Relations Between Teachers' Subject Matter Knowledge, Teaching Experience and Their

Mental Models of Children's Minds and Learning

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Abstract

We studied the relations between teachers' subject matter knowledge (SMK), teaching experience, and mental models (MMs) about children's learning. The subject matter knowledge we tested was wh-constructions in English.

Teachers were classified on a Subject Matter Task, to have high or low SMK. They were then interviewed to determine the nature of their MM of children's learning.

A total of 32 teachers were divided into 4 groups of 8 teachers each: SMK (high and low) and teaching experience (experienced and novice teachers).

The findings were that despite their differences in SMK and teaching experience, the teachers had identical MMs of children's learning.

These data support the notion that teachers' MMs have priority over their SMK.

Relations Between Teachers' Subject Matter Knowledge, Teaching Experience and

Their Mental Models of Children's Minds and Learning

The purpose of this study was to study the relations between teachers' subject matter

knowledge (SMK), their teaching experience, and their espoused mental models (MMs) of

children's minds and learning. We claim that teachers with high or low SMK and those who are

experienced or novice, have the same MM about children's minds and learning. This claim,

which is different than traditional claims, is based on a distinction between SMK and teaching

which has not been made in the teacher cognition literature and which we propose and test here.

The SMK we tested was wh-constructions in English. It is widely known among teachers

of English in Israel that wh-constructions are particularly difficult for Israeli youngsters to learn,

mostly because the equivalent constructions in Hebrew are very different than in English

(Berman, 1978).

We describe: (1) wh-constructions as subject matter from the point of view of linguistics

and the task we gave to teachers, (2) teachers' SMK, (3) teaching experience, (4) MMs, and (5)

relations among teachers' SMK, teaching experience, and MMs.

Wh-constructions

Wh-constructions are divided into two main parts: Wh-questions and wh-relative

clauses.

Wh-questions

These kinds of questions are divided into two kinds: direct and indirect questions.

Direct wh-questions

Wh-questions constitute one of the two major subtypes of interrogative clauses in

English: yes/no (or truth) questions, which question the truth value of a sentence, e.g., Is it

raining? and wh- (or content) questions, which elicit information about a particular part of the sentence, e.g., What did he eat? (Dekeyser et al, 1984; Huddleston, 1984). These two constructions share the process of subject-auxiliary inversion, whereby the subject of the sentence and an auxiliary tense-carrying verb invert their positions. For example, in the declarative sentence He ate the fish the subject he is at initial position in the sentence, while in the wh-question What did he eat? it is preceded by the auxiliary did. Wh-questions are marked, in addition to inversion, by a wh-word (e.g., what, where, how, why) which moves to the beginning of the sentence and refers to a questioned element (wh-movement). For example, the question when in When did they leave refers to the time adverb at four o'clock in the sentence They left at four o'clock. Both children acquiring English as their mother tongue and learners of English as a second/foreign language must become aware of the changes in the structure of the interrogative sentence to produce grammatical wh-questions in English (de Villiers & Roeper, 1995; Quintero, 1992; Weinberg, 1990).

     Subject and non-subject questions. Direct Wh questions are further classified into subject questions (e.g., Who likes John? about the subject of the sentence) and non-subject or object questions (e.g., Who(m) does John like? about an object in the sentence). Subject questions contain a wh-word at the beginning of the sentence, but are unique in that they do not require subject-auxiliary inversion[1], hence the difference in the structure of the two examples. Typical subject questions are about humans (who), objects and events (e.g., what happened? replacing Something happened), and it is also possible to question internal parts of the subject (e.g., How many students left? questioning the declarative sentence 30 students left).

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[1] Other differences between subject and object questions are enumerated in Stromswold (1995).

<u>Indirect wh-questions</u>

When a question is embedded in a main clause to create an indirect wh-question construction, subject-auxiliary inversion is forbidden. For example, compare the direct question sentence <u>How did you feel?</u> and the indirect question sentence <u>I want to know how you felt</u>. While both posit the same question, the first has undergone subject-auxiliary inversion while the second has not and resembles a declarative rather than a question sentence. L2 learners have to unlearn what they know, since the rules of <u>wh</u>-questions and subject-aux inversion are learned gradually for construction type (yes/no and <u>wh</u>), for auxiliary type and for specific <u>wh</u>-words over a period of 6 years.

<div align="center">Wh-relative clauses</div>

Relative clauses were selected for this test because they bear a resemblance to <u>wh</u>-questions in general, and specifically to indirect questions: they contain subordinate clauses that begin with a <u>wh</u>-word which replaces a syntactic element originating at some site in the clause, without subject-aux inversion (Huddleston, 1984; Pinker, 1984). Compare, for example, the indirect question construction <u>They want to know whose book you prefer</u> and the relative clause construction <u>The man whose sister you married has disappeared.</u> In both sentences the wh word refers to an NP, but in the first sentence this NP is questioned while the second construction originates in the combination of the main clause <u>The man has disappeared</u> and the clause <u>You married his sister</u> subordinated to <u>the man</u>. Relative clauses are also part of the English language curriculum in Israel and are taught in grades 9 and 10 and tested in the Israeli matriculation examination.

<u>Learning about wh-questions</u>

In order to produce grammatical questions, learners of English must master the content and function of specific <u>wh</u>-words, <u>wh</u>-movement, inversion rules, and the structure and types of auxiliary verbs in English (Ingram, 1989; Pinker, 1984; Stromswold, 1995). There is a considerable amount of evidence that while children acquiring English as L1 master <u>yes/no</u> questions early on, they have difficulty in learning about the correct structure of <u>wh</u>-questions. They frequently fail to invert subject and auxiliary in <u>wh</u>-questions (e.g., Bellugi, 1965; Brown, 1968; Radford, 1990; Vainikka, 1994), invert them when they should not, and gradually learn to invert for specific <u>wh</u>-questions (Kuczaj & Brannick, 1979; Labov & Labov, 1978). Similar problems are noted for learners of English as L2 who find inversion in both question constructions problematic, and learn it gradually for different auxiliaries (Adams, 1978). <u>Wh</u>-questions remain problematic for a long time, especially for adult learners (Quintero, 1992), and disappearance of subject-auxiliary inversion in <u>wh</u>-questions is among the first changes made in dialectal varieties of English (e.g., Baumgardner, 1990).

<div align="center">Structure of the Wh-Constructions Test</div>

The research tool that was decided on as a measure of the depth of English teachers' knowledge of their subject matter was a test containing 12 sentences with <u>wh</u> words (see Table 1) which they were asked to classify. Table 2 presents the classification of the test sentences according to the categories described above. The test contained 9 direct and indirect <u>wh</u>-questions, and 3 sentences with relative clauses marked by <u>wh</u>-question words.

The above described the subject matter of <u>wh</u>-constructions. We now turn to our study of teachers' SMK of <u>wh</u>-constructions and their MMs of children's minds and learning of <u>wh</u>-constructions.

Teachers' SMK

The psychological description of the subject matter of disciplines, and its related pedagogy, has a century-long history (Shulman and Quinlan, 1996). Among the most influential contemporary scholars to study subject matter is Schwab (1962). At the core of his ideas is that there are two kinds of structures: syntactic and substantive structures of disciplines. The former deal with the ways scholars gather data and analyze and interpret them. The latter deals with the organization of concepts, laws, etc. in a discipline.

Teachers' SMK pertains to the ways subject matter is organized mentally in teachers' minds. We looked at teachers' substantive structure of an aspect of English: wh-constructions. In other words, we looked at teachers' SMK in terms of how <u>wh</u>-constructions were organized in their minds.

<u>Teaching Experience</u>

There has been some literature about the roles of teaching experience in teachers' teaching abilities. By and large, the literature (and common sense) argue that as teachers become more experienced in teaching, they should have larger repertoires of teaching strategies, see a wider band of classroom situations more richly, etc. And as teachers become more experienced, they have a greater likelihood of becoming expert teachers. But, as a caution, expert teachers are always experienced but experienced teachers are not always expert.

<u>Mental Models</u>

The literature of an aspect of the cognitive sciences pertains to MMs. These are cognitive entities that organize how people interpret their world and how they act on it (Johnson-Laird, 1983; Norman, 1983). We use this construct as an heuristic. We did not test Johnson-Laird's or

Norman's versions of MMs. Instead, we used their notions of MMs as a means to test teachers' mental representations of children's minds and learning.

Because much of what we have to say about the nature of the relations among teachers' SMK, teaching experience, and their MMs of children's minds and learning depends on how we define and determine teachers' MMs, we elaborate on teachers' MMs here (Strauss & Rosenberg-Meltser, 1996; Strauss & Shilony, 1994).

<u>Teachers' Espoused Mental Models</u>

Schon (1983) created a taxonomy of professionals' (what he called) theories. Among them are their in-action and espoused theories. In-action theories are those theories professionals show when they practice their profession. Espoused theories are those theories professionals display when they speak about how they practice their profession. Both kinds of theories are implicit. They are between the lines of what people do and say. We studied teachers' implicit espoused MMs (not theories).

In the present study, we tapped teachers' implicit espoused MMs by interviewing novice and experienced high school teachers who teach the sciences and the humanities based on work done by Strauss (1993, 1996) and Strauss and Shilony (1994). We used a semi-structured clinical interview format in which we posed the same initial question to each teacher and then followed up their answers with other questions. Teachers' statements were classified and organized, and it is that organization which constituted our description of teachers' espoused MM of children's minds and learning. The initial question we posed to each teacher asked how they teach material that is difficult for children to learn. Because teachers teach for learning to take place, we could infer their MM of children's minds and learning from their statements.

The MM found among the teachers by Strauss (1993, 1996) and Strauss & Shilony (1994) bears a family resemblance to 1960's information processing models such as that of Atkinson and Shiffrin (1968). Briefly, the MM of children's minds and learning shows an engineering vision on the part of the teachers. The basic premise of this model is that knowledge is possessed by the teacher, and it is external to children's minds. Once one takes that position, two engineering problems follow: First, how does one get the external information inside the child's mind? And second, once it gets there, how can one move it along to the place where it gets stored or, in other words, gets learned?

In order for learning to occur, the content must first enter children's minds, and teachers conceive of children as having openings of a certain size that allow information to enter. Their notion of "opening size" recalls the notion of working memory capacity. Teachers believe that good pedagogy involves serving up knowledge in chunk sizes that can "get through" the openings. For example, teachers said that what makes some subject matter difficult is that it is too complex and, as a result, it may not be able to get "in" the mind. Here teachers see their task as reducing this complexity by breaking the material into component parts so that it will be able to enter the mind's openings. However, even were the material to be of the right complexity, it may never enter the mind if the child's affective states are not primed to receive the content. Conceived of metaphorically, the entrances to children's minds have "flaps" that are open when children are attentive. If children are uninterested or unmotivated, the flaps go down and the material cannot enter the mind.

Teachers believe that once content gets through, it must somehow connect up with already-existing knowledge by means of analogies, associations, familiar examples, and so on. This corresponds to an elaborative-processing model. Accordingly, teachers believe they should

facilitate connection-making between new and old knowledge. If there is no existing knowledge to get connected to, the new knowledge can get driven into memory through repetition, rehearsal, and practice. This new knowledge now becomes part of already-learned knowledge. How does the new knowledge affect the prior knowledge? Teachers believe that there are changes in the amount and organization of prior knowledge, the prior knowledge gets broadened and generalized, it is at higher levels of abstraction that what was in previous knowledge, and more.

These are some of the solutions to the two engineering problems that result from teachers' MMs of the structure of children's minds, how learning takes place in those minds, and how instruction fosters that learning.

Figure 1 illustrates the MM. It contains 11 general categories of knowledge teachers hold about children's minds, learning, and instruction. Each category has a number of components, only some of which appear in the Figure. Table 3 describes the 11 categories.

Now that we have described what we believe are teachers' espoused MM of children's minds and learning, we can turn to the nature of the relations that exist among those MMs, teachers' SMK, and teaching experience.

Relations Among Teachers' SMK, Teaching Experience and Their MMs

We divide this section into two parts that deal with relations between teachers': (1) SMK and their MM and (2) teaching experience and their MM.

Teachers' SMK and Their MMs

Teachers' SMK and their knowledge about the learner (which we describe as a MM) are generally seen as two intertwined kinds of knowledge that teachers have and use when teaching and speaking about teaching. We untangle them, re-explore them, and then re-twine them with

somewhat different relations. In short, we propose to change the traditional ways of understanding their relations.

The claims we make are not intuitive nor are they represented in current theory in the area. Theoretical elaboration has begun only recently (Strauss, 1993, 1996), and several studies have been conducted to put our claims to empirical test (Mevorach & Strauss, 1996; Ravid, Strauss, Zelcer, & Berliner, 1996; Strauss & Berliner, 1996; Strauss, Hanauer, & Polansky, 1996; Strauss & Meltzer-Rosenberg, 1996; Strauss & Shilony, 1994). In the present report we put these idea to test.

The conventional stance about relations between SMK and teaching for children's learning is that the former has priority over the latter. The following quote represents the current view. "Recent research highlights the critical influence of teachers' subject matter understanding on their pedagogical orientations and decisions... Teachers' capacity to pose questions, select tasks, evaluate their pupils' understanding, and make curricular choices all depend on how they themselves understand the subject matter" (McDiarmid, Ball, & Anderson, 1989, p. 198). We chose this quote because it is representative of the conventional view.

The ideas behind this quote, although not stated explicitly, are that: SMK is an important facet of teacher knowledge that comes to bear on their teaching, and that SMK has priority over teaching strategies in that it guides many aspects of teachers' teaching, including posing questions, evaluating children's understanding or, in short, how teachers make teaching decisions. Teachers with high SMK will teach differently than teachers who have low SMK. This is the conventional view.

We propose an alternative understanding of the nature of the relations between SMK and MMs. To illustrate our view, we show how teachers' espoused MM has priority over their SMK

when they speak about teaching. The example comes from one of the categories in teachers' MM: characteristics of subject matter. We provide other examples and elaborate on the relations between SMK and espoused MMs in the discussion.

<u>SMK, Espoused MM, and Characteristics of Subject Matter</u>

The argument goes as follows. Teachers teach subject matter to children for learning to take place, and it is teachers' espoused MMs of children's minds and learning that guide their teaching. If teachers have a large or a small amount of SMK or if their SMK is organized deeply or in a shallow manner, teachers will speak about how they teach in the same ways, ways that belie their espoused MMs of children's learning.

For example, part of teachers' espoused MMs of children's minds and learning is that complex material is difficult to learn and, as a consequence, one should break it up into component parts so that it will be easier to learn. This guides ways they talk about their teaching. Teachers will speak about the breaking up of subject matter if they have considerable or little SMK about the concepts in question and if that SMK is organized deeply or superficially. What this suggests, then, is that teachers' espoused MM overrides and has precedence over SMK when it comes to how teachers talk about <u>how</u> they teach.

Along with this, though, what teachers say when they speak about <u>what</u> they teach <u>is</u> influenced by their SMK. Let us take two teachers as an example, one who has considerable knowledge that is deeply organized and one who has less knowledge that is superficially organized. And let us, again, use the example of breaking material into its component parts when the teachers realize that the material being taught is too complex for the children. Both teachers will speak about the breaking up the material into component parts. As already noted, this means that these teachers have the same MM of children's learning. But the places where

they will break up the material will be different, depending on the teachers' SMK. In other words, teachers will carve the subject matter at its joints (thus belying their MM of children's learning), but the joints will be different (thus belying their SMK).

Our prediction, then, is that teachers with high and low SMK organization will have the same espoused MM of children's minds and learning. And that means that the MM has priority over their SMK because the what of how they speak about their teaching is expressed in the framework of how they teach (their espoused MM).

Teachers' Teaching Experience and Their Espoused MM

The argument made for the relations between teachers' SMK and their espoused MM should hold for teaching experience, as well. We predict that there will be no differences between experienced and novice teachers' espoused MM of children's minds and learning. To use our example, both teachers will speak about breaking up complex material into parts, which indicates that, concerning that aspect of the MM, they are indistinguishable.

It is these two hypotheses that we put to test: that teachers with high and low SMK and who are experienced and novice, will be have the same espoused MM of children's minds and learning.

Method

Subjects

A total of 32 junior high school (7th grade) English teachers participated in the study. English is taught in Israel as a compulsory foreign language. The teachers were divided into four groups from the combinations of two independent variables: level of subject matter knowledge (high, low) and amount of teaching experience (novice, experienced). There were 8 teachers in each of the 4 cells.

Academic Background

The teachers were trained in either universities or teacher training colleges. The former received a BA in linguistics or English literature and then studied two years to become certified as English teachers for junior high school or high school. The latter studied three years, where emphasis was placed on teaching English as a foreign language. These studies led to certification to be an English teacher in junior high school. After completing this course of studies, they studied an additional year and received a B. Ed. (Bachelor in Education).

Subject Selection

All teachers who were potential subjects in the study were given the subject matter test and they were scored as having high, medium, or low scores. Teachers who had high or low scores participated in the study, and were then given the second part of the study: the interview that assessed teachers' espoused MM. A total of 71 teachers (34 novice and 37 experienced teachers) were given the subject matter test and among them, 32 remained in the study. The others had medium SMK.

Assessment of Subject Matter Knowledge and the Espoused Mental Model

As mentioned, teachers were first administered the SMK task and, if they were either high or low on that task, they were given the interview that assessed their espoused MMs of children's learning.

Assessment of SMK (Structure of the wh-Constructions Test)

The study participants were presented with a list of 12 sentences (see Table 1) and a blank sheet of paper on which to write. They were given the following instructions. "Here is a list of 12 sentences. I would like you to look at them carefully and then to classify them

according to whichever criteria you deem correct. You don't have to re-write the sentences. Just write their number, and write according to what you classified them".

To make certain the instructions were clear, the experimenter gave an example. "For example, let's imagine that, arbitrarily, you think that sentences 1, 2, and 3 should be together because of 'x', and that sentences 4, 5, and 6 should be together because of 'y'". The experimenter wrote 1, 2, and 3 on a sheet of paper, circled those numbers, and then wrote 'x' above it. She then wrote 4, 5, and 6, circled those number and wrote 'y' above it.

She then continued giving the instructions. "After you categorize the sentences, I would like you to further differentiate within each category as much as possible, so as to get as specific as possible". The experimenter then differentiated the two hypothetical categories ('x' and 'y') further.

"Now I would like you to differentiate as much as possible within each category you make. For example, you put sentences 1, 2, and 3 together because you believe they have 'x' in common. But now that you think about it, you see that although all 3 indeed belong together, sentences 1 and 2 are more similar to each other than to sentence 3 because of 'z'. So you should further differentiate them and title them 'z'. You would then further differentiate sentence 3 titled 'y'".

In a pilot study, it was found that many teachers did not classify the sentences in terms of wh-elements. So as to make certain that we were testing teachers' SMK of wh-elements, we added another part to the task.

After the teachers classified the sentences according to the above instructions, the experimenter gave them another piece of paper and said, "You just finished categorizing according to the instructions to classify them according to what you deem most correct. Now I

would like you to do the same thing you just did, but this time I would like you to categorize the sentences according to 'wh'". The experimenter did not clarify what she meant by 'wh'. This part was given to all the teachers, even those who had classified the sentences according to wh-elements. This was done because it was rare that teachers classified exhaustively.

The subject matter task was administered in teachers' homes, and it took 5 - 25 minutes to complete.

<div align="center">Criteria for levels of SMK</div>

The optimal classification of the sentences (Figure 2) divided questions (direct and indirect) from non-questions (relative clauses), and then proceeded to differentiate questions into direct and indirect, and direct questions into subject and non-subject questions. This classification was not found among the teachers, perhaps because, superficially, indirect questions and relative clauses share more structurally than do indirect and direct questions.

Teachers' highest (fullest) classification consisted of 2 classes, each of which were further differentiated into 2 classes; thus, there were two levels down and 4 aspects across. The criterion for high SMK was the full classification and correct labels for each of the categories. Figure 3 shows a high level classification.

The criterion for middle SMK was a classification with the first categorization (indicating knowledge that the sentences are wh-elements) and either no further classification or an incorrect classification. An example of a middle SMK classification is found in Figure 4.

The criterion for low SMK was that the teachers did not even make the first- level classification, indicating that they did not use wh-elements as the content, despite the fact that the experimenter asked them to classify according to wh. Examples of low SMK classifications are found in Figure 5.

The above describes our classification system for ascertaining SMK of <u>wh</u>-constructions on the part of English teachers. Teachers with high and low SMK were then interviewed so as to determine the nature of their espoused MM.

<div align="center">Assessment of the Espoused Mental Model</div>

Teachers' espoused MM was assessed by analyzing their interviews. Interviews were conducted with a semi-structured clinical interview technique. The teachers were all given the same initial two questions and, depending on their answers to that question, the interviewer asked further questions.

The initial two questions were as follows. "What is it about <u>wh</u>-elements that make it difficult for students to learn them, and what do you do to make it easier for them to learn <u>wh</u>-elements"? If the teacher did not answer these questions, the interviewer asked the following questions. "Do you think that all <u>wh</u>-elements are the same difficulty for students to learn? Why? Do you think that the difference in the structure of Hebrew and English makes a difference in terms of <u>wh</u>-elements"?

When teachers spoke about the above, the interviewer would, on occasion, ask the teacher to explain what s/he said in more detail, to clarify what s/he had said, or to proceed to another topic.

The interviews were conducted in the teachers' homes, and they were videotaped with a tape recorder backup. The interviews lasted between 20 - 30 minutes.

Criteria for Establishing Teachers' Espoused MMs

To remind the reader, the espoused MM Strauss & Shilony (1994) found had 11 categories and 152 elements. Our main search was for the categories in the teachers' MMs because they are what constitute the MM. Were we to find that one group of teachers had different categories

than those of another group of teachers (and different than those found in Strauss & Shilony, 1994), we could claim that these two groups had <u>qualitatively</u> different MMs. Were we to find that the teachers in all the groups had the same categories as Strauss & Shilony (1994), but one group of teachers had more categories than another group, we could claim that the groups were different <u>quantitatively</u> in terms of their MMs.

We used three levels of stringency as criteria to determine the nature of a teacher's espoused MM. The first was that used by Strauss & Shilony (1994). They claimed that if a teacher mentioned <u>at least one element</u> of a category and did so even only once, that indicates she had that category in her MM. This is a quite liberal criterion to determine if the category exists in the teacher's MM. In the cognitive developmental literature, a similar claim has been made by structuralists when determining if a child has constructed a certain mental structure. Some argued that if the child solves even one task with that mental structure, that is evidence that the child has constructed it.

The second level of stringency to determine the existence of each teacher's MMs is a <u>25% criterion</u>. Here the criterion was that a teacher must mention at least 25% of the elements in a particular category in order for that category to be considered part of the teacher's MM. The third level of stringency was a <u>50% criterion</u>. For a teacher to meet this criterion, she must have mentioned at least 50% of the elements in a particular category in order for it that category to be considered part of the teacher's MM.

<u>Reliability and Validity</u>

The original Strauss & Shilony (1994) study was found to have face and content validity and high reliability. In the present study, we checked for reliability again. The experimenter tested inter-rater reliability by classifying 8 teachers' utterances into elements and categories,

and 4 trained raters rated these same interviews independently, each one classifying 2 interviews. The inter-rater reliability was very high, ranging between 84 and 92 percent agreement.

Results

We steal our thunder by first presenting the data in general terms: The data from all three criteria (at least one element, 25%, and 50%) indicate that there were no differences between the four groups' espoused MM. All the groups had the same qualitative and quantitative MMs. We now present the data for the three criteria.

At Least One Element Criterion

We looked for both qualitative and quantitative differences in teachers' espoused MM.

Qualitative Differences

Relevant data for this criterion are found in Table 3. We see that no teacher's narrative included an element that was different than the elements found in Strauss & Shilony (1994), which is to say that there were no new categories in teachers' MMs of children's learning.

Quantitative Differences

We found that relatively few teachers in the four groups mentioned at least one element in the following categories: 3 - Child's Environment; 10 - Products of Learning in the Mind; and 11 - Demonstrates New Knowledge. We also found that no teachers, in any of the groups, mentioned even one element from Category 9 - Characteristics of Already-Learned Elements in the Mind.

The distribution of frequencies of teachers' categories in the four groups are found in Table 4. Binomial tests for quantitative differences between groups revealed no significant differences.

The data indicate that, with the at least one element criterion, there are no differences between high and low SMK, and experienced and novice teachers' espoused MM. We now present the data for the next most stringent criterion, where at least 25% of the elements in a category is the criterion for the existence of a category.

25% Criterion

The 25% criterion for the existence of a category in teachers' MM of children's learning is more stringent than the previous criterion and, as a consequence, we expected to find that all the teachers had fewer categories than in the previous analysis. Relevant data are found in Table 5.

Qualitative differences. We found no new categories in teachers' MMs of children's learning as compared to those found in Strauss & Shilony (1994). In other words, no teacher's narrative included categories that were different than those found in previous research.

Quantitative differences. We found that none of the teachers had Category 10 - Products of Learning in the Mind. Very few teachers had Category 3 - Child's Environment; Category 4 - Characteristics of Subject Matter; Category 7 - Mental Processes in the Mind, Category 8 - Already-Learned Elements, and Category 11 - Demonstrates New Knowledge.

The frequencies of teachers' categories in the four groups are found in Table 6. Binomial tests for quantitative differences between groups revealed no significant differences.

The data from the 25% criterion indicate that high and low SMK teachers who are experienced and novice teachers have the same espoused MM. We now move to the data from the most stringent criterion: 50% of the elements are the minimal requirement for the existence of a category of the espoused MM.

50% Criterion

The 50% criterion for the existence of a category in teachers' MM of children's learning is more stringent than the two previous criteria and, as a consequence, we expected to find that all the teachers had fewer categories than in the previous analysis. Relevant data are found in Table 7.

Qualitative Differences. We found that none of the teacher's narratives included categories that were different than those found in Strauss & Shilony (1994), which is to say that all the teachers had the same espoused MM of children's learning.

Quantitative Differences. We found that none of the teachers had Categories: 1 - Characteristics of the Learner; 3 - Child's Environment; 6 - Means Used By the Learner to Learn Material that has Entered the Mind; 8 - Already-Learned Elements; 9 - Characteristics of Already-Learned Elements in the Mind; 10 - Products of Learning; and 11 - Demonstrates New Knowledge. Relatively few teachers had the remaining categories, with the exception of Category 5 - Teacher as Intermediary.

The frequencies of teachers' categories in the four groups are found in Table 8. Binomial tests for quantitative differences between groups revealed no significant differences.

The combined results of the three levels of stringency for establishing the nature of high and low SMK and experienced and novice teachers' MMs is that there are no differences among them with regard to their espoused MM.

Discussion

Teachers who had high and low SMK and who were experienced and novice were indistinguishable in terms of their espoused MM. These data support our view that teachers' espoused MM of children's minds and learning has priority over their SMK and their teaching experience. In the introduction, we presented an example of how teachers with high and low

SMK would have the same MM concerning the category: Characteristics of Subject Matter. We now present arguments for two other categories: "Teaching" and "Means".

SMK and "Teaching" as a Category of Teachers' Espoused MM

One element of the Teaching category is Asking Questions. Teachers commonly speak about asking questions in the classroom, and do so for many purposes. Teachers speak about asking questions after a classroom discussion seems to have been settled in order to open up what appeared to be closed, e.g., "If, as you agree, one reason for inflation is the amount of money available in the market, would there be a role of the balance of payments in stemming or encouraging inflation"? Teachers also ask questions that require encyclopedic knowledge, e.g., "How far is it from the earth to the moon"? Questions are sometimes asked to promote debate among the pupils, e.g., "Alice, you seem to disagree with Tom about this matter. What do you think the disagreement is about"? Questions can also be asked to have children clarify their own thinking outloud, e.g., "Jessica, what is your viewpoint here"? Questions are often posed to attempt to determine what the children have understood from the lesson, e.g., "Yael, could you tell us what you think the main points were in this discussion, and why they are of importance"?

We would like to use the last kind of question as an illustration of an aspect of the relations between SMK and espoused MMs. When a teacher asks a child a question for the purpose of determining what she learned in the lesson, that teacher has a number of assumptions about the child's mind. For example, that teacher believes that knowledge is stored in the mind; it can be retrieved; what the child says accurately reflects the knowledge that is in her mind and how it is organized; asking a question causes mental processes that lead to the location and retrieval of stored knowledge; and more. All of these assumptions are part and parcel of teachers' MM of children's minds.

Notice that teachers who have high or low SMK and who are experienced or novice teachers ask questions. We claim that the very asking of questions means teachers have assumptions about children's minds, assumptions that flow from their MM. And we claim that these assumptions are common to teachers who differ in SMK and teaching experience. This is the claim for no differences between teachers' MMs of children's minds and learning.

On the other hand, there should be differences between high and low SMK teachers and experienced and novice teachers concerning what questions they ask. For example, a teacher with high SMK should ask questions of children that reflect that high level SMK and they should ask different questions, in their level, than those asked by teachers with low SMK.

Summary

The main argument here is that the nature of relations between teachers' SMK and their MMs is different than what the conventional view holds. Traditionally, theoreticians and researchers have claimed that SMK has priority over much of classroom teaching. To return to the quote from McDiarmid et al. (1989), teachers' capacity to ask questions, make analogies, listen to children's answers to questions posed, and more, is influenced by their SMK. In other words, teachers' SMK constrains their pedagogical decisions that are in the service of children's learning.

The alternative view posed here is that teachers' MMs and SMK are separate entities: Teachers' MMs deal with their beliefs about children's minds and learning. And teachers have SMK about their discipline. The structure of children's minds and how learning occurs in those minds is independent of the level and extent of teachers' SMK.

These are claims for keeping MMs and SMK conceptually separate. But they do have relations because SM is taught so that it will be learned. A second part of the claim we are

making is that the MM constrains and subordinates SMK. We argue that the MM is the framework within which teachers make pedagogical decisions. Teachers will not teach in a particular way if it is inconsistent with their MM of children's minds and learning.

Notice that we cannot make a parallel formulation about teachers' SMK. That is, it sounds peculiar to say that teachers will not teach in a particular way if that way is inconsistent with their SMK. This is because how teachers teach is not dependent on their SMK. What they teach is, though.

Our formulation of these ideas is that teachers will not teach in ways that are inconsistent with their MM of children's minds and learning. The MM, then, is the main organizing system which gives rise to how teachers' teach. What is taught is dependent on a teacher's SMK, but that decision is dependent on decisions about how to teach. Teachers' SMK is, then, subordinated to their MM.

If the above seems reasonable, it is appropriate to ask why the conventional view is held. We believe that adherents of the traditional view looked through the fact that teachers asked questions, provided analogies, listened to children's answers, etc. They asked themselves how teachers with different SMK are different in their teaching, for instance, in the kinds of questions they asked. They looked at this ample evidence but looked through the fact that teachers ask questions, provide analogies, listen to children, etc. They did not ask themselves what mental representation of children's minds and learning teachers have that leads to them to ask questions in the first place.

The theory-building and empirical work of the view we presented here begins precisely with those kinds of questions. We ask ourselves what does it mean that a teacher asks questions; that she uses analogies when explaining a new concept; that she listens to children's answers to

questions in order to figure out how they understand? What do these (and other) parts of her teaching tell us about her MM of children's minds, how learning takes place in those minds, and the remarkable belief that teachers hold, namely that teaching outside children's minds causes learning to occur in their minds.

The answer we constructed when asking these questions was that teachers have a rich, systematic, structured, and remarkably complex representation of children's minds, learning, and the causal relations between instruction and learning. This representation was described as a MM. It is also a kind of personal psychology.

This implicit MM is the belief system through which teachers make many pedagogical decisions. It does not include, but it has subtle relations to, SMK. The most radical of our claims is that teachers' MM constrains and subordinates their SMK. We attempted to indicate, through several examples, where that subordination comes into play.

Implications for Teacher Education

There are several implications that follow from our theory-building and the empirical results from our three studies. They pertain to: (1) training teachers in the SM; (2) teaching teachers to be aware of their own MMs of children's minds and learning; and (3) introducing teachers to the developmental aspects of the subject matter.

Training teachers in the SM. One of the points that emerges from this study is that teachers' SMK is crucially important to teaching, though it is subordinated to their MM. We found problematic SMK on the part of some teachers in our study about wh-constructions. We believe that were these teachers to have inservice education classes about the structure of wh-constructions, their SMK could become more deeply organized. And this is to the good, of course, because these same teachers would then be able to break their SMK at joints that better

reflect the way <u>wh</u>-constructions are organized. But we add a proviso here. Having more deeply organized SMK will <u>not</u> lead to teachers teaching that SMK in different ways.

<u>Teaching teachers to be aware of their MMs.</u> One of our claims is that the MM we discovered among teachers is implicit, tacit. Teachers are not aware that they hold such a MM, let alone that this MMs influences how they teach. When teachers were taught about learning in their educational psychology courses, nobody taught the mental models they hold. Strauss (1993, 1996) argued that preservice teachers hold this MM before they even take these courses. Because teachers do not know they have a MM, they do not know that what they are being taught is an alternative to their tacit understandings of the mind and learning.

Our recommendation is to help teachers unearth this tacit MM. In so doing, the teachers will become aware of what they believe learning is, something that they haven't given much thought to. And when alternative views are presented, they can be seen by teachers as genuine alternatives because they will now know what they believe children's minds and learning are.

The conceptual change literature in science teaching seems particularly relevant here (Strauss, 1997). These studies demonstrate the amazing power of inadequate models children construct about the world of physics, even in the face of contradictory evidence. Thus, the naive belief that light emanates from objects is held to, even after students learn that what they see is reflected light. Or, they may hold beliefs that light travels faster at night than during the day, that styrofoam doesn't have weight, or that sugar disappears when stirred into tea. These naive beliefs are not taught. But they are learned, just as is the simple information processing model of mind we found in teachers. And they are apparently learned without any formal instruction.

When the falsity of these models, theories, and beliefs are demonstrated in science classes, students often will answer test questions that reveal they have mature "scientific"

(factual) knowledge--and continue outside of school to hold their original beliefs! This literature does, however, suggest ways that can help teachers overcome the inadequate models of their students. But these methods are time-consuming and clearly not always effective.

To return to teachers, if we wish teachers to consider a Piagetian constructivist MM of learning, or social constructivist MMs in the Vygotskian tradition, then a first step in that process would be to have them examine the MMs they already possess. The conceptual change literature suggests ways to replace those MMs, or broaden them, so other forms of pedagogy now outside the MMs commonly held by teachers may be experimented with.

<u>Introducing teachers to the developmental aspects of the subject matter.</u> There is a rich literature now on children's route in the acquisition of knowledge. We know that children gradually develop an awareness of the phonology and the orthography of the language they are exposed to, and they undergo phases in this development. While doing this, they reconstruct the writing system that they are learning, revealing their transient knowledge about it, while at the same time changing their perception of their own spoken language, bringing it to their attention, making it an object of study for them and enabling them to discern its components.

Were teachers to be more aware of this developmental trajectory, they would be more sensitive teachers in that they would better understand the nature of children's developing knowledge about written and spoken language. And, in light of what we wrote above, were teachers to become more aware of their MMs of children's minds, and were they to have more sophisticated understandings of children's developmental trajectories, we believe they could be more effective teachers.

Conclusions

Our research suggests the precedence of MMs in decisions about <u>how</u> to teach, a point contrary to the contemporary view of how teachers' decisions about teaching are made. Another way to express this is that the psychological entity created to describe minds and learning represents the precedence of psychology over other domains that comprise a teacher education curriculum. If we are right, then many current proposals for reforms in education are doomed to failure because they are based on models of mind and learning that are not part of teachers' MMs of how children think and learn.

This line of research deserves to be followed up and expanded, for it offers a chance to explain why classrooms continue to look like they have over decades, if not centuries. The current wave of educational reforms may fail, as well, because nobody has recognized the precedence of MMs over other important <u>but less powerful</u> factors affecting classroom teaching.

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_____

Table 1

Sentences Given for the Classification Task

_____

1. Whom did he see?

2. I didn't like the man who spoke first.

3. Who saw the murder?

4. She told me which students she liked in that class.

5. Whose students drink coffee every morning?

6. The books which he recommended were boring.

7. Whose papers does he always steal?

8. He always mentions how many stories he writes every year.

9. Which students do you like?

10. The man whose sister you married has disappeared.

11. They want to know whose book you prefer.

12. Which books belong to you?

_____

_____

Table 2

Classification of WH sentences in the test.

_____

Questions
_____

Direct questions

_____

Subject questions

3. Who saw the murder?

5. Whose students drink coffee every morning?

12. Which books belong to you?

Non-subject questions

1. Who did he see?

7. Whose papers does he always steal?

9. Which students do you like?

_____

Indirect questions

_____

4. She told me which students she liked in that class.

8. He always mentions how many stories he writes every year.

11. They want to know whose book you prefer.

_____

Relative Clauses

_____

2. I didn't like the man who spoke first.

6. The books which re recommended were boring.

10. The man whose sister you married has disappeared.

_____

_____

Table 3

A Description of Teachers' Espoused Mental Model

_____

The child's mind is the box and, through instruction, teachers attempt to get material into the mind and moved along the mind in such a way that it stays there for a long time, which is another way of saying that it gets learned.

On the left side of the Figure are categories that are not part of learning as such, but they do influence it. There are five categories here: (1) Characteristics of the Material to be taught (e.g., it is complex); (2) the Teacher as Intermediary between the material and the learner (e.g., the teacher breaks a problem into parts for the children); (3) aspects of Instruction (e.g., asking questions); (4) aspects of the Child's Environment (e.g., mass communication); and (5) Characteristics of the Learner (e.g., abilities, intelligence).

We now move from the categories that are not learning as such to the sixth (6) category that involves how the material enters the child's mind. We have labeled that category "Means" because this category's components are the means by which material external to the mind enters it. This category gets at the seam between the external world and the mind. The openings have "flaps" next to them allowing material to enter when they are up or preventing the material from entering if they are down. As mentioned above, these flaps are regulated by the affective system; i.e., if the child is interested and motivated or not.

The mind itself has five categories: (7) Already-Learned Knowledge that exists in the mind. These are concepts, skills, and so forth that have already been learned; (8) Characteristics of Already-Learned Knowledge, such as amount of knowledge; (9) mental Processes that allow

new material that just entered the mind to become part of the already-learned knowledge or, in other words, to become learned. An example would be analogies between new and old knowledge. The next category, Products (10), deals with what happens to the old knowledge when the new knowledge gets learned; e.g., it gets expanded. We labeled this Products because they are the products of learning. And there is a category of the mind that involves they ways the learner (11) Demonstrates Uses of the New Knowledge; e.g., the learner can solve problems that are similar to those just learned.

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Table 4

Distribution of Frequencies (F) and Percentages (%) of Teachers Referring to

Categories of the Mental Model According to the At Least One Criterion

| | Novice Teachers | | | | Experienced Teachers | | | |
| | High SMK | | Low SMK | | High SMK | | Low SMK | |
Category	F	%	F	%	F	%	F	%
Characteristics of the Learner	7	88	8	100	8	100	8	100
Instruction	8	100	8	100	8	100	8	100
Environment	2	25	4	50	3	38	4	50
Characteristics of Subject Matter	8	100	8	100	7	88	8	100
Teacher as Intermediary	8	100	8	100	7	88	8	100
Means Used by Learner to Learn	7	88	8	100	6	75	7	88
Mental Processes	7	88	8	100	5	63	7	88
Already-Learned Knowledge	6	75	4	50	3	38	7	88
Characteristics of Already-Learned Knowledge	0	0	0	0	0	0	0	0
Products of Learning	2	25	2	25	1	13	3	38
Demonstration of Knowledge	1	13	3	38	1	13	0	0

_____

Table 5

Frequency of Four Groups of Teachers' Use of Categories with the At Least One Element

Criterion

_____

| | Subject Matter Knowledge | | |
Teaching Experience	High	Low	Total
Experienced	6	8	8
Novices	7	8	8
Total	7	8	

_____

Table 6

Distribution of Frequencies (F) and Percentages (%) of Teachers Referring to Categories of the Mental Model According to the 25% Criterion

| | Novice Teachers | | | | Experienced Teachers | | | |
| | High SMK | | Low SMK | | High SMK | | Low SMK | |
Category	F	%	F	%	F	%	F	%
Characteristics of the Learner	3	38	5	63	6	75	4	50
Instruction	5	63	3	38	4	50	2	50
Environment	2	25	1	13	0	0	3	38
Characteristics of Subject Matter	4	50	2	25	2	25	2	25
Teacher as Intermediary	3	38	2	25	4	50	4	50
Means Used by Learner to Learn	5	63	4	50	3	38	4	50
Mental Processes	2	25	2	25	3	38	2	25
Already-Learned Knowledge	1	13	0	0	1	13	0	0
Characteristics of Already-Learned Knowledge	0	0	0	0	0	0	0	0
Products of Learning	0	0	0	0	0	0	0	0
Demonstration of Knowledge	0	0	1	13	0	0	0	0

Table 7

Frequency of Four Groups of Teachers' Use of Categories with the 25% Criterion

_____

Subject Matter Knowledge

Teaching Experience	High	Low	Total
Experienced	8	7	8
Novices	8	7	9
Total	8	7	

Table 8

Distribution of Frequencies (F) and Percentages (%) of Teachers Referring to

Categories of the Mental Model According to the 50% Criterion

| | Novice Teachers | | | | Experienced Teachers | | | |
| | High SMK | | Low SMK | | High SMK | | Low SMK | |
Category	F	%	F	%	F	%	F	%
Characteristics of the Learner	0	0	0	0	0	0	1	13
Instruction	3	38	4	50	2	25	5	63
Environment	0	0	0	0	0	0	0	0
Characteristics of Subject Matter	2	25	0	0	2	25	1	13
Teacher as Intermediary	5	63	6	75	5	63	3	38
Means Used by Learner to Learn	0	0	0	0	0	0	0	0
Mental Processes	2	25	2	25	0	0	0	0
Already-Learned Knowledge	0	0	0	0	0	0	0	0
Characteristics of Already-Learned Knowledge	0	0	0	0	0	0	0	0
Products of Learning	0	0	0	0	0	0	0	0
Demonstration of Knowledge	0	0	0	0	0	0	0	0

_____

Table 9

Frequency of Four Groups of Teachers' Use of Categories with the 50% Criterion

_____

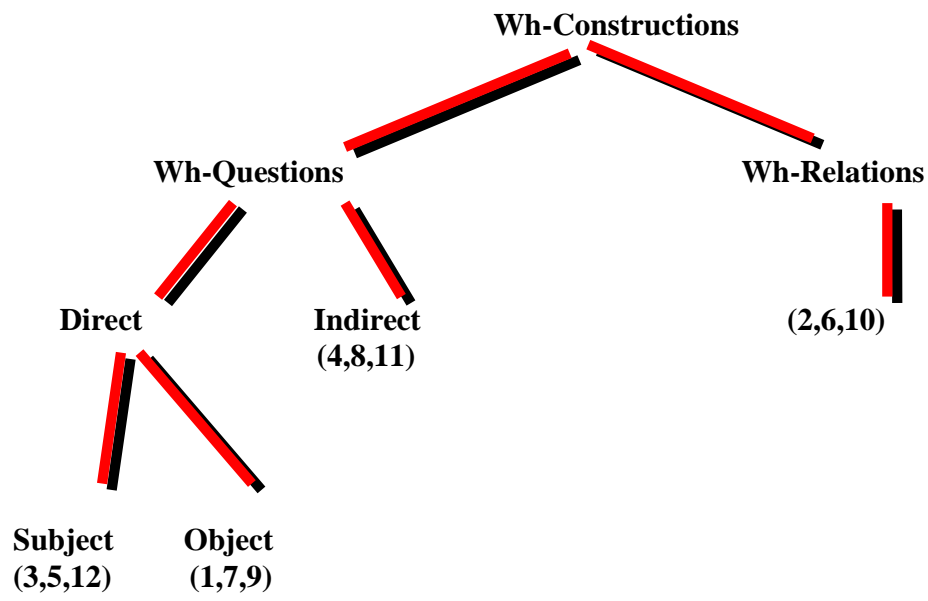| | Subject Matter Knowledge | | |
Teaching Experience	High	Low	Total
Experienced	3	4	7
Novices	4	3	7
Total	7	7	

_____

Figure Captions

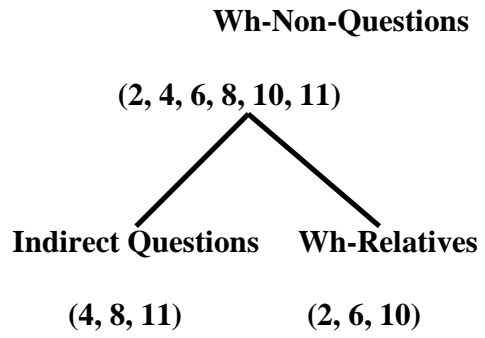<u>Figure 1</u>. Teachers' espoused mental of children's minds and learning.
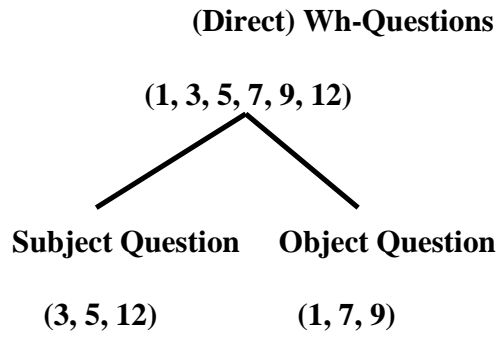
<u>Figure 2</u>. Optimal classification of 12 wh-construction sentences.

<u>Figure 3</u>. High subject matter knowledge classification of 12 wh-construction sentences.

<u>Figure 4</u>. Medium subject matter knowledge classification of 12 wh-construction

sentences.

<u>Figure 5</u>. Low subject matter knowledge classification of 12 wh-construction sentences.

Wh-Constructions

Wh-Questions

Wh-Relations

Direct

Indirect
(4,8,11)

(2,6,10)

Subject
(3,5,12)

Object
(1,7,9)

(Direct) Wh-Questions

(1, 3, 5, 7, 9, 12)

Wh-Non-Questions

(2, 4, 6, 8, 10, 11)

Subject Question   **Object Question**

(3, 5, 12)   **(1, 7, 9)**

Indirect Questions   **Wh-Relatives**

(4, 8, 11)   **(2, 6, 10)**

(Direct) Wh-Questions

(1, 3, 5, 7, 9, 12)

Which (9, 12)

Who (1, 3)

Whose (5, 7)

Wh-Non-Questions

(2, 4, 6, 8, 10, 11)

Which (4, 6)

Whose (10, 11)

<u>Wh-Word</u>

Who　　　　**Which**　　　　**How Many**　　　　**Whose**

(1, 3)　　　**(4, 6, 9, 12)**　　　**(8)**　　　　**(5, 7, 10, 11)**

<u>Sentence Content</u>

Law/Crime　　　　**Books/Stories**　　　　**Students**　　　　**Dis/liking people**

(1, 3, 7, 10)　　　**(6, 8, 11, 12)**　　　**(5, 9)**　　　　**(2, 4, 9)**

<u>Tenses</u>

Past Simple　　　　**Present Simple**

(1, 2, 3, 4, 6, 10)　　　**(8)**

<u>Positive or Negative Sentences</u>

Positive　　　　**Negative**

(4, 11)　　　　**(2, 6, 8, 10)**

<u>Incomplete and Non-Inclusive</u>

　Wh-Questions　　　　**Wh-Sentences**

(2, 6, 8, 9, 10, 11, 12)　　　**(1, 3, 4, 5, 7)**