CHAPTER 15

WHEN A STUDENT PERPETUALLY STRUGGLES

Kristine K. Montis, Minnesota State University—Moorhead

Abstract. *Dyscalculia* is a psychological and medical term that refers to extreme difficulty in learning mathematics and, in particular, to deficits in the production of accurate, efficient arithmetic calculations. A relationship between difficulties in language processing and difficulties in mathematics learning was examined in this yearlong, qualitative case study of a 12-year-old student who displayed many characteristics of dyscalculia. The student's learning experiences during her school mathematics and tutoring sessions demonstrated the vital role language processes play in developing the concept flexibility necessary for success in mathematics. The study has implications for pedagogy in classrooms that include mainstreamed students with learning disabilities.

Occasionally a teacher of mathematics encounters a student who, although willing and hardworking, seems to perpetually struggle and often fail in mathematics class. This failure is especially frustrating, disappointing, and baffling when other students have been successful with the class lessons, activities, and discussions. Such a struggling student, even working one-on-one and using supportive, concrete representations for the mathematics to be learned, often still "just doesn't get it." So what makes mathematics extremely difficult for such a student, and what else can we as teachers do to support and nurture mathematical learning in such students?

This question has no easy or universal answers, but researchers are beginning to suspect that, for some of these students, receptive language and phonological-processing problems are the underlying cause of mathematics-learning difficulties. This chapter summarizes the findings from a case study of a student who exhibited many characteristics associated with *developmental dyscalculia*, a medical term referring to extreme mathematics-learning difficulty not related to traumatic brain injury. I describe observations that led to the conclusion that the student's learning difficulties were phonological in nature, and, finally, I discuss ideas and recommendations for teachers faced with students having similar difficulties.

During Kay's fifth-grade year, I worked with her as a tutor and researcher. Kay was the type of student about whom I, as a teacher, had always worried and thought that I should be able to do more to help. She attended school regularly, was cooperative, and diligently attempted all her schoolwork. But in mathematics and reading, she continually struggled and often failed, even with the one-on-one support I was providing. Kay's classroom teacher agreed that Kay tried hard and wanted to learn but said that Kay's responses were sometimes "just out of nowhere and made no sense." This observation finally led to a breakthrough in my work with Kay and to my understanding how phonological-processing deficits directly affected mathematics learning in Kay's case.

Phonological processing refers to the brain's processing of speech sounds. Children suffering from deficits in phonological processing are hypothesized either to compensate by pulling meaning from context or to struggle through life, living in a language fog (Blakeslee, 1995; Lyon 1995). Phonological-processing deficits do not show up in

This chapter is adapted from Montis, K. K. (2000). Language development and concept flexibility in dyscalculia: A case study. *Journal for Research in Mathematics Education, 31*, 541–556.

standard school hearing tests because the student is able to hear the sound but is unable to accurately process or interpret the sound. A related term, *phonemic difficulties*, is found in research on reading difficulties. *Phonemic difficulties* are difficulties in recognizing or differentiating among speech sounds as they are used in language and are suggested to be the basis of difficulties in learning to read (Siegel, Share, & Geva, 1995; Snow, Burns, & Griffin, 1998). From an information-processing point of view, this type of difficulty also results from a deficit in phonological processing.

An example of how the "fuzzy" phonological perception affected Kay is the "red colt" incident reported by her teacher. In this instance, Kay's teacher had read the class a story in which George Washington borrowed a horse when the redcoats were coming. In her answers about the story, Kay pulled meaning from context and answered questions about the story by referring to a "red colt" that was not actually in the story. I believe that in trying to make sense of what she had heard, Kay guessed "red colt" instead of "redcoat" in the presence of a cue that a horse was involved.

Although the red-colt incident did not occur in a mathematics class, I believe that it illuminates, by analogy, the several incidents in mathematics tutoring sessions in which the difficulty might be attributed to a phonological-processing deficit. I had already noticed that Kay often confused such similar-sounding terms as *five, fifteen, fifty,* and *fifths*. However, for several months I failed to understand the extent of the difficulties this fuzzy perception was causing Kay. The following episodes describe how I concluded that the phonological deficit was tied directly to Kay's difficulty in developing facility with multiple representations (object, picture, spoken word, written symbol) of fractions, as well as in developing the concept of fraction equivalence.

As part of her learning to name fractions, Kay and I made models of fractions by using colored index cards. We made halves, thirds, fourths, and eighths, each in a different color. We practiced making fractions, naming them verbally and in writing. Then we struggled to develop Kay's concept of equivalent fractions.

Only through extensive questioning, reflection, and analysis did I realize that Kay could relate fractions to the written symbols and could correctly fill in the blanks indicated in Figure 15.1 but that she had not yet grasped the verbalization of the denominator as ending with *th*. For the first picture, therefore, Kay answered "three" or sometimes "three over four" but not "three fourths," and for the second picture, she answered "four" or sometimes "four over eight" but not "four eighths." Her fuzzy perception of the terms *eight* and *eighths* had led her to construct the fraction as "four pieces shaded over eight pieces total." She had missed the phonological cue provided by the *ths* in the standard fraction-naming scheme.

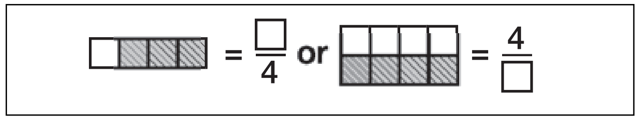

Figure 15.1. Fraction representations not associated with verbalization of denominator as ending in *th*.

The phonological cue of *ths* is essential both in understanding the fractional nature of the amount being named and in recognizing the existence of a fractional relationship between the numerator and the denominator. To Kay, this relationship was just the positional relation *over* between two whole numbers. She was not perceiving the *th* cue or the denoted fractional relationship even though she appeared to be saying and writing the correct answers. Because she had missed the phonological cue provided by the *ths* in the standard fraction-naming scheme, Kay had constructed the numerator and the denominator as separate entities with no connecting relationship. Therefore, because she did not perceive the auditory cue, she had never tuned in to the idea of a fraction as representing a relationship and was unable to proceed to the conceptualization of equivalent fractions as two representations of the *same relationship*. Once the *th* language denoting the relationship of numerator to denominator was pointed out to Kay, she quickly learned to recognize and name equivalent fractions. Almost immediately, she was able to correctly apply the procedure she had been taught in the classroom for finding equivalent fractions, whereas she had previously been applying it in a haphazard and often incorrect fashion.

When improper fractions were introduced in her classroom, we again used the index-card models. Kay could model five halves as five of the one-half pieces of index card and then, after working on the concept, could also show five halves as two wholes and an extra half. But when I encouraged her to relate this thinking to her homework on mixed numbers and improper fractions, she did not spontaneously make the connection between the written symbols and our activities. Her conceptual constructions were inflexible, attached to a specific physical model or representation. She was unable to connect the idea of an index-card model called *five halves* with a written symbol (5/2) that was called *five halves*. For most people, the verbalization *five halves* provides a transitive bridge between the model and the written symbol. Many students must have this relationship pointed out at first; once it has been so noted, most students readily develop the concept flexibility necessary to use any of the concept representations experienced up to that point.

But for a student with a processing disorder like Kay's, the difficulty in making these connections is magnified by her fuzzy perception of speech sounds. She not only missed such phonological cues of distinction as the *ths* in fractions but also ignored phonological cues of generalization, such as naming two different representations with the same word name. In Kay's world of fuzzy perception, she had learned not to trust that vocalizations that sounded the same did, in fact, represent the same things. Therefore, Kay had not developed an understanding of the language of the transitive property that *if a equals b, and b equals c, then a equals c*. In this way, Kay's phonological-processing difficulty complicated for her the process of establishing meaningful connections among the physical models and the verbal and written symbols because she could not trust her perception of similarity in spoken words. Instead, when Kay constructed meaning for each new representation, for instance, for the written symbol 5/2, she also needed to specifically connect this new representation to every other representation that she had previously experienced. Kay was not able to spontaneously make compound or transitive connections among the representations on the basis of a common vocalization of each quantity as "five halves."

CONCLUSION

The evidence collected in this case study showed that Kay was strong in visual organization and used context cues extensively to make sense of her world, including her mathematics experiences. She used a quiet demeanor to prevent others from noticing her frequent confusion and projected an often-misleading appearance of comprehending verbal instruction. Receptive language was a substantial area of weakness and was the basis of her learning difficulties. However, this weakness was not readily apparent because of her ability to respond appropriately, at least superficially, by using context clues.

This case demonstrates how one student's learning difficulties in mathematics may be related to phonological-processing deficits similar to those now being suspected in many reading disabilities (Adams & Bruck, 1995; Blakeslee, 1994; Lyon, 1995; Risey & Briner, 1990). The inability to clearly hear or process the phonemic components of language has obvious implications for developing language and reading skills. The connection to mathematics-learning difficulties becomes apparent when a phonological-processing deficit is introduced to transitive thinking processes used to develop mathematical concepts and representations. For instance, if a model is described in words as *three fourths* and the written symbol is read as *three fourths*, the student with a phonological-processing deficit has no way of knowing whether she should regard these terms as the same. What for most students is a natural development of connections among ideas, terms, and representations based on a transitive use of language is problematic and frustrating for a student like Kay. The situation is also frustrating and baffling to the teacher who is not aware of this type of learning difficulty. Compounding the problem is the likelihood that the deficit may remain unidentified, as it did with Kay, even if standard diagnostic testing is done. This deficit-detection difficulty may be a major reason for the rarity in diagnosis of mathematics disabilities and the intransigence of the belief that some people just cannot do mathematics.

The first step in remedying this situation is for teachers to become aware of the possibility of phonological-processing deficits as a source of students' learning difficulties in mathematics. Characteristics indicative of a phonological-processing deficit include (a) unusual difficulty in learning mathematics or in reading; (b) especially quiet, watchful behavior; (c) reticence to speak in class; (d) odd or incongruent responses to information received verbally; (e) sound-alike word substitutions; (f) apparent confusion or uncertainty when asked simple, informational questions; (g) physical symptoms, such as finger agnosia (inability, with eyes closed, to tell which finger has been lightly touched), imbalanced body posture, left-right confusion; and (h) family history of epilepsy or Attention Deficit (with Hyperactivity) Disorder (ADHD). If a student has several of these characteristics, a hypothesis of phonological deficit should be considered.

Second, teachers should use caution when considering existing diagnoses of student's learning difficulties. As in the case of Kay, legal labels and diagnoses are often inadequate and misleading (Lyon, 1995). The dilemma of the classroom teacher lies in interpreting and applying such diagnoses or the absence thereof. According to the legal definition of *learning disability*, Kay, at the beginning of the study, was not considered a learning-disabled student but instead was categorized as a slow learner, because her measured IQ was below the legal cutoff for learning disabilities. Technically, she was overachieving for her IQ. According to that categorization, she could not be expected to improve her performance and needed only more time, not special materials or approaches, to achieve what other students achieved more quickly and easily.

Both assumptions interfere with expectations of and efforts to assist such a student. Kay was, in fact, able to improve her achievement in both reading and mathematics. Although more time was necessary for Kay's continued growth, another essential factor was the realization that the use of transitive language and thinking was problematic for Kay. This situation required that the instructor take the initiative to understand how Kay perceived and understood the world. The challenge for the instructor is to understand and cope with a student for whom transitive language connections are not sensible and automatic. Clearly, the teacher must bridge this gap, especially because such students, out of embarrassment, commonly attempt to hide their confusion instead of attempting to seek clarification.

Another implication for classroom instruction has to do with accommodations commonly needed to support students with cognitive-processing deficits. Because cognitive-processing deficits require affected students to work more slowly and expend greater effort, those students need extended time to do assignments and close supervision of independent-work periods. The role of the supervisor in this setting is to help the student stay on task, monitor the student's frustration and fatigue levels, and adjust the assignment length or process accordingly. In a classroom with a teacher's aide, the aide may be trained to serve in this role.

The final pedagogical implication of this study is that learning mathematics cannot reasonably be divorced from learning language and making sense of the world as a whole. Over the years, many theorists have noted these connections, but educators have yet to develop adequately sensitive methods for recognizing and dealing with deficits in language development in relation to learning mathematics. Because of fuzzy perception and processing interference, a student with such disabilities has difficulty adequately organizing experience into shared knowledge. Such students have an additional problem learning to see and interpret the world the way other people do so that they can, in turn, develop language with which they may accurately and fluently operate with the ideas and abstractions of mathematics. The challenge this problem presents for mathematics educators is immense. Through this case study, mathematics educators can realize that these types of difficulties exist; understand how they may be manifest in mathematics classrooms; and learn ways that student achievement, understanding, and confidence may be facilitated.

REFERENCES

Adams, M. J., & Bruck, M. (1995). Resolving the "great debate." *American Educator*, *19*(2), 7, 10–20.

Blakeslee, S. (1994, August 16). New clue to cause of dyslexia seen in mishearing of fast sounds. *New York Times*, pp. C1, C10.

Blakeslee, S. (1995, November 14). "Glasses for the ears" easing children's language woes. *New York Times*, p. C1.

Lyon, G. R. (1995). Research initiatives in learning disabilities: Contributions from scientists supported by the National Institute of Child Health and Human Development. *Journal of Child Neurology*, *10* (Suppl. 1), s120–s126.

Risey, J., & Briner, W. (1990). Dyscalculia in patients with vertigo. *Journal of Vestibular Research*, *1*, 31–37.

Siegel, L. S., Share, D., & Geva, E. (1995). Evidence for superior orthographic skills in dyslexics. *Psychological Science*, *6*, 250–254.

Snow, C. E., Burns, M. S., & Griffin, P. (Eds.). (1998). *Preventing reading difficulties in young children*. Washington, DC: National Academy Press.