



A Toolbox for Teaching Price Comparison to Students With Disabilities

Pei-Lin Weng and Emily C. Bouck

Ms. Miles is a high school special education teacher in a self-contained classroom for students with moderate and severe disabilities. So that her students can rehearse their mathematics skills within an authentic setting, she takes them to a local chain grocery store for an hour every Monday to practice purchasing. Ms. Miles finds price comparison to be the most challenging purchasing skill for many of her students. This is mostly due to the complexity of comparing prices that are composed of multidigit numbers and decimal points (e.g., \$1.78 vs. \$1.95). Her students tend to choose products based on appearance and not on price. Ms. Miles believes that comparing prices is an important and beneficial skill to teach because it is related to budgeting, purchasing, and independence. Ms. Miles realizes that price comparison is a challenging skill to teach not only because of the many complicated steps involved in executing the task but also because it requires some difficult prerequisite skills (e.g., understanding the values of numerals, number comparison). Ms. Miles's students are given few opportunities to practice this complex skill outside their weekly shopping trips. Ms. Miles is wondering if there is an explicit method to teach the multidigit number comparison required in price comparison, as well as a strategy to overcome limited, real-setting practice opportunities.

Price comparison is a functional mathematics skill involving purchasing, use of money, and budgeting, with the goal of selecting the best deal based on a person's financial resources (Browder, Spooner, & Trela, 2011). The operational definition of *price comparison* is to compare the magnitudes of the price numbers and then select the lower-priced item or an item that represents the best price + benefit combination (Sandknop, Schuster, Wolery, & Cross, 1992). Like Ms. Miles, many special education teachers find price comparison a challenging task to teach (Weng & Bouck, 2014). Price comparison is more than just comparing the magnitudes (i.e., values) of price numbers. It involves many steps, such as (a) locating grocery items; (b) recognizing numbers on price tags associated with the grocery items;

(c) associating magnitudes with price numbers; (d) comparing values of numbers (i.e., number comparison); (e) understanding the relationship between magnitudes of numbers and semantic meanings such as *more*, *less*, *bigger*, *smaller*, *cheaper price*, and *lower price*; and (f) selecting the desired grocery item (e.g., the lower-price item; Sandknop et al., 1992; Weng & Bouck, 2014).

The operational definition of *price comparison* is to compare the magnitudes of the price numbers and then select the lower-priced item or an item that represents the best price + benefit combination.

Although any of these areas can present a challenge to students with moderate and severe disabilities, comparing the values of multidigit numbers can be the most challenging. Number comparison—the judgment of the magnitude of Arabic numerals (e.g., 25 vs. 33)—is challenging when comparing prices because prices almost always involve multidigit numbers (e.g., \$1.89 and \$3.15; Sandknop et al., 1992; Weng & Bouck, 2014). To execute number comparison independently, students need to demonstrate understanding of several mathematical concepts, including (a) the form of numbers (i.e., Arabic numerals: 2, 22, 134), (b) the values of numbers, (c) mental number lines (i.e., mental representations of numerals organized in sequence from small to large: 0, 1, 2, 3, . . . 20, 21, 22; Gevers, Reynvoet, & Fias, 2003), (d) one-to-one correspondence (e.g., a student counts “one, two, three” for three cups on the desk), and (e) semantic meanings (e.g., *bigger*, *smaller*; Faulkner & Cain, 2009).

Tool #1: Number Comparison Methods

Generally, people use two mathematical models to deal with multidigit number comparisons: (a) the holistic model (i.e., dealing with the number as a whole) and (b) the decomposition model (i.e., breaking it

down by the place values—hundreds, tens, and so on; Moeller, Huber, Nuerk, & Willmes, 2011). Under the holistic approach, there are two ways to compare multidigit numbers containing decimal points. The first way is by directly comparing decimal numbers as a whole by envisioning their position on a number line (e.g., 1.89 and 2.15). To do this, students need to develop

mental number lines that contain a series of numbers with two decimal places (e.g., 1.89, 1.90, 1.91, . . . 2.13, 2.14, 2.15). The second way is by converting the decimal numbers to fractions whose denominator is the same power of 10 (e.g., $\frac{189}{100}$ and $\frac{215}{100}$) and then comparing the numerators (i.e., 189 and 215). In both these methods, the holistic model involves processing and comparing multidigit numbers as a whole, which can be done only by students who have already developed an extended mental number line (e.g., 0, 1, 2, . . . 188, 189, 190, . . . 214, 215; Nuerk & Willmes, 2005). However, it may be difficult for students who have yet to develop an extended mental number line to use the holistic approach alone to compare large numbers (e.g., 78 vs. 85) or numbers with decimals (e.g., 14.74 vs. 12.33).

The decomposition model compares numbers by comparing the digits in the same place value position in each number. For example, in comparing \$2.45 and \$2.49, the digit in the ones place in the first price is compared with the digit in the ones place in the second price (2 vs. 2), the digit in the tenths place to the digit in the tenths place (4 vs. 4), and the digit in the hundredths place to the digit in the hundredths place (5 vs. 9). The comparison sequence begins with the

left-most (or greatest) place value and stops at the place value where the two digits are different.

There is no conclusion regarding which model is more effective for typically developing students. However, many students with moderate and severe disabilities struggle to conceptualize numbers less than 20 (Sandknop et al., 1992). Hence, with larger numbers, it may be more reasonable to teach these students how to use the decomposition model to compare multidigit numbers. This approach allows use of a number line containing only small whole numbers (0–9), which is more portable than an extended number line (e.g., 0–100). However, the decomposition model alone cannot solve all the problems. For example, when students encounter price pairs that do not have digits in the same place value position (e.g., \$9.79 vs. \$11.29), they cannot directly use the decomposition model to compare each place value digit. In cases like this, teachers can teach students to add a leading zero to make the decimals contain the same numbers of digits (e.g., \$09.79 vs. \$11.29). Then students can compare these decimals using the

decomposition-only model (Method 1; see Figure 1).

If adding a leading zero is a difficult concept for some students, they can use a hybrid model—first the holistic model and then the decomposition model (Method 2). This hybrid model uses the holistic model for the whole numbers first (i.e., numbers before the decimal point), and if the whole numbers are the same, then uses the decomposition model for the digits after the decimal point (see Figure 2). For example, if the whole numbers are small (< 20), then the incorporation of the holistic model with the decomposition model is effective when comparing prices with different place values (e.g., \$9.79 vs. \$11.29). Students can compare the whole numbers part first (i.e., ones and tens) using the holistic model (e.g., 9 vs. 11). If the whole numbers are the same (e.g., \$12.29 vs. \$12.79) after using the holistic model to judge, then students proceed with the use of the decomposition model to compare the digits after the decimal point (e.g., 2 vs. 7). Please note that this hybrid model is recommended only for prices that are less than \$20 (e.g., \$15.19 vs. \$18.78; \$18.19 vs. \$18.78) and not for

larger prices (e.g., \$99.29 vs. \$98.75; \$99.19 vs. \$99.98).

Ms. Miles considered her students and the environments in which they were typically shopping. Given her students assessed skills and their typical shopping environment, Ms. Miles decided to teach students to use the decomposition-only model (Method 1). She felt that her students did not have a solid extended mental number line and that decimals were a difficult concept to understand, so a holistic-only method was limiting. She also selected this model because, in the grocery store, most prices that her students encountered involved comparing numbers in the ones, tenths, and hundredths places (e.g., \$2.34 vs. \$3.45 or \$1.98 vs. \$1.78). In her experience, Ms. Miles felt that very rarely in the grocery store setting did her students encounter comparing prices such as \$9.79 versus \$11.29. However, Ms. Miles knows that to prepare her students to be truly independent and apply their price comparison skills across all settings, it will be important to teach them to add the leading zero for unequal place value numbers for true independence with comparing prices (refer to Figure 1).

Figure 1. How to deal with multidigit price pairs using the decomposition-only model (Method 1)

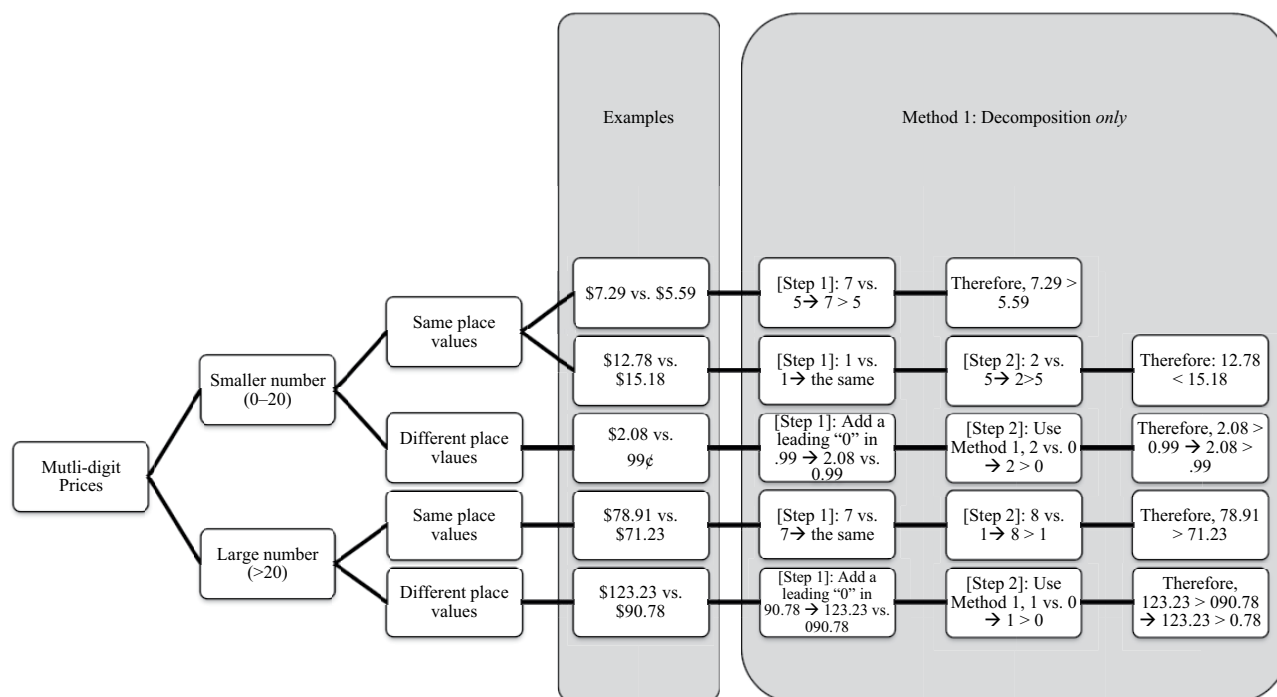
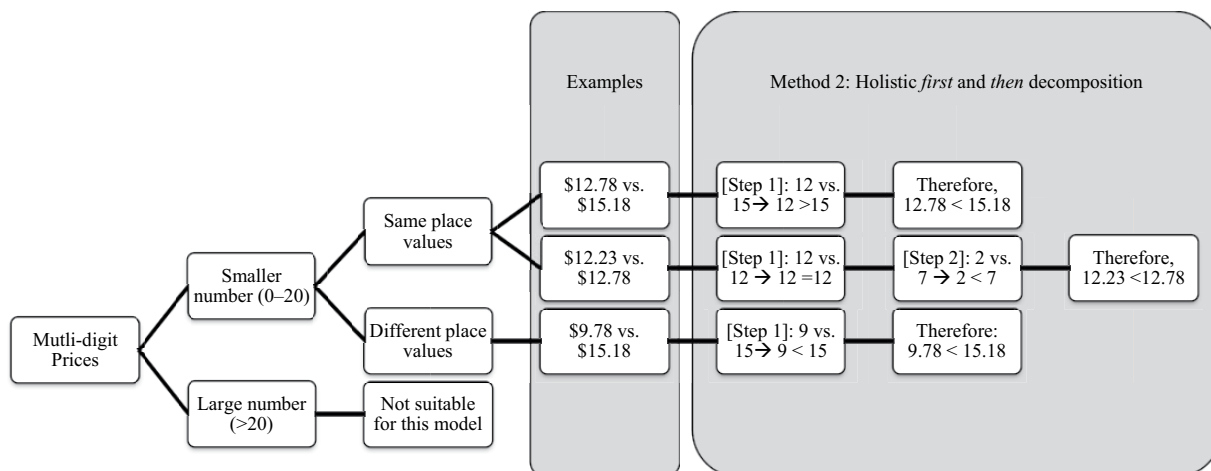


Figure 2. How to deal with multidigit price pairs using the holistic model first and then the decomposition method (Method 2)



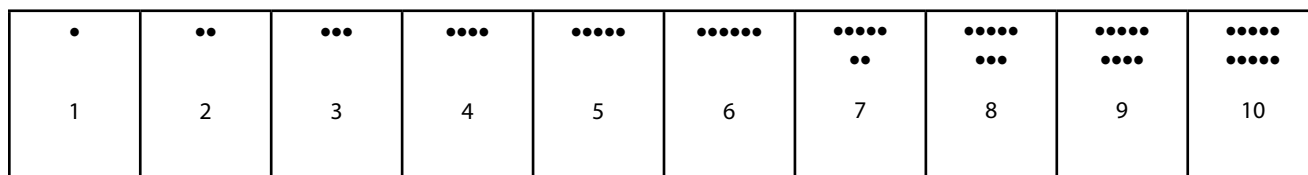
Tool #2: Number Lines

No matter which method is used between Methods 1 and 2 (see Figures 1 and 2, respectively), a number line containing only smaller numerals (e.g., 0–10 or 0–20) should be sufficient to support students who have not yet developed mental number lines or who cannot

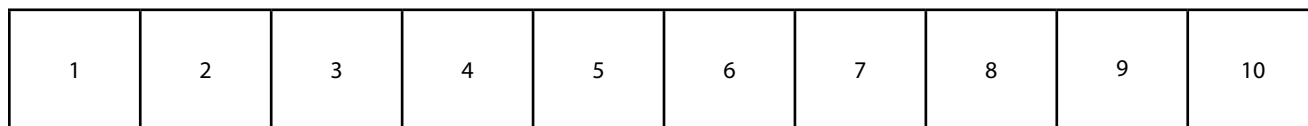
determine which digit is greater or less. Number lines can help students perform the number comparison task by providing visual cues and assisting in their development of a mental number line (Anghileri, 2006; Mosley, 2001). Different types of number lines exist, although the most standard number line is probably the horizontal number line with numbered markings.

Generally, number lines can be presented in many formats to match students' current level of number skills—with or without symbols to support the Arabic numbers and with vertical presentation versus the more standard horizontal number line (Anghileri, 2006; see Figure 3 for different number line options). As students come to develop a mental

Figure 3. Types of number lines with different levels of visual cues



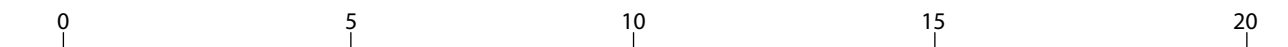
(a) A number track with Arabic numerals and nonsymbolic numerical representations.



(b) A number track with Arabic numerals only.



(c) A number line with Arabic numerals only.



(d) An unnumbered line with landmark numbers only.

(e) An empty number line

Table 1. Decomposition Model Price Comparison Task Analysis

Comparing just digits in the ones place (e.g., \$1.89 vs. \$2.12)	Comparing just digits in the tenths place (e.g., \$1.89 vs. \$1.64)	Comparing just digits in the hundredths place (e.g., \$1.89 vs. \$1.82)
1. Looks at the different prices for each item 2. Says digit in ones place in first price 3. Points to/circles that numeral on the number line 4. Says digit in ones place in second price 5. Points to/circles that numeral on the number line 6. Identifies which of the numerals is closer to zero on the number line 7. Matches numeral closer to zero with price/item	1. Looks at the different prices for each item 2. Says digit in ones place in first price 3. Points to/circles that numeral on the number line 4. Says digit in ones place in second price 5. Points to/circles that numeral on the number line 6. Identifies which of the numerals is closer to zero on the number line or, if they are all the same, says that the numerals are the same 7. If numerals are the same, says digit in the tenths place in first price 8. Points to/circles that numeral on the number line 9. Says digit in the tenths place in second price 10. Points to/circles that numeral on the number line 11. Identifies which of the numerals is closer to zero on the number line 12. Matches the numeral closer to zero with price/item	1. Looks at the different prices for each item 2. Says digit in ones place in first price 3. Points to/circles that numeral on the number line 4. Says digit in ones place in second price 5. Points to/circles that numeral on the number line 6. Identifies which of the numerals is closer to zero on the number line or, if they are all the same, says that the numerals are the same 7. If numerals are the same, says digit in tenths place in first price 8. Points to/circles that numeral on the number line 9. Says digit in tenths place in second price 10. Points to/circles that numeral on the number line 11. Identifies which of the two numbers is closer to zero on the number line or, if they are all the same, says that the numerals are the same 12. If the numerals are the same, says the digit in the hundredths place in the first price 13. Points to/circles that numeral on number line 14. Says the digit in the hundredths place in the second price 15. Points to/circles that numeral on number line 16. Identifies which of the numerals is closer to zero on the number line 17. Matches the numeral closer to zero with price/item

Note. See Bouck, Satsangi, & Bartlett (2016); Sandknop, Schuster, Wolery, & Cross (1992); Weng & Bouck (2014).

number line, the tangible numbers may be faded to an unnumbered or empty line (Anghileri, 2006; Mosley, 2001).

Teachers like Ms. Miles typically present number lines via paper; paper number lines can be easily made and are affordable (Sandknop et al., 1992;

Weng & Bouck, 2014). Paper-based number lines can be made to support any of the aforementioned number line types (Weng & Bouck, 2016; see Figure 3). Paper-based number lines can also be laminated to increase their durability and reuse. However, it can be cumbersome and stigmatizing for

students to carry a paper number line with other materials (e.g., markers, eraser, and arrays of dots), especially in natural settings such as grocery stores. Apps on mobile devices offer options for students to get the support of number lines for price comparison but in more portable and socially

Table 2. Self-Operating Prompting Systems

Self-operated picture prompting system	Self-operated auditory prompting system	Self-operated video system
1. Identify target task		
2. Develop a task analysis		
3. Determine types of pictures to use (drawings, photos, icons).	3. Determine a script of auditory prompts.	3. Determine if student will use video prompting or video modeling.
4. Identify words (if any) to accompany pictures.	4. Determine who will be the voice on the audio system (student, teacher, paraeducator, parent, peer) or whether a tone will be used to prompt the student to the next step.	4. Decide video point of view (Will it be from the student's perspective? Will it depict the student or a different known or unknown individual engaged in the task?).
5. Identify how pictures will be presented (e.g., communication notebook, paper, or an electronic system such as a tablet or smartphone).	5. Determine the system for delivering auditory prompts (e.g., audio recorder, tablet, smartphone). Also, determine if headphones are needed.	5. Identify the system for delivering videos (e.g., DVD player, computer, tablet, smartphone).
6. Develop the prompting system and ask novel individuals to complete the task using the self-operated system. Make edits based on individuals' performance.		
7. Determine if students will use self-management skills when using the self-operated system. Will students self-monitor their progress using a checklist? Will they engage in self-evaluation?		
8. Evaluate student performance as she or he uses the self-operated system.		

Note. Adapted from *Footsteps Toward the Future: Implementing a Real-World Curriculum for Students With Disabilities*, by E. C. Bouck, T. Taber-Dougherty, and M. N. Savage, 2015, p. 35. Copyright 2015 by Council for Exceptional Children.

acceptable ways (Weng & Bouck, 2016). A variety of number line apps exist for iOS devices on the iTunes store, including free and for-cost options (e.g., Number Line, by Math Learning Center [free]; Number Line, by Todd Bowden [free]; and Number Line Manipulative, by Brainiaccamp [\$0.99]). However, prior to purchasing or using any app for educational purposes, educators are encouraged to evaluate it (Bouck, Satsangi, & Flanagan, 2016; Weng & Taber-Dougherty, 2015). Whereas a discussion of app evaluations is beyond the scope of this article, educators are encouraged to review Authors (in press), which discussed rubrics for evaluating apps for students with disabilities.

Tool #3: Self-Operated Prompting Strategies

Aside from use of a number line, other tools can support the teaching of multidigit number comparison. Price comparison requires many steps to

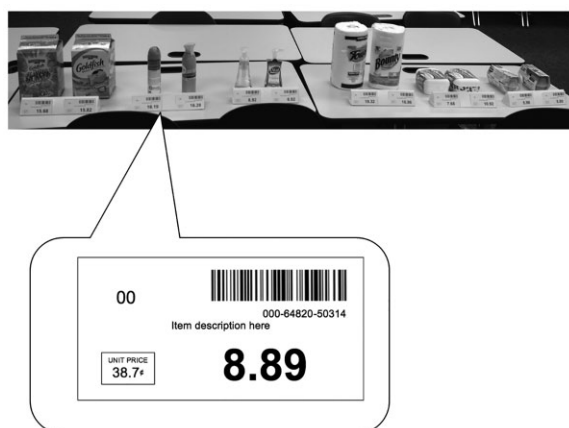
perform and can be broken down into a task analysis (see Table 1 for sample task analyses based on the decomposition method). One method for teaching students with moderate and severe disabilities to complete a task is self-operated prompting systems (Bouck, Dougherty, & Savage, 2015): picture, audio, or video prompts that the learner uses to help him or her perform each step. With self-operated prompting systems, each element of a task is supported by the prompting method. With picture prompts and price comparison, students receive a piece of paper or book with photos or symbols that depict the steps that they need to compare prices. With audio prompts, students might listen to the step-by-step directions (or prompts) on an audio recorder, MP3 player, or smartphone and complete each one to compare prices. Finally, with video self-operated systems, a student might view brief videos on a mobile device or computer depicting each step of

comparing prices, after which the step is completed, or a student might watch the video of the whole task of comparing prices and then complete it (i.e., video modeling; Bouck et al., 2015; see Table 2 for detailed information on creating self-operated prompting with each medium).

Tool #4: Learning Environment and Scheduling

Another consideration for educators like Ms. Miles is the limited opportunity for instruction in natural settings, such as weekly trips to grocery stores. Natural or community-based settings provide real-life situations and natural cues to students. Despite the advantages, the most apparent pitfall of employing community-based instruction is that they are not frequently available to students due to staffing, transportation, safety, and funding issues (Cihak, Alberto, Kessler, & Taber, 2004). If that

Figure 4. A simulated grocery setting in a classroom and mock price tags



involves students engaging in comparing prices in a simulated grocery setting in one part of her classroom three times a week for 15-minute intervals and then in a local grocery store once a week for 30 minutes. Ms. Miles knows that price comparison is more complicated than just comparing price value magnitudes—such as also incorporating preference, quality, cost per unit (cf., Bouck, Satsangi, & Bartlett, 2016; Weng & Bouck, 2014, 2016); so, once her students can compare prices successfully, she will teach those components to help increase their independence and life skills.

References

- Anghileri, J. (2006). Scaffolding practices that enhance mathematics learning. *Journal of Mathematics Teacher Education*, 9(1), 33–52. doi:10.1007/s10857-006-9005-9
- Bouck, E. C., Doughty, T. T., & Savage, M. N. (2015). *Footsteps toward the future: Implementing a real-world curriculum for students with developmental disabilities*. Arlington, VA: Council for Exceptional Children.
- Bouck, E. C., Satsangi, R., & Bartlett, W. (2016). Comparing a number line and audio prompts in supporting price comparison by students with intellectual disability. *Research in Developmental Disabilities*, 53–54, 342–357. doi:10.1016/j.ridd.2016.02.011
- Bouck, E. C., Satsangi, R., & Flanagan, S. M. (2016). Focus on Inclusive Education: Evaluating apps for students with disabilities: Supporting academic access and success. *Childhood Education*, 92, 324–328.
- Browder, D. M., Spooner, F. H., & Trela, K. (2011). Teaching math to students with moderate and severe disabilities. In D. M. Browder & F. H. Spooner (Eds.), *Teaching students with moderate and severe disabilities* (pp. 168–200). New York, NY: Guilford Press.
- Cihak, D. F., Alberto, P. A., Kessler, K. B., & Taber, T. A. (2004). An investigation of instructional scheduling arrangements for community based instruction. *Research in Developmental Disabilities*, 25, 67–88. doi:10.1016/j.ridd.2003.04.006
- Faulkner, V. N., & Cain, C. (2009). Components of number sense an instructional model for teachers. *TEACHING Exceptional Children*, 41, 24–30. doi:10.1177/0040059909004100503

is the case, teachers can use simulated settings. Simulation is a means to teach skills within an environment created by teachers in a school setting (Test & Mazzotti, 2011). A simulation for a grocery store would be to arrange actual products with price tags for students to practice comparing prices. The advantages of conducting simulation instruction in school include more opportunities to practice skills, increased environmental control, flexible scheduling, greater cost and time efficiency, fewer risk factors, and greater behavioral control (Test & Mazzotti, 2011). However, simulation instruction can be limiting in terms of generalizing or maintaining skills in real-life situations.

Teachers should use simulated settings in combination with community-based settings, whenever and as often as possible (Hendricks & Wehman, 2009). There are different ways to combine simulated and community-based instruction: (a) both on the same school day (increasing acquisition and generalization), (b) on consecutive school days (increasing generalization), and (c) multiple sessions in a simulated setting and once in a natural setting per week (Cihak et al., 2004). A careful arrangement of materials in the simulated setting can better facilitate the transfer of skills to the actual grocery store. For example, products used in the simulated setting should be products that students would purchase during their grocery store trips or use

during their daily living activities. Mock price tags should be similar to the price tags that students encounter when going to the grocery store (see Figure 4). This may help students experience fewer problems in identifying price numbers when transitioning from the simulated setting to the grocery store setting during the generalization phase.

After exploring, Ms. Miles determines that there are multiple options to better support teaching price comparison. She decides to implement antecedent prompting techniques to teach her students how to use a laminated paper-based number line, step by step through either audio or video prompts, depending on each student's skills and technology preference. To facilitate the development of the mental number lines, Ms. Miles starts with a number line with dots associated with numerals and gradually fades the dots to increase independence. At the current time, Ms. Miles is focused on teaching her students to compare prices with the decomposition-only method and purposely limits the type of products compared to those with the same number of digits (e.g., \$2.49 vs. \$2.56). However, Ms. Miles is collecting data, and as students demonstrate mastery, she will also teach the “holistic first and then decomposition” method and extend the types of products—and hence prices—compared (e.g., \$9.89 vs. \$12.49). Given the limited number of trips for practicing in a natural setting, Ms. Miles adopts a teaching schedule that

- Gevers, W., Reynvoet, B., & Fias, W. (2003). The mental representation of ordinal sequences is spatially organized. *Cognition*, 87(3), B87–B95. doi:10.1016/S0010-0277(02)00234-2
- Hendricks, D. R., & Wehman, P. (2009). Transition from school to adulthood for youth with autism spectrum disorders: Review and recommendations. *Focus on Autism and Other Developmental Disabilities*, 24, 77–88. doi:10.1177/1088357608329827
- Moeller, K., Huber, S., Nuerk, H. C., & Willmes, K. (2011). Two-digit number processing: Holistic, decomposed or hybrid? A computational modeling approach. *Psychological Research*, 75, 290–306. doi:10.1007/s00426-010-0307-2
- Mosley, F. (2001). *Using number lines with 5-8 year olds*. Oxford, England: BEAM.
- Nuerk, H.-C., & Willmes, K. (2005). On the magnitude representations of two-digit numbers. *Psychology Science*, 47(1), 52–72.
- Sandknop, P. A., Schuster, J. W., Wolery, M., & Cross, D. P. (1992). The use of an adaptive device to teach students with moderate mental retardation to select lower priced grocery items. *Education and Training in Mental Retardation*, 27, 219–229.
- Test, D. W., & Mazzotti, V. L. (2011). Transitioning from school to employment. In M. Snell & F. Brown (Eds.), *Instruction of students with severe disabilities* (7th ed., pp. 569–611). Upper Saddle River, NJ: Pearson.
- Weng, P.-L., & Bouck, E. C. (2014). Using video prompting to teach price comparison to adolescents with autism. *Research in Autism Spectrum Disorder*, 8, 1405–1415. doi:10.1016/j.rasd.2014.06.014
- Weng, P.-L., & Bouck, E. C. (2016). An evaluation of app-based and paper-based number lines for teaching number comparison. *Education and Training in Autism and Developmental Disabilities*, 51, 27–40.
- Weng, P.-L., & Taber-Doughty, T. (2015). Developing an app evaluation rubric for practitioners in special education. *Journal of Special Education Technology*, 30, 43–58. doi:10.1177/016264341503000104

Pei-Lin Weng, Assistant Professor, Department of Special Education and Professional Counseling, William Paterson University, Wayne, NJ. **Emily C. Bouck**, Associate Professor, Department of Counseling, Educational Psychology and Special Education, Michigan State University, East Lansing, MI.

Address correspondence concerning this article to Pei-Lin Weng, Department of Special Education and Professional Counseling, William Paterson University, 1600 Valley Road, Room 3099, Wayne, NJ 07470 (e-mail: wengp@wpunj.edu).

TEACHING Exceptional Children, Vol. 49, No. 5, pp. 347–354. Copyright 2016 The Author(s).

Copyright of Teaching Exceptional Children is the property of Sage Publications Inc. and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.