DOCUMENT RESUME

ED 381 290 PS 023 244

AUTHOR Traynelis-Yurek, Elaine; Strong, Mary W.
TITLE Assessment of Fine-Motor Development of Primary Students with Informal Medical Tests.
PUB DATE 14 Oct 94
NOTE 30p.; Paper presented at the Midwestern Education Research Conference (Chicago, IL, October 14, 1994).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Kindergarten; *Kindergarten Children; *Medical Evaluation; Physical Development; Primary Education; *Psychomotor Skills; *Reading Ability; Whole Language Approach; Writing Ability
IDENTIFIERS *Manual Dexterity; Manual Dexterity Tests

ABSTRACT

This study examined whether informal medical assessments could be used by classroom teachers to assess fine-motor ability and if there is any connection between fine-motor ability and reading achievement. Subjects were 174 half-day kindergarten children from whole-language classrooms in three states. Subjects were pretested in October and posttested in May for fine-motor ability and writing ability. Assessments included a checklist for early writing ability, and a test for Replicating Geometric Shapes, the Finger Agnosia Test, the finger dexterity test, and nine items on the Basic School Skills Inventory (BSSI). Results confirmed that low reading achievements and deficits in fine-motor ability appear related. Further, it does seem feasible for classroom teachers to use informal medical assessments to assess progress in fine-motor ability. The implication for whole-language classrooms is that lack of writing ability may impede achievement in reading. (HTH)

Assessment of Fine-Motor Development of Primary Students with Informal Medical Tests

Elaine Traynelis-Yurek

University of Richmond

Mary W. Strong

Iowa State University

Running Head: ASSESSMENT OF FINE-MOTOR DEVELOPMENT

Abstract

One hundred and seventy-four subjects from three states located in the midwest, the south and the southeast were pre & post tested for fine-motor ability and writing ability. All subjects were in a half-day kindergarten in public school settings in both urban and rural areas. The whole language approach was used in these classrooms. The objectives were to verify if using informal medical assessments could be used by classroom teachers to assess fine-motor ability and if there is any connection between fine-motor ability and reading achievement.

Results of the study confirmed that low reading achievements and deficits in fine-motor ability appear related. Further, it does seem feasible for classroom teachers to use informal medical assessments to assess progress in fine-motor ability. The implication for whole language classrooms is that lack of writing ability may impede achievement in reading.

Use of Informal Medical Assessments to Document Deficits

in Sensory-Fine-Motor Ability of Primary Students

With the advent of the whole language approach for beginning reading instruction, the academic demands on kindergarten and first grade students have somewhat shifted in emphasis. Though an increasing base of letter knowledge and phonemic awareness is still important, other abilities are also being required at this early age. Students are engaged in printing and writing earlier than with the traditional beginning reading approaches. This ability to write is reflected as the student attempts to write little stories in the whole language classroom. For most children, there appears to be a gradual improvement in their ability to print letters. However, there is a body of literature (Vukovich 1968, Levine 1987) which indicates that writing abilities may be developmental in nature. Some research, also reports that deficits in fine-motor ability may correlate with low reading achievement (Roth, McCaul & Barnes, 1993). At this point in early childhood history, most professionals espouse developmentally appropriate kindergarten programs and curriculums. It may be of some importance, for teachers of primary students, to know if students are exhibiting a lag in fine-motor development before expectations of printing are placed on them.

The types of assessment instruments used to screen for fine-motor ability deficits are usually administered by personnel in the school system who are specially trained either as school psychologists or educational diagnosticians. The instruments used may include the Revised Motor Scale, The Developmental Test of Visual-Motor

Integration, the Draw-A-Person or the Bender Gestalt. Most classroom teachers are not trained to use these instruments and the time involved in administration and scoring is prohibitive for a classroom setting. Teacher observation and informal assessment may be the most viable options for classroom teachers to assess and monitor progress in fine-motor ability. When teachers observe a student's lack of ability in producing letters, there is a need to either confirm if more practice is needed or if more developmentally appropriate activities are necessary. The research of Roth, McCaul and Barnes (1993) indicates that in screening kindergarten students to predict at-risk students, fine-motor ability was the lowest score for the students who did not achieve successfully in kindergarten. Kawakami, Oshiro and Farran (1989) describe the difficulty of modifying the principles of the writing process approach for kindergarten students who lacked fine-motor coordination.

A search of the medical literature offers a possible explanation of the development of fine-motor ability and assessments to document development which are administered by neurologists. They are both informal and brief. According to Levine (1987), frequently used fine-motor actions become more automatic. Often, children will trade accuracy for speed when acquiring a new skill, while some concentrate on accuracy more than speed. But children do grow rapidly in their rates of motor sequencing and this may be due to an increasing velocity of nerve conduction (Denckla, 1973). An increased use of the distal portions of the fingers allows for finer dexterity. Motor memory also plays an important role in the development of fine-motor ability. The tests generally used by neurologists are the

copying of geometric shapes (which is linked to age), the finger agnosia test which tests the ability to process a tactile sensation, and the finger dexterity test.

A study was designed to assess kindergarten students in the whole language classroom with these informal measures in conjunction with an informal writing assessment and to compare the results with reading achievement. A major premise of this study is that these informal medical assessments may document a lag in fine-motor ability. A comparison of the results of these assessments with reading achievement may also indicate whether there is a correlation between the results of medically based fine-motor assessments and low achievement in reading in the kindergarten program.

Method

Subjects

There were 174 subjects in the study from three states. These states were located in the midwest, the southeast and the south. All of the subjects attended a half-day session of kindergarten in a public school setting.

The children in the midwestern setting were from middle income families and none of the children received a free or reduced hot lunch. Sixty percent of the subjects in the southeastern setting received a free or reduced hot lunch. Ninety percent of the subjects in the southern setting received a free or reduced hot lunch.

In the classroom settings in the midwest, there were approximately 20 to 25 children in each classroom but there was no paraprofessional assigned to the classroom. The southeastern settings had a paraprofessional assigned to each

classroom and the enrollment in each classroom varied from 15 to 25 students. In the southern states, student enrollment for each class was 23 students as assigned.

There were sixty-six girls in the study and eighty-seven boys. One hundred fifty-five students exhibited right hand dominance and eighteen students preferred the left hand. Data for sex and hand dominance were missing for one student. All of the students had to be 5.0 years old by September for entrance to kindergarten.

Apparatus

The assessments that were employed include both informal fine-motor tests and a checklist for early writing abilities. Standardized Cronbach Alpha for Reliability was performed on these assessments. A test for *Replicating Geometric Shapes* was administered. This test requires the student to reproduce, from a model, six geometric shapes. The shapes are a circle, crossed lines, a square, a diamond, and a triangle. According to Myklebust (1954), the ability to reproduce these figures is age related. Children are believed to have the ability to copy the shapes at the following ages:

a circle, age 3, a cross, age 4, a square, age 5, a triangle, age 6-7, and a diamond, age 7. This informal test is used as an indicator of neurological integrity in children by neurologists (Vukovich, 1968). It has a reliability coefficient of .57.

The *Finger Agnosia Test* measures a student's ability to recognize, with eyes closed, when a finger is touched. At the age of four, it is reported that the thumb should be recognized and between five years of age and six years of age, a child

should be able to recognize when the index finger is touched (Lerner, 1988). This assessment has a reliability coefficient of .83. Vukovich reports that most children identify their fingers by six to seven years of age.

The *finger dexterity test* requires the student to touch each finger to the thumb. Each hand is tested separately (Lerner, 1988). A reliability coefficient of .91 was found for this test.

Nine items from the *Basic School Skills Inventory (BSSI)* were administered to the students. These items are as follows:

1. A three-finger grasp is exhibited when holding a pencil.
2. Print first name.
3. Print from left to right.
4. Copy word correctly from a card.
5. Copy word correctly from the board.
6. Stay in an approximate line when printing.
7. Reproduce letters correctly.
8. Letter size and formation is good.
9. Spacing of letters and words is attempted.

Goodman & Hammill, 1975

Students who are unable to perform four or five items at the age of 5.0 years would be considered to be below average (Hammill & Bartel, 1978). This assessment has a reliability coefficient of .82.

Teachers assigned students to reading groups based on assessments mandated by the school systems and teacher judgement. In the southeastern state, the Brigance

was used for both pre- and post-testing. The school located in the southern state used the Developmental Indicators for the Assessment of Learning-Revised for pre- and post-testing the students. The midwestern state pre-tested only those students for whom it was requested by either parents or teachers. The School Readiness Test by Consulting Psychologists, Inc. was used. All students in this state were post-tested with the Houghton-Mifflin Placement Test for Reading. The reading groups were labeled high, middle, and low.

Procedure

All students were pre- and post-tested with Replicating Geometric Shapes, the Finger Agnosia Test, the Finger Dexterity Test, and nine items on the BSSI. The pre- and post-testing were in October and May of the kindergarten school year. Reliability coefficients were obtained on these assessments with the Standardized Cronbach alpha. Non parametric Chi Square was used to analyze differences between all items on the assessments and the reading achievement groups. An analysis of variance and a t-test examined differences in the number of figures replicated by reading group. All data on age, sex, laterality preference, fine motor ability and reading groups were analyzed with descriptive statistics. Correlation coefficients were obtained on the items of the BSSI.

Results

The study started with two hundred and twenty-five students, but after matching the students who took the pre-test with the students who took the post-test, the resulting figure was 174. The results of a correlations on both a pre- and post-test of the BSSI items indicate that there was a significant relationship in the pre-test

but not in the post-test. The three finger grasp and attempt to space letters and words did not have a significant difference. Correlation coefficients were obtained for all items. (See Tables 1 and 2.)

On the pre-test for Replicating Geometric Shapes, the proportion of students who could replicate the triangle was not statistically different in the three reading groups. Of the students who were successful in each of the three groups, there is a significant difference among the groups in their success in replicating the other four shapes. (See Table 3.) The results on the post-test indicated that proportion of students who could replicate the triangle was statistically different (see Table 4). The analysis of the number of figures replicated indicated that on the average, the low reading achievement group could replicate three figures, and the middle and high reading groups could, on the average, replicate four shapes. A t-test was used to analyze the differences between the mean scores of the pre-test and the post-test ($t = -2.81$, MI = 3.8400, M2 = 4.3571, S.D.1 = .800, S.D. 2 = .762, N1 = 25, N2 = 70).

The reading groups were collapsed into two groups, the low group and the combined middle and high group for comparison of performance on the BSSI items. The low group on the pre- and post-testing had the lowest percentage of success. There is a significant difference between the groups in their success on the items of the BSSI (see Tables 5 & 6).

Three items on the post-test, print name, print from right to left, and attempt to print on line, indicated a significant difference in success among the groups on the Chi Square Analysis (see Table 6).

Finger Agnosia was compared by reading groups. The results indicated the low reading achievement group experienced less success for identifying the left index finger and left little finger (see Table 7). There is a significant difference on the post-test among groups in successfully completing the Finger Agnosia items for all fingers but one (see Table 8). There was no significant difference in groups in identifying fingers except the left thumb.

In the comparison of the Finger Dexterity Test by reading group, the pre-test did not yield any significant results (see Table 9). The post-test results indicated reading groups differed in the dexterity of the right hand in the index, middle, and ring fingers and in four fingers of the left hand. (See Table 10).

Based on additional analysis, gender, age and laterality did not appear to significantly relate to reading achievement in this study. In the high reading achievement group, 52% of the students were girls and 48% were boys. In the middle reading achievement group, 38% were girls and 62% were boys, while in the low reading achievement group, 41% were girls and 69% were boys. Results indicated no differences by gender. Age also was not a factor as students who were older (six years old) were represented in all three groups at post-testing. Finally, eighteen students were left-handed, but were found to be not significantly different from the right-handed students.

Discussion and Conclusions

Data were analyzed for each reading group on all of the informal medical assessments. The reading groups were collapsed to separate the low group from all achieving students for the BSSI. In comparing the items on the BSSI, those items

that are significant indicate that other tasks are more likely to be successfully accomplished. The low group on the post-test had lower percentages of students who were successful than those on the pre-test. This may have been due to the fact that students were moved into different groups during the school year. At the end of the year, the groups would have been stable in regards to ability level. The low group demonstrated an extreme lack in their ability to perform the tasks on the BSSI. Though all items were significant, the lowest percentage was on reproducing letters. These students, after one year in school, were struggling with producing letters and were in the lowest reading group.

The complex fine-motor action of printing letters is reported as dependent on continuous and accurate feedback. The tripod grasp is described as dynamic (Levine, 1987). The pencil must be stabilized, a firm grip is needed to keep it from slipping, and it must also be held flexibly so as to be maneuverable. The pencil must move in such a way as to impart motor feedback to the brain. Students who exhibit problems in this often develop a counter productive pencil grip which indicates they are not serial chaining their writing movements and receiving the necessary feedback which will allow them to develop automaticity in writing. In addition, problems in the area of motor memory could interfere with the ability to print letters.

Pre-testing on both the Finger Agnosia and Finger Dexterity tests did not yield any significant results. Chi Square results for the left hand indicated that two items were statistically different. This may be due to the preponderance of right handers, thus simply indicating the less strong left hand. However, post-testing with the Finger Agnosia Test illustrated a marked difference between the groups. Percentage increases of successful students in the middle and high groups were marked. Again,

poorly achieving students in reading were also deficient on the Finger Agnosia post-test for all fingers. On the post-test of Finger Dexterity, three fingers of the right hand showed a significant difference. Again, because of the large number of right handers in the group, the left hand post-test reflects a normal lack of strength.

It appears that the BSSI and the Finger Agnosia and Finger Dexterity tests do confirm some deficit in fine-motor ability in regards to printing alphabet letters. This also appears to be more evident in the poor reading group. Students with finger agnosia may rely excessively on visual feedback during writing and hold their heads close to the page. This constant need to monitor visually their finger activity decreases the speed of writing (Westman, 1990). Johnson and Myklebust (1967) state that the diagnosis of writing disorders include reading disabilities, visual memory deficits, motor disorders, and dysgraphia. Dysgraphia is defined as a visual-motor apraxia. It is interesting to note that Lindsay and Wedell (1982) have reported low to moderate correlations between a student's developmental abilities, including motor abilities, and later reading achievement.

The ability to draw geometric shapes does appear to be developmental as the students in the middle and high groups could only, on the average, reproduce four figures. In addition, not one figure was able to be replicated by 100% of the children in any reading group on either the pre- or post-test. On the results of the pre-test among the three groups, replicating a triangle did not appear significant. This may indicate that this is a difficult figure for five-year-old students to draw. However, the high group increased dramatically in their ability to draw a triangle. The middle group, on the average, increased nine percentage points above the low group on all shapes.

If the ability to purposefully draw shapes that require approximately the same type of control needed to draw letters is developmental and is below chronological ages indicated, Luria's theory of "kinetic melody" (1973) stating that much time is needed, compounds the student's problem. This theory suggests that a long period of time may be needed to learn to write adequately. It may initially involve memorizing the individual parts of each letter. This is accomplished through coordination of muscles and kinesthetic feedback. The process changes with time and practice and the letter becomes a single movement. At this point the letter is automatized, thus a "kinetic melody". It is explained as changing from a visual-motor behavior to a language and visual-motor behavior. It is possible for a breakdown to occur in any degree at any point in the process.

On a practical level for teachers, Bain, Bailet, Lyons, & Moats (1991) list four characteristics of students with problems in writing as: unconventional grip, finger very near the pencil point, difficulty in erasing, and problems with letter alignment.

Informal medical assessment can be used successfully by classroom teachers to assess fine-motor ability. It may be beneficial from two vantage points. One is that it would determine which students may benefit from practice and the opportunity to build dexterity and automaticity. Students who will be good readers may also need more practice time. In a whole language classroom, there is ample opportunity for students in the high and middle groups to practice their letters to the point of automaticity. The low group may need more structured practice time for this. The second point is that these assessments may be used to confirm that a reading deficit may be more involved than just a slight maturational lag and it may require careful study and consideration in programmatic decisions.

Gunderson states that whole language advocates believe that readiness skills need not be taught (1991). This may put students who are developmentally slow in fine-motor ability at a distinct disadvantage in the whole language classroom. It is possible that the reading-writing connection is more important than the whole language proponents realize. Just as many students are benefitting from the reinforcing connection of reading and writing, there may be those students whose fine-motor deficits are inpeding progress in reading. For these students, instructional decisions about appropriate methodology is paramount.

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Author Notes

Elaine Traynelis-Yurek is an associate professor in the Department of Education at the University of Richmond. Her teaching responsibilities include both undergraduate and graduate courses in learning disabilities and reading. At the present time, Dr. Traynelis-Yurek is chair of the Department of Education. Requests for reprints should be sent to Elaine Traynelis-Yurek at the Department of Education, University of Richmond, Virginia 23173.

Mary W. Strong is an assistant professor in the Department of Curriculum and Instruction at Iowa State University. Dr. Strong has been an elementary school principal for 20 years in Monogalia County, West Virginia. Her present teaching responsibilities include Reading and Language Arts and Early Childhood Education.

Table 1

Items on the BSSI Compared to Each Other

Pre-Test

	3 Finger Grasp (1) N = 169	Print Name (2) N = 169	Print Right to Left (3) N = 169	Copy from Card (4) N = 169	Copy from Board (5) N = 166	Attempt to Print on Line (6) N = 169	Reprod. Letter (7) N = 165	Size & Format. (8) N = 169	Attempt to Space Letters & Words (9) N = 148
3 Finger Grasp (1)									
Print Name (2)	p=.000								
Print Right to Left (3)	p=.001	p=.000							
Copy from Card (4)	p=.008	p=.000	p=.000						
Copy from Board (5)	p=.017	p=.000	p=.000	p=.000					
Attempt to Print on Line (6)	p=.019	p=.000	p=.000	p=.000	p=.000				
Reproduce Letter (7)	-	p=.000	p=.000	p=.000	p=.000	p=.000			
Good Letter Size and Formation (8)	p=.005	p=.000	p=.000	p=.000	p=.000	p=.000	p=.000		
Attempt to Space Letters andWords (9)	p=.001	p=.000	p=.000	p=.000	p=.000	p=.000	p=.003	p=.000	p=1.00

Table 2

Items on the BSSI Compared to Each Other

Post-Test

	3 Finger Grasp (1) N = 149	Print Name (2) N = 149	Print Right to Left (3) N = 149	Copy from Card (4) N = 149	Copy from Board (5) N = 149	Attempt to Print on Line (6) N = 149	Reprod. Letter (7) N = 148	Size & Format. (8) N = 148	Attempt to Space Letters & Words (9) N = 149
3 Finger Grasp (1)									
Print Name (2)	-								
Print Right to Left (3)	-	p=.000							
Copy from Card (4)	-	p=.000	p=.000						
Copy from Board (5)	-	p=.000	p=.000	p=.000					
Attempt to Print on Line (6)	-	p=.002	p=.000	p=.000	p=.000	p=1.00			
Reproduce Letter (7)	-	p=.000	p=.000	p=.03	p=.007	p=.000			
Good Letter Size and Formation (8)	-	p=.000	p=.000	p=.000	p=.000	p=.000	p=.000	p=1.00	
Attempt to Space Letters andWords (9)	-	p=.000	p=.000	p=.000	p=.000	p=.000	p=.05	p=.000	

Table 3

Replicating Geometric Shapes by Reading Groups

Pre-Test

	Students Demonstrating Success			
Shapes	Low	Middle	High	Chi Square and p Values
Circle	21.8% N = 22	36.65 N = 37	41.6% N = 42	x =11.66543 p=.00293
Crossed Lines	24.3% N = 26	35.5% N = 38	40.2% N = 43	x =6.26017 p=.04371
Square	19.8% N = 17	36.0% N = 31	44.2% N = 38	x =9.83466 p=.00732
Triangle	21.6% N = 11	31.4% N = 16	47.1% N = 24	x =3.27496 p=.19447
Diamond	15.8% N = 3	21.1% N = 4	63.2% N = 12	x =6.10672 p=.04720

Test 4

Replicating Geometric Shapes by Reading Group

Post-Test

	Students Demonstrating Success			
Shapes	Low	Middle	High	Chi Square and p Values
Circle	10.2% N = 14	21.2% N = 29	68.6% N = 94	x =15.47172 p=.00044
Crossed Lines	11.4% n = 16	20.7% N = 29	67.9% N = 95	x =7.34622 p=.02540
Square	10.2% N = 13	18.0% N = 23	71.9% N = 92	x =12.88813 p=.00159
Triangle	9.8% N = 11	17.9% N = 20	72.3% N = 81	x =6.17834 p=.04554
Diamond	5.3% N = 4	16.0% N = 12	78.7% N = 59	x =10.66417 p=.00483

Table 5

BSSI By Reading Groups

Pre-Test

Students Demonstrating Success

	Low	Middle & High	Chi Square	p Values
3 Finger Grasp	24.7% N = 24	75.3% N = 73	x =4.24297	p=.03941
Print Name	19.4% N = 19	80.6% N = 77	x =26.19656	p=.00000
Copy Right to Left	19.8% N = 20	80.2% N = 83	x =13.34618	p=.00026
Copy from Card	18.9% N = 17	81.1% N = 73	x =13.30404	p=.00027
Copy from Board	12.6% N = 11	87.4% N = 76	x =32.49068	p=.00000
Attempt to Print on Line	17.9% N = 14	82.1% N = 64	x =4.91769	p=.00282
Reproduce Letters	8.5% N = 6	91.5% N = 65	x =32.08518	p=.00000
Good Size & Formation Letters	18.6% N = 17	81.4% N = 79	x =20.19566	p=.00001
Attempt to Space Letters & Words	19.8% N = 19	80.2% N = 77	x =13.34618	p=.00026

Table 6

BSSI By Reading Groups

Post-Test

	Students Demonstrating Success			
	Low	Middle & High	Chi Square	p Values
3 Finger Grasp	9.3% N = 11	90.7% N = 107	x =4.24297	p=.03941
Print Name	4.9% N = 6	95.1% N = 116	x =38.53050	p=.00000
Copy Right to Left	6.9% N = 9	93.1% N = 121	x =33.65374	p=.00000
Copy from Card	5.0% N = 6	95.0% N = 114	x =33.79421	p=.00000
Copy from Board	2.7% N = 3	97.3% N = 108	x =38.75613	p=.00000
Attempt to Print on Line	5.0% N = 9	95.0% N = 121	x =15.06331	p=.00010
Reproduce Letters	6.7% N = 7	93.3% N = 97	x =9.26498	p=.00234
Good Size & Formation Letters	6.7% N = 8	93.3% N = 111	x =18.06076	p=.00002
Attempt to Space Letters & Words	6.8% N = 5	93.2% N = 95	x =16.62270	p=.00005

Table 7

Finger Agnosia by Reading Groups

Pre-Test

Percentages of Students Demonstrating Success

Right Hand	Low	Middle	High	Level of Significance Chi Square	p Values
Thumb	24.8% N = 26	36.2% N = 38	39.0% N = 41	x = .78935	p=.67390
Index Finger	21.1% N = 16	35.5% N = 27	43.4% N = 33	x =3.30764	p=.19132
Middle Finger	22.4% N = 15	34.3% N = 23	43.3% N= 29	x =1.39924	p=.49676
Ring Finger	22.7% N = 15	34.8% N = 23	42.4% N = 28	x = .91120	p=.61348
Little Finger	24.2% N=24	35.4% N = 35	40.4% N = 40	x =1.01097	p=.60321
Left Hand					
Thumb	22.8% N = 23	36.6% N = 37	40.6% N = 41	x =2.95590	p=.22811
Index Finger	16.9% N =	35.2% N =	47.9% N =	x =8.94418	p=.01142
Middle Finger	18.0% N = 11	37.7% N = 23	44.3% N = 27	x 3.67096	p=.15954
Ring Finger	20.9% N = 14	34.3% N = 23	44.8% N = 30	x =2.81394	p=.24488
Little Finger	20.8% N = 12	37.6% N = 28	41.6% N = 95	x =11.69093	p<.005

df = 2

Table 8

Finger Agnosia by Reading Groups

Post-Test

	Percentages of Students Demonstrating Success				
Right Hand	Low	Middle	High	Level of Significance Chi Square	p Values
Thumb					
Index Finger	7.6% N = 9	19.5% N = 23	72.9% N = 86	x =13.05186	p=.00146
Middle Finger	7.3% N = 8	18.2% N = 20	74.5% N = 82	x =12.36614	p=.00206
Ring Finger	9.2% N = 10	17.4% N = 19	73.4% N = 80	x = 7.44605	p=.02416
Little Finger	10.1% N = 10	20.9% N = 19	69.1% N = 80	x =15.73517	p=.00038
Left Hand					
Thumb	11.4% N = 16	19.3% N = 27	69.3% N = 97	x =4.77950	p=.09165
Index Finger	7.6% N = 9	17.6% N = 21	74.8% N = 89	x =18.04333	p=.00012
Middle Finger	8.0% N = 8	17.0% N=17	75.0% N = 75	x =7.44865	p=.02413
Ring Finger	8.3% N = 9	17.4% N = 19	74.3% N = 81	x 9.12466	p=.01044
Little Finger	8.9% N = 12	20.7% N = 28	70.4% N = 95	x =19.28990	p=.00006

df = 2

Table 9

Finger Dexterity by Reading Groups

Pre-Test

	Percentage of Students Who Demonstrated Success			
Right Hand	Low	Middle	High	Level of Significance p Values
Thumb	26.6% N = 30	34.9% N = 40	38.5% N = 43	p=.80284
Index Finger	26.9% N = 30	35.2% N = 40	38.07% N = 43	p=.94129
Middle Finger	25.9% N = 30	36.1% N = 40	38.0% N = 43	p=.7004
Ring Finger	25.9% N = 30	36.1% N = 40	38.0% N = 43	p=.7004
Little Finger	26.1% N = 30	35.1% N = 40	38.7% N = 43	p=.51706
Left Hand				
Thumb	26.1% N = 30	35.1% N = 40	38.7% N = 43	p=.51206
Index Finger	26.4% N = 30	35.5% N = 40	38.2% N = 43	p=.07519
Middle Finger	26.6% N = 30	35.8% N = 40	37.6% N = 43	p=.28595
Ring Finger	25.7% N = 30	35.8% N = 40	38.5% N = 43	p=.55673
Little Finger	26.4% N = 30	34.5% N = 40	39.1% N = 43	p=.51524

df = 2

Table 10

Finger Dexterity by Reading Groups

Post-Test

	Percentage of Students Who Demonstrated Success			Level of Significance	
Right Hand	Low	Middle	High	Chi Square	p Values
Thumb	11.9% N = 17	20.3% N = 29	67.8% N = 97	x=78.098	p<.01
Index Finger	11.3% N = 16	20.4% N = 29	68.3% N = 97	x=7.46396	p<.05
Middle Finger	1.8% N = 15	20.9% N = 28	69.1% N = 96	x=8.81137	p<.01
Ring Finger	10.7% N = 10	20.7% N = 19	68.6% N = 80	x=8.89367	p<.01
Little Finger	11.3% N = 16	20.6% N = 29	68.1% N = 93	x=2.48474	p=.22484
Left Hand					
Thumb	12.0% N = 17	20.4% N = 29	67.6% N = 97	x=.47757	p=.78759
Index Finger	10.6% N = 17	20.6% N = 29	68.8% N = 97	x=15.03379	p<.01
Middle Finger	10.3% N = 17	20.6% N = 28	69.1% N = 94	x=11.51266	p<.01
Ring Finger	10.1% N = 14	21.0% N = 29	68.8% N = 95	x=11.73072	p<.01
Little Finger	10.1% N = 17	20.9% N = 29	69.1% N = 97	x=15.73517	p<.01

df = 2