

What is the Most Important Source for Teachers' Knowledge Development? A Meta-Analysis of 27 Empirical Studies on the Sources of Teachers' Knowledge

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Abstract. Studying the sources of teachers' knowledge and the importance of different sources is of great significance to promote the development of teachers' knowledge. This paper systematically analyzes 27 empirical studies on the sources of teachers' knowledge in China and abroad in the past two decades or so in terms of methods and findings. The results show that the in-service experience of teachers contains more important sources than the preservice education and primary and secondary education. Teacher's experience and reflection, and exchanges with colleagues are the most important sources of teachers' knowledge development. Educational internships and practicums are the most important sources of teachers' knowledge during their preservice education, while other sources have no significant effect. The usefulness of teachers' knowledge sources is affected by variables such as knowledge category, subject, education stage and shows a certain degree of individual differences. The above results confirm the importance of teachers' practice, reflection, collaboration and exchange and indicate the necessity of improving preservice education. In terms of methods, it merits recommendation for future researchers in this area to use single-category-focused and topic-focused knowledge frameworks, more specific knowledge source frameworks, multiple ways of data collection, random selection of research subjects, and inferential statistical analysis. In addition, further studies should also look into the psychological and social-cultural mechanisms of teachers' knowledge development as well as the sources of teachers' knowledge.

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PROFESSIONAL knowledge is an integral part of teacher competence. Improving the knowledge level of teachers is of great significance to teachers' professional development and the construction of the teaching force. Therefore, teacher knowledge has long been one of the main topics in teacher education. "In general, there exist mainly three major issues in the field of teacher knowledge research: (i) What knowledge do teachers need? (ii) What knowledge do teachers have? (iii) How do teachers develop their knowledge?" (Fan, 2003, p. 6). The research on the sources of teachers' knowledge belongs to the third issue, which began to attract researchers' attention in the 1970s. However, most of the earlier studies dealt with the sources of teachers' knowledge indirectly, and their research approaches were mainly philosophical and there was a lack of systematic and empirical research.

The empirical research on the sources of teachers' knowledge aims to explore the actual sources of teachers' knowledge development and what role various sources play. Thereby, it can provide insights for planning and implementing more effective teacher education and professional development activities. An earlier empirical study on the sources of teachers' knowledge is an investigation by Lianghuo Fan. He focused his research on the sources of teachers' pedagogical knowledge. Through a survey of high school mathematics teachers in the city of Chicago, he found that the most important source of teachers' pedagogical knowledge was their teaching experience and reflection and their daily exchanges with colleagues; in-service training and professional activities were also relatively important sources; in contrast, their experience as students, pre-service training, and reading professional books were the least important sources (Fan, 2003). This conclusion is inconsistent with prior assumptions about the importance of pre-service education, which prompted investigation and reflection on the effectiveness of teacher education and teacher professional development. Since this seminal research, in recent years, researchers have carried out empirical studies on various sources of teachers' knowledge in different disciplines and at different education levels, and the research findings have grown year by year. So, how are these studies designed and implemented? What are the similarities and differences among their conclusions? What is the most important source of teachers' knowledge development? What are less useful sources? What are the implications of these findings for teacher education? The continuous accumulation of studies in this area merits a timely review. This paper systematically analyzes 27 empirical studies on the sources of teachers' knowledge in China and abroad in the past two decades or so and provides an overview in terms of both methods and findings, with the purpose of providing useful information for teachers' knowledge development and teacher education, as well as for future research in this area.

Literature Sources and Overview of 27 Empirical Studies

Literature analyzed in this paper includes studies published either in Chinese or in English, including journal articles, degree theses (dissertations), and monographs. The sources of literature are as follows: journal articles from the Chinese academic journal database in "CNKI" (China National Knowledge Infrastructure); journal articles from the English academic journal database in the "ERIC" (Education Resources Information

Center); degree theses (dissertations) in Chinese from the database in CNKI for doctoral and Master theses, and degree theses (dissertations) in English from the database of “PQDT” (ProQuest Dissertations and Theses); research monographs (books) in Chinese from the “Wenjin” search system of the National Library of China, and those in English from the book search system of the British National Library website.

Due to the large number of journal articles and degree theses (dissertations) and their wide variations in quality, we limited Chinese academic journals to PKU’s Core-listed journals and CSSCI-indexed journals, English academic journals to peer reviewed journals, and Chinese and English degree theses (dissertations) to those at the doctoral level. The literature search terms were set to include “teacher” (or “prospective teacher”), “knowledge” (or “PCK”, “MPCK”, “TPACK”) and “source” (or “development”) in the titles. The English search terms were the corresponding English translations of the Chinese search terms, and the publication time of the literature was set to on or before March 1, 2020. Through the above search, we obtained a preliminary body of literature, and then consulted the abstract or text to further screen for the literature that meet the following criteria: (i) the research topic(s) involves the role of teachers’ knowledge sources; (ii) it collects empirical data through surveys; (iii) based on quantitative statistics and analysis, it ranks or categorizes the importance of various knowledge sources into different levels. According to the above criteria, 31 studies were obtained. Also, one Chinese monograph that meets the above screening criteria was obtained through the citation retrospective method.

The distribution of these 32 pieces of literature in terms of types is as follows: 16 journal articles, four doctoral theses, and nine monographs in Chinese; one journal article, one doctoral thesis, and one monograph in English. It should be noted that these 32 documents are all the empirical studies on the sources of teachers’ knowledge obtained according to the above searching methods and screening criteria. In contrast, the amount of English literature is relatively small, which shows that empirical research on teachers’ knowledge sources has not attracted enough attention abroad. This imbalance is probably also related to the fact that the first work in this field was published in Chinese in China.

Through analysis and comparison, it is found that the results reported in two doctoral theses and three journal articles are derived from the same research in five monographs among the above 32 documents. Considering that monographs are official publications and their content is more detailed than journal papers, this research preferentially selects the monographs for analysis, thus avoiding the overlap of doctoral theses and journal articles. In addition, if the results of a study are reported in two documents, the document published earlier is included in the analysis, and no repeated statistics will be conducted. Finally, 27 pieces of literature are obtained in this study, and their basic information is shown in **Table 1**.

As shown in **Table 1**, the number of related studies was on the rise in the past two decades or so, indicating continuous attention from the researchers to the investigation of teachers’ knowledge sources. From the perspective of the content of teachers’ knowledge, some of the 27 studies focused on teachers’ overall knowledge, and some focused on a specific field or a branch of teachers’ knowledge. As far as the participants in these studies were concerned, there were both in-service teachers and pre-service teachers; the participants’ subject backgrounds varied, but in most of the studies they

Table 1. Basic Information of 27 Investigations on the Sources of Teacher knowledge.

Author	Year	Genre	Range of Knowledge	Survey Object		
				Subject	Educational stage	Quantity
Fan, L.	2003	M	Teaching knowledge	Mathematics	High school	69
Zhang, Q., et al.	2005	J	Teaching knowledge	Multidisciplinary	Elementary and Middle	410
Zeng, C., et al.	2006	M	Mathematics teaching knowledge	Mathematics	Elementary and Middle school	191
Liu, L.	2006	D	Teaching knowledge	Geography	Middle and high school	385
Yuan, G.	2006	D	Teaching knowledge	Physical Education	High school	203
Liao, D., et al.	2009	J	Subject teaching knowledge	Multidisciplinary	Elementary and Middle	79
Zhao, D., et al.	2009	J	Professional knowledge	Language	Middle school	113
Hua, Y.	2010	J	Subject teaching knowledge	Multidisciplinary	Elementary school	200
Zhu, X.	2010	M	Teaching knowledge	Language	High school	129
Shao, G.	2011	M	Professional knowledge	Multidisciplinary	High school	234
Li, M., et al.	2011	J	Subject knowledge	Mathematics	Middle school	40
Zhang, Y., et al.	2011	J	Professional knowledge	Information Technology	High school	92
Han, J. et al.	2011	J	Professional knowledge	Mathematics	Middle school	123
Li, M., et al.	2012	J	MPCK	Mathematics	Middle school	41
Ding, R., et al.	2012	J	Professional knowledge	Mathematics	Normal student	241
Zheng, D., et al.	2012	J	Classroom assessment knowledge	Multidisciplinary	Elementary and Middle school	1,735
Han, S.	2013	D	Professional knowledge	English	Pre-employment, middle school	1,963, 177
Han, J., et al.	2014	J	Professional knowledge	Multidisciplinary	Middle school	430
Fan, L.	2014	M	Teaching knowledge	Mathematics	Middle school	73
Xu, P.	2014	M	Chinese teaching knowledge	Language	Pre-employment	109
Liu, J., et al.	2015	J	MPCK	Mathematics	High school	77
Fu, G., et al.	2015	J	Professional knowledge	Multidisciplinary	Pre-employment	1,531
Zhou, F.	2016	M	Teacher individual knowledge	Multidisciplinary	Elementary and Middle school	807
Li, C.	2016	M	Local knowledge	Multidisciplinary	Elementary and Middle school	961
Li, Y.	2017	M	Physics teaching knowledge	Physical	Middle school	54
Liu, L., et al.	2018	M	Professional knowledge	English	Elementary school	131
Wei, B., et al.	2019	J	Teaching knowledge of scientific practice	Science	Middle school	280

Note: J in "genre" means journal paper, D means doctoral dissertation, and M means work. The number of survey subjects is the number of observations in parentheses, the number of interviews is in square brackets, and the number of valid questionnaires is shown in brackets.

were mathematics teachers; the sample size ranged from dozens to more than a thousand. In terms of research methods, most studies adopted questionnaire surveys, though some used a combination of questionnaires, interviews, and classroom observations. The above 27 studies (hereafter referred to as “previous studies”) are used as the object of analysis in the present study. Given the importance of research methods to research results, we will first analyze the theoretical framework and specific research methods of the previous studies from the methodological perspective, and then analyze their results.

Analysis of Theoretical Frameworks

Investigating the sources of teachers’ knowledge needs to define the scope of teachers’ knowledge and categories of sources. The following is an analysis of the theoretical framework of teachers’ knowledge and knowledge sources in the previous studies.

Theoretical Frameworks of Teachers’ Knowledge

The analysis indicates that there are four modes in which the scope of teachers’ knowledge is defined in the previous studies.

Holistic Mode

This mode considers teachers’ knowledge as a whole, without further division. This does not mean this mode denies the diversity of teachers’ knowledge. The intention of taking teachers’ knowledge as a whole is probably to make the investigation operationally feasible. However, treating teachers’ knowledge as a whole may obscure the peculiarities of various types of knowledge.

Multi-Category Mode

It divides teachers’ knowledge into several categories and then includes each category into the scope of research. For example, Liu (2018) divided teachers’ professional knowledge into knowledge of education theory, curriculum knowledge, subject matter knowledge, and pedagogical content knowledge (hereafter referred to as PCK) and then investigated the sources of these four types of knowledge separately; Han (2013) investigated the sources of knowledge of secondary school English teachers in four aspects: theoretical knowledge of pedagogy, knowledge of English subjects, knowledge of teaching environment, and practical knowledge.

Single-Category-Focused Mode

It only focuses on a specific category of teachers’ knowledge. This mode covers two situations: (1) The single category of knowledge is studied as a whole. For example, Liao, Zhou and Chen (2009) investigated the sources of PCK of primary and secondary school teachers and did not further divide PCK into sub-categories. (2) Divide single-category knowledge into several sub-categories and investigate the source of each sub-category. For example, Fan (2003) focused on teachers’ pedagogical knowledge, and divided the pedagogical knowledge into pedagogical curricular knowledge, PCK, and

pedagogical instructional knowledge, and then investigated the sources of these three types of pedagogical knowledge.

Topic-Focused Mode

This mode is more specific than the single-category-focused mode. It focuses on a topic or a particular content in a specific category (or sub-category) of teachers' knowledge. For example, Li, Wan, and Yang (2011) cited knowledge of Pythagorean Theorem as a case study to investigate the sources of teachers' subject knowledge, while Zheng and Ye (2012) focused on classroom evaluation knowledge of teachers.

The analysis finds that in the previous 27 studies, there is one study in the holistic mode, two studies in the topic-focused mode, 10 in the multi-category mode, and 14 in the single-category-focused mode. In general, multi-category and single-category-focused studies accounted for the vast majority.

Theoretical Frameworks of Teachers' Knowledge

Sources

The "source" of teachers' knowledge can be understood in two different ways, that is, "means by which they developed their knowledge, and something (often prior knowledge) teachers acted upon within their minds to develop the knowledge." (Fan, 2003, p. 46). The former is a macro source, and the latter is a micro source. All of the previous studies have adopted the macro-source meaning. The reason is that empirical research from this perspective is more useful and practical for exploring how to improve teachers' knowledge.

The macro knowledge source framework is generally divided into three parts according to the teacher's growth process: first, the teacher's experience as a learner before receiving professional pre-service training; second, the experience during the pre-service training; third, teacher's experience after entering the job. When the above three parts are subdivided, the sub-sources proposed by previous studies differ in complexity and in quantity. Fan (2003) proposed nine sub-sources and further divided four of the sub-sources into nine specific sources. In the end, seven sources were retained for quantitative investigation from all sources, namely: the experience as a learner; pre-service training; in-service training; organized professional activities; informal exchanges with colleagues; reading professional books and journals; teachers' experience and reflection (Fan, 2003).

Most subsequent studies have used the above framework for reference or made some adjustment on it. The largest number of source categories was found in Shao's (2011) study, which had 17 sources in total. Although the classification of knowledge sources in the previous studies shows a trend towards subdivision, none of them attempted to make rigorous and exhaustive classifications, but rather selected sources according to the practical needs of research. Specifically, there are three factors affecting the selection of sources: 1) the research focus, related to the research purpose or problems to be addressed. For example, if the purpose of the study is to examine the effectiveness of pre-service education, it will not include the source related to the in-service period; 2) the practical educational environment. For instance, the 17 sources in

Shao's (2011) study included not only the traditional activities of teacher professional development but also the new activities which have been advocated since the new curriculum reform in China so as to reflect the reality of educational reform and development; 3) the disciplinary backgrounds of the subjects. For example, Zhang, Dong and Jing (2011) added a source of "practice in information technology" to the surveys conducted on the teachers of information technology.

Analysis of Specific Research Methods

Methods of Data Collection

The methods used in the previous studies included questionnaire surveys, interviews, and classroom observations. Questionnaire surveys were used to investigate teachers' perceptions of their knowledge development, especially the contribution of various knowledge sources to their knowledge development. Classroom observations were used to identify what knowledge teachers actually used in classroom teaching so as to confirm what knowledge teachers had and provide clues of questions for interviews. Interviews were aimed to understand how teachers used specific sources to develop their knowledge. In data collection, questionnaires were used to collect quantitative data on a large scale and identify the general patterns of teachers' knowledge development; Class observations and interviews were focused on individual cases and were to collect more specific and in-depth qualitative information. Theoretically, the extensive use of the three methods can help present a complete picture of teachers' knowledge development, but this also would increase difficulties in the implementation at the operational level. As a result, among the previous studies, only five used all the three methods, and most of the other studies used questionnaires as the main or only method.

Selection of Survey Subjects

Among the 27 previous studies, 23 studies were conducted on in-service teachers, with 15 focused on teachers of one particular subject, such as mathematics, Chinese, English, Physics, Sciences, Information Technology, Geography, and Physical Education and the rest eight on a combination of teachers of different subjects. The in-service teachers were mainly from primary and secondary schools, and there were no surveys conducted on pre-school teachers or college teachers. Besides the 23 studies mentioned above, there were three surveys focusing on pre-service teachers, and one study investigated both in-service teachers and pre-service teachers.

In terms of the sample sizes of questionnaire surveys, the largest one in the previous studies was in Han's (2013) study, which involved 2,140 English teachers, including both pre-service and in-service teachers. Another study with a relatively large sample is Zheng and Ye's (2012) investigation, in which 1,735 primary and middle school teachers were surveyed. The number of teachers surveyed in other studies ranged from dozens to hundreds.

The generalizability of the conclusion of a study is affected by its sample size, yet it is also related to the sampling strategy employed. Only 5 of the previous studies clearly stated that a random sampling strategy was used, by which schools were select-

ed in the target city or school district using stratified random sampling, and then the teachers in sample schools are selected using cluster sampling. For example, Fan's (2014) study in Chicago and Singapore showed that the teacher samples in the two places were 77 and 73, respectively. Although it is not a large size, "as stratification may produce a smaller bound on the error of estimation than would be produced by a simple random sample of the same size, coupled with the sample teachers' multiple backgrounds in major demographic variables, the samples in the two studies could well represent the target population" (Zhao & Bokhove, 2019).

Statistical Analysis of the Data

Quantitative statistical analysis was applied to the data collected by the questionnaire surveys in the previous studies. Some studies also conducted a qualitative descriptive analysis of the data collected from interviews and observations so that qualitative and quantitative data were used to complement each other.

The focus of quantitative statistical analysis was on examining the contributions of various sources to the development of teachers' knowledge, based on the data collected by the Likert Scale in questionnaires. There were two main statistical techniques used in analyzing the quantitative data in the previous studies: (i) descriptive analysis, measuring the importance of each source by the frequency or percentage of each level selected in the Likert scale, or by the mean value of each level selected, and (ii) inferential analysis, including logistic regression analysis (hereafter referred to as regression analysis) and the analysis of variance for repeated measures. Regression analysis calculates the Wald value and parameter estimates of each source, ranks sources according to the Wald value, and then further stratifies them according to the significance of coefficient. The importance of different sources to the development of teachers' knowledge is generally classified as "the most important," "secondarily important," and "the least important." The importance of the sources at different levels has statistically significant differences. Repeated measure analysis of variance makes pairwise comparisons of the means of various sources and distinguishes the importance of different sources according to the mean and significance coefficient. In the study of Wei, Chen, and Chen (2019), the source with the intermediate-ranking of the mean was used as the benchmark source, and other sources were compared with the benchmark source. The significance standard adjusted by the Bonferroni method is used to test whether the difference is significant, and finally, various sources are classified as "more important," "important," and "less important", according to their importance. Although descriptive analysis is straightforward, the difference in frequency, percentage, and mean may not be statistically significant. The rankings obtained from inferential analysis are more accurate when the data from a sample are used to make inferences about the population. Of the previous studies, ten adopted the method of inferential analysis.

Re-analysis of the Results of the Included Studies

In addition to reviewing research methods to provide insights for future research, another purpose of the present study is to quantitatively integrate the results of the previous studies to obtain a more comprehensive picture about the importance of various sources of teachers' knowledge. The theoretical frameworks and statistical analyses presented in

the previous studies do not meet the requirements of the quantitative meta-analysis for selecting and calculating effect sizes. Thereby, this study re-analyzes the results of the previous studies with an alternative quantitative analysis method. The specific criteria includes: (i) the statistical analysis of the data is based on the research results in the original literature, rather than the generalized research conclusions; (ii) the data are classified by knowledge categories, that is, if a study reported sources of several categories of knowledge, then the data about the source of each category of knowledge are examined; (iii) if the results obtained from the same group of participants were reported in different publications, then only one is included in the statistics to avoid repetition; and (iv) the statistical methods used in each of the previous studies determine the inclusion of the results about the importance levels of the knowledge source. For the research results obtained by inferential analysis, the sources in the first and third levels of importance (i.e., “the most important” and “the least important”) and their ranking of importance are included in the analysis. For the research results obtained by descriptive analysis, the ranking of importance was less straightforward: first, there were more ranking values, and in most cases, there were as many ranking values as there were sources; and second, between two adjacent ranking values there might not be a statistically significant difference. In this case, to distinguish the difference in the importance of each source, this study only includes the top two and bottom two sources in the importance ranking to ensure that the ranking values of the results of the descriptive analysis can be compared with those of the inferential analysis, suitable for combined calculation. For writing convenience, the source(s) in the first level of importance in the results of inferential analysis and the top two sources in the importance ranking in the results of descriptive analysis are collectively referred to as the “most important” sources, and the source(s) in the third level of importance in the results of inferential analysis and the bottom two sources in the importance ranking in the results of descriptive analysis are collectively referred to as the “least important” sources.

According to the above methods, 94 pieces of data are obtained, which to a large degree provide sufficient data to reanalyze the results of the previous studies. Of the 94 pieces of data, 49 are from the inferential analysis results, and 45 from descriptive analysis results. From 94 pieces of data, 214 items are the “most important” sources, and 235 the “least important” sources. The frequencies of various sources that are rated as the most important and least important is shown in **Table 2**.

Commonalities in the Conclusions of the Previous Studies

- In-service experience contains more important sources than pre-service training experience and the experience as a student at primary and secondary schools.

As shown in **Table 2**, according to the summaries of in-service experience, pre-service experience, and the experience as a student at primary and secondary schools, we can see that the cumulative frequencies of the most important sources of the three is 177, 30, and 7, while the cumulative frequencies of the least important sources is 94, 107, and 34. **Figure 1** presents the overall differences in the importance of various sources at different stages in a more visual way. In general, there are more important sources from in-

Table 2. The Number of Times Various Sources Were Rated As the Most Important or Unimportant In Previous Studies.

	"Most Important"			"Unimportant"		
	IA	DA	Grand	IA	DA	Grand
On-the-Job Employment						
Self-experience and reflection	36	41	77	0	0	0
Communication between colleagues	28	11	39	0	0	0
Teaching observation activities	14	9	23	2	3	5
Read professional books	13	8	21	14	5	19
Internet resources or TV media	4	1	5	0	2	2
On-the-job training	2	1	3	14	9	23
Post-employment education	0	0	0	25	6	31
Organized teaching and research activities	0	5	5	4	2	6
Technical practice	1	0	1	0	0	0
Educational Research Project Research	0	3	3	0	8	8
Subtotal	98	79	177	59	35	94
Pre-Employment Education						
Pre-employment training	1	1	2	5	17	22
Education internship, internship	8	5	13	2	7	9
Teaching Method Course or Textbook Analysis Course	10	0	10	14	0	14
Educational Theory Courses	1	1	2	20	6	26
Subject professional courses	1	1	2	3	2	5
Microteaching or teaching skills class	0	0	0	22	2	24
Course study during university	0	1	1	0	0	0
social activity	0	0	0	6	0	6
Part-time tutor	0	0	0	1	0	1
Subtotal	21	9	30	73	34	107
Elementary and Middle School Study						
Experience during Elementary and Middle school	5	2	7	13	21	34

IA: Inferential analysis; DA: Descriptive analysis.

service experience to promote the development of teachers' knowledge than from the pre-service experience in pre-service training and the experience as a student at primary and secondary education; and more sources from pre-service training experience and the experience as a student at primary and secondary education are considered the least important. It can be seen that teachers believe that their in-service experience has played a more significant role in the development of their knowledge.

- In the in-service experience, teaching experience and reflection, and exchanges with colleagues are regarded as the most important sources, while their further education for higher academic qualifications is regarded as the least important source, and for other sources, there exist differences in the conclusions about their importance levels.

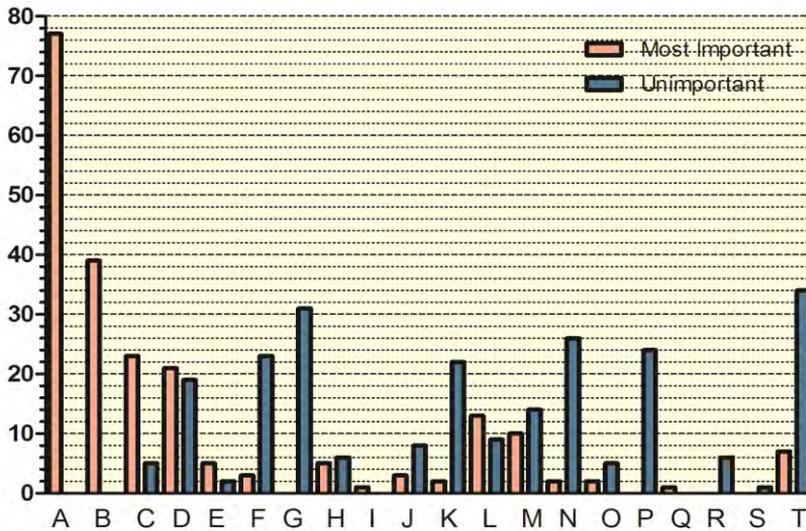


Figure 1. Comparison of the Number of Times Various Sources Were Rated as Most Important or Unimportant.

Note: A-J belong to the source during the employment, A = own experience and reflection, B = communication between colleagues, C = teaching and observation activities, D = reading professional books and periodicals, E = network resources or television media, F = on-the-job training, G = post-employment academic training, H = organized teaching and research activities, I = technical practice, J = research on educational research topics. K ~ S belong to the source of pre-service education period, K= pre-employment training, L=education internship and internship, M = teaching method course or textbook analysis course, N = education theory course, O = discipline professional course, P = micro grid Teaching or teaching skills class, Q = course study during university, R = club activities, S = part-time tutor. T = experience during Elementary and Middle school.

Although there are more important sources in the in service experience, differences also exist in this overall impression. Specifically, the frequency of teachers’ experience and reflection and exchanges with colleagues being rated as the most important sources by teachers is as high as 116, while the frequency of their being rated as the least important sources is 0. In contrast, the frequency of the in-service training being rated as the most important source is 0, while the frequency of it being rated as the least important one is 31. The evaluation of the importance of the above three sources is highly consistent across the conclusions of the previous studies.

There exist differences in the conclusions of the previous studies on the role of other sources. Even in evaluating the same source, some studies considered it as the most important, while others considered it the least important. For example, in the previous studies, “organized teaching and research activities” are regarded as the most important source five times but as least important source six times as well. The frequency of classroom observations being considered as the most important source is higher than that as the least important source, while in-service training and engaging in educational research activities are more often regarded as the least important sources.

- The evaluation of the importance of most sources in the pre-service training is rather low, with the only exception that the importance of teaching practicum and internship are more highly recognized.

In some of the previous studies, pre-service training experience is considered as a whole, and it has been rated as the least important source 22 times. In the other studies, pre-service training experience was classified into more specific sources, such as educational theory courses, mathematics subject courses, teaching method courses, and teaching practicum and internship. However, the overall evaluation is relatively low. Only for teaching practicum and internship, the frequency of being rated as the most important source was higher than the other sources, and higher than that of its being rated as the least important source. This suggests that although the overall evaluation about the pre-service training experience is low, the role of teaching practicum and internship cannot be ignored.

- Experience as a student at primary and secondary schools is regarded more as the least important source.

Teacher's learning experience at primary and secondary schools are rated as the most important source 7 times and as the least important source 34 times. In comparison, it is considered to have less effect on teacher's knowledge development.

Divergencies in the Conclusion of the Previous Studies

In addition to the above commonalities, the effects of various sources on teachers' knowledge development also show some differences due to factors such as knowledge types, subjects, educational stages, and individual teachers.

- The importance of the source varies according to the category of knowledge it is related to.

Teachers' knowledge is diverse and has many sources. Sometimes one source can promote multiple types of knowledge, but its effect on each type differs. For example, in Fan's study on high school mathematics teachers in Chicago, reading professional books and journals were considered the secondarily important source of PCK. In contrast, it was considered the least important source of pedagogical curricular knowledge and pedagogical instructional knowledge (Fan, 2003). As another example, in a survey of pre-service primary teachers conducted by Ding, Ma, and Wang (2012), part-time tutoring is considered the least important source of teachers' knowledge of pedagogical theory. However, it is considered the secondarily important source of curriculum knowledge, subject matter knowledge, and PCK. One source promotes the development of multiple types of knowledge, but the effects differ. This shows that the components of experience in some sources are not single, and teachers can select the component of experience that meets their own needs to construct knowledge.

- The importance of the source varies by subjects and educational stages.

In Fan's study in Chicago, reading professional books and journals is not the most important source for developing high school mathematics teachers' PCK (Fan, 2003). However, in Zhao et al.'s (2009) study on secondary school Chinese teachers and Han's (2013) study on secondary school English teachers, reading professional books and journals is the most important source of multiple types of teachers' professional knowledge including PCK. In the survey conducted on English teachers in junior secondary schools by Han et al. (2014), reading professional books and journals is also the most important source of teachers' knowledge of pedagogical theory, English subject matter knowledge, and PCK. Also focusing on the English subject, another investigation conducted on primary English teachers indicates that the effect of reading professional books and journals on the knowledge development is not the most important (Liu, 2018). It can be seen that the importance of a source varies with subjects and educational stages.

- The importance of the source varies among individual teachers.

The conclusions of the commonalities and divergencies discussed above are drawn from the comparisons of the results in multiple studies. It should be noted that the results of quantitative investigations are determined by the majority of individuals in the sample. Therefore, the generality of the conclusion typically overshadows the particularity of a few individuals or individual groups.

For example, in Fan's study in Chicago, if all the 69 teachers surveyed were taken as a whole, then the evaluation of pre-service training would not be high. However, five of these teachers reported that pre-service training contributed a lot to the development of their knowledge of teaching methods and it was very important (Fan, 2003). This difference can also be found among different groups of teachers with different demographic backgrounds. Still taking Fan's study as an example, among the teachers surveyed, the exchanges with colleagues are regarded as the most important source of teachers' PCK; nevertheless, teachers with different lengths of teaching experience had different views on the importance of this source. Specifically, teachers with more years in teaching tend to obtain less PCK in their daily communication with colleagues, compared with teachers with fewer years in teaching (Fan, 2003). Maybe it is because of the disparities in expertise between senior and junior teachers, that is, senior teachers have more experience and would share their experience with their young colleagues instead of learning from their young colleagues. Junior teachers with less experience would more likely to get help from their senior colleagues and thus learn more.

Discussions and Suggestions

Re-understand the Practice, Reflection, Collaboration and Exchanges of Teachers

Teachers' experience and reflection and exchanges with colleagues are considered the most important sources of their knowledge development. This provides not only empirical evidence for the related theories of teacher professional development, but also guidance for the concrete path of teacher professional development in practice.

From Dewey's introduction of the concept of "reflection" to the field of education to Schon's (1983) advocacy of teachers to become "reflective practitioners", and then to Posner's (1989) proposal of "Experience + Reflection = Growth", it becomes the formula of the growth path for teachers. It emphasizes the importance of teachers' practice and reflection. The results obtained from the analysis of the previous studies in this paper support the above viewpoints from the perspective of teachers' knowledge sources. The nature of teachers' "reflection on practice" or "reflection in practice" is the transformation and reorganization of their own experience. It highlights the significance of the individual teacher's internal cognition and the close association between teachers' knowledge development and practice. Moreover, to a certain extent, it explains why teaching practicum and internships are regarded as an important source of knowledge in pre-service training.

Besides, the importance of exchanges with colleagues found in the previous studies confirms the important values of "teacher collaboration," "team learning" and "organizational learning culture". Exchanges with colleagues are experience sharing, aiming to realize the value-added growth and expansion of experience through interpersonal interaction. If experience and reflection represent the characteristics of teachers' knowledge development in the cognitive dimension, exchanges with colleagues reflect the social nature of teachers' knowledge development and teacher learning. Based on this re-understanding of teachers' experience and reflection and exchanges with colleagues, more attention should be paid to the two sources to promote teachers' knowledge development. More specifically, teachers need "to be reflective, accumulative, associative, and attentive" (Fan, 2003, p. 213). Correspondingly, teacher educators and school administrators should also invest more in creating favorable conditions for teachers to maximize the benefits of the two sources.

Re-think the Focus of Teacher Education

The results of the previous studies show that compared with in-service experience, pre-service training experience plays a very limited role. Except for teaching practicum and internships, which are relatively highly evaluated, most of the other sources during pre-service training are considered of low importance. Given that pre-service training has clear goals, covers a wide range of knowledge, and is taken full time, theoretically it should have played an important role in teachers' knowledge development. However, it is not as it should be. On the contrary, it is in-service experience that encompasses more sources of high importance. Does this mean that the focus of teacher education should shift from pre-service training to in-service training? We believe that current research findings are not enough to support a response to this question. Three more specific issues remain to be explored.

First, is the limited role of pre-service training caused by its existing problems? Or is it because pre-service training is inherently less helpful, and any remedy will not make it as effective as in-service experience? The role of pre-service training revealed by the previous studies reflects what has actually been achieved, and yet, it does not necessarily represent what should and could have been achieved.

Second, is the experience from pre-service training replaced or overshadowed by in-service educational experience, or is it integrated into and further developed by

the in-service experience? From the perspective of teacher education integration, pre-service training and in-service teacher education are closely related. The former lays the foundation for the latter, and the latter is somehow like the extension and expansion of the former. If pre-service training is weakened or ignored, the effectiveness of in-service education will also be impaired.

Third, what is the value of pre-service training to the development of teachers' professional competencies? The previous studies revealed the effects of various sources on the development of teachers' knowledge. However, teachers' professional competence is not limited to knowledge but also includes abilities, ideas, and ethics. If the overall professional competencies of teachers are taken into consideration, the role of pre-service training might have to be re-examined.

To sum up, the role and value of pre-service training should be examined holistically. Given that the maximal effects of pre-service training have not yet defined, further investigation and reflection should be emphasized and the problems should be diagnosed in searching for the paths of reform. This idea also applies to in-service training as in-service training also contains some sources that have limited effectiveness.

Implications and Prospective for the Research on the Sources of Teachers' Knowledge

The research on the sources of teachers' knowledge helps to timely understand and accurately evaluate the usefulness of various sources to provide insights for the improvement of teacher education and teacher professional development. Based on the previous studies, future research in this line can be conducted in a more scientific and in-depth manner.

First, the theoretical framework of sources of teachers' knowledge should be improved. Since teachers' knowledge includes different types, and each type of knowledge has specific components within it, the theoretical framework of teachers' knowledge should not adopt the "holistic mode". Instead, "single-category-focused mode" or "topic-focused mode" might be more appropriate. We believe that, given that there are many sources of teachers' knowledge and the nature and usefulness of each source are different, the theoretical framework of teachers' knowledge sources should also be as specific as possible. For example, it is not advisable to use an overgeneralized source, such as "pre-service training", without looking into more specific sources in pre-service training.

Second, appropriate research methods should be adopted in studies of sources of teachers' knowledge. It is recommended, when feasible, to combine questionnaires, classroom observations, and interviews to collect and triangulate the research data, to use random sampling to recruit the research subjects, and to analyze quantitative data by inferential analysis.

Third, by integrating the investigation of the sources of teachers' knowledge with the examination of teacher education courses or teacher professional development activities, a more comprehensive understanding of the usefulness, the content, the contribution process of knowledge sources can be achieved.

Finally, it should be noted that the usefulness or importance of knowledge sources is ultimately a value judgment. It depends on personal needs and perceptions of

the subject (i.e., the teacher) and is affected by the quality of the object (i.e., the source itself) as well. Teachers' knowledge development is a complex internal cognitive process as well as a social practice influenced by external circumstances. The previous studies present the commonalities and divergencies in the effects of various sources of knowledge, but still little is known about the function mechanism of various sources. Therefore, investigation of teachers' knowledge sources is only a part of the research on teachers' knowledge development. The psychological and social-cultural mechanisms of teachers' knowledge development are a topic for further exploration.

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