Data Driven Instruction:
Using an Item Analysis

Elizabeth Walker (2013)
University at Buffalo

Abstract

The ability to use and understand student data is an expectation for classroom teachers. Data from large scale standardized tests provides a snapshot of student mathematical ability, but is not timely or detailed enough to inform classroom practices. Computerized assessments two or three times a year provide more detailed data about student ability, but may or may not align with current content being studied. Classroom assessments, aligned to learning goals, provide data that can be analyzed item by item to inform classroom instruction and provide a record of student successes and needs over time. Such data analysis is called an item analysis. A sample item analysis of a third grade math assessment demonstrates the use of real time data to inform teaching decisions and create specific feedback for students and parents.

Data Driven Instruction: Using an Item Analysis

With increasing calls for data-driven instruction, first in the No Child Left Behind Act of 2001 with a focus on annual student progress [No Child Left Behind (NCLB), 2002], and recently with the call for data to inform Response to Intervention (RTI) progress plans [Schleppenbach, 2010], teachers are left trying to figuring out how to use student data to inform everyday classroom practices. Schools often respond to annual achievement data by utilizing cut points to identify students performing below grade level and in need of extra support. Some schools utilize computer testing such as Measures of Academic Progress (MAPS) several times a year to fine-tune data at individual and classroom levels. Neither annual standardized assessments nor more frequent computerized measures provide information about student learning and ability in relationship to current classroom content and therefore limit teacher responsiveness [Pella, 2012]. Almost all units or chapters of study, however, culminate with some form of classroom assessment, providing potentially rich data to inform classroom practices and increase teacher effectiveness. An item analysis is a systematic study of this student data used to identify student achievement and areas in need of support.

Quality assessment is complex and begins long before the first class is taught. Assessment is comprised of:

- goals for student learning and ability,
- activities that move students toward those goals,
- methods to measure student progress,
- a procedure to inform both the student and the teacher about that measure,
- a response to the assessment information.

Learning goals, typically included in published curricula, are intended to be the focus of instruction and learning activities. When a unit of study is concluded, an assessment based on learning goals allows the teacher to measure student progress through successful or unsuccessful completion of testing items. Teachers typically respond to errors on assessment items by non-acceptance of incorrect answers or by allowing partial credit. Feedback for both the teacher and student is summarized in a letter or percentage grade which provides little information about what facets of understanding were achieved or what was really measured. Even if notes are written to the student on the assessment, these notes are lost to the teacher once assessments are returned to the student. Assessment records solely in the form of a percentage of items answered correctly limit the ability of teachers to utilize data for future instruction. In addition, if a teacher does not keep a record of types of student misconceptions or errors, there is little opportunity to look for patterns in student responses and to respond to them.

To collect data from assessments a teacher can perform an item analysis. This study of student responses may provide feedback to student and teacher, or can be a tool that informs only the teacher. An item analysis begins with the association of goals with each item on the assessment. While grades are based on successful completion of a task, an item analysis is a record of progress and of types of errors for each student relative to the learning goals.

Sample Item Analysis

I was the math specialist in a rural school district during the fall of the second year of implementing a new math curriculum. The transition was going smoothly until a 3rd grade teachers came to visit me, distressed that all of her students had received low grades on a recent chapter test. A quick look through the assessments revealed a lot of red ink and very low scores. At first glance, it appeared that her students had done extremely poorly on this chapter's material. The teacher was convinced that she would have to reteach the entire chapter and was concerned about the impact on her ability to finish the math curriculum before state assessments in May. She was ready to abort the new curriculum and return to what she was comfortable with.

What had gone wrong? Having students do less than expected on a written assessment is part of the teaching and learning process, but the results on these assessments were poor overall. The teacher had completed each lesson as written in the teacher's manual and the assessment was aligned with the chapter's goals. Her grading was based on an answer key that she had constructed from the assessment. One point was allowed for every answer on the assessment and grades had been computed as the percentage of correct answers. I suggested that we complete an item analysis of the assessment to determine where problem areas lay, and ways to incorporate mini-lessons into the next chapter to address misconceptions. The goal was not to change the grades that had been assigned, but to provide information about what students did not understand, and how these areas could be addressed in future lessons.

The curriculum was very good at identifying learning goals for each chapter and provided multiple questions on chapter assessments aligned with each goal. Because questions were specifically aligned with one goal, it was easy to evaluate student progress and tease out mathematical errors or misconceptions. Multiple questions for each goal allowed holistic determination of students' abilities.

Our first task was to set up a record sheet, or use the one provided by the curriculum, to keep track of adequate progress toward each goal or note the kinds of errors made by students. Our record sheet listed the goals for the chapter and the assessment questions aligned with that goal across the top, and the student names down the side. Space was left at the bottom to create a coding key. When we had finished analyzing all assessments, we would use the coding on the completed record sheet to look for patterns of success or error by student, by class, and by goal.

A student response on an assessment may be incorrect for multiple reasons and the codes that we used for the item analysis needed to provide succinct, but clear, information about types of errors and misconceptions. We decided to use letters as a quick way to code student progress. A student response was first evaluated holistically as making adequate progress toward the goal, or not making adequate progress. The letter A was utilized to represent adequate progress, and N denoted no adequate progress. Students who received an A or N often made errors unrelated to the goal, but which resulted in an incorrect answer. These errors were also coded. For example, C represented an error in computation and D indicated that the student had not followed all the directions. Multiple codes could be entered for an item, such as A/C indicating that a student understood the concept, but had made a computation error. Additional codes were added for new types of errors as they were encountered. We were careful to not assign the same letter for two dissimilar errors by immediately adding and defining new codes in the coding key. It was also important to define codes as they were used to facilitate translation of the data at a later date without relying on memory. In the absence of a key, the letter C might represent Computation, Correct, or have some other meaning. Because multiple questions addressed the same goal, student work was examined holistically for progress toward each goal. Coding the tests together provided mentor-teacher discourse about what each goal, and successful progress toward that goal, meant. The actual data from the class is shown in Table 1.

Student Name	1, 2 Use basic facts to compute extended facts	3, 4 Identify In/Out T table patterns	5 Write equivalent names for whole numbers	6, 7 Solve number stories and write number models	8, 9 Identify place values for multi-digit whole numbers	Number of N’ s by student	10, 11 In out problems with subtraction	12, 13 Solve problems using estimation
Student 1	A/C	A	A/D	A	A	0	A	N
Student 2	A	A/C	A/D	N	A	1	A/C	N
Student 3	A	A	N	A	A	1	N	N
Student 4	N/C	A	N	A	N	3	N	N
Student 5	Absent							
Student 6	A	A	A	A/M	A	0	A	N
Student 7	A	A	A/D	A/M	A	0	A	A
Student 8	A/C	A/C	N	A/C	A	1	A	N
Student 9	A	A	A	A/C	A	0	A	N
Student 10	A/C	A/C	N	A/C	N	2	N	N
Student 11	A	A	A/D	A/C	A	0	A	N
Student 12	A	A	A/D	A	A	0	A	N
Student 13	A	A	A/D	A	A	0	A	N
Student 14	A	A	A/D	A	A	0	A	A
Student 15	A	A	A	A/C	A	0	N	N
Student 16	A	A	A	A	A	0	N	N
Student 17	A/C	A/C	A	A/H	A	0	N	N
Student 18	A/C	A/C	A/D	N	A	1	N	N
Student 19	A	A/C	A	A/C	A	0	A/C	N
Student 20	N	A	A/D	N	N	3	N	N
$A's$	17	19	15	16	16		11	2
$N's$	2	0	4	3	3	12	8	17
$C's$	6	6		6			2	
$D's$			9	2				
$M's$				2				
$H's$				1				
A - Adequate progress, N - Not adequate progress, C – Computation error,								
D - Following directions error, M - Number model missing, H - handwriting caused error								

Table 1: Item analysis for a 3rd grade math test

Three student examples and how they were coded

The goal for the first set of questions on the assessment was: Students will extend basic facts to larger numbers. The questions for this goal were similar to:

1. $4 + \_\_\_\_ = 12$
$40 + \_\_\_\_ = 120$
$400 + \_\_\_\_ = 1200$

2. $15 = 6 + \_\_\_\_$
$150 = 60 + \_\_\_\_$
$1500 = 600 + \_\_\_\_$

Student 1 responses:

1. $4 + \_7\_ = 12$
$40 + \_70\_ = 120$
$400 + \_700\_ = 1200$

2. $15 = 6 + \_9\_$
$150 = 60 + \_90\_$
$1500 = 600 + \_900\_$

Remembering to look at the student's responses holistically, we asked ourselves if this student understood the concept of extending basic facts to larger numbers. This student did show progress toward meeting the goal by the attention to place value for the basic fact in both questions. Her error was a computational one, which was consistently repeated in all parts of question 1. This item was coded as A/C on the item analysis indicating adequate progress toward the goal despite a computation error. In contrast, the original scoring of these two items was $3/6$ correct, or 50% understanding, which tells little about what this student knows and can do.

Student 2 responses:

1. $4 + \_8\_ = 12$
$40 + \_80\_ = 120$
$400 + \_800\_ = 1200$

2. $15 = 6 + \_9\_$
$150 = 60 + \_90\_$
$1500 = 600 + \_900\_$

This student's responses indicated adequate progress toward the goal. Student progress was coded as A for acceptable progress. The original scoring of these two items was $6/6$ or 100% understanding. In this case, the score for these items concurs with the information on the item analysis. On the item analysis, however, adequate progress for this student was associated with a specific goal. This information provided targeted assessment information which the teacher could refer to in conversations with parents or the student themselves after the paper assessment had been sent home.

Student 4 responses:

1. $4 + \_8\_ = 12$
$40 + \_8\_ = 120$
$400 + \_8\_ = 1200$

2. $15 = 6 + \_20\_$
$150 = 60 + \_8\_$
$1500 = 600 + \_1000\_$

This student struggled with these items on many levels. Holistically, he did not show adequate progress toward the goal of extending basic facts, although there was a small beginning of understanding shown in the first question because the number '8' was repeated. There were computational errors in both questions, but also some possible confusion about the sum appearing to the left of the addends. Although we could have coded for all three areas: progress toward the goal, computation, and sum on the left side confusion, we chose to code this student as N/C: N for inadequate progress toward the goal, and C for computation errors. The grade for this student on these two questions was $1/6$ correct or 17% understanding. This score approximately concurs with the student's movement toward the goal of extending basic facts, but not only would this percentage be buried in the overall grade for the assessment, the percentage itself tells little about what this student knows and can do.

The overall assessment also included two learning goals related to the next chapter of instruction. These goals were included as the last two columns of the item analysis. Student success on these items did not impact percentage scores assigned as student grades but these items were coded as a pre-assessment of existing student knowledge. When all student assessments had been coded, counts for individual codes were tallied down each column, and the number N's for each student were tallied across in the third column from the right. Additional columns could have been added to examine other types of errors.

Results

The coding of 13 questions for nineteen students took about 15 minutes (one student was absent) and the results were extremely enlightening regarding individual and class performances relative to the chapter's goals. The percentage of students who had made adequate progress toward the learning goals ranged from a low of 79% on the third goal of "Write equivalent names for whole numbers" to a high of 100% on the second goal "Identify In/Out T table patterns" indicating that the cause of the failing grades assigned by the teacher was not a lack of understanding of the chapter's learning goals. In addition, computation errors were coded multiple times. For each of these cases, the teacher had marked the student's answer as wrong since it did not match her answer key. When each part of a question was marked wrong because of a repeated computation error, such as in questions 1 and 2, the student's percentile score was significantly reduced. Many students showed adequate progress toward the chapter goals, but needed more work on computation skills or in checking for computational accuracy. Students who struggled with computation overall stood out by the proliferation of their errors coded as C across all goals.

An error code of N indicated that a student was still building an understanding of the concept and needed more practice or experience. The error coding of N informed the teacher how many students and in which areas, additional exposure to content was needed. Students who received a code of N only once fell under two goals: "Write equivalent names for whole numbers" and "Solve number stories and write number models". Both of these goals were repeated in future chapters. The teacher could respond to this feedback by increasing scaffolding in these areas and by completing a second item analysis as these goals reappeared to track students' progress.

Three students, (Students 4, 10, and 20) struggled with two or more of the learning goals. A student experiencing difficulty progressing toward multiple goals might benefit from targeted help from the teacher, assistant, or math specialist. Tracking of progress on these goals in future item analyses would provide information about progress or continued need for intervention.

One goal was represented by only one test item, "Write equivalent names for whole numbers." The test question asked students to create a number sentence that resulted in a target number using at least three numbers written on "cards" shown in the problem. The responses of many students were marked incorrect by the teacher because students utilized only two cards instead of three or more cards in their number sentences. It was decided that this question was not an adequate measure of the goal. A note was made by the teacher to reinforce the directions for this particular item in subsequent years or to supplement the assessment with a question of her own. She shared this concern with other 3rd grade teachers who had seen similar results.

Most interesting was the analysis of the next chapter's goals on the pre-assessment portion. Over half of the class showed adequate progress toward understanding one of the goals in the next chapter of study. The teacher, who had originally been distressed about utilizing class time to reteach current goals, now was presented with the opportunity to spend less time, or to incorporate enrichment activities, on a goal for the next chapter.

Conclusion

The use of an item analysis provided a much clearer picture of the ability of students in this 3rd grade class than the sole use of percentage of answers correct. Coding the assessments together, as math specialist and classroom teacher, prompted conversations around the meaning of mathematical goals and what student success in relation to those goals looked like. As a result, we both gained a deeper understanding of possible ways to move students toward mathematical understanding. Learning goals became guiding themes for instruction rather than simply assessment foci at the end of the chapter.

Looking at student progress toward a goal holistically, versus judging an answer as only correct or incorrect, allowed the comparison of percentage correct against error coding totals. Low percentages of correct answers compared to high percentages of holistic understanding of goals prompted the identification of "hidden sources" for low grades such as computation errors or poor understanding of directions. Information about these errors encouraged the teacher to modify her classroom practices to incorporate more ways to check for computation accuracy and clarification of directions as she moved into the next chapter's material. Future item analyses would provide feedback on the progress of these skills.

This teacher was motivated to supplement feedback to students and parents about student progress by including a short individualized item analysis and explanation along with graded tests. She did not anticipate that specific error feedback would replace percentage correct as a grading method, but felt it opened the door to conversations about learning with parents and students, and specific ways that parents could provide support.

For an item analysis to be productive, goals for learning need to be identified before teaching begins and should be clear and explicit. Multiple test items should correlate to each goal and they should require enough student work to allow holistic evaluation of the goal. Completing the analysis with another teacher helps determine what successful goal attainment looks like and the specific categories student errors fall into. Individual letters utilized for codes should be representative of errors or progress, and a clearly defined coding key should be constructed explaining each code. Too many codes dilute the feedback. The coders' goal is to identify three to five types of errors or levels of progress that provide a picture of individual and whole group progress toward learning goals. Examining the final analysis for patterns provides the teacher with feedback to share with students and parents, and specific areas to focus on in future mathematics lessons.

Item analyses not only provide rich, real time information about the successes and needs of students, but also about future instructional opportunities. The inclusion of future goals in end of chapter assessments allows for use of pre-assessment data in planning future learning activities. As teachers become more proficient using data to inform their instruction and provide feedback to students, they not only contribute to the success and growth of their students, but to their own success and growth as educators.

References

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