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ABSTRACT

The accuracy of predictions of future student performance on the basis of graphing data on semi-logarithmic charts and equal interval graphs was examined. All 83 low-achieving students in grades 3 to 6 read randomly-selected lists of words from the Harris-Jacobson Word List for 1 minute. The number of words read correctly and words read incorrectly were scored. Story starters were used to obtain weekly 3-minute writing samples from the 83 students. The compositions were scored for total words written, words written correctly and incorrectly, and correct letter sequences written. Predictions made for the students on the basis of the reading and written expression data collected over 7 weeks were compared to actual data collected for weeks 8, 9, and 10. Analyses of deviations between predictions and actual scores indicated that predictions were more accurate when the data had been graphed on equal interval graphs. (Author/PN)

University of Minnesota

Research Report No. 101

MEASURING ACADEMIC PROGRESS OF STUDENTS WITH LEARNING DIFFICULTIES: A COMPARISON OF THE SEMI-LOGARITHMIC CHART AND EQUAL INTERVAL GRAPH PAPER

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IRLD

Institute for Research on Learning Disabilities

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Director: James E. Ysseldyke

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Abstract

The accuracy of predictions of future student performance on the basis of graphing data on semi-logarithmic charts and equal interval graphs was examined. Predictions made for 83 students on the basis of reading and written expression data collected over seven weeks were compared to actual data collected for weeks 8, 9, and 10. Analyses of deviations between predictions and actual scores indicated that predictions were more accurate when the data had been graphed on equal interval graphs. Implications for training are discussed.

Measuring Academic Progress of Students with Learning Difficulties: A Comparison of the Semi-Logarithmic Chart and Equal Interval Graph Paper

Implementation of Public Law 94-142 requires that an Individual Educational Plan (IEP) be written for all handicapped students receiving special education services. In addition, the same legislation mandates the use of fair and nondiscriminatory assessment practices in monitoring student progress toward IEP objectives. The use of traditional achievement and intelligence tests for such purposes, however, may be a tenuous exercise. Salvia and Ysseldyke (1981) warn that many tests lack evidence of validity or reliability. Jenkins and Pany (1978) point out that achievement tests differentially sample student curricula and therefore provide educators with questionable data about actual student performance. And finally, norm-referenced tests are not adequately designed to measure pupil progress (Carver, 1974; Hively & Reynolds, 1975).

An alternative assessment strategy is the use of repeated measurement and time series analysis of the student's academic skills. This methodology has been outlined in several approaches to delivering special education services: Precision Teaching (Lindsley, 1971), Exceptional Teaching (White & Haring, 1976), and Data-Based Program Modification (Deno & Mirkin, 1977). Common to all three models is the frequent measurement of student skills on various academic tasks related to IEP goals. The collected data typically are plotted on graph paper and the results subjected to a time series analysis. In this way, student progress toward IEP goals and the effectiveness of instructional strategies may be evaluated.

While there are some similarities among these repeated measurement models, there is an important difference involving the type of graph to be used in charting student data. Proponents of the Precision Teaching and Exceptional Teaching models advocate the use of the Standard Behavior Chart (Pennypacker, Koenig, & Lindsley, 1972), a graph on which variables measured along the ordinate (vertical axis) are recorded on a logarithmic scale. Those favoring this semi-logarithmic chart claim improvement in academic performance is proportional, not arithmetical, and is measured and predicted best on the logarithmic scale (Howell, Kaplan, & O'Connell, 1979). The implication for the exceptional student who initially may acquire academic skills at a slow rate is illustrated by White and Haring (1980). These authors noted that graphing typical student performance data on an equal interval chart may be misleading since initially progress is slow. Using the equal interval chart, a successful instructional plan might be abandoned because of lack of improvement, whereas the same set of student data on the Standard Behavior Chart will appear more orderly in its display of growth.

However, many proponents of time series analysis indicate that equal interval graphs serve educational needs just as well. Most graphing procedures used in major texts emphasizing time series analysis in education employ equal interval graphs (Glass, Willson, & Gottman, 1975; Kratochwill, 1978; O'Leary & O'Leary, 1972; Sulzer-Azaroff & Mayer, 1977). The dilemma facing practitioners is choosing the more technically adequate graphing procedure.

Brandstetter and Merz (1978) addressed the issue of the efficacy of both graphing procedures. They found higher rates of student achievement when data were charted on the two types of graphs compared to not charting data. However, their research did not directly compare the semi-logarithmic chart with the equal interval graph. The question of which graph to use is not a trivial one. Test standards developed by the American Psychological Association, American Educational Research Association, and the National Council for Educational Measurement (APA, 1972) require that scaling methods used in assessment procedures be technically adequate. Users of the Standard Behavior Chart and equal interval graph must attend to these recommendations for they are integral to assessment procedures currently recommended for exceptional students.

The research presented here compares the two approaches. Since proponents of the Standard Behavior Chart maintain a significant characteristic of the semi-logarithmic chart is the ability to predict student performance better, we have focused on an analysis of the accuracy of the different predictions generated by each type of chart. Each chart produces different predictions. As may be seen in Figure 1, the projections of student performance from the same set of data on the two types of charts are very different. The research presented here examines efficacy of the linear model (equal interval graph) and the logarithmic model (semi-logarithmic graph).

Insert Figure 1 about here

Method

Design

Student performance on direct, repeated measures of reading and written expression were collected weekly over a 2 1/2 month period for 83 low-achieving elementary students. Using a computer program to simulate charting on both equal interval and semi-logarithmic graphs, each student's data were entered into the computer at the end of the seventh week. Regression equations for each set of student data for both charts were calculated. The slope of each student's performance on both the semi-logarithmic and equal interval chart then was used to predict student performance at weeks 8, 9, and 10 of the data collection period. The estimates of student performance at these times were contrasted with the actual data collected at weeks 8, 9, and 10 by determining the absolute deviation between the scores.

The size of the deviation scores for the semi-logarithmic chart (logarithmic model) was then compared to the magnitude of the deviations on the equal interval graph (equal interval model) for each student on each measure with a paired *t*-test analysis. On those comparisons where significant differences were found, the graphing approach with the smaller average deviation score was considered to be the one making better predictions of student performance.

Subjects

Selection of this low-achieving population resulted from the screening of all 785 elementary students from grades 3-6 enrolled in three elementary schools. The schools were located within communities in rural settings, yet each was within 50 miles of the metropolitan

Twin City area. According to 1970 Census figures, the three communities ranged in size from 2,281 to 6,876.

Screening procedures involved a short duration measure of written expression that significantly discriminated LD and non-LD students (Deno, Marston, & Mirkin, 1982). Each student was administered a story starter and asked to write a composition. For each student, the number of words written in the composition (Total Words Written) was computed. Students who had no history of special education services and scored at or below the 15th percentile were asked to participate in the repeated, direct measurement phase of the study. Cutoffs for the 15th percentile at each grade level are shown in Table 1. Parental permission was received for 83 students. Twenty-six of the students were third graders, 17 were fourth graders, 19 were fifth graders, and 21 were sixth graders. Thirty-two of the low-achieving population were females. The number of males and females at each grade level is presented in Table 2.

Insert Tables 1 and 2 about here

Procedures

All 83 students were administered short duration measures designed for direct, repeated measurement of reading (Deno, Mirkin, & Chiang, 1982) and written expression (Deno, Marston, & Mirkin, 1982) on a weekly basis for 10 weeks.

Reading. Lists of words that were selected randomly from the third grade level of the Harris-Jacobson Word List (Harris & Jacobson,

1972) were used for the reading tasks; these were administered each week. For each list, the student was asked to read aloud for one minute. Test instructions read verbatim to the subject were:

> Here is a word list that I want you to read. When I tell you to start, you can read across the page. Please read as fast and accurately as you can. If you get stuck on any of the words, move on to the next one. I will tell you when to stop reading. Are there any questions? Ready? Begin.

The child then was timed for 60 seconds while the teacher followed along and recorded mistakes on a sheet identical to the one from which the student read. If a student did not respond after approximately six seconds, he/she was told to move on to the next word. At the end of the timing, recording sheets were collected and later scored by trained judges. For each list, the numbers of Words Read Correctly (WRC) and Words Read Incorrectly (WRI) were scored. Estimates of inter-rater agreement ranged from .94 to .98.

In addition to reading the third grade lists, the fourth, fifth, and sixth graders were asked to read a list of words selected from their grade level from the Harris-Jacobson list. For example, each week the fifth graders read both a third grade list and a fifth grade list. For each of these lists, the number of Words Read Correctly from Grade Level (WRCG) and the number of Words Read Incorrectly from Grade Level (WRIG) were counted.

Written expression. Story starters were used to obtain weekly writing samples from the 83 students. Directions to the students were:

> I want you to write a story. I am going to read a sentence to you first, and then I want you to write a short story about what happens. You will have a minute to think about a story to write and then you will have three minutes to write it. When I say "please start writing" you may begin.

Students' responses to each story starter were scored by a trained judge. The compositions were scored for Total Words Written, Words Written Correctly, Words Written Incorrectly, and Correct Letter Sequences Written (White & Haring, 1980). Inter-rater agreement was .87.

Results

On all t test comparisons, the .05 level of probability was used as the criterion level for significance. In the first analysis, the linear (equal interval) and logarithmic models were compared on predictions of student performance at week 8 based upon the slope of the first seven weekly measurements. As may be seen in Table 3, only one of the contrasts was significant; the difference favored the linear model in measuring Words Written Incorrectly.

Insert Table 3 about here

Predicting week 9 performance from the slope of the first seven weeks was the focus of the second analysis. The results from this analysis are presented in Table 4. Four of eight comparisons (Words Read Incorrectly, Total Words Written, Words Written Incorrectly, and Correct Letter Sequences) were significant; all differences favored the linear model, which exhibited smaller deviations between predicted and actual scores. Two other contrasts, which also displayed lower deviations for equal interval graphs, approached significance (Words Read Correctly, p = .054; Words Read Incorrectly on Grade Level Material, p = .069).

Insert Table 4 about here

Week 10 estimates based upon the seven-week slope were examined in the third analysis. As can be seen in Table 5, four of the eight contrasts were significant at the .05 level; again, these favored the linear model. The comparison for Words Read Incorrectly on Grade Level Material approached significance (p = .056), with smaller deviations demonstrated on equal interval graphs.

Insert Table 5 about here

In the final analysis, the deviation scores for weeks 8, 9, and 10 were summed for each student and then averaged for each graphing approach (see Table 6). Again, predictions made by the linear model were significantly more accurate in four of eight cases, with a fifth contrast approaching significance.

Insert Table 6 about here

Discussion

The research described here focused on only one aspect of graphing, the use of time series data to predict future performance. Yet, this in itself is quite significant when the writing of IEP goals is considered. White and Haring (1980) proposed that an analysis of the slope of student data is useful in producing goals and objectives.

Thus, generating predictions from time series data is helpful in the delivery of special services to the exceptional student. The question asked here is, which graph should be used in charting student performance?

Our research indicates that predictions of student performance for weeks 8, 9, and 10, based on seven weeks of data in reading and written expression, are more accurate when data are graphed on the equal interval chart. In no cases did comparisons showing a significant difference favor the Standard Behavior Chart.

The most important implication of this research is for training. It has been our personal experience that educators resist using the Standard Behavior Chart for reasons ranging from "it's overly complex" to "it's difficult to understand." In many instances, those discouraged by the semi-logarithmic graph but interested in graphing are more willing to use equal interval graphs. If increasing the likelihood that special educators will use repeated measurement strategies in their educational planning, interventions, and assessments is a function of the type of graph they prefer (usually the equal interval chart), we believe the research presented here provides an empirical basis for making that choice.

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Table 1

Screening Criteria for Measure of Written Expression

Grade	Sample Size	Mean	Cutoff for 15th Percentile
3	190	17.7	9
4	185	22.7	12
5	225	30.5	19
6	185	36.4	24

Table 2

Distribution of Sexes by Grade Level

Grade	Male	Female
3	14	12
4	10	7
5	14	5
6	13	8

Table 3

Comparison of Linear and Logarithmic Models in Predicting Performance at Week 8

	Sample Size	Type of Graph	Mean Deviation	Standard Deviation	T-value	Probability
Reading Measures						
Words Read Correctly 3rd Grade Level	75	EQ Interval	9.55	7.6	1.67	.100
		Log	9.84	8.3		
Words Read Incorrectly 3rd Grade Level	75	EQ Interval	2.87	1.1	.83	.409
		Log	3.24	3.8		
Words Read Correctly Grade Level	55	EQ Interval	5.99	4.7	.29	.772
		Log	5.97	4.6		
Words Read Incorrectly Grade Level	54	EQ Interval	2.77	2.6	1.62	.111
		Log	3.12	3.1		
Written Expression Measures						
Total Words Written	75	EQ Interval	6.90	5.2	1.35	.183
		Log	7.17	5.7		
Words Written Correctly	75	EQ Interval	6.49	5.3	1.20	.232
		Log	7.05	6.6		
Words Written Incorrectly	75	EQ Interval	1.81	1.5	2.45	.016
		Log	2.42	2.7		
Correct Letter Sequences for Writing Task	75	EQ Interval	28.38	21.3	1.60	.115
		Log	29.89	23.8		

Table 4

Comparison of Linear and Logarithmic Models in Predicting Performance at Week 9

	Sample Size	Group	Mean Deviation	Standard Deviation	T-value	Probability
Reading Measures						
Words Read Correctly 3rd Grade Level	76	EQ Interval	9.69	9.0	1.96	.054
		Log	10.15	10.2		
Words Read Incorrectly 3rd Grade Level	76	EQ Interval	2.81	1.3	2.52	.014
		Log	5.36	8.9		
Words Read Correctly Grade Level	54	EQ Interval	7.30	7.3	1.25	.217
		Log	7.13	6.9		
Words Read Incorrectly Grade Level	54	EQ Interval	3.14	2.9	1.86	.069
		Log	3.90	4.7		
Written Expression Measures						
Total Words Written	78	EQ Interval	8.62	7.0	2.58	.012
		Log	9.45	8.2		
Words Written Correctly	78	EQ Interval	8.23	6.9	1.58	.119
		Log	9.85	12.1		
Words Written Incorrectly	78	EQ Interval	1.94	1.9	2.04	.045
		Log	3.19	5.7		
Correct Letter Sequences For Writing Task	78	EQ Interval	36.12	30.1	2.95	.004
		Log	40.51	35.2		

Table 5

Comparison of Linear and Logarithmic Models in Predicting Performance at Week 10

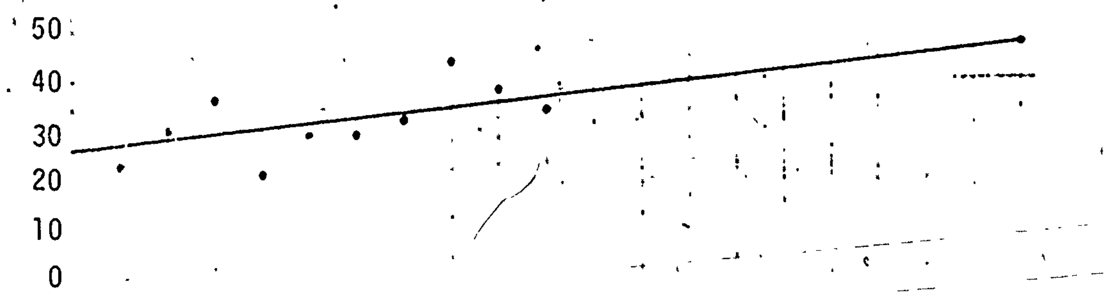
	Sample Size	Type of Graph	Mean Deviation	Standard Deviation	T-value	Probability
Reading Measures						
Words Read Correctly 3rd Grade Level	79	EQ Interval Log	13.56 14.05	9.8 10.6	1.64	.105
Words Read Incorrectly 3rd Grade Level	79	EQ Interval Log	3.43 8.50	1.3 21.3	2.12	.037
Words Read Correctly Grade Level	54	EQ Interval Log	10.11 9.82	9.5 9.2	1.67	.101
Words Read Incorrectly Grade Level	54	EQ Interval Log	4.37 5.80	5.1 7.7	1.96	.056
Written Expression Measures						
Total Words Written	79	EQ Interval Log	9.87 11.29	8.6 9.2	2.95	.004
Words Written Correctly	79	EQ Interval Log	9.31 12.53	8.3 21.4	1.44	.153
Words Written Incorrectly	79	EQ Interval Log	1.75 3.26	1.6 6.2	2.21	.030
Correct Letter Sequences for Writing Task	79	EQ Interval Log	43.03 48.27	34.6 40.9	2.19	.032

Table 6

Comparison of Linear and Logarithmic Models in Predicting Performance at Weeks 8, 9, and 10

	Sample Size	Type of Graph	Mean Deviation	Standard Deviation	T-value	Probability
<u>Reading Measures</u>						
Words Read Correctly 3rd Grade Level	72	EQ Interval Log	10.90 11.24	7.8 8.7	1.51	.136
Words Read Incorrectly 3rd Grade Level	72	EQ Interval Log	2.89 4.92	2.2 8.8	1.99	.050
Words Read Correctly Grade Level	51	EQ Interval Log	7.74 7.60	5.7 5.3	1.17	.248
Words Read Incorrectly Grade Level	50	EQ Interval Log	3.33 4.19	3.0 4.8	1.78	.081
<u>Written Expression Measures</u>						
Total Words Written	72	EQ Interval Log	8.67 9.54	5.1 6.1	2.59	.012
Words Written Correctly	72	EQ Interval Log	8.17 10.06	5.3 12.7	1.41	.162
Words Written Incorrectly	72	EQ Interval Log	1.87 2.81	1.3 3.8	2.23	.029
Correct Letter Sequences for Writing Task	72	EQ Interval Log	36.61 40.51	22.2 27.4	2.39	.020

EQUAL INTERVAL GRAPH: Linear Model (10-week prediction = 48 words)



STANDARD BEHAVIOR CHART: Logarithmic Model (10-week prediction = 60 words)

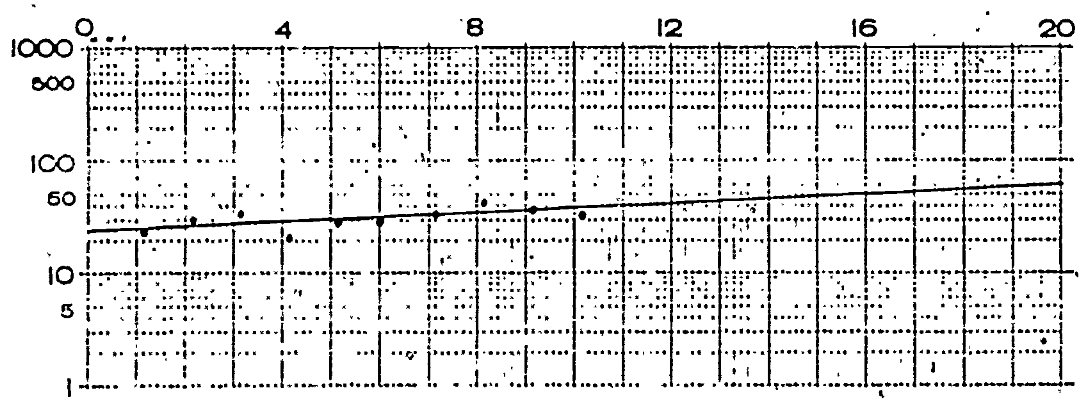


Figure 1. Projections of Student Performance Using Two Types of Charts

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