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Research Brief

Curriculum-Based Measurement of Reading Progress Monitoring: The Importance of Growth Magnitude and Goal Setting in Decision Making

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Abstract. Research regarding the technical adequacy of growth estimates from curriculum-based measurement of reading progress monitoring data suggests that current decision-making frameworks are likely to yield inaccurate recommendations unless data are collected for extensive periods of time. Instances where data may not need to be collected for long periods to make defensible decisions are presented. Recommendations to collect data for upwards of 3 months may be appropriate for students whose rate of improvement (ROI) approximates the criterion to which their performance is being compared. A framework is presented to help evaluate whether a student's ROI is substantially discrepant from an expected rate of growth (i.e., goal line). A spreadsheet program was created that used user-specified parameters for goal line magnitude, dataset variability, and data collection duration, in order to identify critical ROIs to determine whether students were making adequate progress with different levels of certainty. Analyses suggest that decisions may be feasible sooner than previously thought, particularly when growth is highly discrepant from the goal line and variability in the data is limited. Implications, limitations, and directions for future research are discussed.

Curriculum-based measurement of oral reading (CBM-R; Deno, 1985) is used to monitor student response to instruction. Educators use CBM-R to make instructional decisions by administering grade-level passages of connected text across time, calculating the number of words read correctly in 1 minute (WRCM), graphing those observations on time series graphs, and evaluating the trajectory of data (Deno, 1986). Decision rules (Ardoin, Christ, Morena, Cormier, & Klingbeil, 2013) are often used in conjunction with an expected rate of growth (i.e., goal line) to evaluate whether an instructional change should be made. Although the term *aim line* is sometimes used interchangeably with goal line, for the purposes of this article, the term *goal line* will be used to refer to an expected rate of growth. Educators and

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researchers estimate a line of best fit, or trend line, through WRCM observations to summarize student growth. If the rate of improvement (ROI), or the slope of the student's trend line, is less than the slope of the goal line, an instructional change is considered. Conversely, if the ROI is greater than the goal line, a more ambitious goal is considered. Finally, if the ROIs for both the trend and goal lines are generally equivalent, the instructional program and goal are maintained. As straightforward as this process may seem, the technical adequacy of ROI estimates has called into question the accuracy of recommendations from trend line decision rules.

In the context of CBM-R progress monitoring, variability in observations across time is not solely attributable to instructional effects. The average deviation, or residual, from the line of best fit is quantified as the standard error of the estimate (*SEE*). Growth estimates with low *SEE* have observations tightly grouped around the trend line, and growth estimates with high levels of *SEE* have observations widely spread around the trend line. Previous research suggests that observations deviate an average of 10 WRCM from trend lines (Ardoin & Christ, 2009). Instrumentation along with the degree of standardization of administration and scoring influence the magnitude of *SEE*. Hastily constructed instruments, as well as inconsistent data collection procedures, introduce unwanted variability in scores across time. To understand the implications of *SEE*, consider a scenario where a student reads 60 WRCM. If the *SEE* associated with that growth estimate was 10 WRCM, a 68% confidence interval would suggest the student's true score may be as high as 70 or as low as 50. High levels of *SEE* undermine the ability to infer a student's true oral reading rate at any given week.

The precision of growth estimates is quantified as the standard error of the slope (*SEb*) and is calculated from the *SEE*. Whereas *SEE* captures the precision of static scores in a time series, *SEb* can be used to create confidence intervals around a student's ROI. For instance, a student may be improving at a rate of 1.50 WRCM per week, with an *SEb* of 1.10, and be expected to improve at a rate of 2.00 WRCM per week. Using a 68% confidence interval, that student's true ROI may be as high as 2.60 or as low as 0.40 WRCM per week. In this instance, it is uncertain whether that student's true ROI is greater than or less than the expected ROI. Large magnitudes of *SEb* obscure accurate interpretations of student progress.

The *SEb* is related to the length of time data are collected, the frequency with which data are collected, and the amount of variability in the data (i.e., *SEE*; Christ, 2006). Christ, Zopluoglu, Long, and Monaghen (2012) found that requisite levels of reliability for low-stakes decisions (e.g., day-to-day instructional programming; $r = .70$) could be achieved after 14 weeks if data were collected once a week with superior instruments and under tightly standardized conditions. High-stakes decisions (e.g., using progress monitoring results as part of special education eligibility determination; $r = .90$) were not supported even after 20 weeks when collecting one observation per week in highly standardized conditions. In a follow-up study, Christ, Zopluoglu, Monaghen, and Van Norman (2013) explored the reliability of progress monitoring outcomes across a variety of data collection schedules. Christ et al. evaluated schedules where CBM-R observations were collected as often as every day to as infrequently as once a month. The researchers found that the duration (number of weeks) of progress monitoring was substantially more influential than the number of observations collected per week (schedule) on the reliability of growth estimates. They concluded that instructional effects need time to substantiate and that decisions should be withheld for at least 12 weeks under most circumstances.

In prior research studies examining the technical adequacy of growth estimates, no consideration was given to the context in which decisions were being made. That is, the magnitude of observed growth and the criterion against which that estimate was being compared were fixed. This is important to note, since recommendations from decision rules are least accurate when student growth approximates the goal line (Van Norman & Christ, 2016a, 2016b). In one instance, a student may be expected to improve at a rate of 3.00 WRCM per week. If after 6 weeks the student is demonstrating negative growth, a practitioner may question the need to collect 8 more weeks of data before changing the student's instruction. Indeed, if the *SEb* associated with that growth estimate is minimal because variability in the data are minimal, it makes little sense to continue a seemingly ineffective intervention. If the student improved at a rate of 2.80 WRCM per week, or if a lesser ROI was associated with highly variable data, the practitioner may want more information before abandoning a potentially effective program. Rather than make ubiquitous recommendations for data collection procedures, it may be more appropriate and consistent with the idiographic nature of progress monitoring data to consider how much growth a student is currently demonstrating, the variability of WRCM scores, and the criterion against which they are being compared to make decisions.

Purpose

The purpose of this study was to extend recent research to inform progress monitoring practices by identifying critical ROIs to signal whether an instructional change was warranted in various scenarios. This is akin to identifying the minimal important difference (King, 2011) for an intervention in medicine or a power analysis in psychological research. Critically discrepant ROIs were identified as a function of progress monitoring duration, variability in the data, goal magnitude, and the type of decision being made using a formula we developed. With this formula, educators and test developers will be able to determine, with different levels of certainty, the necessary ROI to make a decision given a set of progress monitoring conditions.

DERIVATION

Critically discrepant ROIs that signal the need for an instructional change or an increased goal were derived across several progress monitoring scenarios. Specifically, critical values were identified as a function of variability in the data (i.e., *SEE*), duration of progress monitoring (i.e., 6, 8, 10, 12, 14, or 16 weeks), magnitude of expected growth (i.e., typical and ambitious slope of the goal line), and the type of decision being made (i.e., low- and high-stakes decisions).

Parameters

We consulted previous CBM-R progress monitoring research to identify common levels of variability, duration, and magnitude of expected growth. However, the general procedure described in the next section need not be constrained to the values used in this study.

Variability in the Data

Common *SEE* values were used to estimate *SEb* across durations in a similar fashion to those reported in Christ (2006). *SEE* values in this study were set as 4, 6, 8, or 10 WRCM. *SEE* values reported in Ardoin and Christ (2009) were used, as well as the range of *SEE* values observed in an analysis of a large extant progress monitoring dataset conducted by the first author (Van Norman & Christ, 2016b). *SEb* values were calculated using the following formula from Christ (2006), which was adapted from Cohen and Cohen (1983), assuming a schedule where one observation was collected during one session per week:

$$SEb = \frac{SEE}{SD_{Weeks} * \sqrt{Number\ of\ Observations}}.$$

A step-by-step example of using this formula in Excel is supplied in the Appendix.

Duration

Critical values were explored across six levels of duration. Recent research suggests that decisions should not be made before 6 weeks (Christ et al., 2012, 2013). The durations explored in this study were 6, 8, 10, 12, 14, and 16 weeks.

Magnitude of Expected Growth (Goal Line)

The slope of the goal line was set to one of five levels. Although goal setting is generally unique to each student, values commonly used to describe typical (i.e., 1.00 and 1.50 WRCM per week) as well as ambitious (i.e., 2.00, 2.50, and 3.00 WRCM per week) growth were used in this study.

Decision Type

We derived critically discrepant ROIs required for low-stakes decisions (i.e., day-to-day instructional changes) as well as high-stakes decisions (i.e., special education eligibility). We quantified low- versus high-stakes decisions by specifying what proportion of observed scores had to be greater than (to increase the goal) or less than (to change instruction) the expected ROI. For instance, when considering whether to make an instructional change, low-stakes decisions would necessitate that 70% of observed scores were less than the expected value, as opposed to 90% for high-stakes decisions.

Outcome

Within classical test theory, an observed score is composed of two parts: true score and error. The standard error of measurement (SEM) quantifies the average magnitude of deviations from an observed score if a student was measured an infinite number of times. Thus, when considering a test score, one can visualize the observed score as the mean of a distribution with a standard deviation equal to the SEM. School psychologists often use SEMs to construct confidence intervals around scaled scores to make decisions. For instance, if a student earned a scaled score of 70 on a cognitive ability test and the SEM associated with that test was 1.50, the 95% confidence interval of that score would be approximately 67–73. If the student had to earn a score below 85 to qualify for services, the school psychologist could be reasonably certain that the student's true score was below that threshold. Now consider the slope of an ordinary least-squares (OLS) trend line estimated through CBM-R progress monitoring data. The *SEb* is the standard deviation of differences from that observed score. In addition, an educator may have some expectation for improvement to make an instructional decision. If we wanted to be highly certain as to whether or not an instructional change should be made, we could set the requirement that 90% of scores in the hypothetical distribution of observed scores must be less than the criterion, or in this case, the goal line. Using the formula below, the critically discrepant ROI to make a decision can be derived:

$$\text{Critically discrepant ROI} = \text{Expected Growth} - (\text{Z} * \text{SEb}),$$

where z is calculated from the percentile associated with the goal line in the hypothetical distribution of observed scores. The following z scores corresponded to different decisions: low-stakes decision to increase a goal (percentile = .30; z = –0.52), low-stakes decision to change instruction (percentile = .70; z = 0.52), high-stakes decision to increase a goal (percentile = .10; z = –1.28), and high-stakes decision to change educational placement (percentile = .90; z = 1.28). Each combination of parameters was entered into the formula above using a spreadsheet program to identify critically discrepant ROIs.

RESULTS

Table 1 presents critically discrepant ROIs for low-stakes decisions.

In general, growth was more discrepant when progress monitoring durations were short and variability in the data was high. In line with the relationship between assessment duration and *SEb*, the longer data are collected, the less discrepant observed growth needs to be from the goal line to make a decision. With a goal line of 2.00 WRCM and an *SEE* of 6, growth needed to be less than 1.54 WRCM after 8 weeks of data collection to change instruction, versus 1.83 WRCM after 16 weeks. Unsurprisingly, as variability in the data increased across all durations, the necessary deviation from the goal line

Table 1. Critical Values to Change Instruction and Increase a Goal as a Function of Goal Magnitude, Dataset Variability (*SEE*), and Progress Monitoring Duration for Low-Stakes Decisions

Goal	*SEE*	Progress Monitoring Duration (Weeks)											
		6		8		10		12		14		16	
1.00	4	0.54	1.46	0.70	1.30	0.78	1.22	0.83	1.17	0.86	1.14	0.89	1.11
	6	0.31	1.69	0.54	1.46	0.67	1.33	0.75	1.25	0.80	1.20	0.83	1.17
	8	0.08	1.92	0.40	1.60	0.56	1.44	0.66	1.34	0.73	1.27	0.78	1.22
	10	–0.14	2.14	0.24	1.76	0.45	1.55	0.58	1.42	0.66	1.34	0.72	1.28
1.50	4	1.04	1.96	1.20	1.80	1.28	1.72	1.33	1.67	1.36	1.64	1.39	1.61
	6	0.81	2.19	1.04	1.96	1.17	1.83	1.25	1.75	1.30	1.70	1.33	1.67
	8	0.58	2.42	0.90	2.10	1.06	1.94	1.16	1.84	1.23	1.77	1.28	1.72
	10	0.36	2.64	0.74	2.26	0.95	2.05	1.08	1.92	1.16	1.84	1.22	1.78
2.00	4	1.54	2.46	1.70	2.30	1.78	2.22	1.83	2.17	1.86	2.14	1.89	2.11
	6	1.31	2.69	1.54	2.46	1.67	2.33	1.75	2.25	1.80	2.20	1.83	2.17
	8	1.08	2.92	1.40	2.60	1.56	2.44	1.66	2.34	1.73	2.27	1.78	2.22
	10	0.86	3.14	1.24	2.76	1.45	2.55	1.58	2.42	1.66	2.34	1.72	2.28
2.50	4	2.04	2.96	2.20	2.80	2.28	2.72	2.33	2.67	2.36	2.64	2.39	2.61
	6	1.81	3.19	2.04	2.96	2.17	2.83	2.25	2.75	2.30	2.70	2.33	2.67
	8	1.58	3.42	1.90	3.10	2.06	2.94	2.16	2.84	2.23	2.77	2.28	2.72
	10	1.36	3.64	1.74	3.26	1.95	3.05	2.08	2.92	2.16	2.84	2.22	2.78
3.00	4	2.54	3.46	2.70	3.30	2.78	3.22	2.83	3.17	2.86	3.14	2.89	3.11
	6	2.31	3.69	2.54	3.46	2.67	3.33	2.75	3.25	2.80	3.20	2.83	3.17
	8	2.08	3.92	2.40	3.60	2.56	3.44	2.66	3.34	2.73	3.27	2.78	3.22
	10	1.86	4.14	2.24	3.76	2.45	3.55	2.58	3.42	2.66	3.34	2.72	3.28

Note. SEE = standard error of the estimate.

to make a decision also increased. For instance, after 14 weeks of data collection, when using a 1.50 WRCM goal, the critically discrepant ROIs to increase a goal were 1.64, 1.70, 1.77, and 1.84 WRCM when *SEE* was equal to 4, 6, 8, and 10, respectively. As evidenced in Table 1, the influence of *SEE* depended on assessment duration. After 6 weeks of data collection using a 1.00 WRCM goal, an instructional change was supported with an observed ROI of 0.54 WRCM when *SEE* was 4 and –0.14 when *SEE* was 10 (difference = 0.60). After 16 weeks, critically discrepant ROIs for the same set of conditions were 0.89 and 0.72 WRCM (difference = .17).

As with low-stakes decisions, the impact of *SEE* was offset by longer durations for high-stakes decisions, yet growth needed to be highly discrepant from the goal line to make decisions over relatively brief periods of time (Table 2).

As an example, when collecting data for 8 weeks with an *SEE* of 10 and a goal of 2.00 WRCM, the critical value for changing instruction for a high-stakes decision was 0.15 compared to 1.24 for low-stakes decisions (Figure 1).

DISCUSSION

The outcomes of this derivation highlight the importance of the idiographic features of progress monitoring data and how those data inform decisions. Previous research has established that dataset variability and data collection duration influence the reliability of growth estimates (Christ et al., 2012, 2013). Such findings have influenced recommendations for progress monitoring practices. However, previous research did not consider the goal line student performance was being compared to and the magnitude of observed growth. Published recommendations to collect data for 3 or more months are more appropriate when observed growth approximates the goal line. The contribution of this study was identifying specific ROIs that promote defensible decisions with different levels of certainty given known progress monitoring conditions and outlining the process to do so. School-based practitioners can easily determine whether a student's observed growth is critically discrepant from a goal line using

Table 2. Critical Values to Change Instruction and Increase a Goal as a Function of Goal Magnitude, Dataset Variability (*SEE*), and Progress Monitoring Duration for High-Stakes Decisions

		Progress Monitoring Duration (Weeks)											
Goal	*SEE*	6		8		10		12		14		16	
1.00	4	–0.11	2.11	0.26	1.74	0.46	1.54	0.59	1.41	0.67	1.33	0.73	1.27
	6	–0.68	2.68	–0.11	2.11	0.19	1.81	0.38	1.62	0.51	1.49	0.59	1.41
	8	–1.24	3.24	–0.47	2.47	–0.08	2.08	0.18	1.82	0.35	1.65	0.46	1.54
	10	–1.79	3.79	–0.85	2.85	–0.33	2.33	–0.03	2.03	0.18	1.82	0.32	1.68
1.50	4	0.39	2.61	0.76	2.24	0.96	2.04	1.09	1.91	1.17	1.83	1.23	1.77
	6	–0.18	3.18	0.39	2.61	0.69	2.31	0.88	2.12	1.01	1.99	1.09	1.91
	8	–0.74	3.74	0.03	2.97	0.42	2.58	0.68	2.32	0.85	2.15	0.96	2.04
	10	–1.29	4.29	–0.35	3.35	0.17	2.83	0.47	2.53	0.68	2.32	0.82	2.18
2.00	4	0.89	3.11	1.26	2.74	1.46	2.54	1.59	2.41	1.67	2.33	1.73	2.27
	6	0.32	3.68	0.89	3.11	1.19	2.81	1.38	2.62	1.51	2.49	1.59	2.41
	8	–0.24	4.24	0.53	3.47	0.92	3.08	1.18	2.82	1.35	2.65	1.46	2.54
	10	–0.79	4.79	0.15	3.85	0.67	3.33	0.97	3.03	1.18	2.82	1.32	2.68
2.50	4	1.39	3.61	1.76	3.24	1.96	3.04	2.09	2.91	2.17	2.83	2.23	2.77
	6	0.82	4.18	1.39	3.61	1.69	3.31	1.88	3.12	2.01	2.99	2.09	2.91
	8	0.26	4.74	1.03	3.97	1.42	3.58	1.68	3.32	1.85	3.15	1.96	3.04
	10	–0.29	5.29	0.65	4.35	1.17	3.83	1.47	3.53	1.68	3.32	1.82	3.18
3.00	4	1.89	4.11	2.26	3.74	2.46	3.54	2.59	3.41	2.67	3.33	2.73	3.27
	6	1.32	4.68	1.89	4.11	2.19	3.81	2.38	3.62	2.51	3.49	2.59	3.41
	8	0.76	5.24	1.53	4.47	1.92	4.08	2.18	3.82	2.35	3.65	2.46	3.54
	10	0.21	5.79	1.15	4.85	1.67	4.33	1.97	4.03	2.18	3.82	2.32	3.68

Note. SEE = standard error of the estimate.

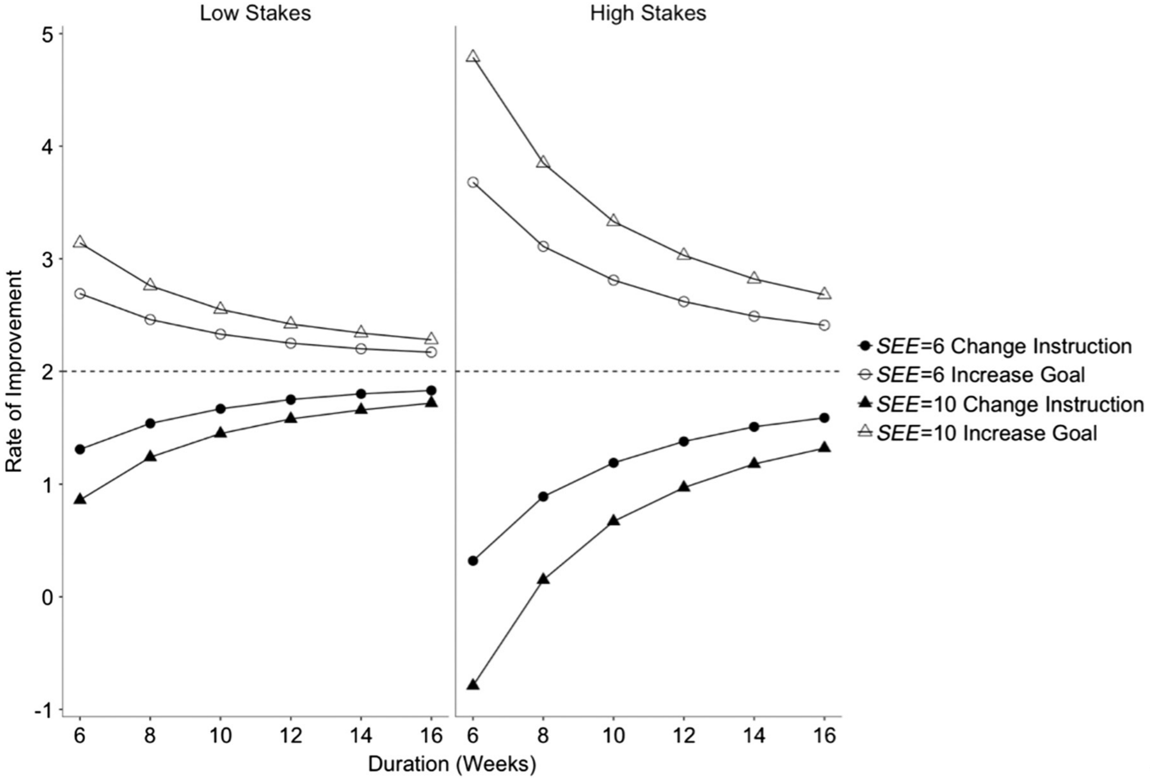
procedures presented here. The Appendix details the process that can be applied to determine whether a given ROI is sufficiently different from a goal line when making a decision using CBM-R progress monitoring data.

Test developers can also use this methodology to provide users with the probability that an observed ROI is critically discrepant from a goal line. One rearranges the aforementioned formula to derive the z score that corresponds to an expected ROI within a distribution with a mean equal to the observed growth estimate and standard deviation equal to the *SEb*. That z score is then converted into a percentile, and the resulting value is interpreted as the probability that the student's true growth is less than or greater than the expected ROI. Naturally, low-stakes decisions would require lower thresholds, whereas high-stakes decisions would require higher thresholds. As a result, it is likely that growth estimates that approximate the goal line will continue to be the most problematic for decision making. Indeed, Figure 1 shows the relationship between critically discrepant ROIs and expected rates of progress as a function of duration and *SEE*. If a student seems to be struggling to the point of showing little to no improvement and variability in the data is minimized, then it may not be warranted to continue delivering an ineffective intervention for upwards of 3 months before making a decision.

Limitations and Future Research

The outcomes of this investigation need to be interpreted in light of potential limitations. First, growth was assumed to be monotonic and linear. Analyses of large extant datasets suggest that growth may be nonlinear for a subpopulation of students across the school year. As a result, duration was limited to 16 weeks in the present article because growth tends to decelerate in the latter half of the school year. Second, the use of OLS is based upon the assumption that observations are independent across time. The application of OLS in this study, as well as virtually all studies on the use of trend line rules, violates that assumption. Future studies should

Figure 1. Minimum Rate of Improvement to Change Instruction or Increase a Goal for Low- and High-Stakes Conditions



Note. Manipulated conditions include dataset variability (standard error of the estimate [*SEE*]), duration of data collection, and expected rate of improvement (dotted line).

investigate the impact of alternate growth estimation methods on critically discrepant ROIs. Third, this study was exploratory in nature and not a simulation. Therefore, conclusive statements regarding the unique contribution of different facets of progress monitoring (i.e., duration versus goal magnitude) on critically discrepant ROIs could not be made. Future studies could make use of simulation methodology to enable inferential analyses. Finally, the formula for the *SEb* in this study, although used in virtually all studies investigating the technical adequacy of CBM growth estimates, places key assumptions on the structure of error terms. By using the *SEE* in the numerator, an assumption is made that error is homogenous across all time points. Homogeneity of error is not always observed with CBM-R time series data, depending on the statistical method used to summarize growth (Yeo, Kim, Branum-Martin, Wayman, & Espin, 2012). It is unclear whether alternate estimation methods would impact results, but given the heavy reliance on *SEb* in this study, some may find the limitation worth noting.

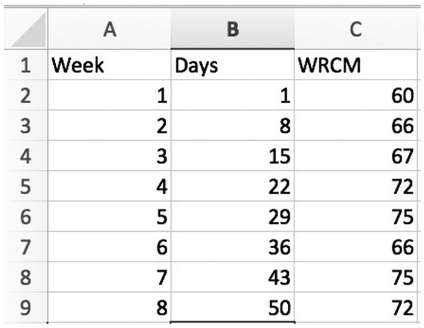
CONCLUSION

The findings of this study are timely given recent research suggesting that CBM-R decision rules are inaccurate for many progress monitoring scenarios. Indeed, based upon this study, trend line rules are likely to be inaccurate when observed growth approximates the goal line, variability in the data is high, and data are collected for less than 2 months. These results are not necessarily revelatory. Rather, they seem to confirm what many CBM users advocated as recent research on the technical adequacy of growth estimates emerged. That is, idiographic decisions with CBM-R data should be made on a case-by-case basis. Therefore, it would beneficial to know the range of *SEE*s and *SEb*s associated with different durations of data collection when considering which tools to adopt. Although some advocate for the use of skilled visual analysis to interpret progress monitoring data, the operational definition of what constitutes skilled has yet to be provided for CBM-R. Further, recent recommendations for using visual analysis (Van Norman & Christ, 2016b) emerged, at least in part, in response to the published limitations of statistically based decision rules. Alternatively, researchers may wish to develop new decision rules not dependent on trend. One such approach may be to estimate a student's current level of performance at a given week, supplement that value with confidence intervals, and compare the resulting range of plausible values against some standard. Nevertheless, if one wishes to continue using trend line rules, this study provides a framework to make decisions on a case-by-case basis.

APPENDIX A

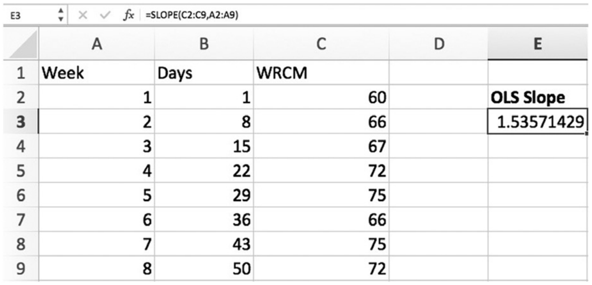
Example of identifying whether a student's observed rate of improvement is sufficiently different from a 2.00 words read correct per minute (WRCM) goal line for a low-stakes decision using Microsoft Excel

1. Enter progress monitoring weeks in Column A, days corresponding to data collection weeks in Column B, and WRCM in Column C.



	A	B	C
1	Week	Days	WRCM
2	1	1	60
3	2	8	66
4	3	15	67
5	4	22	72
6	5	29	75
7	6	36	66
8	7	43	75
9	8	50	72

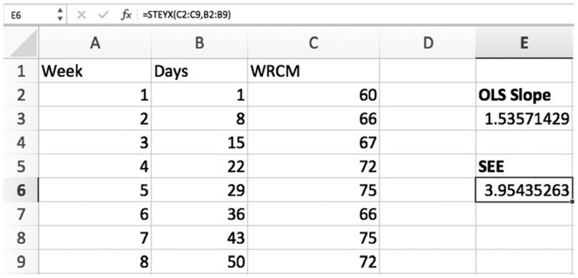
2. Calculate the ordinary least squares slope to estimate observed growth in WRCM increase per week. Use the formula = SLOPE(C2:C9, A2:A9). The first argument is the range of WRCM scores (Column C) and the second argument is the progress monitoring weeks (Column A).



E3 =SLOPE(C2:C9,A2:A9)

	A	B	C	D	E
1	Week	Days	WRCM		
2	1	1	60		OLS Slope
3	2	8	66		1.53571429
4	3	15	67		
5	4	22	72		
6	5	29	75		
7	6	36	66		
8	7	43	75		
9	8	50	72		

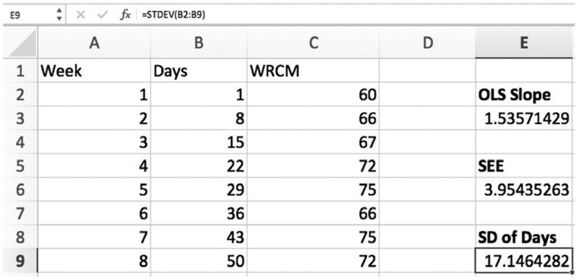
3. Calculate the Standard error of the slope.
   a. Calculate the standard error of the estimate using the formula = STEYX(C2:C9, B2:B9). The first argument is the range of WRCM scores (Column C) and the second argument is the range of progress monitoring days (Column B).



E6 =STEYX(C2:C9,B2:B9)

	A	B	C	D	E
1	Week	Days	WRCM		
2	1	1	60		OLS Slope
3	2	8	66		1.53571429
4	3	15	67		
5	4	22	72		SEE
6	5	29	75		3.95435263
7	6	36	66		
8	7	43	75		
9	8	50	72		

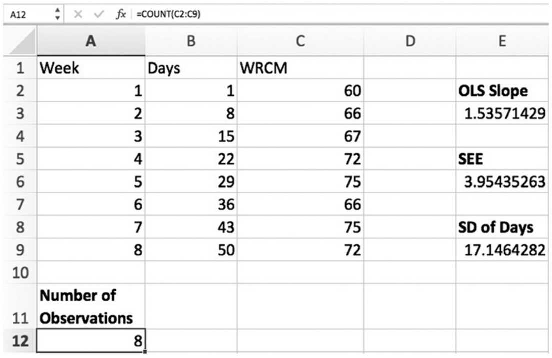
   b. Calculate the standard deviation of progress monitoring days (Column B) using the formula = STDEV(B2:B9).



E9 =STDEV(B2:B9)

	A	B	C	D	E
1	Week	Days	WRCM		
2	1	1	60		OLS Slope
3	2	8	66		1.53571429
4	3	15	67		
5	4	22	72		SEE
6	5	29	75		3.95435263
7	6	36	66		
8	7	43	75		SD of Days
9	8	50	72		17.1464282

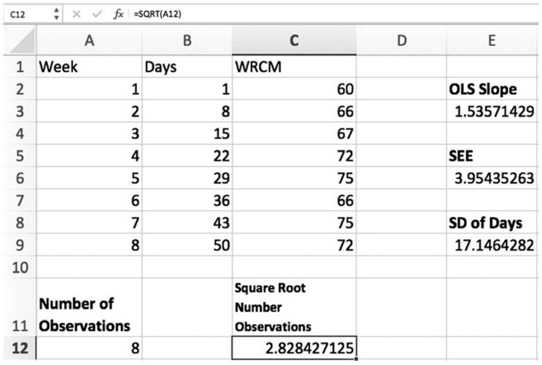
   c. Count the number of WRCM observations (Column C) using the formula = COUNT(C2:C9).



A12 =COUNT(C2:C9)

	A	B	C	D	E
1	Week	Days	WRCM		
2	1	1	60		OLS Slope
3	2	8	66		1.53571429
4	3	15	67		
5	4	22	72		SEE
6	5	29	75		3.95435263
7	6	36	66		
8	7	43	75		SD of Days
9	8	50	72		17.1464282
10					
11	Number of Observations				
12	8				

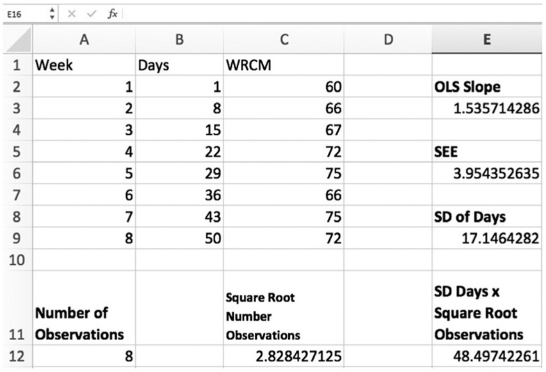
   d. Calculate the square root of the number of observations (Column A, Row 12) using the formula = SQRT(A12).



C12 =SQRT(A12)

	A	B	C	D	E
1	Week	Days	WRCM		
2	1	1	60		OLS Slope
3	2	8	66		1.53571429
4	3	15	67		
5	4	22	72		SEE
6	5	29	75		3.95435263
7	6	36	66		
8	7	43	75		SD of Days
9	8	50	72		17.1464282
10					
11	Number of Observations		Square Root Number Observations		
12	8		2.828427125		

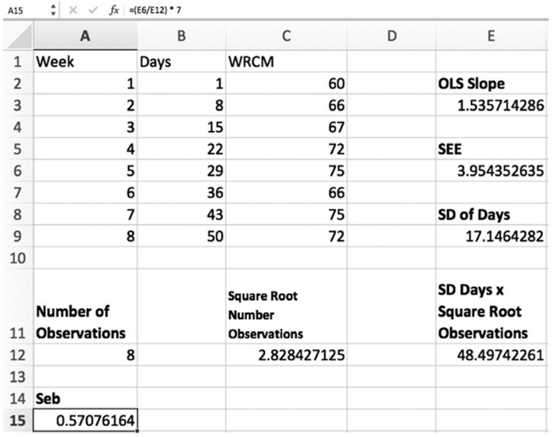
   e. Multiply the Standard Deviation of Days (column E, row 9) by the square root of the number of observations (column C, row 12) using the formula = E9 * C12.



E16

	A	B	C	D	E
1	Week	Days	WRCM		
2	1	1	60		OLS Slope
3	2	8	66		1.535714286
4	3	15	67		
5	4	22	72		SEE
6	5	29	75		3.954352635
7	6	36	66		
8	7	43	75		SD of Days
9	8	50	72		17.1464282
10					
11	Number of Observations		Square Root Number Observations		SD Days x Square Root Observations
12	8		2.828427125		48.49742261

f. Apply the formula for *SEb* outlined in Christ (2006). Divide the *SEE* (column E, row 6) by the product of the SD of Days and the square root of the number of observations (column E, row 12) using the formula = (E6/E12). Finally, multiply that value (.08) by 7 to convert the *SEb* for one day to yield an *SEb* in weekly units.



A15 =(E6/E12) * 7

	A	B	C	D	E
1	Week	Days	WRCM		
2	1	1	60		**OLS Slope**
3	2	8	66		1.535714286
4	3	15	67		
5	4	22	72		**SEE**
6	5	29	75		3.954352635
7	6	36	66		
8	7	43	75		**SD of Days**
9	8	50	72		17.1464282
10					
11	**Number of Observations**		**Square Root Number Observations**		**SD Days x Square Root Observations**
12	8		2.828427125		48.49742261
13					
14	**Seb**				
15	0.57076164				

4. Subtract the goal line (2.00), from the OLS slope (Column E, Row 3) [2.00 – 1.53 = .47].
5. Divide the difference between the goal line and the trend (Step 4) by the *SEb* (.57) [.47 / .57 = .82].
6. The result of Step 5 (.82) is the z-score of the goal line within the hypothetical distribution of observed slopes. Use the function = NORMSDIST(.82) and multiply the resulting value (.7939) by 100 to convert the z-score to percentile (79.39).
7. The goal line is roughly in the 79th percentile of the distribution of observed slopes. For a low stakes decision to change the intervention, the goal line should fall at or above the 70th percentile of the distribution of observed slopes. In this case, we can be reasonably certain that the observed slope is sufficiently less than the goal line to make an instructional change.

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