Morphological awareness and reading comprehension: The case of an English-Turkish Bilingual Child versus a Turkish Monolingual Child

Assist. Prof. Evrim Eveyik-Aydin*

Abstract

The current study aims to investigate the bilingual advantages in morphological processing and reading comprehension by comparing the performances of a 7:4 year-old English-Turkish bilingual child and a 7:10 year-old Turkish monolingual child on two morphological awareness tasks, namely a derivation task and a decomposition task in Turkish developed for the purpose of the study, and on a reading comprehension task. The findings of the study revealed that the monolingual child outperformed the bilingual child both in morphological awareness and reading comprehension tasks. These findings supported Cummin's threshold hypothesis suggesting that a critical level of proficiency in L2 must be reached if bilingual advantages in cognitive and linguistic functioning are to develop. Besides, the findings verified the relation between the morphological processing skills and reading comprehension.

Keywords: morphological processing, monolingual, linguistic functioning, reading comprehension.

Introduction

Morphology is the study of the structure of words and the *morphemes* that are the smallest units of meaning and of grammatical function in a language. Derivational morphemes are affixes that are attached to root words –base/lexical morphemes- to construct new words. Derivational morphology is, therefore, concerned with the principles of compounding and producing distinct words from the base morpheme in different grammatical categories (Verhoeven & Perfetti, 2003; Wang, Cheng & Chen, 2006; Larsen & Nippold, 2007). For example, the word *unbelievable* is a morphologically complex word that is composed of three morphemes, the prefix *un-*, the root *believe*, and the suffix *–able*. The words *believe, belief, (un)believable* show a derivational pattern from a single base morpheme; and the suffix *-able* attached to the base change the grammatical class of the word from verb to adjective.

The linguistic processing of morphologically complex words is explained through the identification of multimorphemic words. The knowledge of base words and affixes can be used in the analysis of the meaning of unfamiliar words. This conscious ability of children to recognize and manipulate the structure of words is referred to as morphological awareness (Carlisle, 2000). This acknowledged definition of morphological awareness is in line with Taft's decomposition theory (1979) which claims that the meanings of complex words are constructed through the parsing of constituent morphemes and the base first, and then assembling the meaning from these components. According to this theory, the words derived from the same base are stored as a single lexical entry. The full-listing theories, on the other hand, claim that complex words have their own representations in the memory (Reichle and Perfetti, 2003). By this view, for example, *blackboard* is represented as a single entity with separate representations for *black, board,* and the word *blackboard.*

Development of the mental representations of prefixes and suffixes is recognized as an essential phase in children's morphological learning (Carlisle & Fleming, 2003). According to the affix discovery principle, as children encounter affixes frequently, they detect a pattern and form a concept for this pattern that is gradually associated with semantic and syntactic knowledge. Thus, when processing a complex word, they monitor their lexicon to find correspondences between the form of an affix and its meaning. However, when they encounter a word with unfamiliar constituent morphemes, the result may be a failure in morphological processing.

Studies on morphological processing in school-age children have frequently focused on recognition of word structures through decomposition (Jones, 1991; Carlisle, 2000; Carlisle & Fleming, 2003; Nippold & Sun, 2008). In a study that investigated the underlying representation of morphophonemic segments among 6-year old first graders, Jones (1991) used decomposition tasks that required learners to leave out a part of some words like *pressure* or *getting,* and comment on the meaning of the base word. The results showed that language-advanced first graders had better representations of morphophonemic segments compared to language-delayed first graders. The results provided evidence for the assumption that children's segments begin in early childhood at phonetic levels, and gradually become more abstract.

Similarly, some other research findings reveal evidence for the developmental increases in awareness of morphological structures and its relation to word meanings. In a series of experiments that assessed children's acquisition of relational, syntactic and distributional knowledge of the derivational morphology, Tyler and Nagy (1989) found that children develop basic knowledge of derivational suffixes before fourth grade. Children first acquire the ability to recognize familiar base morphemes in unfamiliar derived forms. The knowledge of syntactic properties of derivational suffixes (eg. knowing that *regularize* is a verb by virtue of the suffix –ize) increases through eighth grade. The distributional knowledge (eg. knowing that –ness is attached to adjectives but not to verbs), on the other hand, is the most sophisticated level of knowledge. In a study conducted by Singson, Mahony & Mann (2000) the knowledge of derivational suffixes were found to increase with grade level, along with decoding ability and phoneme awareness. Freyd and Baron (1982) found that able fifth graders were superior to typical eight graders at defining derived words due to their greater tendency to find the word meaning from the analysis of words into base and suffixes. Both groups of students were likely to base their definitions on the base words, ignoring or misinterpreting the suffixes. In another study that investigated school-age children's ability to use morphological analysis to explain the word meanings, Larsen and Nippold (2007) tested 50 sixth-grade children with a dynamic assessment task that used a series of prompts. Each one of the children was asked to define 15 low-frequency complex words derived from a high-frequency root. The performance of the students on the dynamic task was found to be related to the literacy skills of these students. Although some of the students identified the morphological constituents of derived words to define the unfamiliar words with minimal assistance, some others needed prompts to a great extent to compete the task. Referring to the literature that shows evidence for the use of morphological analysis as a key word learning strategy by older children and adults (Nagy et al., 1993), Larsen and Lippold recommended training of low performing students on the use of morphological analysis.

These studies revealed the contributions of the ability to use the knowledge of familiar base words and affixes that increase with age and grade level to the successful processing of morphologically complex words. Research findings report some factors that influence the successful use of this ability. First, frequency of the derived word and the base words used in other words are important factors that effect the lexical processing. (Taft, 1979; Reichle & Perfetti, 2003; Carlisle & Katz, 2006). For example, the word *security* that has a Standard Frequency Index value (SFI) of 49.1 is expected to be recognized more rapidly than the word *maturity* that has an SFI value of 35.3, because the value numbers show that *security* is more frequently encountered in print (Carlisle & Katz, 2006). Similarly, the word *friendship* should be easier to learn than the word *citizenship* as the base *friend* is typically learned earlier than the word *citizen.* Another factor that facilitates the morphological awareness is the phonetic structure of the derived words. There is some evidence that words derived with neutral suffixes like -er, -ize, -ment, and –less (e.g. *owner, regularize, enjoyment, homeless, etc.*) are easier to learn as they do not change the stress and the vowel quality of the word to which they are added. On the other hand, nonneutral words derived with suffixes like –tion, -ive, -ous and –ity that are attached to bound morphemes as in the examples of *deception, deceptive, studious,* and *nativity* can be more difficult to learn as they are not transparently related to their base (Tyler & Nagy, 1989; Carlisle, 2000).

The abstract nature of morphologically complex words is another important factor that affects morphological analysis. Research shows that concrete nouns like *blackboard* and air*plane* are learned earlier than abstract nouns like *conclusion* and *friendship* that do not have clear referents. Dual coding theory explains this by the fact that concrete nouns are supported both by verbal information and non-verbal information in the form of vivid mental images evoked by concrete nouns (Sadoski & Paivio, 2001 cited in Nippold and Sun, 2008). However, Nippold and Sun (2008) who investigated the knowledge of derived nominals and derived adjectives in 10-year-old children and 13-year-old adolescents found that derived nominals were generally more difficult than the derived adjectives for both groups despite the more abstract nature of derived adjectives because of their semantic complexity. Although Nippold and Sun could not explain why derived adjectives were more difficult than derived adjectives, they emphasized the impact of frequency of exposure on knowledge of derived words with the examples of some high-frequency derived nominals that were found to be easier than low-frequency derived adjectives in their study.

Morphological awareness and reading

A growing body of research suggests that morphological awareness contributes to reading by allowing readers to parse and spell long words more accurately and rapidly (Tyler & Nagy, 1989) even across different orthographies (Deacon, Wade-Wooley & Kirby, 2007). Research also documented evidence for its close association with reading ability (Ku & Anderson, 2003) and reading comprehension. In Ku and Anderson (2003) study proficient readers outperformed less proficient readers in discriminating the word parts having the same and different meanings, recognizing morphological relations between the words, finding the meanings of low-frequency derivatives and compounds having high-frequency parts, and judging the well-formedness of novel derivatives and compounds.

In a study with third and fifth graders, Carlisle (2000) investigated children's morphological awareness with three tasks contributing to reading comprehension. Participants were first given an oral morphological awareness task that required either deriving a word from a base or decomposing a derived word. This task was followed by the tasks of defining morphologically complex words and reading derived words. Participants' reading comprehension was assessed through their answers to the multiple choice questions about the short passages. The findings of the study showed that the ability to read derived words was the most important factor that contributed to the comprehension of third graders. Whereas, the awareness of structure, meaning, and grammatical roles of the words made the most significant contributions to fifth graders' reading comprehension. Morphological awareness for both graders was found to be the predictive of their reading comprehension at word and text levels as also confirmed by Carlisle and Fleming (2003). Similarly, Nagy, Berninger, Abbott, Vaughan, & Vermeulen (2003) also showed that morphological awareness uniquely predicted reading comprehension in at-risk second grade readers.

Despite the vast amount of efforts to investigate the impact of morphological awareness on monolingual reading, the studies with bilingual children are quite few. In order to investigate the impact of morphological awareness in Chinese-English biliteracy acquisition, Wang, Cheng and Chen (2006) conducted a study with Chinese second and fourth graders learning English using comparable compounding tasks in both languages. The study revealed the contribution of English morphological awareness of the compound structure to character reading and reading comprehension in Chinese despite the big difference between the orthographies of these two languages. However, Chinese morphological awareness was interestingly not related to reading comprehension in English.

In a study with Hispanic primary school children who are becoming bilingual in English, Carlisle et al. (1999) investigated the effects of native and second language vocabulary development and the degree of bilingualism on a task of defining words and the reading comprehension. The study showed that children's performance on the word definition task depended on their word knowledge in the language of task, not on their degree of bilingualism. Children's native and second language vocabulary and phonological awareness significantly contributed to their reading comprehension. The study suggested that for children with limited native language development in the early stages of bilingualism, vocabulary knowledge and metalinguistic development at the word level should have the high priorities in bilingual education programs due to their significant contributions to second language reading comprehension.

In a more recent study conducted with a group of 58 French immersion children across grades 1-3 in the context of the Canadian French immersion program, Deacon, Wade-Wolley & Kirby (2007) examined the relation between performance on a past tense analogy task designed to measure morphological awareness and reading of English and French. The early measures of English morphological awareness was found to be significantly related to both English and French reading, while the early measures of French morphological awareness was found to be significantly related to French reading only. However, later measurements of morphological awareness in French were significantly related to reading in both languages. These results have supported the cross-linguistic contributions of morphological awareness to reading that can change as children develop their language and literacy skills.

Rationale for the Current Study

All studies reviewed so far have demonstrated that morphological awareness is a late linguistic attainment that depends on the presence of some cognitive capabilities like knowledge of word structure, ability to read, and some metalinguistic awareness as pointed out by Nippold & Sun (2008). As bilingualism has often been associated with a greater development of cognitive and metalinguistic abilities in comparison to monolingual children (Diaz & Klingler, 1991), bilingual children can be expected to have more advantages in morphological processing. A significant amount of research has already showed that bilingual children outperformed monolingual children in some aspects of metalinguistic awareness including understanding the arbitrary relation between word and its referents (Ricciardelli, 1992), word identification (Bialystok, 1986), metalinguistic problem-solving and syntactic awareness (Bialystok, 1986; Cromdall, 1999), and some tasks on phonological awareness (Campbell & Sais, 1995). In these studies, bilingual advantages were explained through Cummins' threshold hypothesis (1979) suggesting that children must attain a critical level of proficiency in their native language if advantages in cognitive and linguistic functioning are to be achieved.

However, not much research has been conducted on bilingual children's performance of morphological analysis in comparison to that of monolingual children. Besides, to the best of my knowledge, there are not any studies conducted so far on morphological awareness in Turkish language despite its rich and complex agglutinative word structure that has many aspects to investigate. Therefore, the present study was designed to investigate the impact of bilingualism on the morphological analysis of complex words and on reading comprehension. More specifically the study aims to address the following questions:

1. Does an English-Turkish bilingual child have any advantages in the analysis of morphological structure of derived nominals and adjectivals in Turkish?
2. Does the participant who performs better on morphological awareness tasks also perform better on reading comprehension task?

Methodology

Participants

The data for the present study was collected from two participants. One of them is a 7:4 year old English-Turkish bilingual child, Cora, who was born into an English-speaking American family living in Turkey for the last three years. Cora, the first-born of three sisters, was almost four years old when she first came to Turkey with her family. A week after their arrival, her parents sent her to a kindergarten where she was first exposed to Turkish throughout the day during the week days. Currently, she attends the second grade of a private primary school in which she studies Turkish and English for 10 hours and three hours, respectively. As Turkish is the language of instruction in school, she also studies other school subjects in Turkish. The background questionnaire given to the parents has revealed that the child always speaks English with her parents and sisters at home. Although the parents can speak Turkish at an intermediate level, they prefer English with their daughters unless they help Cora with her school homework. According to her mother, Cora can read and write in Turkish quite well, although she experiences some difficulties in understanding the texts in some classes because of its difficult vocabulary. Therefore, she is encouraging her to do more reading in Turkish. Besides, Cora is almost never exposed to Turkish from television as the family does not watch it often. The children are only occasionally allowed to watch Disney Channel, which is usually in English. Therefore, Cora's exposure to Turkish at home is rather limited to her communication with her parents while working on school assignments. However, she always speaks Turkish to interact with her teachers and friends in school and during the play time.

The monolingual participant of the study, Esin, is a 7:10 year old child whose parents are native speakers of Turkish. Esin attends the second grade of a public school where Turkish is the only language used for instruction. Although her parents can speak English, they have never used that language for communication at home. Esin's only exposure to English was when she was in kindergarten where she had English lessons 3 hours a week. Therefore, her knowledge of English is limited only to the knowledge of a couple of basic words and expressions. Her mother stated that Esin is especially good at mathematics, and drawing, but she also likes reading in her spare time. She has been recently reading *Peter Pan,* which is one of the outstanding classics in children's literature.

Data Collection Procedure and Analysis

Morphological awareness of the participants of the present study was assessed through two oral tasks of morphological structure: a derivation task and a decomposition task. These tasks were developed by the researcher after the determination of derivational morphemes to get focused on in the study.

Turkish agglutinative word forms consist of morphemes attached to a base morpheme or to other morphemes "much like beads on a string" (Oflazer, Say, Hakkani-Tur & Tur, 2003, p.2). As revealed by these researchers in a recent study with 250,000 words reviewed in news texts, more than 6,000 distinct morphological feature combinations are available in Turkish. Having considered the complex nature and generative capacity of these derivations in Turkish, the scope of the current study was decided to be limited to the investigation of morphemes that derive nouns and adjectives. After reviewing the full listing of Turkish derivational suffixes in the prominent work of Banguoğlu (2000), following suffixes were selected to be addressed due to their frequency and productivity in Turkish: Suffixes attached to N to derive N (-lik, -ci, -daş), N to derive Adj (-cı, -lı, -sız), V to derive N (-gi, -i, -im), and V to derive Adj (-gen, -ici, -ık).

After the selection of target derivational suffixes, the following tasks were designed to assess participants' knowledge of Turkish morphological structure.

Derivation Task: The derivation task for the present study was adapted from Carlisle (2000) and Carlisle & Fleming (2003). The participating children were given a base word (e.g., *göz*) and asked to complete a sentence ("Dün kendime yeni bir _____ aldım") using the appropriate derived word (*e.g., gözlük*). The derivation task included 24 derived nouns (e.g., *yazı, kitaplık*) and 24 derived adjectives (e.g., *çalışkan, şüpheci*), with a total of 48 target words. Of twenty four derived nouns and adjectives, 12 were derived from nouns while the other half was derived from verbs. Thus, 4 words were selected for each of 3 suffixes within each 4 categories (see Appendix A).

Selection of words that contain target suffixes was made on the basis of frequency, simplicity, and age-appropriateness. Task included high-frequency (e.g. *arkadaş*) and low-frequency words (e.g. *vatandaş*) derived from high- and low- frequency roots in order to assess children's ability to use morphological analysis based on their knowledge of familiar roots or suffixes.

Decomposition Task: In the decomposition task that is also adapted from Carlisle (2000) and Carlisle & Fleming (2003), the participants were presented a derived word (e.g., *evsiz)* and asked to complete a sentence ("Bu geniş bir _____") using the appropriate base form (e.g., *ev*). The task was developed following the criteria used in the development of derivation task. Thus, the decomposition task also included 48 different words (24 nouns-24 adjectives) derived from 12 suffixes used in the derivation task, with 4 words selected for each suffix (see Appendix B). The sentences in each task were developed not to allow the use of inflected forms.

Before the actual administration of derivation and decomposition tasks to the participants of the study, they were pilot studied with an 8:2 year old second grader to see if the sentences that will be completed by the participants elicit the expected words. After the pilot study, some of the sentences that allowed the correct use of two derived forms of the same root were changed so the participants can only generate the target form. To illustrate, when the child was given the base word *yaz*, he completed the sentence ("Bu ____ kimin?") with the derived word *yazl*ık instead of using the target word *yazı.* Therefore, the sentence was changed to ("Bu _____ okunmuyor") to elicit the use of suffix –ı.

Data was collected on two different days within the same week, in a two-hour session with each child. Before collecting data, the participating children were given a 5-10 minute training and told not to use the inflected forms. When the researcher felt sure that the task was understood by them, the actual tasks were administered.

Reading Comprehension Task: In order to address the second research question, the participants were asked to read a few page story composed of 8 short paragraphs illustrated with pictures intended for pre-school children and answer 6 comprehension questions related to it (see Appendix C). The story was titled "Güzel ve Çirkin: Bella'ya Özel Bir Sürpriz" which is a follow-up of the original Walt Disney Classics "The Beauty and the Beast". The first paragraph was used for some practice questions to make the task clear for the participants. The story used for reading comprehension included words (e.g., *özensizlik, bakımsızlık, ilgisizlik, sevgisizlik, canlı, coşku*) that were derived with the suffixes selected for the study. During this task, some prompts were provided to the participants when they start questioning the researcher in an attempt to find the correct answer.

All data collection procedure was audio-recorded to be analysed. Participants' correct and incorrect answers were calculated to be expressed in percentages.

Results

Derivation Task: The analysis of participating children's performance on the derivation task revealed that Turkish monolingual child generated a greater number of successful derivations compared to English-Turkish bilingual child (see Table 1).

Table 1:

The Performance of English-Turkish Bilingual and Turkish Monolingual Child on the derivation task

Categories of Turkish Derivational Morphemes	**Correct Suppl.** **N**	**No answer** **N**	**Correct; but Unacceptable** **N**	**Incorrect; and Unacceptable** **N**
Noun to Noun				
E-T Bilingual	6/12 (50%)	6/12 (50%)	---	---
T Monolingual	9/12 (75%)	---	1/12 (8%)	2/12 (17%)
Noun to Adj.				
E-T Bilingual	8/12 (67%)	3/12 (25%)	1/12 (8%)	---
T Monolingual	11/12 (92%)	---	1/12 (8%)	---
Verb to Noun				
E-T Bilingual	6/12 (50%)	5/12 (42%)	---	1/12 (8%)
T Monolingual	11/12 (92%)	1/12 (8%)	---	---
Verb to Adj.				
E-T Bilingual	4/12 (33%)	5/12 (42%)	1/12 (8%)	2/12 (17%)
T Monolingual	6/12 (50%)	1/12 (8%)	1/12 (8%)	4/12 (34%)

When the percentages of correct answers are compared for each category, it is seen that Turkish monolingual child outperformed the bilingual child in all categories of derivational suffixes. In other words, in no category did the bilingual child score higher than the monolingual child. Interestingly, the monolingual child also provided more incorrect and unacceptable derivations (e.g. *sırrım, meslekçi, girişik, yırtkan*) than the bilingual child did except for the V-to-N category.

The results of the derivation task also showed that the bilingual child was most successful in deriving adjectives with suffixes that are attached to nouns, whereas the monolingual child was equally successful in deriving adjectives from nouns, and nouns from adjectives. However, both participants were least successful in deriving adjectives with suffixes –gen, -ici, -ık atached to verbs. In this category they both had difficulty with the adjectives *yırtıcı, geçici, kaygan, üzücü,* and *atık*, while they could derive *çalışkan*, *açık*, *kırık,* and *bozuk.* This can be explained through the low-frequency of words they had difficulty with and the abstract nature of adjectives that do not have clear referents.

When participating children's answers in each category were closely examined, children, especially the bilingual child, were found to be more successful with the high-frequency words. For example, in the first category of N to N, the bilingual child could only derive the word *arkadaş* from the base *arka,* while she could not derive the less-frequent words *vatandaş, sırdaş, and meslekdaş* using the suffix *–daş.* Similarly, the monolingual child who could succesfuly derive the word *çalışkan,* could not derive the less-frequent word *girişken*.

Decomposition Task: The results of the decomposition task in which the participating children were asked to decompose the given derived words into their base revealed that the Turkish monolingual child showed a 100 % success in all categories. The performance of the bilingual child also yielded similar results demonstrating that the child could successfully decompose the words except for these two: *tart*ı from V-to-N category and *çaresiz* from N to Adj category. The child unsuccessfully decomposed these words as *tar* and *çar*.

Reading Comprehension Task: As for the short reading task given to participants in order to assess their comprehension, the results revealed the outperformance of the monolingual child over the bilingual child in reading comprehension as (see Table 2).

Table 2:
The results of reading comprehension task expressed in numbers.

	Correct answers with no prompt	Correct answers with prompt	Incorrect answer	No answer
English-Turkish Bilingual Child	2 /6	2/6	---	2/6
Turkish Monolingual Child	5/6	1/6	---	---

As revealed by the table based on the transcribed data, the monolingual child answered all questions correctly by demanding some scaffolding from the researcher only in one question (Q1) of the task. The bilingual child, however, could answer 2 of 6 questions (Q5 & 6) correctly without getting any prompts, and 2 questions (Q2 & 3) correctly with some prompts from the researcher. She did not have any answer for 2 questions (Q1&4) despite some scaffolding from the researcher. The following episodes from the transcribed data illustrate the prompts provided to the participants.

Example excerpt from monolingual subject:

R: Çirkin niçin yıllardır gitmediği seraya gidiyor?
[Why is Beast going to the greenhouse after many years?]
E: eeee ... Sera nedir?
[Um.. What is greenhouse?]
R: Her tarafı cam olan, içinde yaz kış bitki, sebze yetistirilebilen yer.
[A structure made of glass where one can grow plants and vegetables.]
E: Anladım. Niye gitti bilmiyorum?
[I got it. I don't know why he went.]
R : Bella neden bahsediyordu?

[What was Bella talking about?]
E: Kış! Kışı seviyo ama... çiçek istiyo...Yani çiçek almaya gidiyo...
[Winter! He likes winter but ... he wants flowers ... I mean he goes there to get flowers.]

A similar prompt was provided for the bilingual child:

R: Seradaki çiçekler nasıl yıllarca kurumadan kalabilmişler?
[How do you think the flowers in the greenhouse have remained fresh for so many years?]
C: Bakmış çiçeklere, kurumasın diye.
[He took care of them]
R: Kim bakmış?
[Who took care of them?]
C: (referring back to the text to read aloud) bir küreğe dönüşmüş olan bahçıvan ve sulama kabı ile makasa dönüşmüş iki yama...iki yamağı... *Yamağı* ne demek?
[the gardener who transformed into a spade and the watering can who transformed into a pair of scissors, two ....What is *yamağı*]
R: Yamak! Yardımcı, hizmetçi.
[*Yamak* is assistant, servant.]
C : Onlar baktı...
[They took care of them]

To sumarize, the analysis of the findings of the study demonstated that, first, Turkish monolingual child performed much better than the English-Turkish bilingual child in derivation task that requires them to derive nouns and adjectives with suffixes attached to verbs and nouns. Second, both participants were more successful in decomposition task than they were in derivation task. Although the monolingual child outperformed the bilingual child in this task as well, the bilingual child also completed the task with good success. Third, their results obtained from the reading task revealed that the monolingual child who was better at deriving and decomposing tasks was also better at reading comprehension.

Discussion and Conclusion

The present study aimed to investigate an English-Turkish bilingual child's performance of morphological analysis in comparison to that of a monolingual child in order to see if bilingualism has any advantages in morphological awareness. The study also aimed to find if morphological awareness has any impact on reading comprehension.

The data obtained through the tasks of morphological structure provided evidence for early school-age children's ability to recognize word structures through decomposition and derivation as suggested in earlier studies conducted by Jones (1991), Carlisle (2000), and Nippold & Sun (2008). Both bilingual and monolingual child showed some degree of morphological awareness by successfully generating words from the provided base words using the target suffixes and decomposing the words into their base. The performance of the participants also showed that the frequency of the derived and the base words was an important factor affecting their processing as pointed out by Carlisle & Katz (2006). Both children were more successful at the processing of high-frequency words that are supposedly learned earlier as they are more frequently encountered in daily interactions, school materials and in print.

Bilinguals are expected to have more advantages in morphological processing due to their better development of cognitive and metalinguistic capabilities as a result of close contact with two language systems (Diaz & Klingler, 1991). However, the bilingual participant of the study was less successful than the monolingual child in all tasks because of her limited vocabulary and low proficiency in Turkish. This can be explained through the fact that her dominant home language is English, and she is exposed to Turkish only outside of home, mainly in school. In that case, the findings of the study support Cummin's threshold hypothesis suggesting that a critical level of proficiency in L2 must be reached if bilingual advantages in cognitive and linguistic functioning are to develop. In other words, since the bilingual participant did not attain a certain level of proficiency in Turkish, she could not benefit from the positive effects of bilingualism.

The findings of the data coming from the reading task revealed that the monolingual child who achieved better in the morphological awareness tasks also scored better at comprehension. In other words, the present study verified the findings of the studies in which the morphological awareness is found to be the predictive of reading comprehension at word and text levels (Ku & Anderson, 2003; Carlisle and Fleming, 2003; Carlisle, 2000).

Finally, the present study aimed to explore the morphological awareness of an English-Turkish bilingual child and a Turkish monolingual child, an issue that has not been investigated in related studies before. Therefore, its findings cannot be directly compared to the conclusions of the previous morphological awareness studies that are generally conducted with monolingual subjects and within the context of other languages. Besides, it should be noted that these conclusions are based on some small-scale data collected from 2 participants, one bilingual and one monolingual, and no generalizations can be made by any means for other than the described participants and context. Therefore, further studies with greater number of bilingual and monolingual children are strongly recommended in order to verify and expand the findings reported in this study.

References

Banguoğlu, T. (2000). *Türkçenin Grameri* (6.baskı). Türk Dil Kurumu, Ankara.

Bialystok, E. (1986). Factors in the growth of linguistic awareness. *Journal of Psycholinguistic Research, 15,* 13-32.

Carlisle, C.F. (2000). Awareness of the structure and meaning of morphologically complex words: Impact on reading. *Reading and Writing: An Interdisciplinary Journal, 12,* 169-190.

Carlisle, C.F., Beeman, M., Davis, L.H., & Spharim, G. (1999). Relationship of metalinguistic capabilities and reading achievement for children who are becoming bilingual. *Applied Psycholinguistics, 20,* 459-478.

Carlisle, C.F. & Fleming, J. (2003). Lexical processing of morphologically complex words in the elementary years. *Scientific Studies of Reading, 7* (3), 239-253.

Carlisle, C.F. & Katz, L.A. (2006). Effects of word and morpheme familiarity on reading of derived words. *Reading and Writing, 16,* 669-693.

Campbell, R. & Sais, E. (1995). Accelerated metalinguistic (phonological) awareness in bilingual children. *British Journal of Development Psychology, 13,* 61-68.

Cromdal, J. (1999). Childhood bilingualism and metalinguistic skills: Analysis and control in young Swedish-English bilinguals. *Applied Psycholinguistics, 20,* 1-20.

Cummins, J. (1979). Linguistic interdependence and the educational development of Bilingual children. *Review of Educational Research, 9,* 131-149.

Deacon, H.S., Wade-Wooley, L. & Kirby, J. (2007). Crossover: The role of morphological awareness in French immersion children's reading. *Developmental Psychology, 43* (3), 732-746.

Diaz, R. & Klingler, C. (1991). Towards an exploratory model of interaction between bilingualism and cognitive development. In E. Bialystok (Ed.), *Language processing in bilingual children* (pp. 167-192). Cambridge: Cambridge University Press.

Freyd, P. & Baron, J. (1982). Individual differences in acquisition of derivational morphology. *Journal of Verbal Learning and Verbal Behavior*, *21*, 282-295.

Jones, N. K. (1991). Development of morphophonemic segments in children's mental representations of words. *Applied Psycholinguistics*, *12,* 217-239

Ku, Y. & Anderson, R.C. (2003). Development of morphological awareness in Chinese and English. *Reading and Writing: An Interdisciplinary Journal, 16,* 399-422.

Larsen, J.A. & Nippold, M.A. (2007). Morphological analysis in school-age children: Dynamic assessment of a word learning strategy. *Language, Speech, & Hearing Services in Schools, 38* (3), 201-212.

Nagy, W., Berninger, V., Abbott, R., Vaughan, K. & Vermeulen, K. (2003). Relationship of morphology and other language skills to literacy skills in at-risk second-grade readers and at-risk fourth-grade writers. *Journal of Educational Psycahology, 95*(4), 730-742.

Nippold, M.A. & Sun, L. (2008). Knowledge of morphologically complex words:A developmental study of older children and young adolescents. *Language, Speech, & Hearing Services in Schools, 39* (3), 365-373.

Oflazer, K., Say, B., Hakkani-Tur, D.Z., & Tur, G. (2003). *Building a Turkish Treebank: Building and Using Parsed Corpora*. Retrieved from http://www.speech.sri.com/people/gokhan/pubs/ttbank-book.pdf On Dec 2, 2008.

Ricciardelli, L. A. (1992). Bilingualism and cognitive development in relation to threshold theory. *Journal of Psycholinguistic Research, 21*, 301-316.

Reichle, E.D. & Perfetti, C.A. (2003). Morphology in word identification: A wordexperience model that accounts for morpheme frequency effects. *Scientific Studies of Reading, 7* (3), 219-237.

Singson, M., Mahony, D., & Mann, V. (2000). The relation between reading ability and morphological skills: Evidence from derivational suffixes. *Reading and Writing: An Interdisciplinary Journal*, *12,* 219-252.

Taft, M. (1979). Recognition of affixed words and the word frequency effect. *Memory and Cognition, 7* (4), 263-272.

Tyler, A. & Nagy, W. (1989). The acquisition of English derivational morphology. *Journal of Memory and Language*, *28,* 649-667.

Verhoeven, L. & Perfetti, C. (2003). Introduction to this special issue: The role of morphology in learning to read. *Scientific Studies of Reading, 7* (3), 209-217.

Wang, M. Cheng, C. & Chen, S. (2006). Contribution of morphological awareness to Chinese-English Biliteracy acquisition. *Journal of Educational Psychology, 98* (3), 542-553.

Appendix A: Derivation Tasks

Practice: a. (Çiçek) Amcamın bir ________ dükkanı var. [çiçek-çi]

b. (Hediye) Gittiğim yerlerden ______ eşya almayı çok severim. [hediye-lik]

Noun + suffix= N (-lik, - ci, -daş)

1. (göz) Dün kendime yeni bir _____ ___ aldım. [göz-lük]

6. (kitap) Bu odaya daha küçük bir __ ____ koymalıyız. [kitap-lık]

10. (asker) Kardeşim bir süredir ________ yapıyor. [asker-lik]

14. (tuz) Masada ________ var mı? [tuz-luk]

18. (kira) Bu daireye güvenilir bir ________ arıyoruz. [kira-cı]

22. (iş) Bu fabrikada çalışan iki ___________ tanıyorum. [iş-çi]

26. (yol) Otobüsten iki ____ ____ indi. [yol-cu]

30. (süt) Tereyağını bu sabah ____ ____ getirdi. [süt-çü]

34. (arka) Mehmetle kısa sürede ____ _____ olduk. [arka-daş]

38. (sır) Ablam bana her zaman iyi bir _________ oldu. [sır-daş]

42. (vatan) Ülkene faydalı bir _____ ______ ol. [vatan-daş]

44. (meslek) O bize her zaman yol gösteren iyi bir _________ olmuştur. [meslek-daş]

Noun + suffix= Adj (- cı, -lı, -sız)

2. (yalan) O, tanıdığım en ________ çocuk. [yalan-cı]

4. (kavga) O adam kimseyle geçinemeyen _ _______ biri. [kavga-cı]

12. (şaka) O hep etrafındakileri güldüren ____ _____ biri. [şaka-cı]

16. (şüphe) Polisler __________ insanlardır. [şüphe-ci]

19. (akıl) Oğlum kafası iyi çalışan _____ ______ çocuktur. [akıl-lı]

23. (neşe) Orada geçirdiğim günler hayatımın en __________ günleriydi. [neşe-li]

27. (güç) Arkadaşın bunu da atlatır, o ___ ______ biri. [güç-lü]

31. (boy) Kim o uzun ___ ____ adam? [boy-lu]
35. (tat) Çok kötü! Yediğim en ____ ______ elma! [tat-sız]
39. (ses) O, derste pek konuşmayan ________ öğrencilerden. [ses-siz]
43. (huy) Ahmet sürekli ağlayan _________ bir çocuk. [huy-suz]
45. (uygun) Bunlar öğretmenin hoşlanmadığı __ _ _ davranışlar [uygun-suz]

Verb + suffix= N (- gi, -i, im)

3. (çal) En sevdiğim ________ mandolindir. [çal-gı]
7. (öv) Yaptığı güzel yemeklerle misafirlerinden bol __ ______ aldı. [öv-gü]
11. (sev) Çocuklar için en önemli şey ___ _____ görmektir. [sev-gi]
15. (dol) Dişime _________ yaptırdım. [dol-gu]
17. (yaz) Bu _ _______ okunmuyor. [yaz-ı]
21. (sor) Bu cevaplamanız gereken bir __ _______ değil. [sor-u]
25. (tak) Düğüne altın _________ götürdüm. [tak-ı]
29. (ört) Bu masa için daha büyük bir ___ _____ gerekiyor. [ört-ü]
33. (bak) Bahçeye biraz _________ yapmalı. [bak-ım]
36.(doğ) Kadın birkaç saat içinde _________ yapacak. [doğ-um]
41. (seç) Sınıf başkanlığı için ____ _____ yapılacak. [seç-im]
46. (böl) Bu şarkıda en sevdiğim _____ _____ burası. [böl-üm]

Verb + suffix= adj (-gen, -ici, -ık)

5. (çalış) Bunlar benim en ___ _______ öğrencilerim. [çalış-kan]
8. (kay) Dikkat et! _____ ____ zemin! [kay-gan]
9. (çekin) Ali sınıfta pek konuşmayan, ________ biri. [çekin-gen]
13. (giriş) Hayatta daha başarılı olanlar genellikle ________ insanlardır. [giriş-ken]
20. (yırt) Bunlar ________kuşlar. [yırt-ıcı]
48. (üz) Bu yaşadıkların çok __ _ olaylar. [üz-ücü]
24. (yor) Taşınmak ________ bir iş. [yor-ucu]
28. (geç) Bunlar işe yaramayan ________ çözümler. [geç-ici]

32. (aç) Bu saatte lokantalar _______ olmaz. [aç-ık]

37. (kır) İşte rüyamda gördüğüm _______ ayna! [kır-ık]

40. (at) Bunlar denizlerimizi kirleten __________ maddeler. [bat-ık]

47. (boz) Ne kokuyor burada, ____ _____ süt mü? [boz-uk]

Appendix B: Decomposition Tasks

Noun + suffix= N (- ci, -lik, -daş)

1. (kayalık) Bu, rüzgarın etkisiyle oluşan bir __ _______. [kaya]

5. (çiçeklik) En güzel hediye bir demet ______ ____. [çiçek]

9. (kömürlük) Bu, kış için aldığımız kömür_____ ___. [kömür]

14. (buzluk) Çocuğun dolaptan istediği şey____ ___. [buz]

17. (saatçi) Bu bana aldığı yeni _________. [saat]

22. (tarihçi) En sevdiğim ders ______ ____. [tarih]

26. (odacı) Bu üç kişilik, geniş bir ___ ____. [oda]

28. (sözcü) Bu nasıl _____ ______! [söz]

32. (yoldaş) İşte takip edeceğin ____________. [yol]

36. (soydaş) Bu, atalarımızın geldiği ______ ______ ! [soy]

40. (sesteş) Kadife gibi yumuşacık bir ______. [ses]

45. (yurttaş) Ne güzel bir __________! [yurt]

Noun + suffix= Adj (- cı, -lı, -sız)

2. (yardımcı) İhtiyacım olan şey biraz _____ ___. [yardım]

7. (inatçı) Bu gereksiz bir _______! [inat]

12. (kinci) Bu ne bitmeyen bir ________! [kin]

14. (akşamcı) Mezuniyet törenimiz bu __ ________. [akşam]

21. (kararlı) Bu benim için zor bir _________. [karar]

24. (suçlu) Başkasına ait olanı izinsiz almak büyük bir ___ ___. [suç]

27. (öfkeli) Bu ne bitmeyen bir _____ ______! [öfke]

28. (azimli) Başarısının sırrı sahip olduğu ______. [azim]

34. (çaresiz) Ameliyat en son ____ _____ ! [çare]

37. (evsiz) Bu geniş bir ___ _____. [ev]

43. (susuz) Yaşamak için en gerekli şey _____ ______. [su]

44. (habersiz) Bu kutlamamız gereken bir _____ _____. [haber]

Verb + suffix= N (- gi, -i, im)

3. (sorgu) Bilmediğin şeyleri bana _________. [sor]

8. (görgü) Sinemeya git, o filmi _____ _______. [gör]

11. (bulgu) Kaybettiğin atkımı ara ve ____________. [bul]

13. (saygı) Her zaman küçüklerini sev, büyüklerini _____. [say]

19. (yapı) Ödevlerini lütfen zamanında __________. [yap]

20. (korku) Artık benden ________! [kork]

29. (ölçü) Yemek yaparken kullanacağın malzemeyi ________. [ölç]

33. (tartı) Parasını ödemeden önce aldıklarını ___. [tart]

42. (çözüm) Şimdi bu problemleri ______. [çöz]

39. (tutum) İpin bu ucunu sen _____________. [tut]

41. (sayım) Yüze kadar ____ __. [say]

47. (kesim) Banyodan sonra uzun tırnaklarını _____ _. [kes]

Verb + suffix= adj (-gen, -ici, -ık)

4. (değişken) Sen de zamana uy ve ___. [değiş]

6. (konuşkan) Problemi çözmek için onunla __ ____. [konuş]

10. (unutkan) Sana söylediklerimi __ ______. [unut]

16. (üretken) Boş durma, sen de ___ ______. [üret]

18. (kalıcı) Lütfen gitme, biraz daha __ ____. [kal]

23. (yakıcı) Akşam oldu, ışıkları ____ ________. [yak]

25. (uyarıcı) Hata yaptığımda lütfen beni ___ _____. [uyar]

31. (çekici) Sandalyeni biraz öne ________. [çek]

35. (yarık) Odunları baltayla ____ ______.	[yar]
38. (ezik) Püre yapmak için patatesleri iyice _____ _.	[ez]
46. (yırtık) Bir parça bez ___.	[yırt]
48. (kesik) Bu renkli kağıtlardan değişik şekiller _____.	[kes]

Appendix C: Reading Comprehension Questions

1. Çirkin yıllardır gitmediği seraya niçin gidiyor?
2. Çirkin seraya giderken niçin endişeli?
3. Seradaki çiçekler nasıl kurumadan yıllarca kalabilmişler?
4. Bella uyandığında niçin şaşırdı?
5. Çirkin Bella yı nereye götürdü?
6. Çirkin yaptıklarının karşılığında Bella'dan ne istedi?

THE IMPETUS FOR TEACHING ALGEBRA IN THE EARLY GRADES

Assist. Prof. Hülya Kılıç

Abstract

Algebra is one of the core subjects of secondary school mathematics. Having weak conceptual understanding of algebra and a low level of algebraic thinking skills causes low student performance in mathematics courses. Therefore, some scholars suggest introducing algebraic concepts in the elementary level to help students succeed in mathematics. The goal of this paper is to examine some of the current practices and studies on teaching algebra in the elementary grades and discuss their implications on curriculum development and teaching.

Keywords: Algebra, algebraic thinking, elementary mathematics.

Özet

Cebir, ortaöğretim matematiğinin temel konularından biridir. Cebiri kavramsal olarak anlamadaki eksiklik ve cebirsel düşünme becerilerinin zayıflığı, öğrencilerin matematik derslerindeki performanslarının düşük olmasına neden olmaktadır. Bu nedenle bazı akademisyenler, öğrencilerin matematikte başarılı olmasına yardımcı olacağı için cebirsel kavramların ilköğretim birinci kademede verilmesini önermektedir. Bu çalışmanın amacı, ilköğretim birinci kademede cebir öğretimi ile ilgili varolan uygulamaları ve yapılan çalışmaları incelemek ve bunların öğretim programı geliştirmeye ve öğretime yüklediği anlamı tartışmaktır.

Anahtar sözcükler: Cebir, cebirsel düşünme, ilköğretim birinci kademe

Given its important role in mathematics as well as its role as a gatekeeper to future educational and employment opportunities, algebra has become a focal point of research efforts in mathematics education (Knuth, Stephens, McNeil, & Alibali, 2006). Having increased number of students struggle with understanding algebra and obtaining lower scores from the related parts of the international assessment studies such as TIMSS and PISA urge researchers, teachers, policymakers, and curriculum developers of the countries to investigate the causes of the failure in understanding and learning algebra and to figure out possible actions to be taken to eliminate them. The results of several research on improving students' performance on algebra and promoting algebraic thinking imply that teaching algebra in the early years of schooling might be one of the major steps to enhance students' mathematical understanding and algebraic thinking (Bastable & Schifter, 2008; Blanton & Kaput, 2005; Carraher, Schliemann, & Schwartz, 2008; Ferrini-Mundy, Lappan, & Phillips, 1997; Kieran, 2004; Yackel, 1997).

Many scholars argued that algebra should become a part of elementary education (Carraher, Schliemann, Brizuela, & Earnest, 2006) despite of the opposite views of others that young children are incapable of learning algebra because they do not have the cognitive ability to handle algebraic concepts like variables and functions (Tierney & Monk, 2008). However, teaching algebra in elementary school is not a new idea. In a few countries like Japan, China, Singapore, and Russia, some algebraic concepts, at least implicitly, are taught in the elementary grades. Furthermore, in recent years, many countries revised their elementary and middle school mathematics curricula with an intention of improving students' mathematical understanding, in particular understanding of algebra (Cai, 2004a). In this paper, I present a few examples from the countries that algebra is already taught in the elementary school, then give examples from such curricular reforms and discuss the effectiveness of suggested activities on learning and understanding algebra in the early grades. Beforehand, I briefly explain how scholars view algebra and algebraic thinking and how such views are conveyed in recent secondary mathematics curricula.

Algebra and Algebraic Thinking

Algebra is one of the major branches of mathematics whose origin is based on the studies of arithmetic and geometry in ancient times. Kieran (1992) defined algebra as "the branch of mathematics that deals with symbolizing general numerical relationships and mathematical structures and with operating on those structures" (p.391). Similarly, Sfard and Linchevski (1994) identified operational and structural phases of algebra such that operational algebra "like arithmetic, deals (at least at its early stages) with numbers and with numerical computations, but it asks questions of a different type and treats the algorithmic manipulations in a more general way" (p. 196). A structural algebra, on the other hand, entails excessive use of symbols and algebraic notations.

Kieran (2007) also identified three types of school algebra activities. First, algebra involves "generational" activities where situations are generated into equations or expressions. For instance, writing equations containing an unknown to represent problem situations or deriving a rule for the relationships embedded in given numerical sequences could be counted as generational activities. Second, there are "transformational" or rule-based activities such as collecting similar terms, factoring and simplifying expressions. Third, there are "global, meta-level activities" where algebra is used as a tool. For instance, problem solving, modeling, generalizing, analyzing relationships, and justifying are meta-level activities and they are also essential to other activities of algebra. Similarly, Kaput (2008) stated that there are three strands of algebra which are compatible with Kieran's view of school algebra activities. The first strand includes generalizing arithmetic operations and their properties and more general relationships and their forms. The second strand includes the study of functions, relations, and joint variation. The third strand includes modeling of different situations. Furthermore, he noted that at more advanced levels the first strand leads to abstract algebra and the second strand leads to calculus and analysis.

There are different views about what algebraic thinking refers to in school algebra. Blanton and Kaput (2005) conceived algebraic thinking as students' activity of generalizing given data and mathematical relationships, establishing those generalizations through conjecture, and arguing and expressing them in increasingly formal ways. They discussed different forms of algebraic thinking such that (1) it might be using arithmetic as a domain for expressing and formalizing generalizations (generalized arithmetic), (2) it might be generalizing numerical patterns to describe patterns and functional relationships (functional thinking), (3) it might be modeling as a domain for expressing and formalizing generalizations, and (4) it might be generalizing about operations and properties associated with numbers. Their definition for algebraic thinking emphasizes both the importance and the ability of understanding variations and functional relations of variables.

Although generalizing number patterns, recognizing relationships and the similarities and differences between mathematical representations are conceived as involved in algebraic thinking (e.g., Curcio & Schwartz, 1997; Ferrini-Mundy, Lappan, & Phillips, 1997; Slavit, 1999), Kieran (1989) disagreed with the idea that generalization is equivalent to algebraic thinking rather; algebraic thinking is a necessary component for the use of algebraic symbolism in order to reason about and express that generalization. Kieran (2004) argued that algebraic thinking can be interpreted as an approach to quantitative situations that emphasizes the general relational aspects with tools that are not necessarily letter symbolic, but which can be used as cognitive support for introducing and for sustaining more traditional discourses of school algebra. She noted that students do not need to use letter symbolic algebra to analyze relationships between quantities, notice structures, justify their reasoning or prove conjectures.

Briefly, in school settings, algebra is studied in the form of generalizing, forming and solving equations, and working with functions and formulas (Bell, 1995). Teachers put emphasis on simplifying algebraic expressions, solving equations, inequalities, and the systems of equations and factoring polynomials and rational numbers (Kaput, 1999; Kieran 2007). Hence, algebraic thinking refers to students' ability to understand algebraic concepts and to deal with all related procedures and facts both in deductive and inductive manner.

Algebra in Elementary School Curricula

Traditional elementary school mathematics involves only teaching arithmetic procedures and students are introduced to algebra in the middle school (Cai & Knuth, 2005; Fujii & Stephens, 2008; Johanning, 2004; Kaput, 2008; Kieran, 1992; Tierney & Monk, 2008). However, teaching algebra separately from arithmetic is found to be unsuccessful practice in terms of student achievement in algebra (Blanton & Kaput, 2005; Carraher, Schliemann, & Schwartz, 2008; Herscovics & Linchevski, 1994). In the countries discussed below, algebraic concepts and arithmetic are taught simultaneously to emphasize the relationships between arithmetic and algebra and to facilitate students' understanding of more complex algebraic concepts taught in later grade levels.

Watanabe (2008) stated that a smooth transition from arithmetic to algebra is the core idea of Japanese elementary curriculum. Students begin to discuss fundamental algebraic concepts such as variables and functions implicitly during the second grade. The function concept is first introduced when the students learn about multiplication. Teachers encourage students to explore the relationship between a multiplicand and the product such that they want students to pay attention to how the product changes as one of the multiplicand changes. Thus, the students not only practice with the arithmetic of multiplication operation but also realize how multiplication function works. Moreover, in the upper elementary level, students are asked to figure out the relationship between two varying quantities. Teachers give concrete examples such as how the depth of a cup changes with respect to the amount of water in the cup changes or how the length of a rectangle changes with respect to its width providing that the area remains the same. Watanabe also stated that a special attention is given to expressing ideas and relationships embedded in the problems by using mathematical notations. He noted that writing and interpreting mathematical expressions involving arithmetic operations and also using symbols like □, Δ, x in mathematical expressions are emphasized in the Japanese curriculum. For instance, students are expected to interpret 3 + 4 as “4 objects are added to 3 objects” or “4 objects more than 3 objects.” Similarly, they are expected to interpret “3 + □ = 5” as “adding 3 to a number makes 5.” Furthermore, Japanese teachers emphasize expressing mathematical expressions in words. For instance, a 4-by-6 rectangle, the area is found by 4 x 6 = 24. The teacher asks students to write what each number represents, that is “length x width = area.” Students’ ability to make such interpretations can be thought as an example of what Blanton and Kaput (2005) suggested for the forms of algebraic thinking described in the previous section. Both examples are about *generalizing about operations and properties associated with numbers* because in the former example, students are expected to know what addition operation means and in the latter one, they are expected to make connections between the numbers and what each of them represents for in a rectangle. Watanabe indicated that studying such fundamental algebraic concepts in the elementary level helps students gain a deeper understanding of algebra and be successful in secondary school mathematics.

The idea of teaching algebraic concepts and arithmetic simultaneously in the elementary level is also seen in other countries such as China, Singapore, Russia, and the Netherlands. Cai and Moyer (2008) stated that the main goal of Chinese and Singaporean elementary school curricula is to make connections between arithmetic and algebra to facilitate students’ algebraic thinking abilities. They provided some examples from both curricula to show how they would achieve such a goal. They noted that in Chinese elementary schools, the first graders are introduced addition and subtraction operations simultaneously. The students are asked to solve equations written in the form of “1 + ( )= 3”. They are expected to find the value inside the parentheses by doing inverse operations. The same format is used for division and multiplication during the second grade. Cai and Moyer also indicated that because in Chinese elementary schools teachers use both arithmetic and algebraic approaches to solve the problems, students could attain a better understanding of quantitative relationships and have opportunity to explore the similarities and differences between arithmetic and algebra.

In the Singaporean elementary schools, students are expected to solve problems by using pictorial representations. The most common representation is strip diagrams. For instance, students use the pictorial representation shown in Figure 1 to solve the problem: I had $51. After buying 3 watermelons, I had $30 left. Find the cost for 1 watermelon.

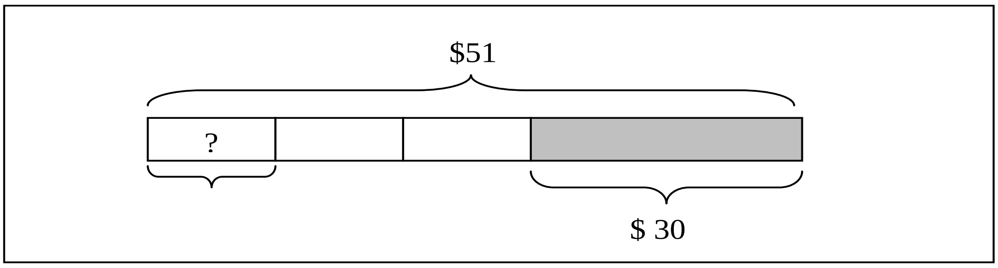

Figure 1. Example of a strip diagram

The students draw a strip to represent whole money and then shade a part which is not spent. Then they divide the remaining part 3 equal rectangles to represent 3 watermelons. They work in backwards to solve the problem. First, they subtract the amount which is not spent and then divide the remaining amount by 3 to find the price of one watermelon. The students are given a bit difficult problems in the fourth and fifth grade but they could solve them by using appropriate strip diagrams because strip diagrams serve as a concrete representation that helps students visualize the problems. Using strip diagrams would definitely contributes to students’ algebraic thinking because students do not use formal algebraic notations but organize the given information to model the problem situation and understand the relationships between the quantities given in the problem (Ferrucci, Kaur, Carter & Yeap, 2008). Cai and Moyer (2008) stated that the students in later grade levels could easily write the algebraic equation represented in strip diagrams by replacing “x” for the unknown value. For instance, the students could find the algebraic equation for the problem given above as $3x + 30 = 51$ by replacing “x” for the value of small rectangle.

In the Netherlands, one of the major goals of mathematics curriculum is to provide opportunities for students to understand the connections between mathematics and reality by applying mathematics in practical situations (van den Huevel-Panhuizen & Wijers, 2005). The elementary students are expected to understand the pattern embedded in a set of numbers or shapes and the mathematical language that includes formal and informal notations, representations, tables, and graphs. The students are given problems that they first solve arithmetically and then explain the reason underlying those arithmetic operations. For instance, the students can solve the problem “I had 5 Euro. I bought a chocolate for 2 Euro. How much money is left?” as “5 – 2 = 3” and then explain that they use subtraction because when they buy something the amount of money they have decreases so they need to take the spent amount away from the initial amount. The students are also asked to make generalizations for given number patterns or repeated situations (e.g. the relationship between the numbers of chocolate bar is bought and how much is paid for the total).

Although arithmetic and algebra is taught together in Russian elementary schools, the sequence of the topics is different than the countries discussed above. In Russia, algebra is introduced before arithmetic. Schmittau and Morris (2004) stated that the students study algebraic generalizations first and they use arithmetic as a concrete application of these algebraic generalizations. For instance, students compare the length of two objects and identify the relationships between them as A=B or A<B or A>B, then they are expected to use such relationships when they are given numerical values for length.

Briefly, the examples given above revealed that the goal of elementary school algebra is to raise students' awareness about the relationship between arithmetic and algebra. The scholars indicated that students are able to understand the relationship and use it to solve problems. They also noted that learning algebraic concepts in the early grades contribute to the development of students' algebraic thinking skills.

Teaching Algebra in the Early Grades

Teaching algebra in elementary level refers to elaboration of students' ability of algebraic thinking and reasoning rather than emphasizing complicated algebraic activities. The studies on elementary school mathematics revealed that elementary students are capable of learning fundamental unifying ideas that are the foundations of both arithmetic and algebra (Carpenter, Franke, & Levi, 2003; Clements & Sarama, 2007). The scholars noted that learning and articulating these ideas both enhance students' understanding of arithmetic and provide them with a concrete basis extending their knowledge of arithmetic to learn algebra. This conclusion is compatible with the main goal of the elementary school algebra discussed in the previous section. However, in recent studies the scholars are not only discussing how to achieve a smooth transition from arithmetic to algebra but also investigating whether elementary students are able to make generalizations, understand the concepts of variable and function, and use algebraic notations. In this section, I present examples from such studies and discuss their findings.

Many scholars investigated whether students are able to recognize the relationships in a given pattern and make a generalization in the early grades (e.g., Curcio & Schwartz, 1997; Threlfall, 1999; Warren & Cooper, 2008; Willoughby, 1997). The studies revealed that even in the kindergarten level students are able to recognize the patterns, extend them, and construct their own patterns. For instance, Warren and Cooper (2008) indicated that 5-year old children participated in their study were capable of recognizing growing patterns such that given geometric representations of number pattern 2, 4, and 6 as a group of small squares, they could recognize the next group would consist of 8 squares, the next one would 10 squares, etc. They also noted that 7-year old children could find the total number of figures or letters in the given pattern and 8-year old children could answer complex questions about the nature of the pattern by making inferences about the given piece of the pattern. For instance, when they were given a pattern like RRGGGRRGGGRR, they could find how many R would be in the set of 60 letters or how many R would be in the set when the pattern was repeated 100 times. Additionally, Warren and Cooper asked students to generalize the pattern for *n* repeats. They stated that some of the students were able to find the answer. They noted that as students practice more on the deconstruction and reconstruction of the given pattern they generalize the given pattern more easily.

The studies on algebraic thinking skills revealed that these skills could be improved by providing opportunities for students work on different subjects of elementary mathematics. Carraher, Schliemann, and Schwartz (2008) conducted a longitudinal study to investigate characteristics of early algebra and development of algebraic thinking skills through the observation of four classes from the second half of the second grade to the end of the fourth grade. They prepared activities related with fractions, ratio, proportion, four operations and negative numbers and each semester the students participated in six to eight activities. They emphasized that throughout one and half a year the students' algebraic thinking had been improved. One of their activities aimed to achieve transition from a particular situation to generalization. They presented a "candy box problem" to the third grade students such that one of the researchers held two boxes in his hand and said that the box in his left hand was John's and the box in his right hand was Mary's. He threw away three candies from Mary's box and put them on the top of the box, thus the number of the candies in each box became equal. The researchers gave students a box of candies and asked them to guess the number of candies in each box without opening the boxes. Then the researcher made a table of students' answers most of which had the same pattern: "The number of Mary's candies is three more than John's candies." Then the researcher asked that what would be the number of Mary's candies if John had N candies where N can be any number. His way of phrasing the question puzzled students since they thought that the number of Mary's candies would be N because N was "any number". Then the researcher rephrased his statement as N could stand for any number so that some of the students were able to figure out that the number of Mary's candies, which is N+3. Although students did get confused about using variables and making generalizations in this problem, they performed better when they were asked to work on a similar problem at the beginning of the second semester of the fourth grade. Carraher et al. asked the following problem to the students:

> Mike has $8 in his hand and the rest of his money is in his wallet; Robin has exactly 3 times as much money as Mike has in his wallet. What can you say about the amounts of money Mike and Robin have? (p.248).

Carraher et al. stated that 16 students out of 63 represented the amount of Mike's money as N+8 and the amount of Robin's money as N+N+N or 3N or N*3 while others used wallet symbols to represent that relation or used algebraic notation but omitted the signs between them. For instance, they wrote "N 8" for Mike's money and "N N N" for Robin's money. Later in the term, Carraher et al. revisited this problem and modified it to discuss solving equations and graphs. The researcher used a table to show what might be some of the points of the graph and then the students plotted the graph. In order to show how to solve an equation, the researcher wrote the equation for the modified problem as "W+8=3W". Some of the students guessed that the answer would be 4. However, the aim of the researcher was to show them how to simplify the equation by eliminating like terms. At the end of the lesson, students were able to figure out the answer by solving the equation.

Two conclusions could be drawn from Carraher and his colleagues' study. The first one is the same as what Warren and Cooper (2008) concluded about patterning activities. The elementary graders are capable of recognizing patterns and make generalizations. However, teachers should be careful about expressing the mathematical terms. In this case, using phrase "any number" was confusing for the students. Instead, the teacher might rephrase it as what the number of candies in Mary's box would be if there were N candies in John's box. The second conclusion is that in the upper elementary level students are more capable of working with algebraic notations and symbols. In this case, fourth graders were able to represent Mike's money as 3N. However, only 25% of the students represented it correctly. To increase the number of students who represent the problem correctly, Singaporean strip diagrams could be used by the teachers. Because strip diagram help students visualize the problem and understand the reasoning underlying the algebraic expressions.

Bastable and Schifter (2008) also investigated the development of algebraic thinking skills by using different tasks in elementary classrooms. They indicated that when the students were given opportunity to discuss their answers for given arithmetic questions or geometric representations they were able to formulate and test generalizations. For instance, in a fourth grade class they observed that the students figured out some properties of square numbers like "if you multiply a square number by a square number, you'll get a square number". Additionally, one of the students found out that "if you take two consecutive numbers, add the lower number and its square to the higher number, you get the higher number's square." His initial example was $2+2^2+3=3^2$, and then his friends found other examples to confirm his conjecture. Bastable and Schifter stated that such activities not only contribute to the development of students' algebraic thinking abilities but also facilitate transition from numbers to algebraic notation. The examples given above could be represented as $a^2 \cdot b^2 = c^2$ where $c = a \cdot b$, and $n + n^2 + (n+1) = n^2 + 2n + 1 = (n+1)^2$, respectively. Although the students may not be able to figure out these generalizations in the elementary level, such problems can be revisited in the middle school while teaching algebraic notations and identities.

Carraher and his colleagues (Carraher, Schliemann, Brizuela, & Earnest, 2006) indicated that algebraic notation can play a supportive role in learning mathematics in the early grades. They stated that symbolic notation, number lines, function tables and graphs are powerful tools that students use to understand and express functional relationships across a wide variety of problem context. They argued that students could achieve the transition from arithmetic to algebra when they were introduced with tables, graphs and algebraic symbolic notations gradually. Tierney and Monk (2008) investigated how the fifth graders made sense of “change” through graphs and tables. One of the tasks they gave students was about comparing graphs of growth of two plants to decide which one was growing faster. The first line started from the origin with a slope approximately 1 and the second line started from a point on the y-axis with a slope approximately 1/2. The students realized that the first plant reached to the same height with the second one within the same amount of time although its height was approximately zero at the beginning. They also interpreted that the steepness of a line shows how fast it grows. It was evident that the students were able to make inferences about the relationships between two varying quantities, in this case, time and height. Another task was about creating a table for the given story problem for a trip and then constructing its graph. One of the problems was follows: Walk very slowly about a quarter of the distance, stop for about 6 seconds, and then walk fast to end. The students draw a time-distance table for the given story. All students were able to fill out the table according to the given information and then draw its graph. Because these students were able to make tables fit to given problems and interpret the graphs of linear lines, Tierney and Monk suggested developing a curriculum that facilitates transition from arithmetic to algebra through representation of varying quantities in stories or graphs. Indeed, working on varying quantities is common in Japanese curriculum such that students practice on the relationships between two varying quantities in different contexts.

In this section, I have given a few examples from the studies on teaching algebra in the early grades. Although those studies were administered on a limited number of students, the findings support the view that students could learn algebraic concepts in the early grades and teaching some basic algebraic facts in the elementary level contributes to the development of algebraic thinking skills of students.

Implications for Curriculum Reforms

Teaching algebra is one of the most popular issues in mathematics education because many students still suffer from learning and understanding algebraic concepts. There is an emerging consensus that reformative actions on teaching algebra require reconceptualizing the nature of algebra in school mathematics (Cai, 2004b). Many mathematics educators advocate that children should be introduced to algebraic concepts and be given opportunities to improve their algebraic thinking skills in the early years of schooling rather than waiting for the middle school years (Carraher et al., 2006).

As discussed above, in a few countries algebra is already taught as a part of elementary school curriculum. It is noted that, in those countries, students are able to recognize patterns, make generalizations about simple patterns and solve simple algebraic problems by using representations or symbols. The effectiveness of those practices could be thought as impetus for curriculum developers of other countries where students struggle with understanding algebra in the middle school (Cai & Moyer, 2008). They should either suggest similar practices for their elementary school students or design new activities that would be more appropriate for their students and aligned with the requirements of their secondary school curriculum.

In Turkey, the new elementary mathematics curriculum was launched in 2006. The curriculum is aimed to foster students' mathematical thinking and learning through various activities. Although algebra is not identified as a major subject area in the elementary level, students are introduced with algebraic concepts such as finding relationships in number patterns during the fourth grade. Then, students are formally introduced with algebra in the sixth grade. Previously, the students began to learn algebra in the seventh grade although teachers were using some symbols like □ and Δ to represent unknown values when solving arithmetic or simple word problems in the fourth or the fifth grade. Then, students were used to replace such symbols with letters like x and y in the seventh grade. In Turkey, there are not large scale studies investigating effectiveness of the new elementary curriculum. Some small scale investigations (e.g., Akkan, Çakıroğlu, & Güven, 2009; Gürbüz & Akkan, 2008; Yenilmez & Teke, 2008) revealed that elementary students are able to understand some algebraic concepts like variables but they have difficulty with using them in different contexts such as carrying out operations between variable expressions or writing a problem statement for given algebraic equation. Therefore, there is an immediate need for large scale studies on the new curriculum to elicit whether it contributes to the development of students' algebraic thinking.

The results of the studies presented in the previous section support the fact that elementary students are able to recognize the rule of the patterns and make inferences about them. The scholars noted that activities about number patterns may facilitate transition from arithmetic to algebra (e.g., Warren & Cooper, 2008). For instance, when students are asked to find the relationship between the entries of ordered pairs (2, 5), (4, 7), (8, 11), … they are able to conclude that the second number is 3 more than the first number and represent the second entry as $n+3$ when the first entry is given as n. Students can also find one of the missing numbers in such pairs because they know the relationship between the entries.

Elementary grade students could be successful at patterning activities but they might have difficulty in understanding algebraic notations. In the countries mentioned above, although elementary students are introduced with the idea of using letters to represent unknown values and scholars noted that students are able to deal with variables and solve equations (Cai, 2004a), students' understanding might be procedural rather than conceptual. For instance, they may overgeneralize the solution of algebraic equations. If they have learned that to find the value of *a* in "a + 2 = 8" they subtract 2 from 8 then they may apply the same operation for "2 x a = 8". They may not differentiate the meaning of "a + 2" and "2 x a." In some textbooks variables are used to represent rules or identities such as A=lw (Area=length x width) or a+b = b+a (commutative property of addition) but such representations before giving away the definition of a variable may not be meaningful for students. They either try to memorize the rules without paying attention to what letters stands for or totally neglect them (Driscoll, 1999). Furthermore, they may assume that an unknown or variable, say *n*, has a single value. For instance, if they have found that *n* is 3 for "2n + 4 = 10" then they may assume that it is still 3 for "3n – 1 = 5." Therefore, curriculum developers and teachers should design or select activities that enable elementary students understand the meaning of algebraic notations. They particularly should pay attention to the language they use because students' language skills may not be developed yet. As I indicated in the previous section, when Carraher et al. (2008) told the students that the number of John's candies is "N" where "N" can be "any number", students replied him back that the number of Mary's candies would also be "N" because "N" could be any number. In that case, Carraher focused on the letter "N" rather than emphasizing the relationship between the John's and Mary's candies such that "N" is used to generalize that relationship. In order not to suffer from such misinterpretations, teachers should assign simple word problems for students and use appropriate phrases that students could understand *the* mathematics involved in the problem correctly. For instance, to address the misconception that an unknown or a variable has a single value, the teacher may tell that there are people with the same name as another (namesake) but each person has different characteristics. Therefore, value of a letter that represents an unknown or a variable may be different in each problem setting.

Although one of the reasons underlying the curricular reforms in elementary mathematics was getting lower scores in international assessment studies, there are no large-scale studies investigating either the effects of teaching algebra in the early grades on the students' performance in international exams or the effects on students' understanding and learning algebra in the later grades (Cai & Knuth, 2005). The researchers should investigate the effectiveness of such intervention on students' performance in international exams by analyzing students' algebra scores in those exams. However, obtaining reliable data about the effectiveness of new elementary curriculum on students' achievement in algebra in later grades entails examination of year-by-year records of students who have begun to learn algebra in the elementary school. It is hard to keep that much information for large group of students therefore many scholars preferred working with small groups. Because the studies with small groups revealed that teaching algebra in the early grades contributes to the development of students' algebraic thinking skills (e.g., Bastable & Schifter, 2008; Ferrini-Mundy, Lappan, & Phillips, 1997; Warren & Cooper, 2008), similar results may be obtained from the large groups when the curriculum is applied as intended.

The implementation of a new curriculum in a way that it is intended entails time for developing appropriate curriculum materials and professional training for teachers. Teachers should be given inservice training about teaching with the new curriculum. Therefore, some scholars study on such training programs to guide elementary teachers how to teach algebraic concepts in the early grades (e.g., Blanton & Kaput, 2008; Franke, Carpenter & Battey, 2008). Otherwise, teachers would either ignore the new curriculum to continue teaching in a way that they are used to teach or choose teaching activities that might not be appropriate for the students' level of readiness. Not only inservice teachers but also preservice teachers should be informed about the new elementary curriculum. Because many preservice teachers do not know much about the new curriculum, they might have a tendency to teach in a way that they were taught in the school. During the teacher education programs, the preservice teachers should be given opportunities to discuss the philosophical, psychological, and educational foundations of the new curriculum and the requirements for effective implementation.

Briefly, teaching algebra in the early grades is not a new idea in mathematics education because it is a part of elementary school mathematics in some countries for many years. But investigating the effects of teaching algebra in the early grades on the development of students' mathematical understanding and their performance in algebra is a recent research problem. The researchers stated that elementary students are capable of understanding some algebraic concepts such as variables and generalizations and they advocated that teaching algebra in the early grades contributes to the development of students' mathematical understanding and algebraic thinking. Although elementary students can understand simple algebraic concepts, the curriculum developers and policy makers should pay attention to the following facts when designing and implementing a new curriculum. First, teaching activities and materials should be appropriate for level of readiness of elementary students such that they should neither lead to root memorization nor misconceptions (Bastable & Schifter, 2008). The activities should help students make a smooth transition from arithmetic to algebra. Second, the curriculum should be piloted in many schools for at least two years and then revised (if necessary) before launch it at national level. The decision about the effectiveness of the curriculum should be given by investigating how it works for a diverse group of students (representative group of the all students in the country) rather than for a specific group of students. Third, elementary teachers should be offered professional development programs about how to implement the new curriculum. The new curriculum would be meaningless and ineffective when the teachers do not know how to implement it.

References

Akkan, Y., Çakıroğlu, Ü., & Güven, B. (2009). İlköğretim 6. ve 7. sınıf öğrencilerinin denklem oluşturma ve problem kurma yeterlilikleri. *Mehmet Akif Ersoy Üniversitesi Egitim Fakültesi Dergisi, 17,* 41-55.

Bastable, V., & Schifter, D. (2008). Classroom stories: Examples of elementary students engaged in early algebra. In J. J. Kaput, D. W. Carraher, & M. L. Blanton (Eds.), *Algebra in the early grades* (pp.165-184). New York: Lawrence Erlbaum Associates.

Bell, A. (1995). Purpose in school algebra. *Journal of Mathematical Behavior, 14*, 41-73.

Blanton, M. L., & Kaput, J. J. (2005). Characterizing a classroom practice that promotes algebraic reasoning. *Journal for Research in Mathematics Education, 36(5),* 412-446.

Cai, J. (2004a). Developing algebraic thinking in the early grades: A case study of the Chinese elementary school curriculum. *The Mathematics Educator [Singapore], 8,* 107-130.

Cai, J. (2004b). Introduction. *The Mathematics Educator [Singapore], 8,* 1-5.

Cai, J. & Knuth, E. J. (2005). The development of students' algebraic thinking in earlier grades from curricular, instructional, and learning perspectives. *Zentralblatt für Didaktik der Mathematik*, *37,* 1-4.

Cai, J. & Moyer, J. (2008). Developing algebraic thinking in earlier grades: Some insights from international comparative studies. In C. E. Greenes, & R. Rubenstein (Eds.), *Algebra and algebraic thinking in school mathematics* (pp.169-180). Reston, VA: NCTM.

Carpenter, T. P., Franke, M. L., & Levi, L. (2003). *Thinking mathematically: Integrating arithmetic and algebra in elementary school.* Portsmouth, NH: Heinemann.

Carraher, D. W., Schliemann A. D., Brizuela B. M., & Earnest, D. (2006). Arithmetic and algebra in early mathematics education. *Journal for Research in Mathematics Education, 37(2),* 87-115.

Carraher, D. W., Schliemann, A. D., & Schwartz, J. L. (2008). Early algebra is not the same as algebra early. In J. J. Kaput, D. W. Carraher, & M. L. Blanton (Eds.), *Algebra in the early grades* (pp.235-272). New York: Lawrence Erlbaum Associates.

Clements, D. H., & Sarama, J. (2007). Effects of a preschool mathematics curriculum: Summative research on the Building Blocks project. *Journal for Research in Mathematics Education, 38*, 136-163.

Curcio, F. R., & Schwartz, S. L. (1997). What does algebraic thinking look like and sound like with preprimary children. *Teaching Children Mathematics, 3*, 296-300.

Driscoll, M. (1999). *Fostering algebraic thinking: A guide for teachers, grade 6-10*. Portsmouth, NH: Heinemann.

Ferrucci, B. J., Kaur, B., Carter, J. A., & Yeap, B. (2008). Using a model approach to enhance algebraic thinking in the elementary school mathematics classroom. In C. E. Greenes, & R. Rubenstein (Eds.), *Algebra and algebraic thinking in school mathematics* (pp.195-209). Reston, VA: NCTM.

Ferrini-Mundy, J., Lappan, G., & Phillips, E. (1997). Experiences in patterning. *Teaching Children Mathematics*, *3*, 282-288.

Franke, M. L., Carpenter, T. P., & Battey, D. (2008). Content matters: Algebraic reasoning in teacher professional development. In J. J. Kaput, D. W. Carraher, & M. L. Blanton (Eds.), *Algebra in the early grades* (pp.333-359). New York: Lawrence Erlbaum Associates.

Fujii, T. & Stephens, M. (2008). Using number sentences to introduce the idea of variable. In C. E. Greenes, & R. Rubenstein (Eds.), *Algebra and algebraic thinking in school mathematics* (pp.127-140). Reston, VA: NCTM.

Gürbüz, R. & Akkan, Y. (2008). Farklı öğrenim seviyesindeki öğrencilerin aritmetikten cebire geçiş düzeylerinin karşılaştırılması: Denklem örneği. *Eğitim ve Bilim, 33,* 64-76.

Herscovics, N., & Linchevski, L. (1994). A cognitive gap between arithmetic and algebra. *Educational Studies in Mathematics, 27,* 59-78.

Johanning, D. I. (2004). Supporting development of algebraic thinking in middle school: A closer look at students' informal strategies. *Journal of Mathematical Behavior, 23,* 371-388.

Kaput, J. J. (1999). Teaching and learning a new algebra. In E. Fennema, & T. Romberg (Eds.), *Mathematics classrooms that promote understanding* (pp. 133-155). Mahwah, NJ: Erlbaum.

Kaput, J. J. (2008). What is algebra? What is algebraic reasoning? In J. J. Kaput, D. W. Carraher, & M. L. Blanton (Eds.), *Algebra in the early grades* (pp.5-17). New York: Lawrence Erlbaum Associates.

Kieran, C. (1989). The early learning of algebra: A structural perspective. In S. Wagner & C. Kieran (Eds.), *Research issues in the learning and teaching of algebra* (pp. 33-56). Reston, VA: NCTM.

Kieran, C. (1992). The learning and teaching of school algebra. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 390-419). New York: Macmillan.

Kieran, C. (2004). Algebraic thinking in the early grades: What is it? *The Mathematics Educator [Singapore], 8,* 139-151.

Kieran, C. (2007). Learning and teaching algebra at the middle school through college levels: Building meaning for symbols and their manipulation. In F. K. Lester, Jr. (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 707-762). Charlotte, NC: Information Age Publishing.

Knuth, E. J., Stephens, A. C., McNeil, N. M. & Alibali, M. W. (2006). Does understanding equal sign matter? Evidence from solving equations. *Journal for Research in Mathematics Education, 37(4),* 297-312.

Lew, H. C. (2004). Developing algebraic thinking in early grades: Case study of Korean elementary school mathematics. *The Mathematics Educator [Singapore], 8,* 88-106.

Schmittau, J., & Morris, A. (2004). The development of algebra in the elementary mathematics curriculum of V. V. Davydov. *The Mathematics Educator [Singapore], 8,* 60-87.

Sfard, A., & Linchevski, L. (1994). The gains and the pitfalls of reification: The case of algebra. *Educational Studies in Mathematics, 26,* 191-228.

Slavit, D. (1999). The role of operation sense in transitions from arithmetic to algebraic thought. *Educational Studies in Mathematics, 37,* 251-274.

Threlfall, J. (1999). Repeating patterns in the primary years. In A. Orton (Ed.). *Pattern in the teaching and learning of mathematics* (pp. 18–30). Cassell, London.

Tierney, C., & Monk, S. (2008). Children's reasoning about change over time. In J. J. Kaput, D. W. Carraher, & M. L. Blanton (Eds.), *Algebra in the early grades* (pp.185-200). New York: Lawrence Erlbaum Associates.

van den Heuvel-Panhuizen, M. & Wijers, M. (2005). Mathematics standards and curricula in the Netherlands. *Zentralblatt für Didaktik der Mathematik, 37,* 287-307.

Warren, E. & Cooper, T. J. (2008). Patterns that support early algebraic thinking in the elementary school. In C. E. Greenes, & R. Rubenstein (Eds.), *Algebra and algebraic thinking in school mathematics* (pp.113-126). Reston, VA: NCTM.

Watanebe, T. (2008). Algebra in elementary school: A Japanese perspective. In C. E. Greenes, & R. Rubenstein (Eds.), *Algebra and algebraic thinking in school mathematics* (pp.183-193). Reston, VA: NCTM.

Willoughby, S. S. (1997). Functions from kindergarten through six grade. *Teaching Children Mathematics, 3*, 314-318.

Yackel, E. (1997). A foundation for algebraic reasoning in the early grades. *Teaching Children Mathematics, 3,* 276-280.

Yenilmez, K., & Teke, M. (2008). Yenilenen matematik programının öğrencilerin cebirsel düşünme düzeylerine etkisi. *İnönü Üniversitesi Eğitim Fakültesi Dergisi, 9,* 229-246.

Review

Merve Baykal

merve.baykal@yeditepe.edu.tr

Yeditepe Üniversitesi Eğitim Fakültesi Eğitim Yönetimi ve Denetimi

Prof. Dr. Yaşar Baykul, İlköğretimde Matematik Öğretimi 6-8. Sınıflar Kitabının İncelenmesi. Pegem Akademi, 2009.

Bu çalışmada, Prof. Dr. Yaşar Baykul'un "*İlköğretimde Matematik Öğretimi*" adlı kitabının 2009 yılında Pegem Akademi tarafından yayınlanan baskısının bir değerlendirmesi yapılmıştır. Kitap ilköğretim matematik alanındaki programların öğrenme ve alt öğrenme alanları ile kazanımlarını ele alan bu kitap, öğrencilerin bilgi ve işleme dayalı problem çözme, kazandıkları becerileri gerçek hayatta kullanma gibi bilişsel gelişimlerinden ve öğrenme kuramlarından kesitler sunar.

İlköğretim 6 ve 8.sınıf öğrencilerine hitap eden kitapta, matematik öğrenimini ele alan 28 bölüm vardır. Birinci bölümde, eğitimin tanımıyla birlikte bazı öğrenme kuram, model ve stillerine değinilmiştir. İkinci bölümde, öğrencinin gerekli beceri ve tutumlarını geliştirmek adına; matematik öğretiminde akıl yürütme, problem çözme, matematiğin dışındaki kavramlarla ilişkilendirme gibi stratejilerle matematik ile ilgili temel kavramlar gösterilmiştir. Üçüncü bölümde, ilköğretim matematik 6 ve 8.sınıfların derslerinin kazanımları ve programları ayrıntılı bir şekilde verilmiştir. Dördüncü bölümde, matematik derslerinde karşılaşılan problemlerin çözümünden, problem çözme sırasında kullanılan stratejilerden, belirsizlikleri ortadan kaldırmak için uygulanan gerekli analizlerin yapılma sürecinden, bu süreçte sahip olunan davranışlardan, davranışların gelişmesi amacıyla yapılan öğrenme ve öğretme etkinliklerinden bahsedilmiştir. Beşinci bölümde, matematik derslerinde öğrencilerin öğrenimini arttıracak materyallerden ve bu materyallerin kullanımı açıklanmıştır. Beşinciden yirmi yedinci bölüme kadar olan bölümlerde, ilköğretim matematik 6 ve 8.sınıflar matematik programında yer alan alt öğrenme alanlarına, kazanımlarına ve matematik kavramlarına ilişkin stratejilere yer verilmiştir. Yirmi sekizinci bölümünde, eğitimin bir sistem olduğunu gösteren hedef, eğitim alanları ve içerikten dördüncüsü olan ölçme ve değerlendirmeden bahsedilmiştir.

Bu kitap, öğrencilerin ilköğretim matematik ile ilgili kavramları ve işlemleri anlamalarına yönelik hazırlanmıştır. İlköğretim matematik öğretiminin öğrencilere sahip olduğu bilgiyi uygulamayı, matematik yapmayı, problem çözmeyi ve değerlendirme yapabilmeyi hedeflemiştir. İlköğretim matematik müfredat programını da öğretmeyi hedefleyen kitapta, kavramların kendi aralarındaki ilişkileri ve işlem becerilerinin kazandırılması üzerinde yoğunlaşmıştır. Öğrencilerin işlemsel bilgi ve becerilerini kazandırmasının yanı sıra, soyut düşünebilmelerini de amaçlamıştır.

Kaynak

Baykul, Y. (2009). *İlköğretimde Matematik Öğretimi 6-8. Sınıflar*. Pegem Akademi, Ankara.