Effects of Learning-Style-Based Homework Prescriptions on the Achievement and Attitudes of Middle School Students

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This research was designed to examine the effects of the use of individualized, learning-style based homework prescriptions on the achievement and attitudes of middle level students. Sixth-, seventh-, and eighth-grade students from an urban, parochial school in New York City were provided either learning-style-based homework prescriptions or guidelines for traditional study strategies. Each group demonstrated increased levels of achievement in reading, mathematics, science, and social studies and higher attitude-test scores after treatment. However, the students in the experimental group who used individualized learning-style-based homework prescriptions clearly showed larger gains.

Multivariate analyses of variance and pairwise comparisons were used to examine whether the use of homework prescriptions significantly affected the achievement and attitudes of middle level students when compared to the use of traditional study strategies. Data showed significant differences in achievement between the experimental and control groups. Findings supported significantly higher gains in knowledge of learning styles, reading, mathematics, science, and social studies achievement, attitudes toward homework, and attitudes toward learning styles among students in the experimental treatment condition. Significance was reported at the $p < .001$ level and effect sizes indicated moderate to very strong interactions. These findings supported those of other studies (Brand, 1999; Geiser, 1999; Geiser et al., 2000/2001) whose authors examined the effects of learning-style-based homework prescriptions. These results, as well as recommendations for further research, are discussed in depth.

Throughout the years, adolescent students have intrigued the adults, parents, and teachers with whom they interact. One stereotype of adolescents is that "they are inattentive, impulsive, and intellectually flighty" (George, Stevenson, Thomason, & Beane, 1992, p. 72). Certainly there are youngsters for whom one or more of these descriptors are accurate, but

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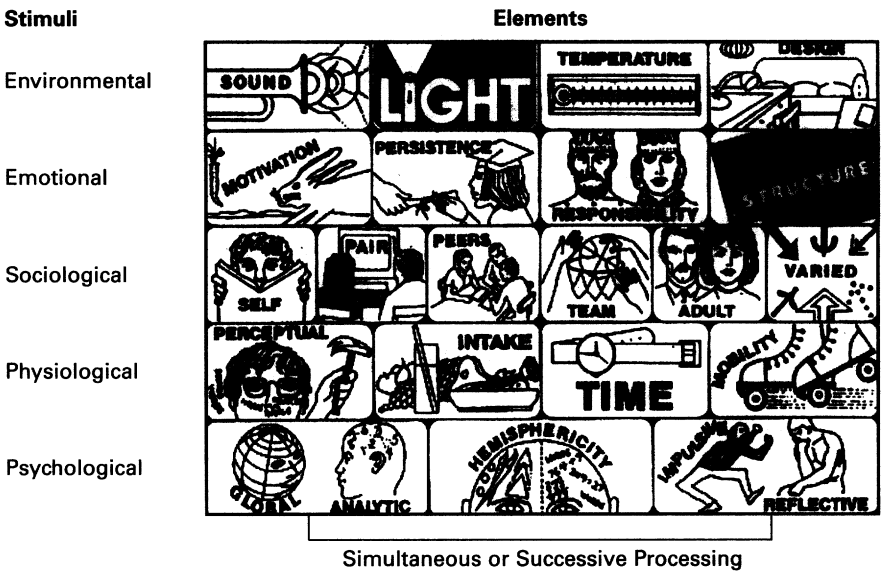
other adolescents pay attention, complete long-term projects, and pursue scholarly interests seriously. Middle level students often experience multiple difficulties due to hormonal changes in their bodies and minds that occur during adolescence (Dunn, 1988). Research at the middle level indicates that most students are taught in a formal classroom setting through the use of traditional instructional methods such as lecture, assigned readings, drill, and independent practice. Learning-style researchers indicate that many students achieve well in a traditional educational environment, but the majority of students do not (Bauer 1991; DeBello, 1985; DellaValle, 1984; Dunn, 2001; Dunn, Giannitti, et al., 1990; Elliot, 1991; Gesier, 1999; Geiser et al., 2000/2001; Gremli, 2000/2001; Roberts, 2001).

This research focused on specific aspects of the Dunn and Dunn Learning-Style Model, the only one of three comprehensive models specifically designed for middle level students (Tendy & Geiser, 1998/1999). Learning style is the way each individual begins to concentrate on, process, internalize, and retain new and difficult information (Dunn & Dunn,1992, 1993, 1999; Dunn, Dunn, & Perrin,1994). The Dunn and Dunn Learning-Style Model consists of five strands of learning-style elements: environmental, emotional, sociological, physiological, and psychological (see Figure 1). Within each strand, four or more elements are identified. The environmental strand addresses learners' preferences for sound, light, temperature, and seating design. The emotional strand examines students' levels of motivation, persistence, responsibility (conformity versus nonconformity), and need for structure. The sociological strand focuses on students' preferences for learning alone, in pairs, in groups (with peers), working with or without a collegial or authoritative adult, or their preferences for a variety of these elements. The physiological strand identifies students' perceptual strengths (visual, auditory, tactual, or kinesthetic), time-of-day energy levels, and preferences for intake and mobility. Finally, in the psychological strand, the informational processing styles of learners—global or analytic and impulsive or reflective—are assessed. Extensive research on the Dunn and Dunn Learning-Style Model spanning a 34-year period documented the advantages of diverse instructional strategies based on the learning-style preferences of students of all ages (Dunn, 2003).

Researchers involved in experimental studies of middle level students reported significantly higher achievement test scores when participants experienced instruction congruent with their learning-style strengths (Dunn & DeBello, 1999; Dunn & Geiser, 1998; Geiser et al., 2000/2001; Hodges, 1985; Solomon, 2000). Despite those findings, many students remained unaware of how they could master new and difficult material most effectively, particularly if their learning styles had never been identified and they had not been provided with responsive instruction to allow them to function maximally (Dunn, 2000). Teachers often lacked either the motivation or skill to teach to the

Figure 1. Dunn and Dunn Learning Styles Model



learning-style strengths of their students (Lux, 1987). In effect, teachers' failure to make that effort substantially decreased students' chances for academic success. In such cases, computer-generated prescriptions for studying and doing assignments based on identified learning-style strengths conceivably might improve students' chances to perform well in school (Brand, 1999; Dunn & Geiser, 1998, Geiser et al., 2000/2001). This investigation sought to examine the effects of learning-style-based homework prescriptions on the achievement and attitudes of middle level students.

Schools across the nation have reversed poor academic achievement by providing failing students with instructional approaches responsive to their learning-style preferences (Dunn & DeBello, 1999). However, relatively few students have access to teachers who teach with learning-style responsive approaches. Equal opportunity suggests that these students should not be denied the chance to perform well because they lack the means of accessing a nontraditional system available to others and proven successful in secondary schools (Brand, 1999; Geiser, 1999; Geiser et al., 2000/2001; Marino, 1993) and in higher education (Lenehan, Dunn, Ingham, Murray, & Signer, 1994; Nelson et al, 1993). Perhaps one alternative to nontraditional instruction for teachers who are reluctant to change their teaching style for a myriad of reasons would be to provide homework prescriptions designed for middle level students based on their identified learning-style strengths. Students can be taught to capitalize on their learning-style strengths when concentrating on

new and difficult information (McManus, 2000; Roberts, 2001; Schiering & Dunn, 2001).

Energy and substantial resources have been allocated each year to govern how instructional time is spent in classrooms. However, the learning process includes both hours spent in school and at home studying and doing homework. Activities included in studying and completing homework assignments often are intertwined. Homework assignments can include more than a requirement that something tangible be submitted to the teacher. Assignments may require a student to read, memorize, ponder, reflect, and study. Likewise, studying may not be limited to mental processes without the production of something physical. Studying often requires practice with paper and pencil, with computer, listening, watching, manipulating, and creating (Geiser, 1999). Therefore, the terms "homework" and "studying" are directly related and have been used interchangeably in this investigation.

The effectiveness of homework is a prominent topic for debate among educators, politicians, parents, and students. The consensus appears to be that homework and study assignments potentially can be worthwhile or, on the other hand, counterproductive. Palardy (1995) considered homework to be a haphazard teaching practice of questionable value that failed to incorporate any accommodations for students' differences. Similar concern was expressed by Gage (1978), who warned that time could be squandered and the way in which the homework time was spent needed to be examined. Walberg (1991) concurred that the quality of time spent studying was crucial. He stated that productive time can be increased by making instruction responsive to individual differences and by teaching small-group and individually managed study skills so that students can concentrate more fully on what they personally require. The positive effects of homework on the achievement levels of middle level students have been evidenced worldwide across several cultures (Cooper, 1989; Hernandez-Gantes, 1995; Peng & Wright, 1994; & Walberg, 1991).

The assessment of students' learning styles and their relationship to study strategies continues to receive the attention of researchers and practitioners. A series of studies conducted at the elementary (Carns & Carns, 1991; Turner, 1992), secondary (Brand, 1999; Geiser et al., 2000/2001; Marino, 1993), and higher education (Callan, 1999; Dunn, Deckinger, et al., 1990; Nelson et al., 1993) levels indicated that students who studied through their learning styles, as indicated via computer-generated homework prescriptions (Dunn & Klavas, 1990), achieved statistically higher achievement-test scores than either those same students when studying without homework prescriptions or other students who were not provided homework prescriptions. Researchers and educators can make the changes needed in education if there is continued research on these concepts, reporting findings and translating them into

practical applications that are implemented in schools worldwide (Burke et al., 1999/2000).

Walberg (1991) stressed the need for study strategies tailored to students' individual differences. Brand (1999) provided students with a complete description of their personal learning styles and the skills with which to maximize them. He reported significant gains in vocabulary achievement of ninth graders when participants studied according to the strategies outlined in their homework prescriptions. Geiser et al. (2000/2001) concurred that the application of learning-style theory to homework practices empowered learners to individualize their methods of studying by taking advantage of their unique learning-style strengths.

The current investigation was designed to examine the effects of learning-style-based homework prescriptions based on the globally-formatted learning-style identification instrument, *Learning Style: The Clue to You!* (LS:CY; Burke & Dunn, 1998). The difference between global and analytic learners, with respect to assessment instruments, led Burke et al. (1999/2000) to investigate how cognitive style interacted with testing instruments. It was hypothesized that global students would respond to a global-format learning-style assessment more accurately than they did to an analytical-format learning-style assessment. Thus, Minotti and Dunn (2001) responded to the need for a computerized scoring guide for the instrument to allow educators to effectively use this identification assessment to diagnose and prescribe individualized homework prescriptions for their students. The initial use of the LS:CY computerized scoring guide and related homework prescriptions was performed in this study.

Method

Participants

The sample used in this investigation was comprised of sixth-, seventh- and eighth-grade students from an urban, parochial elementary school in New York City. The majority of students registered in the school were from low-socioeconomic backgrounds. The school's population was approximately 57% Hispanic, 39% African-American, and 4% Caucasian. The total school population was 562, of which 181 students were enrolled in grades 6–8. The school population was comprised of two classes for each grade from kindergarten through grade 8.

A convenience sample of pre-formed classes was used, from which students were assigned randomly to the experimental and control groups. All 181 students in grades 6–8 were selected to participate in this investigation; 167 consented. There was a fairly even distribution of male and female students—48.3% and 52.7%, respectively.

The sample population consisted of 80 males and 87 females enrolled in heterogeneously grouped, regular education classes. The sample consisted of two preformed classes for each grade, one class of each gender. Although the participants did not represent a random sample, the students were randomly assigned to the learning styles or traditional conditions within each of the six classes. The demographics of both groups were comparable and represented an inclusive sample of students in terms of gender, ethnic background, age, and prior achievement levels. Consistent with the total school population, the sample was predominantly Hispanic (see Tables 1 and 2).

Permission to conduct the investigation was granted by the school administration. Consent to participate in this study was sought and obtained from both students and parents or guardians. The school administration and teachers classified the participants' academic standings as diverse, ranging from low-achievers to gifted and talented, based on several criteria such as scores on the Iowa Test Basic Skills (ITBS; Hoover, Hieryonomus, & Trisbie, 1993), students' GPAs, and teachers' recommendations.

Materials

The materials used for this investigation consisted of the following identification and assessment instruments: LS:CY, the Semantic Differential Scale (SDS; Pizzo, 1981), the LS:CY Computerized Scoring Guide (LS:CY-SG; Minotti & Dunn, 2001), a handout on homework tips, a learning-styles pretest, achievement tests, and student study logs used to record the strategies used for studying and completing homework assignments.

Instruments

Learning Style: The Clue to You. LS:CY is specifically designed to respond to characteristics of both global and analytical learners by the inclusion of stories, fantasy, holistic writing, imagery, humor, and pictures (Dunn & Dunn, 1993; Dunn & Griggs, 1995). This assessment incorporates five stories as a prelude to the identification of middle level students' predispositions toward any of a diverse group of learning-style characteristics. Each of the five stories contains the elements of three strands of learning styles and each centers around the theme of mystery and detectives. This theme was chosen because of its high level of interest among middle level students. Each story is followed by a series of questions that pertain to the student's learning style. Figure 2 indicates the learning-style strands that are revealed in each story.

Test-retest reliability coefficients for each element of the instrument ranged from a minimum of .727 (visual) to a maximum of .994 (light). The mean value of the coefficients was .937. Correlation coefficients among items within each element were used to compute Cronbach's alpha as an estimate of internal-consistency reliability. The LS:CY internal consistency

Table 1. School Demographic Data

Grade	Males	Females	Asian	African-American	Caucasian	Hispanic	Other	Total
K	30	28	3	15	0	40	0	58
1	33	34	1	27	0	38	0	67
2	28	36	1	25	1	37	0	64
3	29	42	0	25	0	42	0	71
4	33	32	0	25	7	34	0	65
5	24	32	1	19	1	35	0	56
6	32	31	1	33	2	27	0	63
7	39	29	0	23	0	45	0	68
8	21	29	3	25	1	21	0	50

Table 2. Demographic Data for the Sample Population By Group

	Experimental Group	Control Group
Subjects	84.0	83.0
Males	40.0	40.0
Females	44.0	43.0
Mean age of subjects	12.4	12.3
Mean GPA	80.3	81.2

Figure 2. Learning-style strands addressed in the LS:CY assessement.

	Elements		
Story One	Physiological	Sociological	Environmental
Story Two	Emotional	Psychological	Sociological
Story Three	Physiological	Psychological	Environmental
Story Four	Emotional	Psychological	Environmental
Story Five	Sociological	Emotional	Physiological

reliability coefficients were based on an average of the Cronbach's alpha for the two administrations. The internal consistency-reliability coefficients for LS:CY ranged from .76 to .99 with a mean of .94. The internal consistency reliability coefficients for the LSI ranged from .56 to .88 with a mean of .76.

The LS:CY took approximately 40 minutes to administer. Student responses were taken from the LS:CY answer document and entered manually into the scoring guide (Minotti & Dunn, 2001), from which an individualized homework prescription was generated for each student instantaneously.

The Semantic Differential Scale. The Semantic Differential Scale (SDS) developed by Pizzo (1981) was used to assess the students' attitudes toward learning styles and homework. Pizzo created the SDS to compare the attitudes of students tested in congruent versus incongruent acoustic environments. This instrument was modified and used by subsequent researchers to Pizzo (DeBello, 1985; Dunn, Giannitti, et al., 1990; Hodges, 1985; Ingham, 1991; Miller, 1998; Pizzo, Dunn, & Dunn, 1990). These researchers used the SDS to examine students' attitudes toward design, sociological, and structure preferences. White (1996) used the SDS to measure middle level students' attitudes toward studying and doing homework in mathematics. The reliability coefficient of the SDS has been reported as .98 and .99 in two sessions of administration.

The SDS survey was administered as a pretest measure of the students' attitudes toward homework. A second SDS was administered as a pretest measure of the subjects' attitudes toward learning styles. The SDS pretest surveys took approximately 15 minutes to administer. At the culmination of the 2-week treatment period participants were asked to take two posttest attitude surveys to measure their attitudes toward homework as well as attitudes toward learning styles after experiencing the treatment conditions.

Learning Style: The Clue to You! Scoring Guide. This computer-based program was designed to allow teachers to generate both learning-style profiles and homework prescriptions related to the instument. The scoring guide program allows users to enter data onto a one-page form and then, through the use of predefined macros, generate a printout of both the students' learning-style profiles or homework prescriptions. Several safety routines are included that prevent end-users from altering data or scoring algorithms. Each element of LS:CY is responded to in writing by the student three times to ensure internal validity. On this 3-point Likert scale, to ensure accuracy, the respondent must answer the question identically for each occurrence. Any variation in responses is viewed as a nonpreference for the element in consideration. The scoring guide generates a prescription based on the summed and cross-checked values that correspond to the appropriate element and response.

How do we learn? A researcher-developed learning-styles pretest titled was developed to test for students' prior knowledge of learning styles. A jury of learning style experts concurred that this tool accurately and effectively assessed students' prior knowledge of learning styles.

Achievement tests. Students' mean achievement test scores in language arts, math, science, and social studies were used as a baseline measure of achievement before treatment and were compared to unit test scores in those subject areas following the 2-week treatment period.

Study logs. Study logs were used to verify compliance and assess whether the participants actually followed the study strategies outlined in the individualized homework prescriptions or Homework Tips booklet for the experimental and control groups respectively. Parental verification was required in the form of a signature on their child's study log entry each night during the treatment period. All students complied with the study log requirement and their parents were cooperative in signing off on the study log entries each night.

Procedures

Initially, the participants were administered a pretest on their knowledge of learning styles and two attitude surveys. The first measured the students' attitudes toward learning styles, the second measured their attitudes toward studying and completing homework assignments. All three elements were administered consecutively in one session. Each of the six classes that participated in this investigation was tested separately in a vacant, climate-controlled computer lab.

On the second day of this investigation, the experimental group experienced an introduction to learning styles via an animated, computerized, slide show presentation followed by a group discussion. In addition, a copy of the slide show was sent home to allow the parents of the participants to view the presentation. The control group viewed an animated, computerized, slide show presentation as well, one on traditional homework and study strategies. The parents of the control group also were provided with a copy of the presentation. Shortly thereafter, the instrument was administered to the experimental group to test for students' individual learning-style preferences.

The control group received a booklet of tips for studying and completing homework assignments. It provided suggestions for using traditional study methods, rather than the learning-style based homework prescriptions. The Homework Tips booklet was distributed to the participants in the control group in a nearby conference room while the experimental group was taking the LS:CY assessment in the computer lab. The parents of the students in the control group also were given a copy of the Homework Tips booklet.

Related homework prescriptions were computer-generated for each of the students in the experimental group based on the results of the instrument during the course of the school day. Later that afternoon, participants in the experimental group had their individual homework prescriptions explained to them and were directed to use the suggestions for studying and doing homework assignments for a 2-week period. The parents of the students in the experimental group also were provided a copy of the computer-generated homework prescriptions.

All students were required to report what they did differently based on the suggestions outlined in either the Homework Tips booklet for the

control group or the learning-style based homework prescriptions for the experimental group. Each participant was given a study log and a special pen to use for recording this information each night after studying and completing the homework assignments. In addition, each participant was directed to turn in his or her study log with homework assignments each day in school during the 2-week period. The participants' parents were asked to sign off on their child's log entry each night and to provide photographs, if possible, of their children studying and doing homework assignments. Although parents complied by signing the students' study log entries for the entire duration of the investigation, no photographs were submitted.

At the culmination of the 2-week period, each student was asked to return his or her study log. At that point, the control group students met with the researcher for a group discussion on the strategies outlined in the Homework Tips booklet and the extent to which they had used them. At the end of the session, the participants in the control group were administered the SDS as a posttest measure of their attitudes toward studying and completing homework assignments. The members of the control group then were given the opportunity to take LS:CY to identify their individual learning-style preferences and receive computerized homework prescriptions just as their classmates in the experimental group had. Those students who opted to do so viewed the animated presentation on learning styles prior to the administration of the instrument.

The teachers of the classes participating in this investigation administered unit tests on the content covered in language arts, math, science, and social studies during the 2-week treatment period, which were provided by the textbook publishers based on the chapters taught in each subject area examined during the treatment period. The scores from the aforementioned subject-area tests were used as posttest measures of achievement. It should be noted that the six teachers participating in this investigation were not informed of which students were randomly assigned to the experimental and control treatment conditions.

Results

The dependent variables for this investigation comprised: achievement as measured by content-area unit tests, attitude as measured by SDS, and knowledge of learning styles as measured by the survey. The independent variable was the method of study strategies used (learning-style based methods and traditional methods).

Statistical Procedures

The design for this investigation was a pre- and posttest format. A multivariate analysis of variance (MANOVA) was used. An initial measure acted as a

covariate and as a variable. This covariate consisted of students' average test scores in reading, math, science, and social studies. A subsequent measure—students' posttest scores in each of the content areas—served as a posttest measure or dependent variable. In addition, simple tests of main effects and pairwise comparisons were used.

It was hypothesized that there would be significant pre- and posttest differences in reading, mathematics, science, and social studies achievement-test scores of students who used their individual learning-style based homework prescriptions versus students who used traditional homework and study strategies. An analysis of mean achievement-test scores by subject in the form of pre- and posttest measures is presented in Table 3. Results of measures of students' attitudes are depicted in Table 4.

Profile plots were generated for the mean pre- to posttest scores for each of the four subject areas examined, all of which indicated strong interactions. Figure 3 depicts a graphic representation of the differential effects. The profile plot of mean pre- to posttest scores for reading achievement clearly illustrates the difference in rate of reading achievement between the experimental and control groups. Both groups were essentially similar at the onset and both groups demonstrated an increase in reading achievement after using either the homework prescriptions or Homework Tips booklet. However, the groups improved at different rates. The students in the experimental group, who used individualized learning-style based homework prescriptions, evidenced larger gains when compared to their control group counterparts who used traditional study strategies.

The profile plot of pre- and posttest mean scores for mathematics achievement provides a graphic representation of the experimental and control group students' gains in mathematics. As depicted in the profile plot, the experimental and control groups were similar before treatment in terms of level of mathematics achievement. Both groups demonstrated an increase in mathematics achievement after using either the homework prescriptions generated by the LS:CY!-SG or the traditional study strategies outlined in the Homework Tips booklet. However, the groups clearly improved at different rates. The experimental group students' mean mathematics achievement score increased 6.8 points. The control group evidenced smaller gains, with a rise of less than 1 point (see Figure 4).

Levels of science achievement for all participants are graphically presented in Figure 5. The experimental and control groups were basically equivalent in levels of science achievement before treatment. The nonparallel lines indicated a significant interaction which indicated that study methods used by the participants affected the level of science achievement. Although both groups evidenced increased levels of achievement in science,

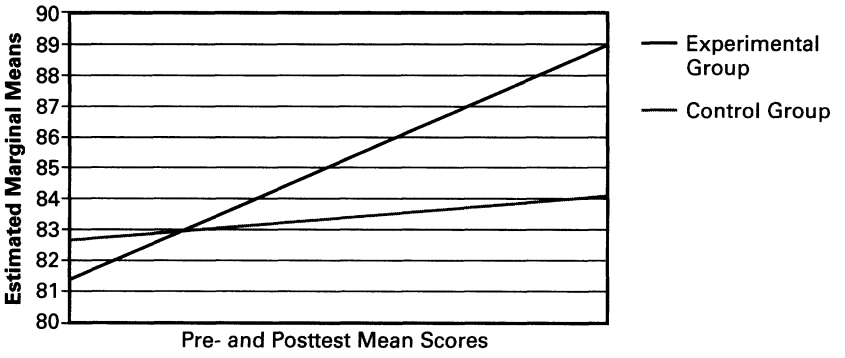
Table 3. Achievement Gains of Experimental Group Versus Control Group

	Experimental Group	Control Group
Pretest knowledge of LS	1.54	1.53
Posttest knowledge of LS	3.78	1.94
Pretest reading	81.29	82.46
Posttest reading	88.86	83.03
Pretest mathematics	82.00	81.85
Posttest mathematics	88.87	82.45
Pretest science	81.79	81.81
Posttest science	88.80	82.56
Pretest social studies	81.64	81.11
Posttest social studies	88.68	81.96

Table 4. Attitudinal Gains of Experimental Group Versus Control Group

	Experimental Group	Control Group
Pretest attitudes toward homework	46.02	45.86
Posttest attitudes toward homework	56.82	48.44

Figure 3. Profile plot of pre- and posttest mean scores for reading achievement.



the experimental group demonstrated more gain with a mean increase of 7 points from the pre- to posttest measures.

Similar trends were reported in social studies. Figure 6 depicts the profile plot for estimated marginal means of social studies achievement. Both groups demonstrated essentially similar levels of social studies achievement before treatment with mean scores of 81.6 and 81.1 for the experimental and control groups respectively. However, after using the individualized learning-style based homework prescriptions, the experimental group evidenced a higher mean social studies score of 88.7, an increase of 7 points,

Figure 4. Pre- and posttest mean scores for mathematics achievement.

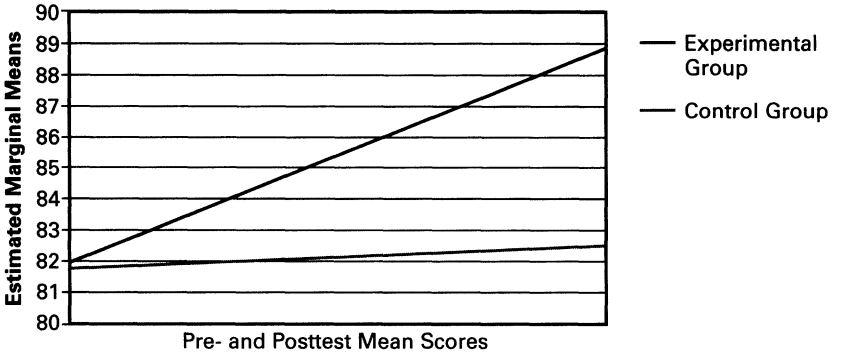


Figure 5. Profile plot of pre- and posttest mean scores for science achievement.

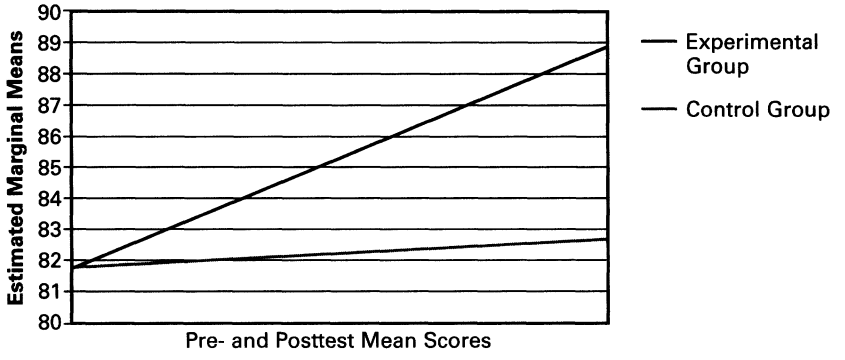
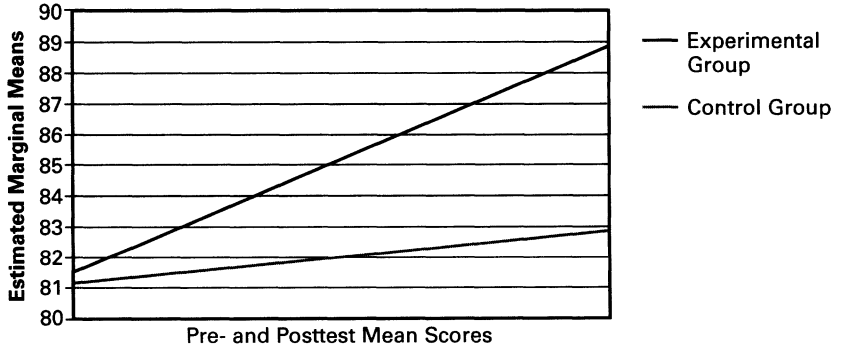


Figure 6. Profile plot of pre- and posttest mean scores of social studies achievement.



when compared to the control group students' mean score of 82.0, which was a gain of less than 1 point in social studies achievement.

Both groups evidenced increased reading achievement scores after the treatment period. The students in the control group who did not use the homework prescriptions evidenced a marginal gain of less than 1 point in reading achievement from an average pretest score of 82.46 to and average posttest score of 83.03. However, the experimental group increased at a greater rate, from a mean score of 81.29 before treatment to a mean score of 88.86 after using the homework prescriptions as depicted in Table 3. Significance was established at the $p < .001$ level.

In the area of mathematics, both groups demonstrated increased levels of achievement after the treatment. However, the experimental group increased at a greater rate. The mean pretest score in mathematics for the control group was 81.85 before treatment and 82.45 after treatment, indicating a slight gain of less than 1 point (Table 3). The experimental group evidenced a larger gain after treatment with the mean mathematics score rising from 82.00 before using the homework prescriptions to 88.87 after treatment. When examining science achievement, similar results were found. Both the experimental and control groups demonstrated increased levels of achievement after the treatment. The average science test score for the control group students rose slightly from 81.81 at the pretest measure to 82.56 at posttest (see Table 3). The mean science score of the experimental group improved by 7 points from 81.79 at pretest to 88.80 at posttest indicating a much greater increase in science achievement after using the homework prescriptions when compared to the control group ($p < .001$).

The fourth subject examined was social studies achievement. Consistent with the results in reading, mathematics, and science, increased levels of achievement were reported in social studies after the treatment following a similar pattern. Although both groups demonstrated an increase in social studies achievement after using either the homework prescriptions or the Homework Tips booklet, the experimental group clearly evidenced greater gains. The mean social studies test score of the experimental group from pretest to posttest measures rose approximately 7 points from 81.64 to 88.68, where $p < .001$ (see Table 3). However, the control group demonstrated only a minimal increase with a mean social studies pretest score of 81.38 to a mean posttest score of 81.96.

In each of the four subject areas examined all students' demonstrated higher levels of achievement after treatment. However, the groups improved at significantly different rates. The students in the control group who used traditional study strategies demonstrated marginal achievement gains in reading, mathematics, science, and social studies after treatment. Conversely, the students in the experimental group demonstrated significantly larger

gains in all four subject areas after using individual learning-style based homework prescriptions.

A multivariate analysis of variance (MANOVA) was performed and revealed the effects of the treatments and interactions of this investigation (Table 5). This test established whether there were significant differences among the means, or between groups, and determined the average variation within each group. The MANOVA results revealed there were significant main effects for the mean achievement pretest to posttest measures for reading (.619), mathematics (.515), science (.504), and social studies (.498), indicating moderate to strong interactions. This indicated that all students, regardless of group, gained in knowledge from the pretest to posttest in each of the four subject areas examined. In addition, there was also a significant pretest to posttest interaction, which signified that the two groups learned at different rates. The students in the experimental group who used learning-style based homework prescriptions clearly evidenced significantly larger gains in reading, mathematics, science, and social studies achievement ($p < .001$).

Results of multivariate analyses of variance of pre- and posttest scores by subject and group revealed significance at the $p < .001$ level for reading, mathematics, science, and social studies test scores. Partial eta squared values were calculated to determine effect sizes (see Table 5).

It was also postulated that students who used study strategies congruent with their identified learning-style preferences would demonstrate improved attitudes toward homework. Table 4 presents the mean attitudes toward homework scores of the experimental and control groups from the pre- to posttest measures, which clearly indicated that both groups were similar regarding attitudes toward studying and completing homework assignments before treatment, with mean scores of 46.02 and 45.87 for the experimental and control group, respectively. However, after using the homework prescriptions, a 10 point difference in attitudes toward homework scores as measured by the SDS was significant at the $p < .05$ level for the experimental group (46.02 to 56.81), which revealed that the treatment produced statistical significance. The control group demonstrated a marginal increase of approximately three points from the pre- to posttest measures, which indicated only a slight rise in students' attitudes toward homework, which was not significant.

Mean attitudes toward homework scores are presented in Table 4. The experimental and control groups demonstrated fairly comparable attitudes toward homework at the onset of the investigation with mean attitude scores of 46.02 and 45.87 respectively before treatment. After using either the individualized homework prescriptions generated by the scoring guide or the guidelines for studying outlined in the Homework Tips booklet for the

Table 5. Multivariate Analysis of Variance for Achievement Scores by Subject

	Wilks' lambda	*f*	Hypothesis *df*	Error *df*	Sig.	Partial eta squared
Pre/post reading	.381	267.758	1.000	165.000	.000	.619
Pre/post reading (group)	.455	197.432	1.000	165.000	.000	.545
Pre/post math	.485	174.999	1.000	165.000	.000	.515
Pre/post math (group)	.572	123.313	1.000	165.000	.000	.428
Pre/post science	.496	167.580	1.000	165.000	.000	.504
Pre/post science (group)	.602	109.065	1.000	165.000	.000	.398
Pre/post social studies	.511	158.087	1.000	165.000	.000	.489
Pre/post social studies (group)	.629	97.343	1.000	165.000	.000	.371

2-week treatment period, both groups evidenced an increase in attitudes toward homework. However, the experimental group demonstrated a larger gain of approximately 10 points from 46.02 at the pretest measure to 56.81 at the posttest. The control group demonstrated a smaller gain of fewer than 3 points from 45.87 before treatment to 48.44 after using the study strategies outlined in the Homework Tips handout.

A profile plot was generated to graphically represent the interaction revealed (see Figure 7). The non-parallel lines clearly depict the difference in attitudes toward homework between the two groups after treatment. All students demonstrated improved attitudes toward doing homework after treatment regardless of which group they were assigned to. However, the control group students who used traditional study strategies revealed a minimal gain whereas their experimental group counterparts evidenced significantly higher attitudes toward homework after using individual learning style based homework prescriptions.

The multivariate analysis of variance conducted for mean attitudes toward homework scores revealed a strong interaction pre- to posttest measures as indicated by the partial eta squared value of .759 and a moderate interaction for pre- to posttest by group (.545) as presented in Table 6. These values represent ample effect sizes. Significance was $p < .001$.

Discussion and Conclusions

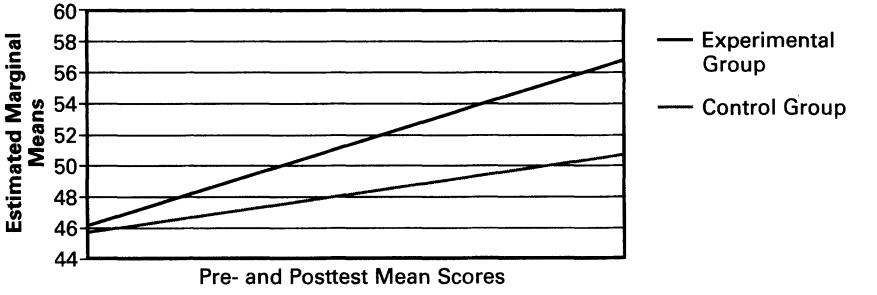
The link between homework and achievement is a pronounced one. The implications of this research concerning studying and completing homework assignments through one's learning-style strengths should provoke educators, parents, and students to explore and seriously consider this concept, which certainly warrants further study. Parents and educators unwittingly have hidden the truth from children concerning individuals' differential abilities, learning styles, and strengths in diverse areas. Children are eminently proficient at dis-

Table 6. Multivariate Tests Concerning Attitudes Toward Homework

Effect	Wilks' lambda	*f*	Hypothesis *df*	Error *df*	Sig.	Partial eta squared	Observed power
Prepo	.241	519.755	1.000	165.00	.000	.759	1.000
Prepo (group)	.455	197.394	1.000	165.00	.000	.545	1.000

Note. Prepo refers to pre- and posttest measures.

Figure 7. Profile plot of pre- and posttest mean scores for attitudes toward homework.



cerning their own special strengths and recognizing their own difficulties (Burke et. al., 1999/2000). Individuals need to acknowledge and understand their own learning style as well as learn to appreciate the differing styles of others. The assessment of learning styles is the first step toward each student's understanding of how to best concentrate on, process, and retain new and difficult information (Dunn & Griggs, 1995). In addition to not making children aware of their learning-style strengths, closer examination of the results of this investigation suggests the significant differences between groups could not have occurred if classroom instruction was sufficient. Given the effects of using learning-style-based homework prescriptions, by comparison, classroom instruction combined with traditional study strategies was not effective.

Examination of Table 2 reveals significantly higher levels of achievement and attitudes demonstrated by the experimental group in contrast with the gains evidenced by the control group after treatment. Closer scrutiny indicates although the control group certainly demonstrated gains in both achievement and attitudes, they were minimal and not statistically significant. Careful consideration of the marginal gains made by the control group hints toward the inadequacy of traditional homework and study strategies based of traditional classroom instruction. This trend crosses over the four content areas examined as depicted in Table 2.

The use of individualized homework prescriptions based on the identification assessment, LS:CY and related homework prescriptions generated by the scoring guide were extremely effective in improving the achievement level and attitudes of the parochial middle level population examined in this

study. This investigation has revealed shortcomings of traditional study strategies based on traditional classroom instruction provided by certified teachers at the middle level in contrast with the use of individualized learning-style-based homework prescriptions. In this particular case, the effects of students teaching themselves were greater than those of classroom instruction. Therefore, homework prescriptions have the potential to enhance instruction at the middle level by having positive effects on the achievement and attitudes of adolescent students.

Middle level teachers can better meet the challenge of individualizing instruction for diverse learners by embracing learning-style responsive instruction. One can only imagine the power of teaching through students' individual learning-style strengths in the classroom and providing individualized homework prescriptions for students to teach themselves, a model for instruction with the potential to change the lives of middle level students. The findings reported here provide data upon which educators can develop future research investigations concerning the effects of computerized homework prescriptions on global learners' achievement and attitudes. Several recommendations for future research stemmed from the results of this investigation, using different sample populations, such as rural students or those attending public or vocational schools and then determining the effects of using individualized homework prescriptions on students' achievement, attitudes, and behavior. In addition, subsequent studies might be conducted comparing achievement and attitudes by gender, culture, academic ability levels, or specific subject areas in relation to use of learning-style-based homework prescriptions. The results of this investigation may warrant a qualitative study concerning the need for effective staff development to alert educators to the need for individualized homework prescriptions and provide them with the tools to accommodate their students' learning-style strengths.

The research base on learning styles and homework should continue to be expanded. Relatively few researchers have reported results of using individualized homework prescriptions based on the Dunn and Dunn Learning-Styles Model on the achievement and attitudes of middle level students. Of those researchers, all used the analytically-formatted Learning Style Inventory (Dunn, Dunn, & Price, 2000) and its related homework disc (Dunn & Klavas 1990) to diagnose and prescribe individualized homework prescriptions for adolescent learners. This study was the first of its kind to use LS:CY and its related computerized scoring guide.

Students experience a plethora of teaching styles and strategies throughout their numerous years of schooling in the educational process. The vast research base of quality experimental studies on the effects of matching and mismatching students' individual learning styles with complementary instructional methods consistently evidenced positive results. However, at some point

during their educational careers, many students have found themselves in classrooms where the teaching strategies used were not congruent with their learning-style strengths. In such scenarios, the degree to which learners mastered effective homework techniques and study skills determined how well they adapted to and overcame what could potentially have been devastating situations for students. If learners were taught how to study and complete homework assignments effectively through their individual learning-style strengths, they would learn how to adapt and teach themselves the content. This skill would prove to be an invaluable tool they could rely on to succeed as they pursue higher levels of education during their lifetimes.

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