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Action research improves math instruction

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Third-grade detectives made a fun game of investigating common subtraction errors in teacher-made examples, as well as in peers' work and in their own.

Three Suffolk, Virginia, elementary school teachers—Paula Beckett, Deb McIntosh, and Leigh-Ann Byrd—are also new graduate-school candidates who have enrolled in the mathematics specialist program at their local university. Upon learning that an action research class was one of their first requirements, all were feeling a bit intimidated and quite overwhelmed. That soon changed as they began the "practitioner-based" research process in their math classrooms. Beckett, McIntosh, and Byrd share their journeys of self-study and the spirit of critically examining their own mathematics instructional practices. Their discussions highlight the research projects and illustrate how teachers can take charge of their development as well as investigate issues related to student achievement within the confines of their classrooms.

Subtraction error patterns

Beckett teaches third grade. Although her mathematics instruction focuses on the connectedness of addition and subtraction and she uses contextual problems with models and manipulatives, her students continued to struggle with two- and three-digit subtraction involving regrouping. After reteaching the concept numerous times, using a variety of strategies, she realized that her students were still failing to grasp the idea and were also beginning to exhibit signs of anxiety when tackling this type of problem. Typical student misunderstandings included inversion errors—what Beckett calls *upside-down subtraction*—as well as basic-fact errors, adding instead of subtracting, and errors with regrouping a ten (see **fig. 1**).

By conducting a literature review, Beckett learned about using error patterns to assist with mathematical understanding. Error patterns are misconceptions and erroneous understandings that students make when learning new mathematical concepts. Students may incorrectly apply the procedures for one mathematical concept to another. For example, when multiplying fractions, students might approach the problem by finding a common denominator because that was the process for adding fractions with unlike denominators (van de Walle, Karp, and Bay-Williams 2010).

Beckett found numerous articles on error patterns but little existing research that focused on the use of error patterns as a means of instruction. For the purpose of her action research project, she wanted to investigate whether this approach might help her frustrated students develop a rich comprehension of subtraction with regrouping.

The action research process began with some background readings about common error patterns in subtraction, and Beckett began formulating ideas about how error patterns could be used when working with third graders. Initially, she administered a twenty-problem pretest comprising two-digit subtraction. She began her instruction of subtraction by telling her students that they were going to be subtraction detectives. They were each given base-ten blocks and a magnifying glass. The day's lead investigator was given a detective's hat to wear.

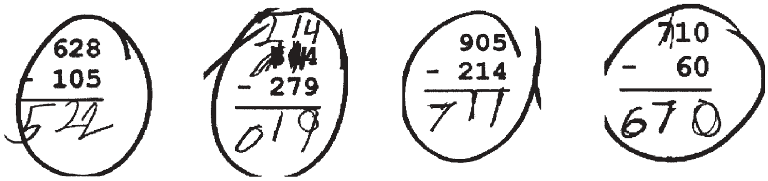
Beckett then introduced her third graders to one common error pattern they had committed on their pretest, the one in which they had used inverse, or upside-down, subtraction. Beckett presented problems for students to explore and instructed them to determine if an inversion or upside-down subtraction had been employed. Students used their magnifying glasses to become subtraction detectives, solving subtraction mysteries by discovering errors. After a short amount of time, they became quite efficient at identifying problems in which an inversion error was committed. Within two days, students began looking at problems and identifying the places in which inversion errors could take place. They marked these places with a simple dot at the top. After giving them several examples, their instructor observed that students became quite excited about searching for such problems. With great accuracy, they were able to identify the problems and pinpoint the place in which inversions could occur.

After the class became aware of inversion errors, Beckett introduced other errors, and the process began over again. She based her decision on which error pattern to teach next by examining the results of the pretest students had taken at the beginning of the study. Observing students as they searched for errors, Beckett began to notice that the children seemed to make a game of it. They also seemed eager and ready to participate each day, especially enjoying their ability to identify mistakes that the teacher made. Students were expected to not only identify the error but also explain it and show it to the group. They were given the task of solving subtraction mysteries and proposing solutions to fix them. Students worked hard to become one of the top detectives so that they could circulate around the room to double-check the work of others.

After a two-week period of sixty-minute daily mathematics instruction, Beckett administered a posttest—the same teacher-made assessment that students had completed at the beginning of the study. The purpose of the research was to determine if student knowledge of common error patterns involving two- and three-digit subtraction with regrouping would help reduce future mistakes when students perform subtraction computation problems. Could it be that if students were made aware of common errors, they would be less likely to commit them?

FIGURE 1

Among the common errors for third graders learning subtraction are basic fact errors, errors with regrouping a ten, inversion, and adding instead of subtracting.



Descriptive statistics from the pretests and posttests revealed a remarkable decrease in some of the error patterns. Over half the students had scored below 50 percent accuracy on the pretest and had shown little knowledge of subtraction with regrouping, although this skill was taught to them during the previous academic year. Only 12 percent of students had been proficient in using the subtraction algorithm. After the action research project, over 75 percent of students were proficient with the subtraction algorithm. No longer did any student show little knowledge of the subtraction process. In fact, none of them scored below 80 percent accuracy on the posttest.

As a result of this action research project, Beckett discovered that highlighting error patterns with subtraction proved to be a definite benefit for students. It not only was a different way of teaching subtraction but also put the responsibility on students to check for errors. They were able to identify the errors and became proficient at determining a way to fix them.

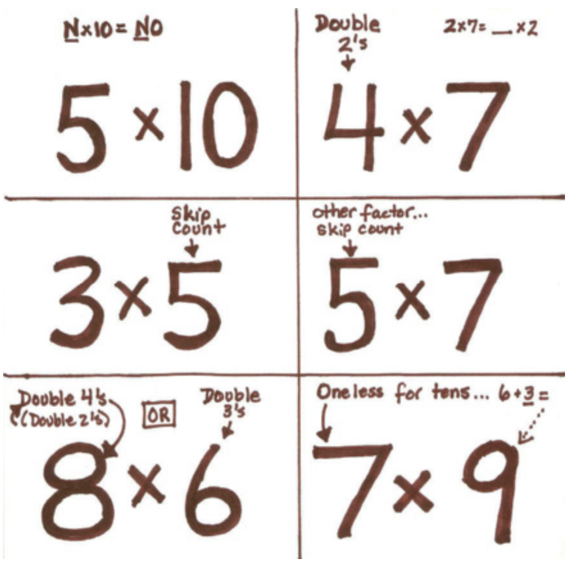
Multiplication facts and flashcards

Learning the basic multiplication facts can be taxing for many students, and McIntosh's fourth-grade class was no exception. More often than not, teachers use flashcards as a strategy to assist students with recall and speed. However, McIntosh wanted to implement a different strategy involving flashcards, and this action research project allowed her to collect data to determine its effectiveness. McIntosh had recently read about an instructional approach in which students would invent strategies and look for patterns when learning different multiplication facts. For example, students could use the double-your-twos strategy for learning the fours facts. Specifically, when students encountered a problem such as 4×2, they would think 2×2 (= 4), then double the product (8). As a class, McIntosh's students invented different strategies for learning the basic multiplication facts (see **fig. 2**). McIntosh was trying to develop within her students a conceptual understanding of the multiplication facts apart from relying solely on instant recall.

McIntosh administered a pretest involving 100 problems, which she required students in her two classes to complete in three minutes. The assessment results were evaluated according to the number of problems attempted and the number of facts solved correctly. Pretest scores for the first class showed an average of 49 problems attempted (range: 12–84 problems) and an average of 96 percent correct (range: 86–100 percent). The second class averaged 34 problems attempted (range: 14–95), with an average of 80 percent correct (range: 14–100 percent).

FIGURE 2

After McIntosh had both of her classes invent different strategies for learning basic multiplication facts, students chose the strategy that works best for them.



Classes then spent the next four weeks learning the facts by looking for patterns and connections among them. Students used index cards to make multiplication flashcards. At the top of each card, they included the individual strategy that would help them determine the product. Students were required to practice daily with the flashcards: with their peers for ten minutes and for at least ten minutes at home. Their home practice had to be confirmed by a parent; the teacher required daily written validation.

After four weeks of study, McIntosh administered the posttest. Results showed significant gains. The first class attempted an average of 23 additional problems, jumping from an average of 49 to 72 attempted (range: 36–100), while also improving the average percentage correct from 96 percent to 99.7 percent (range: 98–100 percent). The second class attempted an average of 29 additional problems, jumping from an average of 34 to 63 attempted (range: 26–100), while improving the average percentage correct from 80 percent to 95 percent (range: 81–100 percent). An added bonus was that the students really enjoyed practicing their facts in this way.

Because these results were so promising, McIntosh plans to continue using the flashcard production and practice as an instructional strategy for cementing conceptual understanding and recall of multiplication facts. She also decided to have her students use the strategy to help them understand and recall their science vocabulary. Students illustrated, defined, and noted special strategies for each vocabulary term and were held responsible for practicing with them in class and at home. McIntosh even came up with writing assignments, sorts, and other activities that use both sets of flashcards.

Physical activity and math learning

Byrd's class of second graders is quite active, and their attention span is best described as *short.* To address such needs, Byrd's mathematics instruction had to be student centered and hands on. With this in mind, Byrd based her research on the use of physical activity games in the math classroom. Would such games help students learn basic mathematical skills that they need to progress to third grade? Computer games that focus on specific skills are now the norm, but what about those good, "old-fashioned," energetic games involving physical movement?

The second-grade Standards of Learning, Virginia's expectations for student learning and achievement, require students to round one- and two-digit numbers to the nearest ten. Byrd planned her research around this objective and the use of physical mathematics activities. The primary research question for the investigation was whether mathematics instruction involving physical activity games increases student achievement in rounding to the nearest ten.

Byrd organized her research using a pretest-posttest design. She created an assessment instrument similar to the Standards of Learning test. Byrd first administered the pretest and then proceeded to teach students—through physical activity games—the skill of rounding. These games included Rounding jump (students jump on a floor-sized number line to the multiple of ten to which the given number rounds); Beanbag-toss rounding (students throw a beanbag onto a floor-sized number line, run to pick up the bean bag, and continue to the multiple of ten to which the number rounds); and Flyswatter rounding (students "swat" the multiple of ten using different forms of locomotion, such as skipping and hopping).

Byrd's students played the games for three 50-minute sessions, then Byrd administered the posttest. Analysis of the collected data indicated a mean score of 16.9 percent on the pretest and 89.2 percent on the posttest, a mean difference of 72.3 percent. Clearly, these physical games motivated students to actively participate in the learning process, addressed their different learning profiles and readiness levels, and assisted them in mastering the concept of rounding.

The literature review that Byrd had endeavored to complete before conducting her action research was a task she had looked forward to but was ultimately the most challenging of the three topics. Unlike her colleagues' topics, limited research was available that concentrated on physical activity involving body movement as a means to learn math. Byrd proceeded to review the literature focusing on games and different content areas, as well as the influence of games on student learning in general.

Thoughts on action research

Reflecting on the entire research process, these teachers realized that action research is a beneficial process for improving instruction and can be tailored to specific student needs. The process allowed all three instructors to target particular issues in their classrooms and investigate and improve their own instruction while involving their students. It also allowed Beckett, McIntosh, and Byrd to stay current with the vast research resources related to their areas of instruction. Accessing this research can spur teachers to try new ideas and can discourage them from using methods that have been found ineffectual. The authors encourage all their colleagues to take part in some sort of action research endeavor, perhaps by taking a class at a local university or college or by participating in a professional development opportunity offered through the school system. In this way, action research may become a larger part of every teacher's constant pursuit of new, improved, effective ways of reaching students.

Action research addresses specific student needs, targets classroom issues, keeps teachers current, and discourages ineffectual methods.

REFERENCE

van de Walle, John A., Karen S. Karp, and Jennifer M. Bay-Williams. *Elementary and Middle School Mathematics.* Boston: Allyn and Bacon, 2010.

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