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Effects of Programmed Learning Sequences on the Mathematics Test Scores of Bermudian Middle School Students

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Abstract

This research compared the effects of a Programmed Learning Sequence (PLS) (Dunn & Dunn, 1993) versus Traditional Teaching (TT) on 100 sixth-grade Bermudian students' test scores on a Fractions Unit. Fifty-three males' and forty-seven females' learning styles were identified with the *Learning Style Inventory* (LSI) (Dunn, Dunn, & Price, 2000) to determine whether those with specific styles fared better or less well with either of the two approaches. Attitudes toward learning fractions traditionally versus with the PLS were assessed with the *Semantic Differential Scale* (SDS) (Pizzo, 1981).

The control group's mean-posttest score (M = 5.98) was statistically lower ($p < .001$) than the experimental group's mean-posttest scores (M = 7.86) (n = 100). In addition, the control group's mean-gain difference between the pre- and posttest (M = 2.28) was statistically lower ($p < .001$) than the experimental group's (M = 4.27). Furthermore, the experimental group's mean attitude-test score toward learning with the PLS (M = 4.47) was significantly higher than the control group's M = (3.0) at the $p < .001$ level for all responses. Both achievement- and attitude-test scores translated into large effect sizes.

Effects of Programmed Learning Sequences on the Mathematics Test Scores of Bermudian Middle School Students

Many Bermudian middle school children perform poorly in mathematics as evidenced by their *Terra Nova Test* scores (*Ministry of Education Annual Report*, 2002). However, their administrators and teachers have been exposed to reports from United States' practitioners describing the reversal of low performance when students' learning styles were accommodated with responsive instructional materials (Andrews, 1990; Braio, Dunn, Beasley, Quinn, & Buchanan, 1997; Dunn & DeBello, 1999; Fine, 2003; Mitchell, Dunn, Klavas, Lynch, Montgomery, & Murray, 2002; Perrin, 1990; Roberts, 1998/1999; Roberts, Dunn, Holtschnieder, Klavas, Miles, & Quinn, 2000/2001; Stone, 1992). As one result, similar reports began emerging independently from three Bermudian middle school researchers who examined the effects of Programmed Learning Sequences (PLSs) with tactual and kinesthetic components to teach language arts (Bascome, 2004), science (Roberts, 2004), and social studies—the latter with special needs students (Lister, 2004).

Internationally, students need to master new and difficult academic material on an almost daily basis. Some achieve this goal conventionally, whereas others learn very differently from their peers and begin to fail. For example, De Paula (2004) in Brazil, Hlawaty (2004) in Germany, Honigsfeld (2000, 2004a, 2000b) in Hungary; Honigsfeld & Gard (2004) in Sweden, Honigsfeld & Cooper (2004) in New Zealand, Honigsfeld & Lister (2004) in Bermuda, Pengiran-Jadid (2003, 2004) in Brunei, and Ulubabova (2004) in Russia each found that the learning styles of same-age, highly achieving 13-year-olds were statistically different from their poorly achieving classroom counterparts. Such extreme differences in style appear to be consistent among Bermuda's middle school high- versus low-achieving populations (Honigsfeld & Lister, 2004).

Tully (2004), a middle school principal, became concerned about the high level of energy among the middle school students in his school when he realized that teachers teaching about fractions were teaching traditionally through lectures, discussions, and readings, to their highly mobile students in every class. Therefore, he explored answers to the following questions.

1. Will middle school students evidence statistically higher achievement test scores when learning a unit on fractions taught with a Programmed Learning Sequence (PLS) than when the same unit is taught traditionally to a comparable class?
2. Will middle school students evidence statistically higher attitudinal test scores after learning a unit on fractions taught with a PLS than when the same unit is taught traditionally to a comparable class?

Learning Style

According to Dunn and Dunn, learning style is the way each individual begins to concentrate on, process, internalize, and retain new and difficult information (Dunn & Dunn, 1993). Their learning-style model consists of five strands, each of which includes between three and six variables. Identification of those variables that affect each student provides an overall picture of the conditions in, and resources with which, each student is likely to achieve effectively when the subject content is new and difficult.

The Dunns' *environmental* strand addresses individuals' need for Quiet versus Sound, Bright versus Low Light, Warm versus Cool Temperatures, and Formal versus Informal Seating Designs while concentrating. Their e*motional* strand examines levels of Motivation, Persistence, Responsibility (Conformity versus Nonconformity), and Structure. The *sociological* strand focuses on preferences for Learning Alone, in Pairs, in Groups (with peers), working with/without a Collegial versus an Authoritative Teacher, or needing Variety, as opposed to consistent approaches. The *physiological* strand identifies Perceptual Strengths—whether individuals remember 75% of what they read, discuss, see, hear, touch, or experience within a 40–50 minute period, their Time-of-Day energy levels, and their preferences for Intake and/or Mobility while learning. Finally, the *psychological* strand examines Global versus Analytic processing styles and Impulsive versus Reflective traits that combine into hemispheric preferences (see Figure 1).

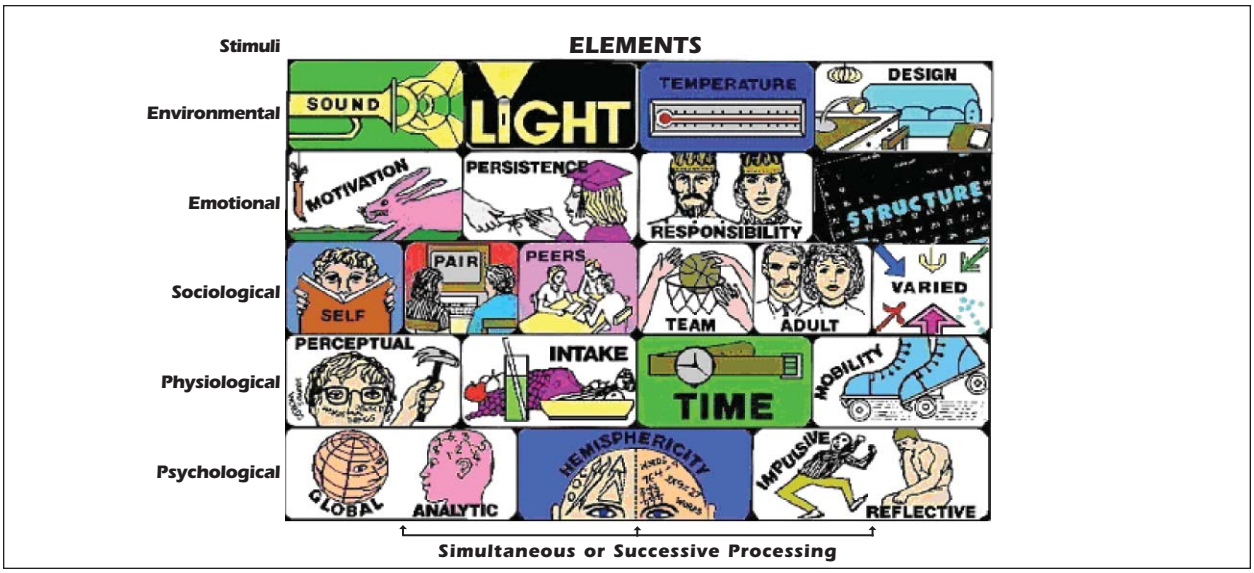

Figure 1. Learning Styles Model designed by Dr. Rita Dunn and Dr. Kenneth Dunn

Middle School Students

Middle school students generally are active and mobile; many prefer background music or conversation (Sound) and interaction *while* concentrating. Some of them consistently challenge adult, parental, or school authority, but conform to the latest fads and customs of their peers. They struggle for independence while simultaneously feeling a strong need for discipline and guidance (Dunn, 1990).

General patterns of learning-style elements are representative of middle school students (Price, 1980). For example, their need for sound increases dramatically after fourth grade and peaks by ninth grade. They are less inclined than third or fourth graders to work with adults present. Persistence on individual tasks declines steadily from the sixth through eighth grades for most adolescents, whereas peer orientation rises steadily from the fourth through the eighth grades. The higher the grade level, the less preference they indicate for a formal seating design and structure, although these traits vary substantially among individuals (Dunn & Griggs, 1995). According to Griggs (1989), adolescents are torn between the need to behave and think like their peers and the need to develop their personal individuality and uniqueness.

Bauer (1991) explored the relationships among 44 learning-disabled and emotionally handicapped, middle school students' mathematics achievement and their learning-styles. The students were randomly assigned to treatment groups and instructed through methods that both complemented and were dissonant from their perceptual preferences. No significance was achieved with response to only one perception, but students achieved statistically higher math test scores when a dual visual/tactual instructional resource was used to introduce the mathematics content. In that treatment, significantly higher achievement and attitudes were reported at the $p < .02$ and $p < .003$ levels respectively. One instructional resource that is responsive to students with tactual/visual preferences is the PLS (Dunn & Dunn, 1993).

Orazio (1999) investigated the effects of matching and mismatching global and analytic instructional resources with middle school students' processing styles. The math achievement- and attitude-toward-learning-math test scores of seventh graders increased between 68 and 86 percent with global, as opposed to analytic instruction. The Dunns' PLS requires a global beginning that introduces each lesson or unit in an anecdotal, holistic format (Dunn & Dunn, 1993).

Programmed Learning Sequences (PLSs)

After an initial, story-like, global introduction, the PLS teaches content in small, sequential steps (analytic) without requiring direct teacher intervention. Like any other method, it only appeals to certain students' styles and is not equally effective for everyone. The specific information or skills that students need to master, is translated into clearly stated objectives. The PLS teaches to those objectives with periodic visual/tactual reinforcements every seven or eight frames. Students gradually master the objectives as they proceed through the PLS. They may pace themselves and study anywhere in the classroom that is most responsive to their unique preferences for Sound, Light, Temperature, Seating, and approved Intake (whichever elements their teacher permits).

Unless they need and seek assistance, individuals work through the material by themselves or with a classmate or two. Two peers who work well together may do so because PLSs are an alternative for students who *lack independence, need structure, enjoy variety, prefer learning either alone or in a pair, enjoy reading or listening to text that is supported by illustrations, and learn from tactual resources.* An accompanying tape is available when students need or want to hear the material read to them, which also makes PLSs effective for students who do not read well. Because PLSs use a short-story beginning, they appeal to many *global* processors (Gremli, 2002/2003; Ming, 2004; Roberts, 2004).

Subjects, Materials, and Procedures

Subjects

The sample was composed of sixth-grade students from one middle school in Bermuda. The majority of students were from middle socioeconomic backgrounds. The school's population was approximately 90% Black, with 8% Mixed Race and 2% Caucasian. The total school population was 283, of whom 100 students were enrolled in the sixth grade.

All 100 sixth graders were selected to participate in this experiment. They were of similar ethnic and socioeconomic backgrounds and represented a fairly even distribution of 53 males and 47 females enrolled in heterogeneously grouped Regular Education classes that were randomly assigned to either two experimental or two control groups. The population of both the experimental and control groups was academically comparable and represented an inclusive sample of students in terms of gender, age, and prior achievement levels. Both the experimental and control groups were initially comprised of 50 students each. However, attrition of one student per group resulted in a final *n* of 98.

Materials

Materials consisted of the *Learning Style Inventory* (LSI) (Dunn, Dunn, & Price, 2000), the *Semantic Differential Scale* (SDS) (Pizzo, 1981), and school unit achievement tests approved by the Ministry of Education (2001) and based directly on the required math program taught each school year.

The Learning Style Inventory

The *Learning Style Inventory* (LSI) (Dunn, Dunn, & Price, 2000), based on factor analysis, is a comprehensive approach to the diagnosis of each individual's style. It assesses preferences in the following areas: immediate environment (Sound, Heat, Light, and Design); emotionality (Motivation, Responsibility, Persistence, and Structure); sociological needs (Self, Peer, or Adult Oriented or learning in Several Ways); and physiological needs (Perceptual Preferences, Time of Day, Intake, and Mobility).

The LSI is a 104-item, self-report questionnaire, which was developed through content and factor analyses. It measures students' perceptions of how they most prefer to learn. It uses a five-point Likert-scale and can be completed in approximately 30 to 40 minutes. The LSI has both high reliability as well as face and construct validity. Among nine different instruments that measure learning styles, the LSI was rated as having good or better validity and reliability than the others (DeBello, 1990; Tendy & Geiser, 1998/1999). Based on the LSI scores of 817 randomly selected students in grades 5 through 12, Price and Dunn (1997) reported that 95% (21 of 22) of the reliabilities were tactual to or greater than .70 for the Likert scale of the English version of the LSI. Similarly high reliability coefficients were indicated for the Hungarian, Malay, and Swedish transla-

tions with the following exceptions. When reliabilities were calculated for the five subgroups, only limited number of low coefficients were found such as: for the Bermuda sub sample, the subscale for Late morning (.43) and for the Swedish sub sample the elements of Temperature (0.05) and Design (-.14) had low reliabilities. Results for these elements should be interpreted with caution.

The Semantic Differential Scale

Attitudes toward instruction were assessed using the *Semantic Differential Scal*e (SDS) (Pizzo, 1981). The SDS is a Likert-type instrument that examines attitudes toward two treatments or variables. Pizzo originally developed this scale to compare the attitudes of students tested in an acoustic environment congruent with their preferences for an element of styles with those of students tested in an acoustic environment incongruent with their preferences for sound (Pizzo). Other researchers subsequently employed the SDS and reported its reliability and validity with several diverse populations (Dunn, Bruno, Sklar & Beaudry, 1990; Dunn, Giannitti, Murray, Geisert, Rossi, & Quinn, 1990). It was administered in Bermuda to identify the learning styles of middle school students by Bascome (2004). The SDS is a self-report questionnaire consisting of a 5-point Likert-type scale with three primary factors (Evaluation, Potency, and Activity) and two possible factors (Stability and Receptivity) to compare the attitudes of students tested in congruent versus incongruent environments. A 1 on the SDS indicates a Strong Response and a positive attitude toward the given statement; 5 indicates a Weak Response and attitude. Indifference is measured by a score of 3. In this investigation, the SDS was used to compare the attitudes of students who were exposed to learning fractions traditionally with the attitudes of students who were exposed to learning fractions with the PLS.

Programmed Learning Sequence (PLS) is an instructional method that programs course content so that it can be learned visually, tactually, or on tape in small sequential steps without direct teacher instruction. It includes a global beginning and a shaped cover. PLSs are very responsive to students who need structure and small steps, followed by periodic game-like reinforcements (Dunn & Griggs, 2004).

Procedures

The LSI (Dunn, Dunn, & Price, 2000) was administered at the beginning of the school year. On conclusion of the data collection procedures, each student's Inventory was electronically scored. The total data set was organized, digitally stored in data files, and then compiled into a Microsoft Office Excel (2003) spreadsheet by Price Systems. The Excel spreadsheet was transferred into the *Statistical Package for Social Science* (SPSS) Version 10.0 software for analysis.

The three control and three experimental classes were administered a pre-test on the Fractions Unit divided into seven sections: (a) Simple Fractions; (b) Simple Addition of Fractions; (c) Simple Subtraction of Fractions; (d) Adding and Reducing Fractions; (e) Subtracting and Reducing Fractions; (f) Changing an Improper Fraction to a Mixed Number, and (g) Changing an Improper Fraction to a Mixed Number and Then Reducing it. Tests were graded and a graph of means was produced (see Figure 2).

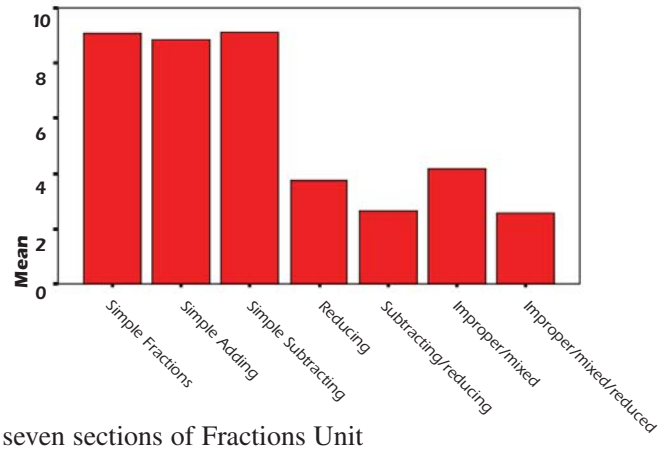

Figure 2. Graph of means for seven sections of Fractions Unit

The construct of learning styles was introduced at the first parent-teacher meeting in October, accompanied by a summary of its different components. Both the control and experimental groups previously had been taught with PLSs as part of the administration's efforts to differentiate instruction. Each lesson lasted 60 minutes. The control groups were taught fractions in a traditional classroom using conventional methods—explanations that used the white board, discussions, readings, and the textbook. The experimental groups were taught fractions with a PLS that included tactual and kinesthetic instructional resources. That classroom provided both bright and low lighting, informal and conventional seating, quiet areas and sections that permitted student interaction and mobility—provided students remained self-disciplined.

In each classroom, the experimental group was divided into three sections for three 20-minute lesson segments using the PLS that incorporated tactual resources and a kinesthetic Floor Game. Students experienced each resource for 20 minutes, but in a sequence responsive to their learning-style strengths. Thus, all three experimental groups experienced the PLS with the tactual and the kinesthetic resources, but in a different sequence. The control group also was taught the unit on fractions in three, 20-minute sections, but used lectures, white boards, discussions, and textbooks in a traditional format (see Figure 3).

PLS 20 Minutes	Group One	Group Two	Group Three
Tactual 20 Minutes	Group Three	Group One	Group Two
Kinesthetic 20 Minutes	Group Two	Group Three	Group One

Figure 3. Design for the experimental groups

Data Analysis

The purpose of this investigation was to determine (a) if middle school students would earn significantly higher achievement test scores when learning a unit on fractions taught with a Programmed Learning Sequence (PLS) than when the same unit was taught traditionally to a comparable class and (b) if students would register statistically higher attitudinal test scores after learning that same unit on fractions with a PLS as opposed to learning it traditionally. Data were examined and analyzed with the *Statistical Package for the Social Sciences (SPSS) for Windows 10.0* (2000). Means and standard deviations were calculated for the descriptive statistics. Inferential statistics were established by univariate analyses of variance (ANOVAs) and independent sample *t*-tests. The level of statistical significance was set at an $\alpha < 0.05$.

Eta-squares (η^2) were reported as effect sizes to determine the magnitude of the results regardless of sample size. As suggested by Huberty and Lowman (2000), effect sizes should be reported for group mean comparisons involving multilevel grouping variables, such as the two-level pretest, posttest, and difference variables. An $0.25 < \eta^2$ was reported as a large effect size, $0.01 < \eta^2 < 0.24$ as a medium effect size, and $\eta^2 < 0.01$ as a small effect size (Cohen, 1988).

Findings

Hypothesis One

Analysis of the data with a univariate analysis of variance (ANOVA) indicated that students who had learned with a PLS in the sequence that accommodated their visual/tactual learning styles demonstrated significantly higher test results when compared with their peers who had not been taught using a PLS that incorporated tactual materials. The consequent analysis clearly revealed that both the control and experimental group's initial knowledge of fractions was similar before treatment. In addition, both the post-test scores and mean difference between their pre- and post-test scores revealed a positive association in both the control and experimental groups (see Table 1).

Table 1
Descriptive and Inferential Statistics for Pre Test, Post Test, and Mean Differences: Means, Standard Deviations, F-values, p-values, and Effect Size

	Control *M* *(SD)*	Experimental *M* *(SD)*	*F*	*p*	*n2*
Fractions Unit Pre Test	3.82 (2.79)	3.71 (2.33)	.004	.948	.000
Fractions Unit Post Test	5.98 (2.93)	7.86 (2.29)	12.336	.001	.116
Pre- and Post-Test Difference	2.28 (1.90)	4.27 (2.46)	19.517	.000	.172

An ANOVA revealed that this middle school sample evidenced significantly higher Fractions Unit post-test scores when instructed through a Programmed Learning Sequence than when taught traditionally. Significant differences were found for both the individuals' post-test scores as well as the mean difference between the pre- and post-test scores of each group. This meant that the experimental group scored significantly higher than its control group counterpart in the post-test scores of the Fractions Unit. In addition, the difference between the means of the pre-test and the post-test score of the experimental group was significantly greater than the difference between measures of the control group. The strength of associations between group and test variables, as assessed by η^2, were both considered large effect sizes, indicating that the type of instruction (PLS versus traditional) is likely to have large effects on equivalent samples under similar conditions.

Hypothesis Two
Significantly higher attitude scores, as measured by the *Semantic Differential Scale* (SDS) (Pizzo, 1981) were found for the experimental group experiencing a Fractions Unit taught through the use of a PLS with tactual and kinesthetic instructional resources than when that same unit was taught traditionally to a comparable class. Results of responses for each question of the SDS revealed a significant reply rate of 92% at the higher end of a favorable mean (4 to 5 out of a possible 5 rating). Data indicated that most participants preferred the PLS tactual and kinesthetic instruction significantly more than they did the traditional instructional methods (See Table 2).

Table 2
Semantic Differential Scale Frequency Responses by Number

SDS Response	Frequency	Percentage	
1 (Weak or Negative)	5	1	
2	7	1	
3 (Neutral)	33	6	
4	206	35	92 %
5 (Strong or Positive)	337	57	
Total	588	100	

Note: The total frequency count of 588 reflects the product of 5 possible responses for all 12 word-pair associations.

Summary and Discussion

The experimental group scored significantly higher than its control group counterpart did on post-test scores on the Fractions Unit. In addition, the difference between the means of the pre-test and the post-test score of the experimental group was significantly greater than the difference between measures of the control group. Because of the strength of associations between group and test variables as assessed by η^2, both considered large effect sizes, it can be assumed that this type of instruction (PLS versus traditional) would have similarly large effects on equivalent samples under similar conditions.

The positive effects of the PLS on Bermudian sixth-grade students' Fractions Unit assessments- and attitude-test scores, suggest that knowledge of learning-styles should become part of daily instructional decision making. As one alternative to traditional teaching, the PLS, which improves students' ability and attitudes, might make an excellent approach to differentiating instruction and simultaneously increasing students' appreciation of schooling.

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