayer (2009) was conducted by Karahan et al. (2017). The researchers found that the Cronbach Alpha reliability coefficient of the scale was 0.71 and the fit indices were significant. The 5-point Likert-type test, which consists of 16 items, aims to measure teachers' perceptions of interdisciplinary teaching.

The Interview Form for Evaluation of Implementations

The interview form by the researcher includes 6 open-ended questions. The first three of the questions are questions that examine the development of skills teaching efficacy, design self-efficacy and perceptions of interdisciplinary teaching in support of the 3 questionnaires used in the research. The other three questions are designed to establish their views on teaching. These are questions about the practice of course research, about their views on working collaboratively with their colleagues, and about expressing the positive and negative aspects of education and its permanence. The questions were administered in writing to 6 teachers selected with maximum diversity sampling from the group and subjected to descriptive analysis.

Implementation of Research

The aim of this training is for each teacher to have an idea about each type of workshop, so that a holistic perspective can be created for the lesson plans to be developed as a professional learning community.

The Istanbul Design Skill Workshops (DSW) Academy, where the research was carried out, it consists of the sections of discovery, production and dissemination covering an education period. The discovery period, which started in September 2021, ended in December 2021, after which the production period continued until February 2021. The dissemination period ended in March 2022 and the final tests were carried out. During the dissemination period, which began after the end of the research, teachers attended school-based training sessions and implemented the practices with their colleagues.

During the exploratory phase, teachers were given practical training in workshop types. As all those working as trainers are teachers, a teacher-to-teacher exchange of experience was realised during the discovery phase. The trainers are teachers who have experienced and practised each type of workshop, coordinated by a specialist in interdisciplinary approaches (STEM/STEAM educator). During the 9-week discovery phase (one day per week), teachers participated in workshops. They carried out practical activities by recognising the types of workshops. Istanbul DSW Academy trainings were held once a week in two centres on the European and Anatolian sides, the same training was given to both groups.

During the production period, the teachers prepared interdisciplinary activity plans with groups of teachers from different branches, which they formed optionally. They applied the interdisciplinary activity plans they prepared with the students in the workshop environments. They revised and finalised their plans by discussing them. This study was transformed into a booklet and digitally published by the Istanbul Provincial Directorate of Na-

Table 2. Implementation Schedule and Contents.

Research Step	Period (Week)	Implementation Step
DISCOVERY period in which hands-on work is done in workshop types	1	Application of pre-tests and start of research
	2	STEM Workshop
	3	Software-Design Workshop
	4	Nature and Animal Care Workshop
	5	Drama and Critical Thinking Workshop
	6	Wood-Metal Workshop
	7	Life Skills Workshop
	8	Indoor Sports and Saloon Sports
	9	Music Workshop
	10	Visual Arts Workshop
PRODUCTION period, in which activity plans are developed and implemented with students with the lesson study model	11	Formation and planning of working groups
	12	Discussions on plans
	13	Practice with students
	14	Revision of plans
	15	Finalization of the production period
	16	Making plans for workshop types
DISSEMINATION period, of trainers for teachers	During The month	Realization of school-based teacher training and implementation of the post-tests

tional Education (IstMEM-DSW Examples of Interdisciplinary Activities Teacher’s Booklet, 2022).

In the third and final stage, called dissemination, the teachers who had completed the training at the DSW Academy in Istanbul started to take part in in-service teacher training. To do this, they first identified the type of workshop they would train, and then created teacher training activity plans together with the teachers who had chosen the same type of workshop. They then carried out school-based training for teachers working in schools with workshops. Similar to the training they had received themselves, they provided their colleagues with one-day training sessions in which the workshop types were introduced and practical activities were carried out. The whole process is summarised in **Table 2**.

Table 3. Normality Analysis of Data.

	Test	Statistics	df	Sig
Perception of Skills Teaching Efficiency	Pre test	0.584	49	0.000
	Post test	0.707	49	0.000
Design Self-Efficacy	Pre test	0.933	49	0.008
	Post test	0.905	49	0.001
Perception of Interdisciplinary Teaching	Pre test	0.867	49	0.000
	Post test	0.967	49	0.176

Analysis of Data

In order to analyse the data obtained from the data collection tools used in the research, it was first examined whether they showed a normal distribution (**Table 3**).

Since the Shapiro-Wilks test is recommended for normality analysis in case the group size is less than 50 (Büyükoztürk, 2015), the analysis was performed with the related test. Since the p value of the tests was less than 0.05, it was determined that the scores did not show normal distribution (except for the last application of the perception test for interdisciplinary teaching), and analysis was performed with the non-parametric Wilcoxon signed-rank test.

Descriptive analysis was used to evaluate the interview questions in a qualitative research study. Data analysis steps in qualitative research; it consists of the steps of organising raw data, reading all of the data, coding the data, creating themes or descriptions, linking themes or descriptions, interpreting the meaning of themes or descriptions (Creswell, 2014). The data was subjected to descriptive analysis.

Findings

In this section, findings were obtained from the data obtained with the help of data collection tools and presented.

Findings Regarding Perception of Skills Teaching Efficiency

Table 4. Findings Regarding Perception of Skills Teaching Efficiency.

Skills Teaching Efficiency Perception	Posttest-pretest scores	N	Average rank	Total rank	z	p
Collaboration	Negative ranks	7	140.64	1020.50	-30.895*	0.000
	Positive ranks	31	200.60	6380.50		
	Equal	11				
Communication	Negative ranks	8	230.31	1860.50	-30.021*	0.003
	Positive ranks	32	190.80	6330.50		
	Equal	9				
Creativity	Negative ranks	10	150.70	1570.00	-20.008*	0.045
	Positive ranks	22	160.86	3710.00		
	Equal	17				
Problem solving	Negative ranks	13	130.85	1800.00	-20.232*	0.026
	Positive ranks	22	200.45	4500.00		
	Equal	14				
Critical thinking	Negative ranks	6	100.75	640.50	-30.331*	0.001
	Positive ranks	23	160.11	3700.50		
	Equal	20				
Perception of Skills Teaching Efficiency	Negative ranks	12	160.71	2000.50	-30.718*	0.000
	Positive ranks	34	250.90	8800.50		
	Equal	3				

*Based on negative ranks

There is a significant difference between the skill teaching proficiency perception scores before and after the application ($z = 3,718$, $p < 0.05$). Since the observed difference is in favour of the post-test, it can be stated that the application has a positive effect on teachers' perceptions of skill teaching proficiency.

When the scores of the sub-dimensions of perception of competence in skill teaching before and after the application are examined, it is seen that there is a significant difference in each of them ($p < 0.05$). Since the observed difference is in favour of the post-test, it can be stated that the application has a positive effect on all sub-dimensions of teachers' skill teaching competence perceptions (**Table 4**).

Findings Regarding Design Self-Efficacy

There is no significant difference between the design self-efficacy scores before and after the application ($z = 1,461$, $p > 0.05$). Although there was an increase in the positive ranks in favour of the post-test, this difference was not significant, and it was found that the application was not effective in improving the design self-efficacy of the teachers (**Table 5**).

Table 5. Findings Regarding Design Self-Efficacy.

	Posttest-pretest scores	N	Average rank	Total rank	z	p
Design Self-Efficacy	Negative ranks	16	160.88	2700.00	-10.461*	0.144
	Positive ranks	22	210.41	4710.00		
	Equal	11				
	Total	49				

*Based on negative ranks

Table 6. Findings Regarding Perception of Interdisciplinary Teaching.

	Posttest-pretest scores	N	Average rank	Total rank	z	p
Perception of Interdisciplinary Teaching	Negative ranks	10	170.45	1740.50	-40.361*	0.000
	Positive ranks	39	260.94	10500.50		
	Equal	0				
	Total	49				

*Based on negative ranks

Findings Regarding Perception of Interdisciplinary Teaching

There is a significant difference between the perception scores of interdisciplinary teaching before and after the application ($z = 4.361$, $p < 0.05$). Since the observed difference is in favour of the post-test, it can be stated that the application has a positive effect on teachers' perceptions of interdisciplinary teaching (Table 6).

Findings Obtained from the Interview Questions for the Evaluation of Implementations

The answers given in the interview with 6 teachers among the study group were analyzed descriptively, coded and themes were created. It is presented with direct quotations and support.

Findings of the answers to the questions: “What can be done to teach students 21st century skills? What do you think the DSW Academy training process adds to you in terms of skill teaching?”

Among the 21st century skills of teachers, it was seen that the components of collaboration (f = 3) and creativity (f = 2) were most emphasised. The assessment that an interdisciplinary approach and teaching based on applied activities is a 21st century necessity was made by all interviewed teachers (f=6). As an example, the answer of the teacher coded T6, who emphasised the issues of collaborative work and creativity, is given below:

“I think that in the DSW Academy training, our individual achievements, our creativity motivation and collaborative work are given great importance.” (T6 coded teacher’s response)

Findings of the answers to the questions: “How would you rate yourself about designing? What do you think the DSW Academy training process adds to your design skills?”

Some of the teachers stated that they think of designing as a lesson plan or activity design (f = 3) rather than designing products. There are also teachers who answered by evaluating design as an interdisciplinary field (f = 3). Below is the answer of the teacher coded T5 and T3 that illustrates this idea:

“I can say that the interdisciplinary relationship has opened my horizons. I create and implement a design for each lesson every week.” (T5 coded teacher’s response)

“Designing has always been in my life, but I was thinking about only one field. I have seen that it has a great contribution to my design in different fields with DSW Academy and it is related.” (T3 coded teacher’s response)

As can be seen from the answers, it was interpreted that DSW Academy studies are effective in the formation of interdisciplinary design ideas. In order to exemplify this thought, the answer of the T4 coded teacher was given:

“I can say that the DSW Academy education opened a different window for me, not in terms of design skills, but in terms of why I made the design and how I would apply it.” (T4 coded teacher’s response)

Findings of the answers to the questions: “What do you think about interdisciplinary teaching? What do you think the interdisciplinary practices in the DSW Academy education process add to you?”

The teachers stated that their interest in the interdisciplinary approach increased and they started to do research (f = 3), they witnessed the benefits to the students (f = 2), and the contribution of collaborating with their colleagues (f = 1). Below is the response of the T6 coded teacher, who considers interdisciplinary approaches as a collaboration with colleagues:

“During the DSW Academy process, I saw that we were able to create a joint product by agreeing with my friend in an area that seemed relatively far away from my field. The coming together of different disciplines has created a very valuable situation to combine forces in a way.” (T6 coded teacher’s response)

Findings of the answers to the questions: “What did you encounter when you carried out the interdisciplinary activities in the lesson study practice you did with your groups? What were the positive and negative aspects?”

The interviewed teachers stated that positive contributions were made in the planning part (f = 3), the students’ approaches during the application were positive (f = 1), and the low level of commitment of the group members might negatively affect the application (f = 1). As an example, the answer of T1 coded teacher is given:

“I can say that I had a little difficulty. I saw myself getting too far away from making lesson plans. It was great to have our friends from different branches with us. Where we had difficulties while integrating them into the lessons, their ideas came into play and our lesson plans became whole.” (T1 coded teacher’s response)

Findings of the answers to the questions: “How did collaborating with your colleagues make you think? What were the positive and negative aspects?”

It was observed that the teachers interviewed gave positive evaluations in terms of sharing experiences (f = 3), working towards a common goal (f = 2) and enriching their perspectives (f = 1). The answers of T2 coded teacher who exemplify the situation are given:

“As someone who has always believed in the importance and power of collaboration, I can say that it is very enjoyable. In particular, different ideas, thoughts, opinions and suggestions allowed my perspective to be enriched. I didn't feel any negative side of it.” (T2 coded teacher's response)

Findings of the answers to the questions: “What were the positive and negative aspects of DSW Academy training? Do you continue to apply the knowledge and skills you acquired in training?”

There are teachers who evaluated the positive aspects of DSW Academy education as stimulating (f = 2) and emphasized the importance of being practical (f = 2). The answer of the teacher coded T6, which sets an example for these answers, is given below:

“After I got the logic in my head and assimilated it, it created a very convenient and easy-to-apply learning style theme for me. In addition to applying the knowledge and skills I gained in education in my classroom, I also give ideas and feedback to my colleagues around me.” (T6 coded teacher's response)

As the negative aspects of DSW Academy education, there were teachers who stated that the discovery period in which the workshop lessons were held should be longer (f = 3) and that there were deficiencies in the preparation of schools and teachers for this system (f = 1). The answer of the T3 coded teacher is given as an example:

“DSW Academy is more application and product oriented than theory. When designing something, I examine whether it is related to which achievement in which lesson is addressed. I have

expertise in one area, but I add other areas to my teaching as much as possible.” (T3 coded teacher’s response)

There were teachers who stated that they had plans to work in collaboration with their colleagues ($f = 3$) and that they were trying to establish a workshop ($f = 1$) to apply the knowledge and skills they had acquired in the DSW Academy. The answer of T2 coded teacher summarizing these ideas is given below:

“I share it with my other branch friends, and while I am preparing my annual plan for the next year, I have the idea of cooperating with my friends from different disciplines by adding interdisciplinary activities to my plan.” (T2 coded teacher’s response)

Conclusion and Discussion

In this research, the concepts of STEAM education and professional learning communities (PLC) were brought together under the roof of DSW in the sample of Turkey, and the implementations were studied.

The following results were obtained with the application made in the research: The STEAM professional learning community, improved teachers’ perceptions of skill teaching self-efficacy and all its sub-dimensions in a positive way. The skills teaching questionnaire and the interview questions were found to be mutually supportive. The fact that the most emphasised 21st century skills component in the answers given to the interview questions was collaboration, was supported by the fact that it was the most developed dimension ($z=3.895$, $p=.00$) in the pre-post survey.

The STEAM professional learning community did not make a significant difference in improving teachers’ design self-efficacy and was ineffective. It can be said that the design skills questionnaire and the data from the interview question are mutually supportive. The fact that there was no significant difference between the pre-post tests in the findings of the questionnaire was confirmed by the teachers’ statements that their design skills did not develop significantly. However, the teachers stated that their interdisciplinary design thinking and design skills in creating lesson plans and activities had improved.

The STEAM professional learning community has improved teachers’ perceptions of interdisciplinary teaching in a positive way. The positive result obtained from the perception scale for interdisciplinary teaching is also supported by the answers to the interview questions. Teachers expressed ideas about developing DSW Academy’s interest in interdisciplinary approach, working collaboratively with colleagues and evaluating its positive reflections on students.

It was stated that positive contributions were made in the planning part of the course research practice made during the activity development process of DSW Academy, the students' approaches during the application were positive, and the low level of commitment of the group members could negatively affect the practice. Teachers were very positive about their collaboration with colleagues in terms of sharing experiences, working towards a common goal and enriching their perspectives. Teachers, who stated that the DSW Academy training was stimulating, that it was very important to be practical, and that the discovery period should be longer, also stated that they shared the knowledge and skills they acquired at the DSW Academy with their students and colleagues in the classroom.

The results obtained in this study are supported by research that indicating that professional learning community practices in STEM/STEAM education have positive effects on learning (Boice et al., 2021; Cook et al., 2020; Ekici et al., 2018; Fulton & Britton, 2011; Han et al., 2021; Kelley & Williams, 2013; Khumwong et al., 2017; Phusavat et al., 2017; Phusavat et al., 2018; Pollard, 2019; Suriel et al., 2018; Swanson, 2018; Swanson Hoyle, 2017; Thana et al., 2018; Vossen et al., 2020; Woodruff, 2021). When evaluating the use of the lesson study model in the production period, which is one of the application steps of the research, it can be associated with STEM education and lesson study. The studies in which STEM education plans are supported by the lesson study model also support this research with positive results (Aktürk, 2019; Aykan & Yıldırım, 2021; Lertdechapat & Faikhamta, 2021). Based on these results, it can be stated that lesson study and professional learning communities in STEM/STEAM education make positive contributions for teachers.

The development of teachers' perceptions of skills teaching self-efficacy shows the STEAM professional learning community studies are effective in achieving this goal. Furthermore, the development of all sub-dimensions of 21st century skills further strengthens this finding. Khumwong et al (2017) reached a conclusion that supports this study, stating that STEAM professional development workshops improve teachers' STEM teaching activities and that one of the most developed dimensions is the development of 21st century skills. Similarly there are studies that have concluded that STEM education practices improve teachers' STEM teaching self-efficacy (Arendall et al., 2018; Francis et al., 2018; Gardner, Glassmeyer & Wothe, 2019; Kelley et al., 2020; Kurtulan, 2021, Santaolalla et al., 2020). Dong et al. (2019) stated that teachers' STEM teaching self-efficacy, pedagogical design self-efficacy and peer support have a direct impact on STEM teaching participation; they found that the strongest predictor among them was teaching self-efficacy.

It is also noteworthy that the practices that were carried out on teachers' design self-efficacy were ineffective. Similarly, Kayalar (2018) stated

that engineering design skills were not developed as a result of STEM education with prospective teachers. This finding was interpreted in a critical appraisal of the applications made in the research as meaning that studies were only carried out within the content of the STEM workshop on the development of design skills, and that the applications were generally carried out with more emphasis on interdisciplinary approaches to teaching skills.

In summary, this research concluded that the STEAM professional learning community study positively improved teachers' perceptions of skills teaching self-efficacy and interdisciplinary teaching, but was not sufficient to develop design self-efficacy. It was found that teachers' views of practice were positive and that interdisciplinary collaboration contributed to this. In the light of the research findings, the following suggestions were made:

In the study, the achievements of the students with the professional learning community (PLC) practice in STEAM education were not examined. Future research can investigate how teachers' professional development practices affect students.

As one of the limitations of the research, professional learning communities were considered as "people participating in the practice" and the organisational structure was neglected. Detailed and in-depth research, including the school's management structure, can be conducted in professional learning communities' researches on teachers in a particular school.

In this study, due to the interdisciplinary focus, small groups were formed with teachers from different branches. In other studies, the studies of group teachers from the same branch can also be examined.

The lesson study carried out during the production period, which is the second of the stages of the Istanbul DSW Academy applied in the research, was treated within the integrity of the research, but was not studied separately. In-depth studies can be conducted on the effectiveness of lesson study practices.

This study, which was carried out within the scope of DSW Academy, can be adapted to other educational approaches where interdisciplinarity and practice are at the forefront.

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Turkish Pre-Service Teachers' Perceptions of Factors Influencing Physics Problem-Solving Abilities

Ahmet Zeki Saka,¹ Jazlin Ebenezer,² Tolga Saka³

1. Trabzon University, Trabzon, Turkey
2. Wayne State University, Detroit, USA
3. Kafkas University, Kars, Turkey

Abstract: The purpose of this study was to identify the factors that influenced pre-service teachers' perceptions of their abilities to solve structured physics problems. 1185 pre-service teachers from different disciplines, enrolled in physics courses in one Turkish University from 2008 to 2017 participated in a descriptive survey. The factors influencing the pre-service r physics problem-solving abilities, ranking from most to least, were as follows: personal characteristics; quality of secondary or university physics teaching; secondary school physics education, and physics learning environment. The study implies the need for: (i) equal opportunities; (ii) knowledge integration; and (iii) learning affordances, which are relevant not only to Turkey but also to worldwide physics education.

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About the Authors: Ahmet Zeki Saka, Dept. of Mat. and Sci. Ed, Fatih Faculty of Education, Trabzon University, Turkey, E-mail: azsaka@gmail.com

Jazlin Ebenezer, College of Education, Wayne State University, Detroit, USA, E-mail: aj9570@wayne.edu

Tolga Saka, Faculty of Education, Dept. of Math. and Sci. Edu, Kafkas University, Kars, Turkey, E-mail: tsaka@gmail.com

Correspondence to: Dr. Ahmet Zeki Saka at Trabzon University of Turkey.

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Introduction

A SIGNIFICANT goal of physics education is to equip students with problem-solving skills, which is one of the 21st-century skills (Docktor et al., 2015; Hsu et al., 2004; Trilling & Fadel, 2009). Some researchers claim that students can learn the physics concepts while doing practical physics problems (Freitas et al., 2004; Gök, 2014; Johnson, 2001; Sing, 2009). That is while solving physics problems, students can develop a conceptual understanding of a physics phenomenon and related mathematics knowledge (Docktor et al., 2015). However, if the pre-service teachers are deficient conceptual understanding of a particular physics phenomenon and related ding mathematical knowledge, they will be unable to analyze the given physics problem (Og ünleye, 2009).

Problem-solving involves defining the underlying concepts/principles, analyzing procedures, as well as evaluating and interpreting the solution. However, understanding the fundamental laws and theories of physics does not guarantee that students are able to organize the related facts around the physics problems to solve them (Gök, 2014). Because most of the physics problems can be solved using several methods (Haratua & Sirait, 2016, Jonassen, 2011), students need to qualitatively analyze them, e.g., sketching, restating the problem with their words, and reviewing/revising relevant equations or theorems (Gustafsson et al., 2015).

Too often teachers solve physics problems procedurally that only requires physics and mathematics knowledge to assess students' knowledge (Örnek, 2009). Therefore, students' physics problem-solving skills remain very limited or even poor after an advanced undergraduate course (Gerace & Beatty, 2005). For this reason, traditional teacher-cantered problem-solving method-is a factor influencing students' physics problem-solving skills (Docktor et al., 2015; Gök, 2014; Freitas et al., 2004). However, developing students' physics problem-solving skills require physics teachers, for instance, helping them to make predictions and interpretations by drawing relationships between their prior and new knowledge (Hohensee, 2016), which they generally tend to neglect (Soylu & Soylu, 2006). Teachers' inability or the lack of competency to connect students' prior knowledge to physics problem-solving deters skill development (Carrier, 2013; Hohensee, 2016; Soylu & Soylu, 2006).

Literature Review

Earlier studies pertaining to physics problem-solving have had several foci; beliefs (Mistades, 2007), attitudes (Balta et al., 2016; Erdemir, 2009; Good et al., 2019), achievement (Ghavami, 2003; Taşoğlu, 2009), conceptual understanding (Erg ün, 2010), instructional strategies (Good et al., 2019; Gök,

2012), learning (Şahin & Yörek, 2009), assessment (Docktor et al., 2015; Gök, 2014) physics teachers' problem-solving difficulties (Ogünle, 2009), teachers' conceptions and practices of physics problem-solving (Asikainen & Hirvonen, 2010; Freitas et al., 2004), teachers' views of different physics teaching approaches (Mulhall, 2005), and the differences between the expert and novice problem solvers (Kohl & Finkelstein, 2008). However, none of them has investigated pre-service teachers' self-perceptions of the factors influencing problem-solving skills over years.

Previous studies have focused on varied factors of undergraduate physics students' learning and/or approaches: for example, teacher-related epistemological factors (Karatas & Erden, 2017; Kingsley, 2011; Lin et al., 2013; Stathopoulou & Vosniadou, 2007), students' and experts' metacognition (Gašević et al., 2015; Jonassen et al., 2003), students' epistemological beliefs (Elby, 2001; Fletcher & Luft, 2011), students' attitudes and beliefs about learning physics and the structure of physics knowledge (Erdemir & Bakırcı, 2009; Guido, 2018; Shin et al., 2003), students' expectations of physics teaching (Marshall & Linder, 2005) and students' difficulties/inabilities/misunderstanding of problem-solving strategies (Gök, 2011; Gök & Sılay, 2009; Pol et al., 2005). Further, some studies, which have challenged students' problem-solving skills, have suggested student-centered instructional practices for problem-solving (Ali, 2019; Saka, 2011; Çalışkan & Selçuk, 2010; Gök, 2012). Moreover, there have also been few comparative studies that handle different features/factors, e.g., grade, science background (Al-Omari & Miqdadi, 2014; Kırılmazkaya, 2010).

When the article is examined, we have observed that many studies have been conducted on physics pre-service teachers and on the solution of physics problems. We have seen that studies on the learning approaches of physics pre-service teachers are generally carried out by taking into account the focal points such as epistemological factors-beliefs (Elby, 2001; Fletcher & Luft, 2011; Karatas & Erden, 2017; Kingsley, 2011; Lin et al., 2013; Stathopoulou & Vosniadou, 2007), metacognition (Gašević et al., 2015; Jonassen et al., 2003), attitude towards physics learning (Erdemir & Bakırcı, 2009; Guido, 2018; Shin et al., 2003), expectations from physics teaching (Marshall & Linder, 2005) and problem solving strategies (Gök, 2011; Gök & Sılay, 2009; Pol et al., 2005). However, when the studies on the solution of physics problems are examined, we have observed that these studies are generally carried out by taking into consideration the fundamentals such as achievement (Ghavami, 2003; Taşoğlu, 2009), beliefs (Mistades, 2007), attitudes (Balta et al., 2016; Erdemir, 2009; Good et al., 2019), conceptual understanding (Ergün, 2010), teaching strategies (Good et al., 2019; Gök, 2012), learning (Şahin & Yörek, 2009) and evaluation (Docktor et al., 2015; Gök, 2014). In addition, we have seen that there are studies based on difficulties in problem solving (Ogünle, 2009), problem solving understand-

ings and practices (Asikainen & Hirvonen, 2010; Freitas et al., 2004), views on physics teaching approaches (Mulhall, 2005), and the differences between expert and novice problem solvers (Kohl & Finkelstein, 2008). This situation highlights that there are no studies examining physics pre-service teachers' self-perceptions about the factors affecting their problem-solving skills. Furthermore, there has been no long-term systematic documentation of pre-service teachers' self-perceptions of the factors that affect problem-solving. We identified this neglected area in relation to the pre-service teachers' perceptions of the factors influencing their physics problem-solving abilities. By doing this, the current study purposes to elicit influential factors that need to be handled within teacher preparation programmes. Thus, this study will provide insights into preparing better physics teachers in problem-solving so that they can confidently teach their physics students so that their achievement will improve. When pre-service teachers are conscious about developing students' physics problem-solving skills, they will take an active role in learning those competencies. This study will enrich problem-solving literature and fill in the apparent gaps. Therefore, this study aimed to identify pre-service teachers' self-perceptions of the factors that impact their physics problem-solving skills. For these reasons, the following research question framed this study:

What are pre-service teachers' self-perceptions of the factors (h that affect physics problem-solving skills?

Theoretical Framework

Even though several behavioral psychologists or cognitive theorists have strived to explain problem-solving processes (Anderson, 1987; Docktor, 2009; Docktor & Heller, 2009; Ormrod, 2004), all of them concur that problem-solving involves complex skills (Adams & Wieman, 2015; Csapó & Funke, 2017). Those skills include understanding the problem, thinking of possible solutions, elaborating the problem, solving the problem, and revising the problem solving (e.g., Adams & Wieman, 2015; Bassok & Novick, 2012; Dinica et al., 2014; Van Gog et al., 2005). Therefore, understanding the problem-solving plays a significant role in improving problem-solving skills (Treffinger et al., 2008). Similarly, experience has a pivotal role at handling, make a decision and take an action to solve a problem. For example, previous research has reported that experienced and inexperienced problem solvers revealed variations in retrieving relevant physics information/knowledge from long-term memory and processing time for solving physics problems (Canham & Hegarty, 2010; Tai et al., 2006; Tsai et al., 2012). In other words, these studies emphasized that experienced problem solvers followed a hierarchical process based on physics rules, principle-based approaches, and metacognitive strategies to arrive at logical solutions

(Friege & Lind, 2006; Ince, 2018; Taasobshirazi & Farley, 2013). Physics educators, who have adjusted and/or adapted these problem-solving techniques suggested by behavioral and cognitive researchers, have offered some problem-solving frameworks for physics teaching (Heller & Heller, 2000; Lin & Singh, 2013; Malone, 2008; Reddy & Panacharoensawad, 2017; Singh, 2008). These frameworks generally contain stages of problem-solving to make the complex physics problem-solving clear. These stages of problem-solving elicit a variety of representations or problem (Byu & Lee, 2014; Niss, 2012; Taasobshirazi & Ferley, 2013; Williams, 2018). For this reason, exploring pre-service teachers' self-perceptions of the factors that influence physics problem-solving skills may give insight about their problem-solving variations.

Methodology

Description of University

The participating Physics pre-service teachers come from a Turkish University located in northern Turkey. The northern university consists of 50000 students with almost 5,000 in education. This university has an elementary and a secondary education program that takes four years with the nearly same core courses in the faculty of education. Pre-service teachers participating in this study were enrolled in the following departments and programs: Math and Science Education (Physics Teaching Program, Science Education Program), Elementary Education (Elementary Education Program), and Computer and Instructional Technology Education (Computer and Instructional Technology Education Program). Students in these program areas take two semesters of fundamental physics in the faculty of education together with methods courses. In contrast, secondary physics pre-service teachers also participated in this study. They come from the department of Math and Science Education from two different backgrounds. The first one is the physics education program at the time of the study was five years long. After 2016, the secondary education program was shortened to four years same as the other programs mentioned above. The physics pre-service teachers spend the first three and half years taking physics courses in the physics department of the faculty of science. In the first-year program, students take two semesters of fundamental physics courses and other physics courses. Upon completing the physics courses, the physics pre-service teachers take one and a half-year of methods of teaching and learning physics in the faculty of education. The second group of pre-service teachers is from the Department of Physics in the Faculty of Science. Students in this program also take two semesters in the first year of fundamental physics in the faculty of science to-

gether with other physics courses. When they graduate from the Department of Physics in the Faculty of Science, they could pursue the physics teacher certificate program as physics pre-service teachers.

Description of Physics Course and the Nature of Teaching

Physics pre-service teachers take traditional physics courses in the Department of Physics in the Faculty of Science. Whereas pre-service teachers from the departments of Elementary Education, Science and Technology Education, and Computer and Instructional Technology Education take Physics-I and Physics-II in the Faculty of Education. Both programs in the two terms of the first year take four theoretical credits without application. These courses are prescriptive and structured. These courses are offered two times per week for 15 weeks. Each week the instruction is four hours long. The enrolment in the two physics courses is about 45 students each. The lectures are given in theatre-type halls where seats are in circular rows.

Both groups of pre-service teachers are taught through lectures and they copy notes from the chalkboard. For homework they are assigned about 10 physics problems found at the end of each chapter. When the class meets again the pre-service teachers voluntarily or when called by name come to the board and work through the problem with the assistance of the instructor. Other pre-service teachers in class concurrently check their work based on the student's work on the board. At times, pre-service teachers are assigned problems to be solved in class and they work through these problems in small groups. At the end of the term, as a means of preparing for the final examination, pre-service teachers are assigned many physics problems.

Research Design

This research adopted a descriptive survey design. Descriptive research is the type of research, which tries to define the event or events people come through, without interpretation and as it is. The data gathering method of this research type focuses on discovering the specific events (Lambert & Lambert, 2012).

Participants

The participating pre-service teachers, prior to admission to the university identified in this study, have studied in one of the eight different types of high schools, namely, Anatolian High School, Private High School, Science High School, Classical High School, Vocational High School, Imam Hatip

Table 1. Description of the School Types.

School Type	Definition
Anatolian High School	The aims of Anatolian High School; to prepare students for higher education programs according to the interests, abilities and achievements of the students, to learn at a level that can follow the foreign languages and scientific and technological developments in the world. The average exam scores of Anatolian High Schools are between 450 and 500, and the rate of graduates to settle in universities is high (URL1)
Private High School	Turkey opened paid in secondary educational institutions are opened various types of secondary schools by the Ministry of Education (URL2).
Science High School	Students with high skills in science and mathematics prepare higher education in the field of mathematics and science. It is the foundation for the training of highly qualified scientists in the areas of mathematics and science (URL3).
Classical High School	Classical high schools are institutions that provide education and education for the middle and high school or imam-hatip middle school with four years of education and / or daytime education. These institutions aim to prepare students for tertiary education, profession, life and business by giving them a common general culture at secondary level (URL4).
Vocational High School	It is aimed at educating the human power in accordance with the national and international occupational standards required in business, service and health fields (URL5).
Imam Hatip High School	It is the secondary education institutions which are in the secondary education system opened by the Ministry of National Education to prepare both vocational and tertiary education in order to train the personnel in charge of İmamlik, Oratory and Kur'an Course Teaching (URL6).
Super High School	These high school-type Anatolian High Schools cannot meet the demand for intensive students as a result; they are established as an alternative for similar purposes (Ergüder, 2005).
Anatolian Teacher Training High School	Anatolian teachers are high school students aiming to prepare students for higher education institutions that educate teachers, to instill the spirit of teaching to the students, to give the behaviors required by the teaching profession and to give a common culture to all the students at the secondary education level (MEB, 1992).

Table 2. Categories of High Schools.

Category of High School	School
1	Classical High School
2	Super High School
3	Anatolian High School, Private High School, Science High School
4	Anatolian Teacher Training High School
5	Vocational High School -Imam Hatip High School

High School, Super High School, and Anatolian Teacher Training High School. The description of school types is represented in **Table 1**. Each of these schools has different academic standing. For example, Science High Schools are the highest academic status.

Table 2 represents similar academic schools that are grouped together because of the smaller number of research participants that represent each type of school.

Table 3. Research Sample for Pre-Service Teachers.

University	Year	Department				
		Physics Edu.	Physics Teac. Cert.	Sci. Edu.	Element. Edu.	Comp. & Ins. Tech.
Trabzon University (N=1,185)	2008-2009	30	20	30	30	25
	2009-2010	30	20	30	30	25
	2010-2011	30	20	30	30	25
	2011-2012	30	20	30	30	20
	2012-2013	30	35	30	30	20
	2013-2014	25	35	30	30	20
	2014-2015	20	35	30	30	20
	2015-2016	15	30	30	30	20
	2016-2017	10	15	30	30	20

Those who successfully complete high school and wish to do higher studies enter a university, based on their Higher Education Entrance Examination (HEEE) grades. A percentage of students who have secured average scores in the HEEE are admitted to the universities identified in this study. It means universities enrol students from different parts of the country as well as local students because of their home base and family ties.

Participants in the study consisted of 1,185 pre-service teachers from different disciplines enrolled in physics courses in the Northern University during 2008-2017. The total number of participants is composed of 220 pre-service teachers from Physics Teaching Program, 230 from Physics Teacher Certificate Program, 270 from Elementary Education, 270 from Science Education, and 195 from Computer and Instructional Technology Education. **Table 3** represents pre-service teachers' university, years they took to complete the program, each type of department, and undergraduate programs. Because participants take physics course in the same context as the first year of different undergraduate programs, data analysis is the same.

Development of Survey Instrument

The five-point Likert-type scales (Never-1, Seldom-2, Sometimes-3, Often-4, and Always-5) survey instrument originally consisted of 25 items. The survey items were validated by eight science teacher educators. The instrument was first pilot tested with 200 pre-service teachers who did not take part in this study. From each of the departments stated above, 75 pre-service teachers were randomly selected. These pre-service teachers were requested to specify their perceptions of those factors that impact their physics problem-solving abilities. The influential factors were then categorized, and the fre-

Table 4. Pre-Service Teachers' Perceptions of Factors Influencing Their Physics Problem-Solving Abilities According to School Types.

	Sum of Squares	df	Mean Square	F	p
Between groups	3943.66	4	1067.37	7.11	0.000
Within groups	173748.62	1179	108.45		
Total	178412.35	1184			

Table 5. Variation of Pre-Service Teachers' Perceptions of Physics Problem-Solving Abilities According to School-Type.

H S	H S C	N	α=0.05	H S C	1		2				3				4				5			
					2	3	4	5	1	3	4	5	1	2	4	5	1	2	3	5	1	2
1 2																						
A	3	3	3	M D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P	0	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
S	5	3	3		3	5	1	8	0	5	8	1	0	5	1	8	1	3	8	8	1	1
C	1	2	1		1	4	6	4	7	4	4	7	0	6	4	9	4	4	7	9	1	7
L	3	3	3		3	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
V	5	4	2		2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
I	4	2	2		2	0	9	0	7	0	0	9	9	9	0	0	5	0	9	0	9	7
H	4	2	2		2	0	7	2	1	0	0	8	7	7	0	1	5	2	8	1	3	1
S	2	2	2		2	5	8	8	2	5	6	7	3	8	6	3	1	8	7	3	2	2
U	8	9	9		9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A	1	3	3	3	0	9	0	7	0	0	9	9	9	0	0	5	0	9	0	9	7	
T	4	3	3	3	0	7	2	1	0	0	8	7	7	0	1	5	2	8	1	3	1	
T	5	3	3	3	5	8	8	2	5	6	7	3	8	6	3	1	8	7	3	2	2	

MD: Mean Difference; HS: High School; HSC: High School Category; APS: Anatolian, Private, Science; VIH: Vocational, Imam Hatip; ATT: Anatolian Teacher Training; CL: Classical; SU: Super.

quency tabulated. Based on item analysis, four questions were dropped. Finally, the survey questionnaire consisting of 21 items (See Appendix) was administered to 1185 pre-service teachers in the study. The reliability coefficient (Cronbach alpha) of the instrument, based on the SPSS 27.0 program, was found to be 0.825. After gathering survey data from the pre-service teachers; they were presented to the participants for to establish consistency. Then, the survey data were categorized based on shared philosophy or approaches of the pre-service teachers that reflect the meaningful outcomes of the survey.

Analysis of Data

The survey data were analyzed with SPSS 27.0 using standard deviation, mean (see Appendix), t-test, and one-way variance (ANOVA).

Results

To identify the pre-service teachers' perceptions of those factors that influenced their physics problems-solving with respect to the type of schools, ANOVA analysis was conducted (see **Table 4**).

The data analysis related to variance of pre-service teachers' perceptions of factors influencing physics problem-solving abilities according to the type of school, a significant difference was found at the level of $p = 0.000 < 0.05$ (see **Table 4**). To find out the origin of this difference, Tukey-b and Post-Hoc Tests were conducted (see **Table 5**).

Table 5 depicts a difference between the pre-service teachers graduating from Anatolian High School, Private High School, Science High School and Super High School and Anatolian Teacher Training High School concerning their perceptions of factors influencing physics problem-solving abilities. Compared to the pre-service teachers graduating from Anatolian High School, Private High School, and Science High School, physics problem-solving abilities of those who graduated from Super High School and Anatolian Teacher Training High School were better. Also, there is a significant difference between the graduates of Classical High School and Super High School and Anatolian Teacher Training High School with respect to the pre-service teachers' perceptions of factors influencing their performance in physics problem-solving. Pre-service teachers graduating from Super High School and Anatolian Teacher Training High School indicated better abilities in physics problem-solving than the graduates of Classical High School. To show pre-service teachers' perceptions of the factors influencing their physics problems-solving based on their undergraduate program, ANOVA analysis was utilized (see **Table 6**).

To show pre-service teachers' perceptions of the factors influencing their physics problem-solving abilities based on their undergraduate program, an ANOVA analysis was utilized (see **Table 6**). The results show no statistical difference ($p = 0.43 > 0.05$, $F = 0.879$) based on the undergraduate program they had attended. In terms of gender, there was also no statistical difference ($X_F = 3.18$, $X_M = 3.15$, $t = 1.02$, $p = 0.31 > 0.05$, $F = 2.76$). It is indicated that there is not a meaningful difference between undergraduate programs included physics courses in the faculty of education such as science teacher, physics teaching, physics teacher certificate, elementary education, computer, and instructional technology education with respect to pre-service teachers' perceptions of the factors influencing their physics problem-solving abilities based on their undergraduate program.

Based on the findings of the survey, the pre-service teachers' perceptions of main factors influencing their physics problem-solving were indicated sequentially from biggest to smallest one as follows: the secondary and university teachers' ability to make the physics courses likeable, enjoyable,

Table 6. Variation of the Pre-Service Teachers' Perceptions of Physics Problem-Solving Abilities Based on the Undergraduate Program.

	Sum of squares	df	Mean square	F	p
Between groups	0.96	3	0.321	0.879	0.43
Within groups	356.72	1181	0.343		
Total	357.68	1184			

Table 7. Mean Values of Pre-Service Teachers' Perceptions of the Factors Influencing Their Physics Problem-Solving Abilities.

Categories of Factors Influencing	Supporting Examples	Mean
Pre-service Teacher Characteristics	Difficulty in performing mathematical operations	2.44
	Poor study habits	2.76
	Lack of basic geometry knowledge to learn physics	2.91
	Negative disposition to physics learning	3.05
	The inability to translate theoretical ideas into practice	3.24
	Lack of physics knowledge at a proficient level	3.30
	Difficulty in converting scientific units	3.33
Quality of Secondary or University Physics Teaching	Excessive use of formulas and mathematical operations	3.23
	Insufficient use of teacher-centered methods and prevalent use of traditional methods and techniques for physics learning	3.61
	Ineffective board use in physics teaching	3.35
	Physics course offering that has no value to everyday life	3.63
	Absence of group works and the activities	3.25
Secondary School Physics Education	Insufficient use of examples in physics problem-solving	3.42
	Not enough weekly course hours for physics in secondary education	2.77
	No physics course offered or physics taught by non-disciplinary teachers	3.21
	Conditioning only to obtain test results at the private courses.	3.15
	Insufficiency of pre-university physics teaching	3.39
Physics Learning Environment	Multiple-Choice Questions in University Entrance Physics Examination	3.62
	Classroom physical structure and facilities	3.45
	Living insufficient conditions to study effectively	2.87
	Crowded classrooms	3.15

and valuable to their lives (3.63); focusing merely on the discriminators of the multiple-choice type HEEE ignoring the problem-solving procedure (3.62); the secondary and university teachers' capability of using appropriate methods and techniques of teaching (3.61); a lack of necessary materials needed for physics courses (3.47); inappropriate examples used in class (3.42); pre-university physics education (3.39); teachers' insufficient use of

board (3.35); lack of knowledge of basic physics measurement units and difficulty in converting one form into another (3.33); and lack of physics content knowledge (3.30) are among the primary reasons for inability in solving physics problems (see Appendix for the survey). In addition, the pre-service teachers' perceptions of factors influencing their physics problem-solving according to the survey findings have been grouped in **Table 7**.

Table 7 depicts that pre-service teachers' perceptions of factors influencing their performance in physics problem-solving enumerated from the most influential to the least are as follows: pre-service teachers' characteristics (21.03), quality of secondary or university physics teaching (20.49), secondary school physics education (16.14), and physics learning environment (9.47).

Discussion

Compared to the pre-service teachers who graduated as high school students from Anatolian High School, Private High School, and Science High School, the ability to understand and solve physics problems by those graduated from Super High School and Anatolian Teacher Training High School is superior (see **Tables 2** and **4**). In the research, which was carried out by Yıldırım et al. (2011), it was pointed out that the problem-solving perception of Science High Schools is higher than those on Anatolian and General High Schools. This could be explained because the education program of science high schools includes more lesson hours of physics and science in the weekly lesson program. By this way, students who take education in the science high schools can get higher level of interaction with physics problems than other types of schools' students (Berberoğlu & Kalender, 2005).

Tables 2 and **4** also reveal that pre-service teacher as high school students who graduated from Super High School and Anatolian Teacher Training High School can solve physics problems at a higher level than those of Classical High School. As for the research which was carried out by Korkut (2002), it is concluded that there is no effect of having an education from Super or General high schools on students' problem-solving skills. Since problem-solving is an inquiring task, the students find out the solution pathway to reach course objectives from problem situations or given information (Docktor et al., 2015; Dinica et al., 2014). In addition to this, the solving problem is one of the main tools for teaching physics, and it is the main part to manage the scientific goals of explaining, predicting, or elaborating (Malinovschi, 2003). Thus, when students have ability in relation to the problem-solving skills, the physics teaching process could contribute to the students for reaching course objectives at the expected level. In this case, teachers able to have reached their students' physics curriculum target. This is because of the effect of the curriculum implemented in Super High School

and Anatolian Teacher Training High School, and the fact that the pre-service teachers were channelled more efficiently than those from the other types of high schools. As well, students who graduated from Anatolian Teacher Training High School are more conscious about their secondary education than other schools with respect to school aims and culture, which are highly influenced by the Turkey Ministry of National Education (TMNE).

Table 6 shows that there is no meaningful difference between the reasons for their inabilities in problem-solving with respect to the undergraduate program and their gender. The developmental level of problem-solving abilities in physics does not vary among the pre-service teachers according to the undergraduate program they followed and their gender. There is no meaningful difference between physics pre-service teachers and others. Similarly, it is underlined that gender/sex does not affect problem-solving skills in the research carried out by Çilingir (2006), Gültekin (2006), Özkütük et al. (2003), Tümkaya and Iflazoğlu (1999). Unlike the previous research, it is pointed out that female student's problem-solving skills are higher than male students in the research of Ferah (2000), Katkat and Mızrak (2003), Serin and Derin (2008) and Yıldırım and colleagues (2011), yet the research of Korkut (2002) and Koray and Azar (2008) male students' problem-solving skills found higher than female students. However, it can be expected that pre-service teachers who participate in physics courses could develop more physics problem-solving abilities compared with other pre-service teachers from other programs such as science, elementary, and computer and instructional technology. The absence of meaningful difference between the two previous groups suggests that pre-service teachers who participate in physics courses are not paying serious attention to learn how to solve physics problems.

Our study results showed that there was no gender difference in pre-service teachers' perceptions of problem-solving abilities. However, Şahin and Yörek (2009) indicate that there is a gender difference in students' beliefs regarding learning physics, participating in physics activities, and working to make sense of physics. In contrast to the results of our study, Neber et al. (2008) indicated that high school male students are more active and willing to use problem-solving abilities compared to the counterpart female students. However, in line with our study Çalışkan and Selçuk (2010) found no significant difference in relation to using self-regulation problem-solving strategies between female and male pre-service teachers. Pre-service teachers' perceptions of factors influencing their performance in physics problem-solving is based on the following reasons: the pre-service teachers' characteristics (21,03); quality of secondary or university physics teaching (20.49); secondary school physics education (16.14); and physics learning environment (9.47) (**Table 7**). With respect to pre-service teachers' characteristics, the pre-service teachers identified that they could not perform mathematical

skills such as four operators, integrals, and derivatives and recognized that they were deficient in three-dimensional or visual thinking. They also stated that insufficient math skills led to poor understanding of physics concepts. They admitted that they could not understand what the physics problem is asking for and the main points of the question. Pre-service teachers also recognized their lack of theoretical knowledge and ability to correlate problem data with related physics principles as well as their difficulty in unit conversion. These self-identified factors could definitely weaken physics problem-solving abilities. Aligned with pre-service teachers' perceptions, Mathan and Koedinger (2005) emphasize that when students do not have enough content knowledge, they are not proficient in problem-solving. Furthermore, Mulhall (2005) points out that the importance of mathematics in teaching and learning physics is often regarded as the "language of physics". For this reason, the pre-service teachers ought to be good at mathematics to understand physics ideas. Pre-service teachers discussed their attitudes towards learning physics. Desoete et al. (2004) clearly state believing in oneself has a relationship with the ability to reason practical tasks such as physics problem-solving (Hammer, 1994). Pre-service teachers perceived the quality of secondary or university physics teaching as a major factor influencing their physics problem-solving performance. As pre-service teachers have pointed out, teachers' educational strategies are crucially essential, especially using appropriate materials and activities relevant to the subject matter (Karamustafaoğlu, 2006).

The results of this study concur with the statement of Mulhall (2005) and Oğünleye (2009), who state that there is a strong correlation between physics teachers' poor ability to understanding the subject matter and the ability to provide guidelines to students on how to solve physics problems. Park and Lee (2004) point out that students, high school physics teachers, and university physics educators do not have sufficient knowledge to relate to everyday applications of physics problem-solving, and thus, might have a negative influence on solving physics problems. Students taking physics courses who do not realize they might be potential pre-service teachers and eventually school teachers also affect how they learn and what they want to learn (Mitchell & Carbone, 2011; Mulhall & Gunstone, 2012; Şahin & Yörek, 2009). Some students assume that physics is not connected to the real world; others perceive those ideas learned in physics have strong and useful relationships with a variety of real contexts (Mistades, 2007). Such mixed attitudes toward physics learning either negatively or positively affect pre-service teachers' problem-solving abilities at higher levels.

In relation to secondary school physics education conducted at the secondary education level, most pre-service teachers emphasized that they had studied physics superficially to pass the multiple-choice questions HEEE that promotes memorization. In fact, the pre-service teachers emphasized

special schools that prepare them for national examinations for university entrance were not able to develop their critical thinking because of the use of multiple-choice questions in the HEEE. Because of much focus on preparing for the HEEE, pre-service teachers felt that their critical thinking skill development necessary for problem-solving was compromised. Pre-service teachers thought that they were good problem-solvers, until they did their undergraduate studies, only to realize that they had not attained proficiency in problem-solving because of learning physics through rote memory. Pre-service teachers indicated that insufficient laboratory tools lead to lack of translating theoretical information into practical physics in terms of the physics learning environment. Crowded class conditions provide insufficient space for physics problem-solving practical activities. They indicated that they gained knowledge at the comprehension level, but could not reach the analytical and synthetic levels. Conceptual learning gains in introductory physics courses and conceptual understanding in high school (Şahin, 2010; Zavala et al., 2007) and university learning (Şahin, 2009) have a direct impact on advanced learning.

Implications

Pre-service teachers' perceptions of factors influencing their performance in physics problem-solving are interpreted according to the research data. This study points to various issues the pre-service teachers encountered during their education in solving physics problems. To resolve the issues on developing pre-service teacher problem-solving abilities, this study implies the need for: (i) equal opportunities; (ii) knowledge integration; and (iii) learning affordances.

Equal Opportunities

According to data, students in majority of Turkish schools do not have equal opportunities for developing physics problem-solving abilities. For example, the problem-solving abilities of pre-service teachers who were graduates of Anatolian High School, Private High School, and Science High School were higher than those who graduated from Super High School and Anatolian Teacher Training High School because of the school status. The equality difference comes from the school's type. Because these schools include the type of Anatolian High School, Private High School, and Science High School. They have students over the standard level. Because students are selected to these schools according to the national exam scores, they usually have proficiency level physics teachers, or teachers could have the opportunity to teach physics in these schools according to the professional experience or examination scores of professional developments. However, espe-

cially private schools and science schools present much more weekly physics course hours than usual. This opportunity could provide students interaction with physics problem-solving processes and activities much more than usual. Other school types have standard level weekly physics course hours. Besides, they have almost the same student and teacher level. On the other hand, since pre-service teachers who participating physics courses are not paying serious attention to learn how to solve physics problems, there are not meaningful difference between undergraduate programs and gender of pre-service teachers such as physics teaching, science, physics, elementary and computer and instructional technology.

The gap in student knowledge and abilities is a world-wide educational phenomenon between the haves and have-nots. Turkey, according to accounts given in this study, seems to be perpetuating the problem of inequality. Such social justice issues should be addressed if we want all potential pre-service teachers in Turkey to have equal opportunities to learn physics problem-solving. Evidence in this study clearly implies that the goal of science education, regardless of schools, should be to provide students equal and more opportunities for problem-solving at all levels from early childhood to higher education. To achieve this goal, students also have an important role to play. They should also put forth conscious effort to learn physics and perceive learning physics as more than a subject to pass but a course that provides the development of a set of life-long abilities. At the same time, the teachers must be knowledgeable about teaching approaches that help students to learn problem-solving. TMNE ought to take steps in providing equal opportunities to build student self-efficacy in physics problem-solving. It requires the TMNE to make policy changes concerning the nature of government examination and the administration of large-scale evaluation. Equity issues raised in this Turkish study on pre-service teachers' perceptions about their physics problem-solving abilities have wider applications.

Knowledge Integration

Since the pre-service teachers' readiness level in fundamental physics concepts and the skills of mathematical operations are deficient, they have a lack of ability to integrate their knowledge in solving physics problems. Developing a deep understanding of physics concepts, principles, rules, and unit conversions are requiring necessary abilities at the K-12 level. This study also indicated that the pre-service teachers were confused in physics problem-solving because their early education adopted a random rather than a strategic approach. The study also suggests that the pre-service teachers did not realize the importance of developing problem-solving abilities in physics to the desired level. Thus, pre-service teacher knowledge integration involves both the "what" and "how" of physics learning, beginning from early child-

hood to tertiary science education. Teacher educators need to take into consideration this kind of knowledge that can be best developed to improve physics problem-solving abilities in the preparation of the pre-service teachers. Pre-service teachers can then be expected to integrate the same strategies systematically with their own students. This knowledge integration will have positive effects on school students' learning and achievement. On the contrary, if pre-service teachers have not developed sufficient physics problem-solving abilities, they will not be able to advance high school students' physics problem-solving abilities. Because pre-service teachers potentially have a huge impact on high school education, a strong knowledge baseline must be set from which to develop the physics problem-solving abilities of students at the university level.

The pre-service teachers indicated that the insufficient number of problems solved was one of the reasons why they did not develop the ability to solve physics problems. If traditional instruction can be decreased in the beginning stage and if the number of problems students should work is increased, problem-solving abilities can be developed (Moreno, 2006). An increasing number of studies emphasize that teacher specialization in problem-solving enables the organization and presentation of the knowledge in different ways (Sabella, & Redish, 2007). As a result, paying attention to developing complex processes and elaborating knowledge from different dimensions are necessary to improve pre-service teachers' abilities in physics problem-solving.

A series of efforts need to implement to eliminate difficulties encountered in the problem-solving process (Bingham, 2004). Thus, a specially designed course should be developed and implemented in physics education programs to improve physics problem-solving abilities of pre-service teachers. It could take place special courses with special context, activities, and following problem-solving strategies especially focussing to improve physics problem-solving abilities of pre-service teachers. This process needs to be implemented step by step according to the effective selected activities which contain detail descriptions and applications about the stages of the physics problem-solving. After pre-service teachers analyzed common mistakes of pre-service teachers' physics problem-solving process, they could be warned about defined inabilities for the physics problem-solving process. When they are informed about determined problem-solving strategies, they need to orientate for practicing problem-solving strategies to the different kinds of problems based on two indicating application stages. This process could ensure pre-service teachers to be ready same kind of perceptions to organize their solution strategies for the physics problem-solving process. Because it is emphasized that skilled problem solvers manage their solution strategies according to the main principles or concepts (Ince, 2018; Reddy & Panacharoensawad, 2017). This process ensures students integrate major

ideas, context, and procedures as well-integrated knowledge base for guiding their problem-solving with a hierarchically structured form (Ince, 2018; Simamora et al., 2017). By this way, pre-service teachers could resolve physics problem-solving skills based on the deficiency points and have a habit and common approach about physics problem-solving strategies.

Learning Affordances

The pre-service teachers think that the secondary school's physics teachers and the university physics instructors have great impact on the development of their problem-solving abilities. They believe that teacher knowledge and instructional inadequacy in problem-solving develop negative attitudes and strongly affect students' physics problem-solving abilities. Thus, pre-service teachers need to be provided conceptual, physical, and care affordances.

Conceptual causes contain the poor understanding of the necessary physics concepts, principles, and rules that lead to difficulties in unit conversions; developing test techniques concentrating only on the results rather than the problem-solving stages; using the appropriate methods and techniques efficiently and having adequate in-class problem-solving practice. This reality necessitates the quality assurances of physics teachers and physics teaching and learning in secondary and higher education. Fact that most pre-service teacher perceptions toward physics are shaped early on in their education, there is a need for change in physics teaching at the high school and university levels to accommodate the learning needs of the pre-service teachers.

The instructional practice of lectures in Turkish physics classes at all levels should give way to defensible methods of teaching physics. Problem-solving abilities can be developed by decreasing traditional instruction and increasing strategies of teaching that promote physics pre-service teacher ownership of learning (Moreno, 2006). For students' responsibility to take root, physics teachers and university instructors need to make their lessons interesting by increasing the sense of wonder, resolving their prejudices toward physics, informing about what worked where, giving examples from daily life, and teaching them how to create the physics formula instead of merely having them memorize (Moelter & Jackson, 2012). Physics teachers need to teach clearly by bringing physics to the level of students, developing experiences that would create interest in physics classes. Some pedagogical practices are using technology, bringing visuals to the classroom, giving concrete examples, and engaging students in investigations. These experiences will promote interactive and interpretive discourse about the conceptual and practical as advocated by contemporary physics educators and teacher educators (Anderson et al., 2014; Mulhall, 2005). Those physics teachers and educators who advocate conceptual change inquiry have been

suggesting the probing of learners' conceptions and using these as frameworks to learn scientific models and explanations through a variety of methods (Glynn et al., 1995; Treagust & Duit, 2015). Effect level of teaching methods of pre-service teachers during the practicing lesson contributes to the student understanding and the construction of fundamental physics knowledge of students (Saka & Saka, 2006). Such conceptual change inquiry teaching practices have greater likelihood to develop students' understanding of physics explanatory models and using these in manipulating physics problems. Making a conscious effort to improve mathematics knowledge and understanding as well as developing language literacy in physics class based on aims and objectives of the physics curriculum (Achieve, 2013) will likely improve student problem-solving abilities. Hence, to improve pre-service teachers' problem-solving abilities in physics, secondary and tertiary teachers need to have professional development in defensible methods of teaching physics and physics problem-solving. Studies must be conducted on the effect of professional learning of physics teachers on their classroom enactment and student development of physics problem-solving.

Physical affordance is concerned with the insufficiency of the necessary materials needed to teach physics. To accommodate the need for rich and relevant physics materials, new curriculum should be developed, and textbooks written using evidence-based problem-solving pedagogies. Curriculum developers and science educators need to collaborate in determining the physics core ideas and related mathematical concepts that are useful and necessary to the understanding of physics problem-solving. The pre-service teachers pointed out is the inability of teachers to make physics courses likable and enjoyable and providing orientations to focus on problem-solving stages and strategies of the problem-solving process. Therefore, pre-service teachers should see their education as an integral process of "growth" and gradual "development" based on their effective teaching through collaborative investigations into physics problems-solving that has personal meaning. Pre-service teachers must also be inquirers and strategic planners and be open to continual development in physics problem-solving. When such dispositions to physics learning are embraced, pre-service teachers will be able to foster, support, and motivate their students. Such dispositions should improve pre-service teachers' abilities to physics learning (Liu et al., 2017; Saad & BouJaoude, 2012) and this, in turn, will spill over into learning physics problem-solving strategies and stages. Pre-service teachers must have a commitment to their own professional development for the benefit of themselves and their students.

Care affordance is regarded as requiring taking into consideration problem-solving strategies and stages in the process of physics problem-solving. In this context, various researchers in different areas have stressed the positive contributions to teaching strategic problem-solving in physics

education (Muallem & Eylon, 2010; Warren, 2010). One crucial result of strategic problem-solving in physics education is student academic achievement (Foster, 2000; Ghavami, 2003). On the other hand, according to Çalışkan et al. (2010), strategic methods of problem-solving promote the development of students' cognitive and meta-cognitive awareness. Simultaneously, problem-solving strategies provide an increase in the metacognitive awareness level of students and make it easier for them to transfer their knowledge to other fields (Metallidou, 2009). Therefore, physics education needs to support strategic problem-solving by providing enough opportunities in effective learning environments, including computer-assisted instruction (Uclo et al., 2005). A problem-solving strategy is defined as harmonizing the stages of a problem in various ways that lead to its solution. In this process, every stage taken into consideration constitutes a general problem-solving strategy (Schunn et al., 2005), while the sub-stages compose more specific behaviors (Çalışkan & Selçuk, 2010). Besides, it is stated that problem-solving stages can also change according to time, person, and situation (Bingham, 2004). Therefore, when students consider the stages of problem-solving, they may gain more strategic knowledge (Pol et al., 2008), which enables them to analyze the problem, apply relevant content knowledge, plan, and solve the problem (Gunawan et al., 2017). In line with this view, it is crucially important that teacher educators take an active role in encouraging pre-service teachers regardless of grade level to improve their strategic problem-solving abilities so that they can use it consciously and systematically in their classroom (Selçuk et al., 2007). It is revealed that pre-service teachers could reach this contribution regarding for the problem-solving skill development by the way caring problem-solving strategies and stages for the process of physics problem-solving.

In this study, we indicated a different aspect of the producing contribution to the physics problem-solving skills development of the pre-service teachers by identifying the factors influencing well-structured physics problem-solving abilities as perceived by pre-service teachers based on their own educational and learning experiences. According to pre-service teachers, the factors influencing their physics problem-solving abilities, ranking from most to least, are as follows: pre-service teachers' characteristics; quality of secondary or university physics teaching; secondary school physics education, and physics learning environment. In order to develop pre-service teacher problem-solving abilities, it is necessary to resolve the issues posed by the foregoing factors: (i) equal opportunities; (ii) knowledge integration; and (iii) learning affordances. These indications could regard as meaningful tools for stimulating and awarding pre-service teachers about sources of common errors and ensuring them to follow more strategic pathways to be an effective problem solver. At the end of this process, when pre-service teachers reflect their own problem-solving skills to their students more be-

yond the standard level, they could ensure direct contribution to their students' physics problem-solving skills and physics achievements. It is considered these implications for contextual challenges are relevant to world-wide physics education.

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Appendix. The analysis results of mean and standard deviation of pre-service teachers' perceptions of the factors influencing their physics problem-solving (Never-1, Seldom-2, Sometimes-3, Often-4, Always-5).

Pre-service teachers' perceptions of the factors influencing their physics problem-solving abilities (N=1185)	Mean	Standard Deviation
Difficulty you experienced in mathematical operations affects your ability to solve physics problems negatively?	2.44	1.10
Do your study habits affect your ability to solve physics problems negatively?	2.76	1.27
Do the weekly course hours being very limited during the pre-university education process affect your ability to solve physics problems negatively?	2.77	1.27
Do you believe that the place where you stay, not being conducive, to study effected your ability to solve physics problems negatively?	2.87	1.29
Do you think your lack of basic geometry knowledge essential for physics courses affected your ability to solve physics problems negatively?	2.91	1.30
Does your bias toward physics courses affect your ability to solve physics problems negatively?	3.05	1.31
Do you think you're having been conditioned only to obtain test results by the cram schools you attended affected your competency in solving physics problems negatively?	3.15	1.31
Do the crowded conditions of the classes affect your ability to solve physics problems negatively?	3.15	1.27
Do the physics courses containing a lot of formulas that require mathematical operations affect your ability to solve physics problems negatively?	3.23	1.25
Does your inability to put theoretic knowledge into practice effect your ability to solve physics problems negatively?	3.24	1.24
Does the absence of group works and the activities that provide the students with a sense of responsibility (project works) effect your ability to solve physics problems negatively?	3.25	1.23
Do you think the fact that there were no lessons or courses that were taught by the teachers of different disciplines during secondary education affected your ability to solve physics problems negatively?	3.21	1.34
Does lacking the knowledge of the physics-related concepts at a satisfactory level affect your ability to solve physics problems negatively?	3.30	1.21
Do you think lacking the knowledge of core concepts related to physics, and having difficulty relating one into another effect your ability to solve physics problems negatively?	3.33	1.03
Does the teachers' insufficient use of board exercises in physics education effect the development of problem-solving skills negatively?	3.35	1.22
Does the insufficiency of pre-university physics education affect your ability to solve physics problems negatively?	3.39	1.37
Does the insufficiency of the examples of problem covered during the course affect your ability to solve physics problems negatively?	3.42	1.14
Does the inadequacy of the materials necessary for physics courses affect your ability to solve physics problems negatively?	3.45	1.22
Does the physics teacher's inability to use the appropriate methods and techniques efficiently in physics education affect your ability to solve physics problems negatively?	3.61	1.14
Do you think that dependency of HEEE on test-solving techniques lead to the habit of focusing only on the result regardless of the problem-solving steps?	3.62	1.23
Does the teacher's inability to make the physics course likable and enjoyable effect your ability to solve physics problems negatively?	3.63	1.23

The Skewed Role of Home Education in Child Development in China

Lei Zhang

Yan'an University, Yan'an 716000, Shan'xi, China

Abstract: Home education plays a unique, vital role in child development that differs from that of formal education. Currently, there is an abnormal phenomenon in Chinese basic education: home education becomes academically focused. This article gives an overview of skewed home education in basic education students, analyzes its causes and harms, and proposes relevant suggestions for a more reasonable implementation of home education with the aim of promoting legitimate home-school partnerships for student healthy growth.

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About the Author: Lei Zhang, School of Marxism, Yan'an University, Yan'an 716000, Shan'xi, China, E-mail: 794065648@qq.com

Correspondence to: Lei Zhang at Yan'an University of China.

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Introduction

THE FUNDAMENTAL role of education is to socialize children by teaching cultural values and norms and equipping them with the skills needed to become productive members of the community. There are many forms of education in human society. In the Chinese context, “school education” is the term denoting formal education, and “family education” refers to the informal, home-based education being delivered to children through daily life experiences. Child development is contingent on the joint efforts of the school, family, and society, with each of them playing a unique role in child education. Student healthy growth is the product of the effective partnership between them (Yan, 2023). In 2022, the Ministry of Education of China and other twelve departments issued the “Opinions on Improving the Mechanism for the Partnership between the School, Family, and Community in Child Education,” which affirms the school’s leading role in home-school collaboration and its responsibility for providing guidance and advice on home education (Ministry of Education, 2022).

Recent years, however, have witnessed an ambiguous division of responsibility between the school and home in Chinese basic education. Using the initiatives of “home-school partnership” and “parental involvement in child learning” as excuses, schools are breaking the boundaries between school and home education by making parents direct executors of school education and transferring some of the school’s responsibilities to the parent. Consequently, home education is being deprived of its original function, and parents are overburdened with responsibilities for child academic development, resulting in the mistaken role of home education in child growth (Yuan, 2020). To meet the school’s requirements, parents have to invest massive amounts of time, money, and energy in private child tutoring. Student academic performance has become the primary evaluation indicator for the success of home education, which interferes with parents’ making legitimate educational decisions and increases parent-child tension (Chen, 2008). This article gave an overview of signs of skewed home education at the basic education level, pinpointed its causes as well as consequences, and proposed measures to bring home education back on track, with the purpose of promoting a reasonable home-school partnership for healthier child growth.

Signs of Skewed Home Education

Home education is an education conducted at home with a focus on an all-rounded person. It covers a wide variety of facets, including fostering proper behavioral habits, cultivating morality and character, and developing the basic life knowledge and skills of the child. However, the responsibilities that

should be handled by the school have been burdening home education in China.

Digital Education Imposes Extra Burdens on Parents

China's digital education has transitioned from the 1.0 to 2.0 eras in consequence of the universal coverage of the "Three Links and Two Platforms Program" (namely, the school link to a broadband-based network, the class link to excellent teaching content, the individual link to the online learning space, the national public educational resource, and educational administration platforms). Digital transformation has significantly increased the efficacy of instruction, and the use of educational administration platforms and other public communication platforms has successfully improved the efficiency of school management (Lu & Zhou, 2020).

On the other hand, digital platforms have been misused by schools, giving them opportunities to transfer educational responsibility to parents by taking advantage of the policy of home-school partnerships. Between 2019 and 2020, Central China Normal University's Institute for Educational Governance Studies (hereinafter referred to as CCNU's IEGS) conducted a survey on home-school collaboration and found that the online parent group had become a "stressful group" or "anxiety-fueling group," an unbearable burden to the majority of parents. Numerous parents polled complained that teachers dumped teaching duties on them via online parent groups, and they must accept it without reservation. There were endless messages about assignments for parents, including but not limited to correcting the child's homework and checking their reading and recitation. Sometimes they were even required to pay visits with their children to museums or other public places in order for the latter to complete relevant assignments or conduct community-based activities and social practice. During these events, parents must take photos and upload them onto the platform as evidence of their engagement. The phenomenon of blurred boundaries of responsibility was pervasive in home-school partnerships. The survey research team suggested that school and home education should each have their own focus and that teachers should not utilize digital platforms to transfer instructional duties to parents (China Youth Daily, 2021).

Students' Homework Becomes Assignments for their Parents

Teachers assign homework to students after class for specific purposes. It is an integral part of the curriculum and a necessary process between curricular implementation and evaluation. For students, homework is of great signifi-

cance in that it helps them consolidate the knowledge and skills acquired from in-class learning, develop problem-solving ability and scientific learning methods, and nurture academic resilience (Gao, 2023).

Nevertheless, under the misused “home-school partnership,” helping their child with homework and correcting it have become compulsory “homework” for parents. If they do not do their “homework” well enough, they will be blamed by the teacher (Liu, 2017). The 2019-2020 research by CCNU’s IEGS found that only 14.1% of parents surveyed did not have to help kids with their homework; 26.8% of them felt the need but did not do it; 23.3% helped kids with their homework in 1-2 days per week; 11.1% did so in 3-4 days per week; and 24.7% did so almost every day. That is to say, only about 40% of parents were not involved in their children’s homework. The research team also found through interviews that the majority of parents were not happy about this phenomenon. They had an exhausting day at work; it was so much that they had to help kids with their homework after work. Some assignments were far more difficult than they could handle. The parent-child tension fueled by homework completion has sparked heated debate online. Despite the Ministry of Education’s explicit stipulation that parents should not be given any academic assignments or required to check or correct their children’s homework, parents apparently did not dare to publicly disobey teachers for fear that their kids might be unfairly treated at school (China Youth Daily, 2021).

After-school Private Tutoring and Training Become a “Must”

To reduce student academic burden, the Chinese government has released a series of papers on this issue, including 2018’s “Measures for Reducing the Burden on Primary and Secondary School Students” (Ministry of Education of China, 2018) and 2021’s “Opinions on Further Reducing the Burden of Homework and Off-Campus Training for Compulsory Education Students” (State Council of China, 2021). Under the current education and talent selection systems, however, these burden reduction policies increased worries among parents, who feared that their implementation might negatively impact their kids’ academic results. As a result, parents tend to enroll their children in as many off-campus tutoring programs as possible to win the educational competition (Li et al., 2023).

According to the 2019 *Annual Report on Chinese Children’s Development: Children’s Out-of-School Life Condition*, jointly issued by the China National Children’s Center and Social Sciences Academic Press (China), participation in extracurricular programs has become an important component of children’s out-of-school life. 60% of them were signed up at

off-campus tutoring institutions, spending 3.4 hours there in the five school days and 3.2 hours on the two-day weekend on average. The average cost of extracurricular tutoring for each child was 9211 CNY per year, accounting for 12.84% of their household income (People.cn, 2019). These results of the report found support from data from the 2019-2020 research by CCNU's IEGS, which showed that students spent an average of 0.5 hours every day on private tutoring from Monday to Friday and 2.34 hours at off-campus training institutions on the weekend (China Youth Daily, 2021).

Consequences of Skewed Home Education

Reasonable home education provides appropriate educational resources and home learning environments for children and can play a vital role in fostering their characters, habits, and social adaptation (Chen, 2012). On the other hand, a skewed home education can produce dire consequences, such as exacerbated burdens on the child and parent and impaired parent-child relationships.

Increased Burden on the Child

Legitimate home education should provide children with opportunities to experience different learning materials and methods from those taught at school. The intention is to broaden the scope of their competencies and interests. Academically focused home education means children need to deal with subject-based knowledge and skill training arranged by parents while going through all the pressures of disciplinary knowledge study in school. This is an unnecessary burden and a waste of time (Liu, 2023). Moreover, when home education becomes supplementary to formal schooling, the child is deprived of the chance to go for home-based hands-on practice. Under this education paradigm, the child can hardly make time to develop interests and hobbies, let alone social skills. Feeling overburdened, they may lose their aspirations and enthusiasm for learning. Even worse, the double burdens have detrimental effects on their physical and mental health (Xi, 2023).

Exacerbated Burden on the Parent

In the process of their children's growth, the parent needs to bear all kinds of pressure: economic, emotional, educational, social, and more. A skewed home education significantly increases the burden on the parent. First, when home education is dominated by school education, the parent may have to unwillingly accept and practice the school's educational ideas, which are likely contradictory to their own educational notions (Lyu, 2023). Second, when school education intrudes on home education, the parent needs to be

overly involved in the children's assignments and other academic activities. Fully loaded with their own professional duties, they may choose to send their kids to private tutoring institutions. To guarantee that their children achieve ideal exam results at school, the parent may enroll them in a lot of subject-based tutoring programs, which can elicit colossal amounts of expense and, as a result, exacerbate their economic burden (Lu, 2023). Third, with a blurred boundary in home education, the parent may have to play conflicting roles concurrently. To play the role of the parent well, they need to create a harmonious home atmosphere and provide tailored education for their kids; in the meantime, they have to play the role of the teacher to implement instructional tasks imposed by the school. That can heighten their psychological burden and compromise their quality of family life (Li, 2023).

Impaired Parent-Child Relationships

Overemphasis on academic knowledge and skills in home education often results in the neglect of the child's affective needs and potential for unique development, leading to alienation and conflicts between the parent and child. An overburdened child is most likely deprived of the opportunities to have meaningful emotional communication with their parents as well as personal time for play and leisure. Over time, they may nurture grievances against their parents, resulting in mounting parent-child tension (Chen, 2023). Furthermore, under the unscientific home-school partnership, the parent may lose autonomy in child education and cannot administer personalized education to their children, which can also instigate the latter's resistance to the former's educational involvement (Chen, 2023). In addition, the loss of the inherent functions of home education may negatively impact the relationships between all family members. The lack of smooth communication and meaningful interaction between them can produce a tense and incompatible home atmosphere. It may make the child feel isolated and helpless and is detrimental to their emotional development and character building (Chao, 2023).

Causes of Skewed Home Education

Schools' Attempts to Transfer Their Own Responsibilities to Parents

In the broad educational system, the school and family are each expected to fulfill their respective duties. Generally, society holds the school primarily responsible for the instruction of disciplinary knowledge. However, a considerable portion of teachers disregard the boundaries between school and

home education, making the practice of school-home partnership an infringement on the latter (Shan, 2020). A pronounced sign of this is that the teacher has attempted to dump some of the instruction-related duties on the parent.

Zheng (2022) conducted a questionnaire survey on the issue of division of responsibility in home-school partnerships, which included as participants both teachers and parents in certain primary schools in Tianhe, Zengcheng, and Conghua Districts of Guangzhou City. The survey results showed that carrying out school-based duties without reservation, helping kids with assignments, and correcting their homework on the part of the parent were pervasive in primary education. Some of the teachers polled claimed that it was justifiable for parents to correct their kids' homework, yet they never made it an obligation. At the same time, parent participants in the survey argued that the misconduted home-school partnerships consumed excessive amounts of their time and energy, that they were allotted responsibilities that should not have rested with them, and that their home education was rendered an extension of formal schooling.

Wrong Notions of Home Education among Parents

The parent's view of and attitudes towards home education are determinants of its outcomes and quality (Li, 2023). Parents with misconceptions about home education tend to be fixated on kids' academic achievements, disregarding the importance of their moral, emotional, and social development. Such one-sided home education makes child all-round growth impossible. Other parents may implement unscientific home education methods, which make it a blind and arbitrary education, resulting in ineffective communication with their children and failure to achieve its expected effects (Zhao, 2020). On the other hand, a portion of parents hold the mindset of "perfectionism" in home education, expecting that their children should excel in all aspects (Zhang, 2023). This expectation leads to parents being overly strict with their children but ignoring their personal traits and peculiarities. As a result, home education's role in providing tailored education is sacrificed.

Social Pressures on Parents

The ever-heightening social expectation of education contributes to the intensive social pressures faced by parents, skewing their attitudes towards home education. Social competition is a major factor in unreasonable home education. Currently, the process of education is a rat race for the majority of Chinese students. Parents hope that their children can stand out in the competition and enjoy a brilliant future (Li et al., 2023). In this milieu, parents frequently prioritize their kids' academic success and intellectual prowess

over the most crucial concerns in home education, such as their physical and mental health, moral development, and character building. In the meantime, the biased definition of success by society is also a contributor to skewed home education. In today's Chinese society, being successful in life is most often defined as "career success" or "wealth accumulation" (Niu, 2022). This simplistic conception misleads parents into overly emphasizing their children's academic and career success and deviating from the original focuses of home education, such as children's interests and hobbies, emotional experience, and purpose of life.

Suggestions for Bringing Home Education Back to the Right Track

The child first receives care and education from their family, primarily their parents, at home. The institutionalization of the education system means more educational responsibilities are shifted to schools. Nonetheless, the place of home education is irreplaceable in cultivating the child's morality, character, and habits. The 2022 release of the Home Education Law marked the elevation of the standing of home education from a "private matter" to a "national concern." The law affirms the legal recognition of the roles of the parent in child education and the necessity of providing social support for home education (Ministry of Education of China, 2022). To give full play to the role of home education in the healthy growth of basic education children, it is imperative to develop a reasonable understanding of home-school collaboration, clearly define the boundary of home education, and optimize the communication channels for home-school partnerships.

Establish an Appropriate Notion of Home-School Partnership

Suchomlinski (2021) argues that school or home education alone cannot accomplish the sophisticated task of cultivating a whole person. A scientific attitude towards home-school partnerships is of vital importance for the proper implementation of home education. The school management should see parents as an equal party in the home-school partnership. It is important that they listen to the opinions of parents when formulating home-school collaborative programs. The implementation of these programs must be based on the principles of mutual respect and prioritizing child development. Teachers should not see themselves as superiors and transfer instruction-related duties to parents. Also, school leaders should involve parents in school management decision-making for the optimal development of students (Jiang, 2019).

From the standpoint of parents, the stereotypical image of the school is that it is the holder of absolute educational authority. Parents tend to accept its requirements without reservation. Nevertheless, increasing research and practice have shown that rational coordination between the school and parent is crucial for healthy child growth (Wang, 2019). Parents should enhance their consciousness of educational involvement and actively exercise their right to supervise school operations, but in the meantime, have the courage to reject any unreasonable requirements of the school regarding specific instructional duties (Jiang, 2013).

Clearly Define the Boundaries between School and Home Education

The school is a specialized and formal educational institution. School education is a form of structured education that transmits knowledge and skills to students through class-based instruction. Home education, on the other hand, occurs among family members, is unique to each family, and is infused into everyday life. The distinction between the two forms of education determines the division of responsibility between them (Zhang, 2018). Both the teacher and parent must be aware of the boundaries when implementing home-school partnerships. It is important for the parent not to interfere with the teacher's instructional plan. The teacher must keep in mind not to transfer their job responsibilities to the parent. Some teachers may view parental involvement in correcting kids' homework as a proper form of home-school partnership. However, correcting students' homework is part of their instructional duties, which should not become a burden on parents. A workable way of communicating with parents about students' homework is to have conversations with parents after they have finished correcting it themselves to inform parents of the learning situations of their children at school and get an idea of the students' home learning (Guo, 2023).

At the same time, those parents with low home education capabilities may need the guidance of the teacher on child education. In this case, it is worth noting that the teacher must be thoughtful in giving advice to these parents to avoid imposing arbitrary opinions on them. They should listen empathetically to the parents and provide pertinent counseling to help them realize successful family education (Zhong, 2023).

Improve Communication Channels for Home-School Partnerships

An effective use of communication channels makes the home-school partnership better meet the school's needs and suit the features of home educa-

tion. Among the various channels in use, the digital platform and parents' meetings are the most popular means of communication between teachers and parents.

Proper Use of Digital Platforms

Teachers and parents favor digital platforms in the Internet era because they are not limited by temporal and spatial constraints. Nevertheless, the functions of digital platforms have not been properly utilized in home-school communication (Xi, 2018). The online parent group, the most widely accepted digital avenue between teachers and parents, has restricted usage, being mainly used by the teacher to announce assignments for students as well as praise or admonishments for certain individual students. The teacher dominates the online parent group, while parents passively receive information. The parent group can serve more meaningful purposes. For instance, using the online group, the teacher can engage parents in conversations over hot educational topics and exchanges of home education experience; listen to the latter's reactions to emerging issues at school; and share useful information about home education to improve parents' capacity in this regard. Along with the parent group, other Internet-based platforms, such as the class-specific public platform and Blogger, can be adopted for the aforementioned purposes (Liu, 2021).

Properly moderating online communication on digital platforms can help avoid pointless, time-wasting chats. Furthermore, it is important not to overlook the value of face-to-face interaction in addition to Internet-based communication. The combination of timely Internet-based communication and traditional in-person exchange can significantly improve the efficacy of home-school partnerships (Zhang et al., 2018).

Enhancing the Traditional Parents' Meeting

Traditionally, the parents' meeting provides important opportunities for teacher-parent and inter-parent communication (Yang, 2012). Nonetheless, there are shortcomings in current parents' meetings. Teachers typically dominate the meeting, with parents acting as the listeners. Students, the targets of their concern, are excluded from the meeting. It is imperative to make changes to its organization to enhance home-school communication. First, a moderate amount of student participation in the parents' meeting helps improve its relevance and parent-child understanding. Students should be permitted to give their comments on the home education they received to enable parents to understand their real feelings and consider home education from their standpoints. Second, the parents' meeting should be played out in a more equal fashion. With the teacher delivering speeches at the teacher's

desk, parents may somewhat feel distanced from the former. A more casual layout like the “round table meeting” can help create a harmonious atmosphere for more open conversations. Third, the parents’ meeting gives the teacher a good opportunity to understand students’ home education. Therefore, the meeting should allow parents ample time to express their views on education and fully respect the diverse notions of education among parents. That will facilitate the teacher’s providing pertinent advice on their students’ home education.

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