

The Sources of Teachers' Knowledge of Instructional Materials

Fan Lianghuo

Abstract

This study investigated how teachers develop their knowledge of instructional materials. The research data were collected from 77 mathematics teachers in three best high schools in the metropolitan area of Chicago, U. S. through a questionnaire survey, classroom observation and teacher interview. The findings of this study reveal that there are various sources by which teachers can develop their knowledge of instructional materials. Overall, teachers' own teaching experience and reflection, and their daily exchanges with their colleagues are the most important sources; teachers' attending organized professional activities, inservice training, and experience as school students are the secondarily important sources; and their reading professional journals and books, and preservice training are the least important ones. Statistically, the contributions of those three kinds of sources to the development of teachers' knowledge of instructional materials are significantly different.

Introduction

Since the early 1980s, the study of teacher knowledge has received mounting attention from researchers in various disciplines, including teacher education, education policy, psychology, and curriculum and instruction of different subjects such as English, mathematics, science, and physical education (e.g., see Elbaz, 1981; Shulman, 1987; Feiman-Nemser & Parker, 1990; Clandinin & Connelly, 1995; etc). However, for the three major issues in the field of teacher knowledge: 1. What knowledge do teachers need? 2. What knowledge do teachers have? and 3. How do teachers develop their knowledge? most studies have focused on the first two issues, and much less have focused on the last one. In fact, this issue has received little or no attention at all in many recent comprehensive studies and extensive literature reviews on teacher knowledge or teacher professional development (e.g., Carter, 1990; Aichele, 1994; Fenstermacher, 1994).

The study presented here was part of a larger research project which investigated how mathematics teachers develop their knowledge in the domain of pedagogy. The general research question of the study is "How do teachers develop their knowledge of instructional materials?" More specifically, it is intended to attack the following two questions:

1. Are there different sources of teachers' knowledge of instructional materials?
2. If the answer to the above question is "yes", then how do different sources contribute to the development of their knowledge of instructional materials?

It is clear that the core instructional materials for most mathematics teachers are textbooks, but textbooks, in a broader sense, also include reference books, problem booklets, and other materials. For example, the secondary textbooks developed by the University of Chicago School Mathematics Project (UCSMP) include, in addition to students' edition and teachers' edition of textbooks, a series of reference materials, including *Lesson Masters*, *Teaching Aid Masters*, *Assessment Sourcebook*, *Technology Sourcebook*, *Answer Masters*, and so forth. It seems appropriate to refer "main textbooks" to the core instructional materials and "peripheral textbooks" to the other instructional materials. Below I will use "textbooks" to generally refer to instructional materials.

According to NCTM's *Professional Standards for Teaching Mathematics* (NCTM, 1991), teachers' knowledge of instructional materials is an essential part of their pedagogical knowledge. The *Standards* identified five components of teachers' pedagogical knowledge under the rubric of "knowing mathematics pedagogy". Regarding the first component, knowledge of instructional materials and resources, it claims,

Teachers are responsible for posing worthwhile mathematical tasks. They may choose already developed tasks or may develop their own tasks to focus students' mathematical learning. To do so, they often rely on a variety of instructional materials and resources, including problem booklets, concrete materials, textbooks, computer software, calculators, and so on. Teachers need a well-developed framework for identifying and assessing instructional materials and technological tools, and for learning to use those resources effectively in their instruction. (NCTM, 1991, p. 151).

The influence of instructional materials, or textbooks, on teachers' teaching practice has received increasing attention from researchers (e.g., see Krammer, 1985; Sosniak & Stodolsky, 1993; Fan & Kaeley, 1998). Although there exists disagreement about the magnitude of the influence of textbooks, researchers generally agree that teachers rely heavily on textbooks in their day-to-day teaching, and they decide what to teach, how to teach it, and what sorts of exercises to assign to their students largely based on the textbooks they use (Robitaille & Travers, 1992). It seems to me, as textbooks convey various pedagogical information and orientations to teachers, how much the textbooks teachers are using affect their teaching depends on how much teachers actually know about the textbooks, which is further related to how teachers get to know the textbooks, the theme of this study.

A Conceptual Framework

A conceptual framework is established to investigate the sources from which teachers develop their pedagogical knowledge, particularly in this study, of instructional materials. Briefly speaking, the framework has three major components in terms of teachers' experience: experience as learners, preservice training experience, and inservice experience.

Experience as learners. By the term I mean teachers' experiences as learners before accepting formal preservice training, which obviously happened mostly in formal educational environments: school. Researchers (e.g., Lortie, 1975) have argued that teachers' experiences as school students, or "apprenticeship of observation", is an extremely important source of their knowledge of teaching methods. To me, this experience can also be a source of their knowledge of instructional materials. This is particularly true when teachers teach the same textbooks (or of a revised version) as they learned in school. This phenomenon is not as rare as it might be thought, especially for popular textbooks in curriculum-decentralized countries such as the U.S. and U.K., and for national standard textbooks in curriculum-centralized countries like China and Japan.

Preservice training experience. There is no question that it is an essential purpose of preservice training to provide prospective teachers with adequate pedagogical knowledge in both curriculum and instruction. Actually, "mathematics pedagogical courses" and "student practical teaching" have been described and discussed by researchers (e.g., McDiarmid, 1990; Grossman, 1991) as sources of teachers' pedagogical knowledge, though not specifically on instructional materials.

Inservice experience. Teachers' inservice experience herein means their professional experience after formally becoming school teachers. For the purpose of this study, four kinds of teachers' inservice experience were identified. The first kind is "inservice training" experience by which teachers received formal and systematic professional training, including graduate degree programs, and non-degree programs such as summer courses. Studies have shown that inservice training programs can be influential or insignificant for teachers to develop their pedagogical knowledge (e.g., Garoutte, 1980; Scholz, 1995).

The second is teachers' experience of attending "organized professional activities". By "professional activities" I exclude those specially designed for professional training, which have been taken into account above. "Organized professional activities" are those organized by a certain organization, such as general conference, seminar, workshops, etc. Although there is little empirical research available investigating how much teachers benefited in terms of knowledge by attending such professional activities, it is reasonable to expect that these activities could contribute, more or less, to the growth of teachers' pedagogical knowledge, including that about textbook reform and curriculum development.

The third is teachers' "non-organized professional activities", which are often more casual and can occur within teachers' everyday professional life. Under that I list "classroom observation", "informal (daily) exchanges with colleagues", and "reading professional journals and books", for I believe they could be helpful for teachers to acquire knowledge about textbook use as well as general pedagogy, though those factors have been largely ignored in the literature on teacher knowledge.

The last is "teachers' own teaching experience and self-reflection". It is self-evident that teachers' teaching practices can provide important opportunities for them to acquire or produce many kinds of new knowledge, including knowledge of instructional materials such as the structure and characteristics of a textbook. In addition, by "self-reflection" I specifically mean teachers' own reflection which is originated from their experience and is on their experience. Researchers have conceptualized "reflection" as "the set of process (of evaluation one's own teaching) that enables a professional to learn from experience" (Brown & Borko, 1992). The reason for me to add "self-reflection" is mainly that I believe what teachers can learn from their own teaching experience will be very limited both in quantity and quality without necessary self-reflection on such experience.

Although the above analysis has identified various possible resources of teachers' knowledge of instructional materials, it is clear how those sources comparatively contribute to the development of teachers' knowledge of instructional materials cannot be answered without adequate empirical evidence, which is the main purposes of this study.

Methodology

The study was conducted in the State of Illinois of the United States, and as mentioned earlier, was part of a larger research project which investigated a broader issue, namely, how teachers develop their pedagogical knowledge. The methodology described here mainly focuses on the part related to this study.

The research subjects of the study consisted of all the 77 mathematics teachers in three high-performing high schools, a stratified random sample from the top 25 of the 194 public high schools in the metropolitan Chicago area in terms of their students' average scores in 1996 Illinois Goal Assessment Program (IGAP) math test, a state-required test. All the three selected schools are typically good suburban public schools with a large predominantly white student population, and more than 80% teachers having at least one Master's degree. Among the teacher participants, about 25% had taught mathematics for less than 5 years, about 25% for 6 to 15 years, and about 50% for more than 15 years.

Three instruments were designed and employed to collect the original data. The first is a questionnaire which is based on the conceptual framework aforementioned and consists of 22 questions for the larger research project (However, I shall only report the data from the questions which are targeted on the research questions of this study). The questionnaire was distributed to all the 77 teachers in May 1997 and collected from 69 of them in June 1997, a response rate of 89.6%.

The second is classroom observation, designed to identify what knowledge of instructional materials teachers actually demonstrate and utilize in their teaching. The classroom observation was applied to nine teachers with three teachers from each school: one randomly selected from teachers with 0-5 years teaching experience, one from those with 6-15 years teaching experience, and the other more than 15 years. Two normal classes of each teacher were observed. All observations were conducted in September 1997 and documented with audio recorders and field notes.

The third is interview which was applied to the nine teachers observed and the three math chairs in the schools. Following the classroom observations, the interviews with teachers focused on how they developed their pedagogical knowledge including that of the instructional materials demonstrated in the classes observed, while the interviews with math chairs focused on the school working environments for teachers to seek professional development. Each interview took about 45 minutes and was audiotaped.

All the instruments were tested on a small scale before being finalized.

The raw data collected from the questionnaire were examined and the data from the interview were transcribed, and then, according to the conceptual framework discussed earlier, all the data were coded for data processing and analysis. Quantitative methods were used to the data collected from the questionnaire to obtain some general patterns about how teachers developed their knowledge of instructional materials. In contrast, qualitative methods were used to the data collected from classroom observations and interviews to depict in-depth how certain teachers developed their particular knowledge.

In addition, attention was also paid to the influence of teachers' background on the development of their knowledge during the process of data analysis.

Results and Discussions

The following question in the questionnaire was specifically designed to address the research issue of this study. The question has a series of three connected parts.

Part A. Think of the most recent period that you taught. Please fill in the following information.

Course name	Title of the textbook for the course	Years of your using this textbook
-------------	--------------------------------------	-----------------------------------

Part B. How do you feel about your knowledge of this textbook in terms of the textbook's overall characteristics, content arrangement and structure, teaching styles implied, etc.?

Not very good Fairly good Very good

Part C. How much did the following sources contribute to your knowledge of this textbook.

Sources	Very much	Somewhat	Little	No contribution	N/A
a. your experience as a school student	4	3	2	1	
b. pre-service training	4	3	2	1	N/A
c. professional training received since becoming a teacher	4	3	2	1	N/A
d. organized professional activities	4	3	2	1	N/A
e. informal exchanges with colleagues	4	3	2	1	N/A
f. reading professional journals and books	4	3	2	1	N/A
g. your own teaching practices and reflection	4	3	2	1	

According to teachers' response to Part A, in 67 teachers who provided the course name, 10 taught Algebra, 22 Geometry, 15 Advanced Algebra, 18 Precalculus (including statistics, trigonometry, & discrete mathematics) and 2 Calculus. There were 29 different textbooks used by 66 teachers (three others did not provide the information). For 65 teachers who gave the exact numbers of years of using their textbooks, the length ranged from 1 year (15 teachers) to over 10 years (2 teachers), with a median of 3 years and an average of 3.2 years (standard deviation: 2.4 years).

Sixty-eight teachers responded to Part B. The data showed that about 70% teachers chose "very good", about 29% chose "fairly good", and about 1% (only 1 teacher) chose "not very good" to evaluate their knowledge of the textbooks mentioned in Part A.

Parts A and B were designed to provide a stimulant for teachers to answer as well as a context for us to look at teachers' answers to Part C, which is the focus of this study.

The teachers' responses to Part C are displayed in Table 1.

Table 1. Distributions of the numbers of teachers giving different evaluation about the contribution of various sources to the development of their knowledge of textbooks

Sources	Degree of the contribution			
	Very much	Somewhat	Little	No contribution
Experience as students	4 (5.9%)	10 (14.7%)	13 (19.1%)	41 (60.3%)
Preservice training	1 (1.5%)	7 (10.3%)	14 (20.6%)	46 (67.6%)
Inservice training	13 (19.1%)	14 (20.6%)	11 (16.2%)	30 (44.1%)
Organized professional activities	5 (7.4%)	16 (23.5%)	13 (19.1%)	34 (50.0%)
Informal exchanges with colleagues	36 (52.9%)	20 (29.4%)	10 (14.7%)	2 (2.9%)

Table 1 (... cont'd)

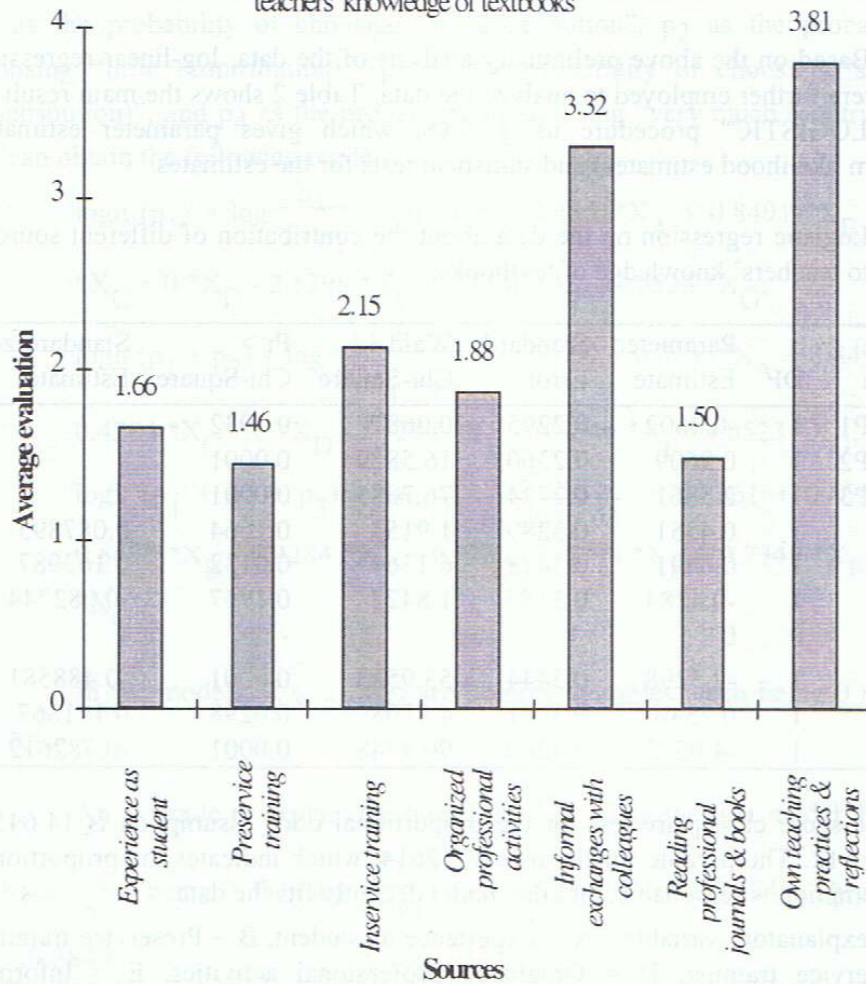
Sources	Degree of the contribution			
	Very much	Somewhat	Little	No contribution
Reading professional journals & books	2 (2.9%)	6 (8.8%)	16 (23.5%)	44 (64.7%)
Own teaching practices & reflection	57 (83.8%)	9 (13.2%)	2 (2.9%)	0 (0%)

Note: $n = 68$. The figures in parentheses are percentages of teachers giving the corresponding evaluation. The sum of the percentages in each row might be not exactly 100% due to rounding.

Two initial results can be obtained from the above table. First, there are a variety of sources from which teachers can develop their knowledge of textbooks, and for different teachers, their main sources for developing their knowledge of textbooks could be very different. Second, in terms of the combined percentages of teachers' choosing positive evaluation: "very much" and "somewhat", overall teachers' "own teaching experiences (practices) and reflection" (97.0%), and "informal exchanges with colleagues" (82.3%) are the two most important ways in which those teachers gained their knowledge of textbooks, while "reading professional journals and books" (11.8%) and "preservice training" (11.8%) are the least important sources. The other three have moderate influences, with "inservice training" being 39.7%, "organized professional activities" being 30.9%, and "experience as student" being 20.6%.

Figure 1 presents a general comparison of the contribution of different sources to teachers' knowledge of textbooks, which is based on their average evaluation in Part C.

Figure 1. Comparison of the contribution of different sources to teachers' knowledge of textbooks



Note: By the ordinal scale in the figure, 4 = very much, 3 = somewhat, 2 = little, and 1 = no contribution.

From Figure 1, we can see that the order of the sources for teachers to develop their knowledge of textbooks is, from the most important to the least important, teachers' "own teaching experience (practices) and reflection" (3.81), "informal exchanges with colleagues" (3.32), "inservice training" (2.15), "organized

professional activities" (1.88), "experience as student" (1.66), "reading professional journals and books" (1.50), and "preservice training" (1.46), consistent with the results obtained from Table 1.

Based on the above preliminary analysis of the data, log-linear regression models were further employed to analyze the data. Table 2 shows the main result of "PROC LOGISTIC" procedure using SAS, which gives parameter estimates (maximum likelihood estimates) and statistical tests for the estimates.

Table 2. Logistic regression on the data about the contribution of different sources to teachers' knowledge of textbooks.

Variable ^a	DF	Parameter Estimate	Standard Error	Wald Chi-Square	Pr > Chi-Square	Standardized Estimate
INTERCP1	1	-0.0602	0.2295	0.0687	0.7932	-
INTERCP2	1	0.9609	0.2360	16.5829	0.0001	-
INTERCP3	1	2.3861	0.2724	76.7085	0.0001	-
A	1	0.4551	0.3289	1.9153	0.1664	0.087895
B	1	0.8491	0.3428	6.1364	0.0132	0.163987
C	1	-0.4284	0.3157	1.8422	0.1747	-0.082744
D ^b	0	0	-	-	-	-
E	1	-2.5298	0.3444	53.9533	0.0001	-0.488581
F	1	0.7346	0.3381	4.7208	0.0298	0.141867
G	1	-4.0523	0.4260	90.4748	0.0001	-0.782612

Note: The score chi-square test for the proportional odds assumption is 14.6452, with DF = 12. The p-value for the test is 0.2614, which indicates the proportional odds assumption is reasonable, and the model decently fits the data.

^aFor the explanatory variables, A = Experience as student, B = Preservice training, C = Inservice training, D = Organized professional activities, E = Informal exchanges with colleagues, F = Reading professional journals & books, G = Own teaching experiences and reflection. For each teacher, 7 repeated observations were created for the data process. They are, in terms of the values of explanatory variables, (1, 0,0,0,0,0,0), (0,1,0,0,0,0,0), (0,0,1,0,0,0,0), (0,0,0,0,0,0,0), (0,0,0,0,1,0,0,0), (0,0,0,0,0,1,0), and (0,0,0,0,0,0,0,1). Total number of observations is 68 x 7 = 476, as one teacher did not provide the information. For the response variable Y, there are 4 response levels: 4 = very much; 3 = somewhat, 2 = little, and 1 = no contribution.

^bThe parameter for D is set to 0, as unsaturated models are used here.

Log-linear regression models have been increasingly used by researchers to analyze categorical data since the 1970s (e.g., see Christensen, 1997; Agresti, 1996; Ishii-kuntz, 1994; and Everitt, 1992). Briefly, from the above table, defining p_1 as the probability of choosing “no contribution”, p_2 as the probability of choosing “little (contribution)”, p_3 as the probability of choosing “somewhat (contribution)”, and p_4 as the probability of choosing “very much (contribution)”, we can obtain the following models,

$$\text{logit}(p_1) = \log \frac{p_1}{1-p_1} = -0.0602 + 0.4551 * X_A + 0.8491 * X_B - 0.4284 * X_C + 0 * X_D - 2.5298 * X_E + 0.7346 * X_F - 4.0523 * X_G;$$

$$\text{logit}(p_1 + p_2) = \log \frac{p_1 + p_2}{1-p_1-p_2} = -0.9609 + 0.4551 * X_A + 0.8491 * X_B - 0.4284 * X_C + 0 * X_D - 2.5298 * X_E + 0.7346 * X_F - 4.0523 * X_G;$$

$$\text{logit}(p_1 + p_2 + p_3) = \log \frac{p_1 + p_2 + p_3}{1-p_1-p_2-p_3} = 2.3861 + 0.4551 * X_A + 0.8491 * X_B - 0.4284 * X_C + 0 * X_D - 2.5298 * X_E + 0.7346 * X_F - 4.0523 * X_G;$$

In the models, X_A, \dots, X_G are dummy variables, each being 0 or 1, and $\sum X^2 = 1$.

An example to explain the models is that, using the first model, let $X_A =$

1, X_B, \dots, X_G being 0, then $\log \frac{p_1}{1-p_1} = -0.0602 + 0.4451 = 0.3849$. Therefore, p_1

$= \frac{e^{0.3849}}{1+e^{0.3849}} = .595$. That is, the logit model predicts, when evaluating Source A

(experience as students), 59.5% teachers chose $Y = 1$ (“no contribution”); in contrast, let $X_G = 1, X_A, \dots, X_F$ being 0, we can calculate $p_1 = 0.016$. Namely, when evaluating Source G (teachers’ own teaching experiences and reflection), only 1.6% teachers chose $Y = 1$ (“no contribution”). Actually, the magnitudes of these slope estimates imply teachers’ preferences of choosing $Y = 1$, relative to the explanatory variable D (note: we set 0 for Source D). Similar explanations apply to the other two models.

For p_4 , because $p_4 = 1 - p_1 - p_2 - p_3$, it means that the smaller the coefficient of a explanatory variable is, the bigger p_4 is. In fact, since $\log \frac{p_1 + p_2 + p_3}{1 - p_1 - p_2 - p_3} = \log \frac{1 - p_4}{p_4}$, from the above third model, we can obtain that when evaluating Source A (experience as students), only 5.5% teachers chose $Y = 4$ ("very much contribution"); but when evaluating Source G (teachers' own teaching experiences and reflection), as high as 84.1% teachers chose $Y = 4$ ("very much contribution").

In short, according to the parameter estimates shown in Table 2, the order of importance of the sources to the development of teachers' knowledge of textbooks is teachers' "own teaching experience and reflection" (G: -4.0523), "informal exchanges with colleagues" (E: -2.5298), "inservice training" (C: -0.4284), "organized professional activities" (D: 0), "experience as student" (A: 0.4551), "reading professional journals and books" (F: 0.7346), and "preservice training" (B: 0.8491).

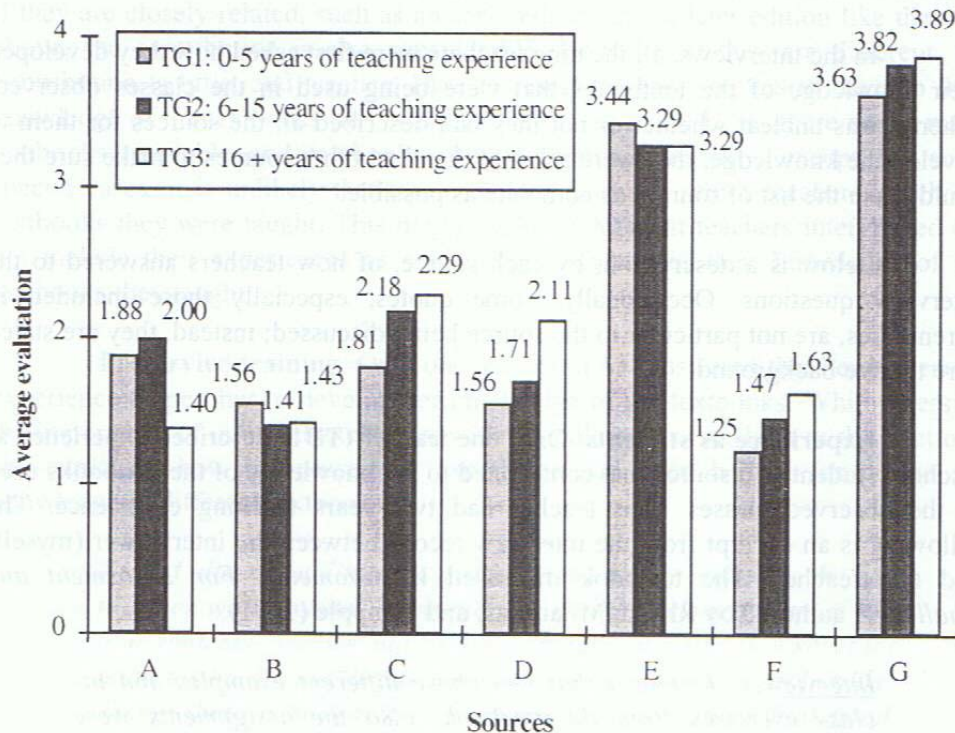
It is easy to see that the order of importance of the different sources based on the above models is the same as revealed by teachers' average evaluations of the sources.

Moreover, from each value of $Pr > \text{Chi-Square}$ in Table 2, which is the significant level of the Wald chi-square test statistic, the square of the ratio of the parameter estimate to its standard error, and detects if the parameter equals zero (Namely, the explanatory variable does not affect the predicted probability, the preference of teachers' choosing), we can see that, compared to "organized professional activities", teachers' "own teaching experience and reflection" and "informal exchanges with colleagues" are significantly more important at the 0.05 level, their "inservice training" and "experience as student" have the same importance as "organized professional activities", and "reading professional journals and books" and "preservice training" are significantly less important.

To this point, it is natural to see how the length of teachers' teaching experience affects their evaluation of the contribution of different sources to their knowledge of textbooks. For this purpose, the teachers were classified into 3 groups: TG1 consisting of teachers with 0-5 years teaching experience, TG2 with 6-15 years, and TG3 with 16 or more years. Figure 2 presents the average evaluation

of the teachers in those three groups of the contribution of different sources to their knowledge of textbooks.

Figure 2 : Comparison of three group teachers' average evaluation of the contribution of different sources to teachers' knowledge of textbooks



Note: 1. For sources, A = Experience as student, B = Preservice training, C = Inservice training, D = Organized professional activities, E = Informal exchanges with colleagues, F = Reading professional journals & books, G = Own teaching experiences and reflection.

2. The evaluations are shown by the ordinal scale in the figure, 4 = very much, 3 = somewhat, 2 = little, and 1 = no contribution.

From Figure 2, we can see that overall the average evaluations of the three groups for each of those sources are rather close. Applying chi-square tests to the original data revealed that there was no significant difference among the distributions with those three groups for each source. In other words, the length of

teachers' teaching experience did not significantly affect how they think about the importance of different sources in developing their knowledge of textbooks.

Compared with the questionnaire data, the interviews with the nine teachers revealed more specific and contextualized evidence of how different sources contributed to the teachers' knowledge of textbooks.

In the interviews, all the nine teachers were first asked how they developed their knowledge of the textbooks that were being used in the classes observed. When it was unclear whether or not they had described all the sources for them to develop the knowledge, they were asked if they had other sources to make sure they could make the list of sources as complete as possible.

Below is a description, by each source, of how teachers answered to the interview questions. Occasionally, some quotes, especially those included in parentheses, are not particular to the source being discussed; instead, they are stated here to give background.

Experience as students. Only one teacher (TB1) described experience as a school student as a source that contributed to his knowledge of the textbooks used in the observed classes. This teacher had two years teaching experience. The following is an excerpt from the interview record between the interviewer (myself) and that teacher. The textbook discussed is, *Geometry: For Enjoyment and Challenge*, authored by Rhoad, Milauskas, and Whipple (1991).

Interviewer: I noticed that you chose different examples and in-class exercises from the textbook; also the assignments were different from the textbook. I think you know pretty much of the textbook. My question is, how did you get your knowledge of the textbook, like the structure, the lessons, the arrangement, exercises, and questions of the textbook?

TB1: Well, that's actually the textbook I used when I was in high school geometry. So I was very familiar with that one. ... I was taught out of that one in 1984, 14 years ago.

Interviewer: So maybe it's a new edition.

TB1: Yes, a newer edition. It's just a different edition, but it's pretty much word for word the same.

It was the first time that this teacher taught the textbook, and the other source he mentioned is "reading the text by myself".

It seems clear that whether a teacher's experience as a student contributed to his/her knowledge of a textbook depends on how the textbook he/she is teaching is related to the one he/she was taught. If they are the same, the contribution is big; if they are closely related, such as an early edition and a later edition like the case above, the contribution is also considerable. However, if they are different, the contribution is little, and teachers have to resort to other sources to develop their knowledge of the textbooks they will teach. Because in the U. S., there are so many textbooks available and textbooks change relatively quickly, except for some special cases, it is unlikely that teachers, especially for senior teachers, teach the textbooks they were taught. This might explain why most teachers interviewed did not include their experiences as students as a source of their knowledge of the textbooks they taught.

Preservice training. Only one teacher, TAI, answered that her preservice experience helped her to develop her knowledge of the textbooks. While stressing the importance of informal exchanges with her colleagues (see later in this section), she explained how her preservice experience had been helpful for her to get knowledge of different textbooks:

TAI: I did do a little bit [with textbooks] in college. We got together with a group of people. We had a working group of like four students. And we had to come up with an evaluation sheet for math textbooks and decide what we liked and what we didn't like. Things that we thought were good and things we didn't think good. And we had to write them. Once we had our evaluation, we went in one day, and there was just a stack of books around the room, and we had to go through them and do evaluations for all of them. That helped me look for things like that is a good idea that I'd like to incorporate into my classroom, and that is something that the textbook is talking about and it probably isn't that valuable. So this kind of helps me out.

No other teacher listed preservice experiences as a source that contributed to his/her knowledge of the textbooks he/she was teaching.

Inservice training. According to an item in the questionnaire not given here for brevity, only a small number of teachers in the recent five years received

inservice training focusing on textbooks and other teaching resources, with the percentage being 21.7%. This is largely consistent with the interview data, which revealed that most teachers did not receive inservice training for the textbooks they were teaching. Only one teacher, TB3, pointed out that attending professional training had been useful to enhance her knowledge of the textbooks.

[After teacher TB3 identified that her own teaching experience and reflection had been the major source for her to develop her knowledge of textbooks and other teaching materials]

Interviewer: Are there any other sources?

TB3: Well, my other sources would be sometimes (colleagues). Or in the summertime, I go to workshops. This summer I went to Illinois State University for two classes. Sometimes I go down to Champaign. They have a little bit of everything for textbooks or teaching strategies. Sometimes it's on algebra. Sometimes geometry. Sometimes calculators.

Organized professional activities. One teacher, TB2, who was teaching a reform textbook, *Calculus: Concepts and Applications* (Foerster, 1998), said that she attended two or three different conferences in the past year and spent a week at a program that past summer on the calculus reform, and that experience was useful for her in developing her knowledge of the reform textbook she was teaching. She was the only one recognizing organized professional activities as a source for developing knowledge of textbooks.

The reason that not many teachers listed attending organized professional activities as a source of their knowledge of textbooks seems to be that not many those kinds of activities are available which focus on textbooks.

Informal exchanges with colleagues. Six of the nine teachers pointed out that they got their knowledge of the textbooks they were teaching from their colleagues.

The following is a discussion between the interviewer and teacher TA1 about both her specific knowledge of the textbook's arrangement of a special topic: velocity and speed, and her general knowledge of the textbook, *Algebra 1: An Integrated Approach* (Larson, Kanold, & Stiff, 1995, pp. 62-67)

Interviewer: In the algebra class I observed, the textbook has "Example 6: Finding velocity and speed". You did not include it in the class. This is because you did not have enough time?

TA1: A little bit. More because later on in algebra speed and velocity equations will come up again. ...

Interviewer: Why do you know it will come up again in the textbook?

TA1: Because I taught it before. I had experience.

Interviewer: But if it was your first time you taught the textbook?

TA1: Then it was my colleagues helping me out by telling me: don't worry about this right now; we'll get to it in Chapter four when it comes up again.

Interviewer: How did you develop your general knowledge of the textbooks?

TA1: (I did do a little bit in college. ...). But again too, I'd have to say that a lot of it comes from my colleagues, who have been through it already and can tell you things. Probably the first time looking through that textbook and seeing velocity, I wouldn't have known that it would come up again later. But they are there to tell you that this point we can rely on later.

Teacher TC1's pre-calculus class and algebra class, both of which he was teaching for the first year, were observed. He described how he acquired knowledge of the textbooks from his colleagues.

Interviewer: Who sets the purposes of the course [Pre-calculus]?

TC1: The school. The math department.

Interviewer: How did you know those purposes?

TCl: OK. The textbook has very basic objectives for each lesson. We decide which lessons are going to come out of the book that we're going to teach. ... When I do it, I went to a previous teacher. He's taught it for several years. And he said, OK. here's the order we go through as far as chapters and the material we're trying to cover. The book is very good about having good objective in there. But sometimes I feel like the book skips algebra concepts that students need or doesn't hit them hard enough. It just kind of brushes them.

Interviewer: How did you know that?

TCl: OK. I've been told by other teachers. But I've also noticed the lack of algebra skills in these students.

.....

Interviewer: How did you develop your general knowledge of the textbooks?

TCl: First I read them over the summer by myself ... Now as you go through there, you look at concepts and you say, OK, is that a key concept or not? For that kind of knowledge, I rely mainly on some of other teachers now, because I don't have a great feel for that yet. ...

Interviewer: So you had exchanges with your colleagues about the textbooks?

TCl: Yes. I talked about -- like I said, I found out last year I was going to teach this class, so I went to the people who were teaching it last year, and talked to them about, what are the key concepts? What chapters are we going to hit? ...

Four other teachers, not quoted above, also answered that they learned knowledge of the textbooks from their exchanges with their colleagues.

Reading professional journals and books. No teacher interviewed explicitly described "reading professional journals and books" as a source of their knowledge of the textbooks they were using. Comparing this to the result of the questionnaire survey, we can be quite sure that it is by no means a major source. I

think there might be two reasons. One is that teachers did not read professional journals and books very often; the other is that the professional journals and books teacher have access to, such as *Mathematics Teachers*, are usually devoted to mathematics content and general instructional issues, not to textbooks.

Own teaching experience and reflection. Except for the two teachers, TB1 and TC1, who were teaching for the first time the textbooks for the classes I observed, all of the other teachers interviewed expressed that their own teaching experience and reflection had contributed to their knowledge of the textbooks.

Below are excerpts from the interviews with teacher TA3 and TB3, who gave more detailed explanations than other interviewees about the issue.

Teacher TA3 has taught mathematics for more than 20 years. One of her classes I observed was calculus; the textbook was *Calculus with Analytic Geometry* (Larson, Hostetler, & Edwards, 1994). The other was a geometry honors class; the textbook was *Geometry: For Enjoyment and Challenge* (Rhoad, et al., 1991). The conversation began with the calculus class.

Interviewer: How did you get the general knowledge of the textbooks?

TA3: I've taught calculus out of many textbooks. This is probably about the fifth book I've taught calculus from. So I've seen a lot of textbooks.

Interviewer: How about geometry?

TA3: Actually, I taught geometry 18 years ago. I didn't teach geometry for a long time. I just went back to teaching geometry three years ago. I would say that my view of geometry changed because I teach the classes that come after geometry.

Interviewer: So you mean you learned that from your teaching experience?

TA3: Yes.

Interviewer: Did you get any of that kind of knowledge of textbooks from other sources?

TA3: No. No. I don't read textbooks very carefully.

Interviewer: But you do know what's good and what's not very good, what's the limitation of the textbooks. Is that right?

TA3: Yes.

Interviewer: So you know that from your experience?

TA3: Experience. Yes. I have a lot of experience. I've been teaching for 22 years, so I have a lot of experience.

Teacher TB3 has 27 years of teaching experience. The classes observed were both geometry, but one for lower level students, and the other for regular students. Both classes were using the same textbook: *Geometry: For Enjoyment and Challenge* (Rhoad, et al., 1991). The teacher explained how she developed her knowledge of textbooks from her experience.

Interviewer: In your classes I observed, I noticed you used different examples and questions from the textbooks, but you also assigned students some questions in the textbooks. You must have certain knowledge of the textbooks. My question is, how did you develop that kind of knowledge?

TB3: I have taught that course more than one time. The textbook is not new to me. So after I know what the textbook is like, then I know which problems the students had trouble with last year.

Interviewer: That's from your own experience?

TB3: That was from my own experience from having taught it previous year. When I've taught it the previous year, then I make a note in the textbook, or actually on my assignment sheet, as you've probably noticed. ... When I know a problem has given my class trouble, then I circle the problem. And the next year, I make sure I pay special attention to the really hard ones that everyone was frustrated with.

Interviewer: How many years have you taught out of this textbook?

TB3: Maybe three years.

Interviewer: So it is different from the first year you taught?

TB3: Usually. That's why I think it's extremely poor to have a teacher teach one year and never teach it again. Because everything they learn and they think will be not used again. Like this is a bad question in the book; it was silly. You know, you don't sometimes know how poor a question is and how confused the students are until you've presented it. Now in most textbooks, they suggest what to give. I don't know if you've seen the teachers' editions.

Interviewer: No. I didn't see it.

TB3: They give you suggestions with problems. The first year I usually follow their suggestions. However after I follow their suggestions, a lot of times I don't like the quality of the problem, and that's when I'd start giving them extra sheets. Now luckily, because I'm an older teacher, even when I get a new book, I have old papers from previous books. I didn't throw anything away. So let's say next year, people don't want this book, and we get a new book. Geometry is still geometry. Just because it's Chapter 4 in this book, it may be Chapter 2 in another book. Although the problems won't match, the chapters will still match. Your experience still helps.

Interviewer: So can I say your own teaching experience and reflection about how to use the textbook is a major source for you today?

TB3: Absolutely.

Interviewer: Are there any other sources?

TB3: Well, my other sources would be sometimes [informal exchanges with colleagues and attending summertime workshops].

Other sources. In addition to what discussed above, the interviews also revealed that there are two other kinds of sources, which were not originally highlighted in the conceptual framework mentioned earlier.

The first source is "reading textbooks". Needless to say, a teacher can get knowledge of textbooks from reading them, for example, one can know roughly the structure of a chapter in a textbook from reading the chapter. In the interviews, not all teachers particularly described "reading textbooks" as a source of their knowledge of the textbooks, and two teachers even explicitly pointed out that they usually did not read the textbooks very much because they had taught the textbooks previously. Nonetheless, five teachers stressed that when they first time taught a course, reading the textbook was very important for them to know the textbook. Look at how some of them explained below.

Interviewer: How did you get all of that kind of knowledge of the textbook [calculus]?

TB2: Once again, what I did was, this summer I spent three months with the textbook . With the calculus book I went through each section and I did handful of problems for each section, and kind of got a feeling of what it was going to be about it. So, that's the first thing I did. I went through the textbook as though I was a students and did the problem myself.

.....

Interviewer: How did you develop your knowledge of the teaching resources (a UCSMP textbook)?

TC2: Well, I read it in the teachers' edition. My business experience [see below on this page] helped me because I helped that textbook, but that was secondary. The thing was, I can't remember absolutely everything, and so I read. Bottom line is I read the teachers' edition.

.....

TB3: ... But if it were a brand new book, then in the summertime, I would sit down and I would read the beginning of every chapter. In teachers' edition, they say how long it should take for superiors. And then, I map out my lessons in the summertime. That doesn't mean that they'll stay that way, but it gives me a rough idea.

It is clear that "reading textbooks" is especially important for teachers who teach the textbooks for the first time, but remains helpful every time they teach. Because in some sense it is teachers' current experience, I believe it is appropriate to treat it as a kind of teachers' "own teaching experience and reflection" under the context of this study.

The second source is particularly found with Teacher TC2, who worked as an editor of secondary mathematics textbooks at a publishing company. Therefore, she described her "business experience" as an important source of her knowledge of the textbooks. However, it should be pointed out that not only is the number of teachers who had worked in other careers before getting teaching jobs very small, but also understandably this kind of "business experience" is likely unrelated to school textbooks. So Teacher TC2's case is very unusual. Nonetheless, it reminds that there are indeed various sources for different teachers to develop their knowledge of textbooks.

Table 3 summarizes the data from the interviews discussed above. It shows that there are various sources for teachers to develop their knowledge of instructional materials; and the most important sources are their own teaching experience and reflection (G) and their daily exchanges with their colleagues (E), which are consistent with what we found through analyzing the data from the questionnaire.

Table 3. A summary of sources of teachers' knowledge of textbooks from interview data

	A	B	C	D	E	F	G	Other sources
TA1		yes			yes		yes	
TB1	Yes							Reading text
TC1					yes			Reading text
TA2					yes		yes	
TB2				yes	yes		yes	Reading text
TC2					yes		yes	Reading text; Business experience
TA3							yes	
TB3			yes		yes		yes	Reading text
TC3							yes	
Total	1	1	1	1	6	0	7	

Note: For sources, A = Experience as student, B = Preservice training, C = Inservice training, D = Organized professional activities, E = Informal exchanges with colleagues, F = Reading professional journals & books, G = Own teaching experience and reflection.

Conclusions

This study investigated how teachers develop their knowledge of instructional materials, or textbooks. Based on the analysis of the data collected from both the questionnaire and interviews, the following conclusions can be drawn from the study.

1. There are various sources by which teachers can develop their knowledge of instructional materials.
2. Overall, teachers' own teaching experience and reflection, and their daily exchanges with their colleagues are the most important sources; teachers' attending organized professional activities, inservice training, and experience as school students are the secondarily important sources; and their reading professional journals and books, and preservice training are the least important ones. Statistically, the contributions of those three kinds of sources to teachers' knowledge of textbooks are significantly different.
3. Moreover, the length of teachers' teaching experience does not play a significant role in their viewing of the contributions of those sources to their knowledge of textbooks.

Finally, I would like to point out again that this study was conducted in American educational settings. Because of the differences of educational and cultural environments (including both the curriculum system and teacher training system) among different countries, especially between the Western and Eastern countries, it would be interesting to see how the results will be if we further extend the study to other countries, especially the Eastern countries.

References

- Agresti, A. (1996). *An introduction to categorical data analysis*. New York: John Wiley.
- Brown, C. A., & Borko, H. (1992). Becoming a mathematics teacher. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 209-242). New York: Macmillan Publishing Company.
- Carter, K. (1990). Teachers' knowledge and learning to teach. In W. R. Houston, M. Haberman, & J. Sikula (Eds.), *Handbook of research on teacher education* (pp. 291-310). New York: Macmillan Publishing Company.
- Christensen, R. (1997). *Log-linear models and logistic regression*. New York: Springer.
- Clandinin, D. J., & Connelly, F. M. (1995). *Teachers' professional knowledge landscapes*. New York: Teachers College Press.
- Elbaz, F. (1981). The teacher's "practical knowledge": Report of a case study. *Curriculum Inquiry*, 11(1), 43-72.
- Everitt, B. S. (1992). *The analysis of contingency tables*. London: Chapman & Hall.
- Fan, L., & Kaeley, G. S. (1998). Textbooks use and teaching strategies: An empirical study. Paper presented at the American Educational Research Association Annual Meeting, San Diego.
- Feiman-Nemser, S., & Parker, M. B. (1990). Making subject matter part of the conversation in learning to teaching. *Journal of Teacher Education*, 41(3), 32-43.
- Fenstermacher, G. D. (1994). The knower and the known: The nature of knowledge in research on teaching. In L. Darling-Hammond (Ed.), *Review of research in education* (pp. 3-56). Washington DC: American Educational Research Association.
- Foerster, P. A. (1998). *Calculus: Concepts and applications*. Berkeley, CA: Key Curriculum Press.

Garoutte, M. W. (1980). Effects of in-service training upon the pedagogical knowledge of inner city teachers. Doctoral dissertation, University of Missouri-Columbia. Dissertation Abstracts Online Accession No.: AAG8117429.

Grossman, P. L. (1991). *The making of a teacher: Teacher knowledge and teacher education*. New York: Teachers College Press.

Ishii-kuntz, M. (1994). *Ordinal log-linear models*. Thousand Oaks, CA: Sage.

Krammer, H. P. M. (1985). The textbooks as classroom context variable. *Teaching & Teacher Education*, 1, 273-278.

Larson, R. E., Hostetler, R. P., & Edwards B. H. (1994). *Calculus with analytic geometry*. Lexington, MA: Heath.

Larson, R. E., Kanold, T. D., & Stiff, L. (1995). *Algebra 1: An integrated approach*. Lexington, MA: Heath.

Lortie, D. C. (1975). *Schoolteacher: A sociological study*. Chicago: University of Chicago Press.

McDiarmid, G. W. (1990). Challenging prospective teacher's beliefs during early field experience: A quixotic undertaking? *Journal of Teacher Education*, 41(3), 11-20.

National Council of Teachers of Mathematics. (1991). *Professional standards for teaching mathematics*. Reston, VA: NCTM.

Rhoad, R., Milauskas, G., & Whipple, R. (1991). *Geometry: For enjoyment and challenge* (New edition). Evanston, IL: McDougal, Littell & Company.

Robitaille, D. F., & Travers, K. J. (1992): International studies of achievement in mathematics. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 687-709). New York: Macmillan Publishing Company.

Scholz, J. M. (1995). Professional development for mid-level mathematics. Paper presented at the Annual Meeting of American Educational Research Association, San Francisco, CA.

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, 57(1), 1-22.

Sosniak, L. A., & Stodolsky, S. S. (1993). Teachers and textbooks: materials use in four fourth-grade classrooms. *The Elementary School Journal*, 93, 249-275.