

Using the PointScribe Writing Program to Help Develop and Promote Handwriting among Special Needs Children

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Children with developmental and learning disabilities, such as cerebral palsy, Down syndrome, autism and attention deficit disorder, have been shown to have deficiencies with their Visual Motor Integration (VMI), and this is often reflected in minimal to a complete lack of handwriting skills. The PointScribe (PS) writing system is a total sensory approach integrated into a tablet PC that attempts to capture a child's visual attention when learning to write. This study used an advanced prototype version of the PS program that was earlier tested in a pilot study. The results from this study suggest that the PS writing program does significantly increase writing performance among children with special needs.

Many special needs children such as those with cerebral palsy, Down syndrome, autism and attention deficit disorder have been shown to have deficiencies with their Visual Motor Integration (VMI) when compared to their typical peers (Desai & Rege, 2005). This deficit is often associated with a severe inadequacy in handwriting skills. For example, DuBois, Klemm, Murchland, and Orzols (2007) performed a study which found that a majority of children with Down syndrome had difficulty with writing, particularly in the areas of functional writing skills such as organization, legibility, accuracy, and speed). Interestingly, this study revealed that boys had significantly more trouble than girls in these specific areas of writing. Over the past few decades, occupational therapists (OTs) along with educational researchers have investigated the effects of assistive technology as an intervention to these writing deficiencies among children with special needs. Educational researchers have also been interested in exploring secondary factors thought to contribute to poor motor skills, lack of motivation, and lack of attention.

Past studies have illustrated the effects and value of computer technology in helping specific populations of learning disabled children. For instance, Heimann, Nelson, Tjus, and Gillberg (1995) found a significant improvement in reading and communication skills in preschool children with autism through an interactive multimedia computer program. In addition to the autistic children, improvements were also found in children with a variety of learning disabilities as well as with their typical peers. The computer program incorporated on-screen animations and videographic material that provided immediate feedback in order to help maintain the visual attention of the child.

Another study examined the contribution of computer-based instruction on early reading skills in preschool children at high risk for learning disabilities (Mioduser, Tur-Kaspa, & Leitner, 2000). Their results indicated that the group that received the computer intervention significantly improved their phonological awareness, word recognition, and letter naming skills compared to their peers that did not receive the computerized reading intervention. Educational researchers also concluded that the use of a touch-screen computer coupled with sound was of optimal value when producing these results. Additionally, the computer interaction seemed to benefit not only these specific skills, but it also seemed to benefit the children's motivational and confidence levels.

Parette, Hourcade and Heiple (2000) also found other non-technical benefits to the importance of structured computer experiences for young children. Their compilation of past research showed that computers and appropriate software can enhance opportunities for inclusion by providing opportunities for children with disabilities to interact with their typical peers on group computer activities. This has been proven to be a great socialized activity where children with all types of backgrounds, disability or not, can learn together.

Not only have researchers found tangible benefits to computer assisted education for children with special needs, but the children themselves also seem to prefer the computer methods. Vaughn, Schumm and Gordon (1993) based their research on the fact that elementary school students rank using computers as one of the instructional activities they enjoy the most. Lahn (1996) found that preschool children preferred software programs with higher interaction requirements, especially programs that used animation, sound, and voice features when compared to more static programs from earlier generations. Children with disabilities seem to be very compliant and engaged when working with the computer programs. This not only makes learning fun for the children but also simplifies the tasks for the OTs and all of those involved with the learning technology.

The present study

The PointScribe (PS) writing program is an innovative technology that promotes a total sensory approach incorporating touch, sight, and hearing to help captivate a child's attention when learning to write, especially those with learning disabilities. The PS software was developed by computer science students at the United States Air Force Academy and has undergone recent renovations. The PS software uses a stylus tablet PC to allow for hands-on interaction by the student. A previous study with the initial version of the software showed significant results for the group receiving the PS intervention as they achieved significantly higher gain scores than the control group who did not receive the PS intervention (Yip, Katayama & Stewart, 2007). Although it was found that the children in the PS condition actually took longer to complete tasks than the control group, this can be attributed to capturing the children's attention and motivation for a longer period of time.

The purpose of the present study was to follow up the previous study with a more integrated version of PS. The newer version used in this study had more feedback options (e.g., positive and negative reinforcement feedback), more personalized options (e.g., themes, color schemes, music) and more writing templates (e.g., all capital letters, lower-case letters, numbers 0-9, shapes). The updated program also allowed the OTs to create their own shapes and save it to the library for future practice with an individual child. Because the results of the pilot study suggested that the PointScribe program may have distinct advantages over the paper-and-pencil method, the authors of this study chose not to exclude any child from the intervention in this study in order for them to gain all the potential benefits from the program (Yip, Katayama, & Stewart, 2007). Therefore, a comparison group was not used as part of the design of this study. A pre-and-posttest design was used to assess gain scores on both the hard copy writing tests as well as the computerized PS tests. The research team was interested in measures of accuracy, attention, and time from the pre-and-posttests for each student in the study. In essence, each child served as their own control. The authors of this study were interested in investigating if there would be increases on all three measures (accuracy, attention, time). Finally, the authors were interested in testing if there would be some gender differences between the gain scores.

Method

Participants

Sixty-seven special needs (Down syndrome, ADHD, developmental delay, and autism) preschool and elementary school children, ages 3 to 8 participated in this study. Administrative approval was obtained from the director of special education programs at each of the participating school districts and parental consent forms were signed before any child could take part in the study. In addition, for the purpose of this study each child had to have an Individual Education Program (IEP) and had to score below a 70% on PointScribe pretest to be included in the present study. Further, each child needed to have at least two hours of contact with an OT per week as prescribed in their IEPs. A total of 16 OTs from five different school districts participated in the study. Certain students' data were not included in the study because their pretest scores were too high; however they were still allowed to use the PointScribe program with their OTs to work on their psychomotor skills.

Each participant was given a code as a safeguard to protect anonymity as much as possible. A standardized coding process was used whereby participants were coded by the students' first and last initials, a 2-3 letter school code, and a 2 digit district code that corresponded to each school. For example, DY-KL-20 would indicate that "DY" was the students' initials, "KL" would represent the school, and "20" would indicate the school district. Only the occupational therapists (OTs) and the paraprofessionals working with the students had the computer login and password to access the PointScribe program and data, thereby providing an additional safeguard for student confidentiality.

Materials

Facilities. The testing facilities varied according within and between each school district. Some schools would utilize “resource rooms” while others utilized a “special needs classroom.” However, the commonality between all the rooms was that they were separate from the regular classrooms.

PointScribe Software. The initial prototype of PointScribe was developed by computer science majors at the United States Air Force Academy. In the year leading up to the present study, the program had undergone several renovations by two computer software engineers: one was the original developer and is now a First Lieutenant in the United States Air Force, and the other was a volunteer commercial software expert. The version used in this particular study was beta version .92 and was written in Java script language. The program could only be used with a PC computer operating in Windows XP. The stylus tablet PC was essential for this program because the display surface also functioned as the writing surface. The PS program was easily personalized for each student in the program (see Appendix A). Within the program were various lessons that help the student practice lines, shapes, letters, and numbers. The OTs were able to personalize the lesson to each students’ needs and abilities by adjusting the theme (e.g., baseball) the colors (e.g., black background with orange shapes), the tolerance of the shape (how wide the margin of error allowed), and the sound (e.g., “take me out to the ballgame”). When the student touched the stylus at the starting point, the music and animation were initiated. As long as the student stayed within the tolerance band and did not lift the pen from the screen, the music would continue playing. If the student successfully completed the task, they were rewarded with positive reinforcement sounds such as fireworks, applause, clapping, etc. However, if the student lifted their pen off the screen, stopped the exercise, went backwards with their pen, or went outside of the tolerance band, the music stopped playing, a negative yet constructive sound was played such as an “aaaw” or “try again” and the lesson went back to the beginning. Each stroke that the student made appeared on the screen until the lesson was completed or terminated, thus providing additional feedback for the student to “see” their work without the tolerance bands. During the practice sessions OTs were allowed to give their students as many repetitions as they deemed necessary as long as the students were willing to participate.

During the testing sessions, the theme and positive reinforcement were randomly selected. The tolerance band was standardized for all repetitions at four inches. Once the students’ code was entered into the program for the testing session to begin, the OT was then given one repetition to demonstrate the shape for the student. Then the student was allowed one practice trial before the actual testing session began. During the testing session, the student was given five trials in which the student’s accuracy, average time to complete each shape, and error type (i.e., going outside the boundaries, going backwards, or lifting the stylus off the screen) was recorded and stored on the computer. Subjective data such as attention rating by the OT, and each student was feeling the day of the test was handwritten into a study log that would later be collected by the researchers. The information was then coded as a Microsoft Excel document and emailed to the researchers for data compilation. Once all the data was gathered, it was formatted into SPSS version 14.0 for further analysis.

Tablet PC. A private grant through FalconWorks helped us with the purchase of 14 Toshiba Satellite R-10 and R-20 Tablet PCs for the participating schools. Due to the limited supply of the tablet PCs available, they were allocated according to the number of children in each school district and the need that each district had based on the input provided to us from the OTs. Prior to the study, the PointScribe software was loaded onto the computers and tested for proper functionality by the software developers and the researchers.

Pencil and Paper Test. A pencil and paper test was developed in conjunction with the OTs in order to best assess the handwriting progress of the students. The shapes and letters used in the tests were recommended by the inputs provided by the OTs. In total, there are eight different shapes and three letters of the alphabet, each consisting of five trials. The shapes included were: vertical lines, horizontal lines, diagonal lines, circles, triangles, squares, and crosses. The letters included were: “C”, “L”, and “M.”

Scoring Rubric. The pencil and paper test was scored using the Test of Visual-Motor Skills-Revised Alternate Scoring Method (TVMS-R) (Gardner, 2004). Additionally researchers composed an additional rubric for scoring the items that were not included in the TVMS-R (straight lines and letters) The TVMS-R is a common assessment tool used in public schools that provides researchers a way of assessing a participant’s ability to “translate with his or her hand what he or she visually perceived” (Gardner, 2004, p. 24). The TVMS-R provides a numerical score to geometric designs based on eight classifications of errors including: (1) Closure (lines overextended or under extended); (2) Angles (rounded, dog-eared, degree change, greater or less than allowable, added, omitted); (3) Intersecting and/or overlapping individual lines (penetrate, under extend, unequal extensions); (4) Size of design or part of design (modified, smaller, larger, longer, shorter); (5) Rotation or reversal (design or part of design); (6) Line length (unequal, longer, shorter); (7) Over penetration, under penetration; (8) Modification of design (changes in shape, missing part[s], added part[s]).

Reliability for this test was calculated in two ways. The first utilized the Kuder-Richardson reliability formula and yielded a KR-20 score of .84. The second method calculated Cronbach’s alpha of .90. Both measures are deemed to be dependable estimates of inter-rater reliability (Gravetter & Forzano, 2005). The rubric produced by researchers follows the design and the point scale of the TVMS-R (see Appendix B for rubric).

Design and Procedure

This study used a mixed-model design. Students were all given the same pre-test, provided the same PointScribe intervention, and then given the same post-test. Scores were compared from pre and post intervention thereby allowing for a within-subjects design to be utilized. Between-group comparisons were also used to detect differences between male and female participants.

Data Collection. The design of this study is similar to the initial PointScribe study. Prior to all testing and instruction of the students, several training workshops were conducted to educate the OTs on how to instruct the students using the PointScribe program and the tablet PCs. Once the

OTs were comfortable with the software and hardware, they were instructed to administer the pencil-and-paper pretest as well as the PointScribe pre-test. All pencil-and-paper pretest were delivered to the researchers either by mail or pickup for scoring. PointScribe pretest data were then transmitted to researchers via internet. For this transmission, some OTs were able to transmit directly from their respective school while others had to take the PC with them to a different internet connection to transmit the data due to school firewalls or lack of school internet connection. The authors discuss these and more limitations later in the discussion portion of this paper.

Once pre-testing was completed, the OTs were instructed to initiate the PointScribe intervention. The intervention period of approximately eight weeks consisted of each student using the PointScribe writing program approximately four times a week with their OT. At the conclusion of the intervention, all of the OTs were responsible for personally administering the pencil-and-paper as well as the PointScribe pre and posttests. The posttests were delivered to the researchers in the same manner as the pretests.

Results

All data were coded and entered into SPSS version 14.0 for analysis. A total of 67 data sets were entered (65 were complete sets). Of the sample 60% were male and 40% were female. The most common learning disabilities among the special needs participants were autism (16.4%) and developmental delays (14.9%) whereas hydrocephaly (1.5%) and primary communication disorders (3.0%) made up the least common disabilities among our sample. Table 1 presents the breakdown of the categories of disabilities among our sample.

Our first prediction was that there would be an increase in accuracy between the pre-and-posttests. Table 2 presents the ANOVA results of the gain scores between the PointScribe pre and posttests, $F(1, 65) = 5.165, p = .026$. The posttest scores on PointScribe ($M = 41.56, SD = 18.51$) were significantly higher than the pretest scores ($M = 50.94, SD = 20.31$). Table 3 presents the dependent t -test results for the gain scores on the hard copy tests. Students also achieved significant gain scores on the hard copy tests as well, $t(67) = 16.387, p = .000$. Scores on the hard copy posttests ($M = 41.61, SD = 20.05$) when compared to their scores on the hard copy pretests ($M = 36.69, SD = 18.33$).

Our second prediction was that there would be an increase in attention rating from pretest to posttest. Table 4 shows the average attention gain on PointScribe from pre to posttest, $F(1, 65) = 1.791, p = .185$. There was no significant increase between the two tests.

Gender Differences

The next hypothesis involved investigating performance differences between genders. The amount of practice time allotted to males ($M = 12.93, SD = 2.77$) vs females ($M = 12.19, SD = 1.66$) was not significantly different nor were other factors as shown in Table 4. However, there was a significant difference in the gain scores on the PS program. Among the sample, females obtained higher gain scores ($M = 12.01, SD = 7.62$) than the males ($M = 7.43, SD = 8.40$).

Correlations

In addition to the stated hypotheses concerning differences between tests, the authors were also interested in investigating a number of correlations among the variables. This is an important investigation because there is limited evidence in the literature about the motivation and attention factors and how they relate to performance outcomes among special needs children (Desai & Rege, 2005; Dubois et al, 2007). As the authors predicted, there was a significant positive correlation between attention ratings on the hard copy pretests and the scores on the hard copy pretest, $r(67)=.33$, $p=.00$. A significant positive correlation was observed between attention ratings on the hard copy posttest and the scores on the hard copy posttest, $r(65)=.34$, $p=.00$. On the PS tests, the authors also found support for our prediction of a significant positive correlation between pretest attention ratings and pretest scores, $r(67)=.59$, $p=.00$. There was a significant positive correlation between the PS posttest attention ratings and posttest scores, $r(67)=.52$, $p=.00$. Likewise, there was a significant positive correlation between posttest attention scores and overall -gain scores on the posttest, $r(67)=.42$, $p=.00$. There was a positive correlation between overall average attention gains on and overall -gain scores on the PointScribe program, $r(67)=.409$, $p=.00$.

Regarding the relationship between practice sessions, cumulative time spent practicing writing with the PS program and gain scores the study provided support for both predictions. The number of practice sessions was significantly correlated with gain scores on PS, $r(67)=.574$, $p=.00$. Cumulative practice time (in minutes) was also significantly correlated with gain scores on PS, $r(67)=.35$, $p=.004$. However, there was a negative correlation between average practice time per session and gain scores on PS, $r(67)= -.25$, $p=.04$. This was due to the great variation of time per session. Finally, although not statistically significant at the .05 level, a positive correlation was found between gain scores on PS and gain scores on hard the copy tests, $r(65)=.228$, $p=.068$. Overall, it appears that the more frequent students were exposed to the PS program, the greater their gain scores on the PS program.

Discussion

A main reason for performing this study was to build upon the previous pilot study using PS and continue to investigate its effectiveness when OTs are given the opportunity to modify and personalize the program to meet each students' writing needs. A few minor differences were made in this study compared to the pilot study (Yip, Katayama, & Stewart, 2007). The main difference in the present study from the pilot study was that each child was allowed to experience the benefits from the program. This decision was made with the knowledge that students in the pilot study did significantly improve their writing abilities with the PS program when compared to the control group. Therefore, the authors felt an ethical obligation to not withhold the benefit from any child in the present study. As a result, a comparison group was not used in this study. Additionally, the program underwent a few substantial modifications to make the program more customizable for each child. Throughout the study, the authors wanted to see if the improvements to the PS program would help with overall accuracy in writing. As the results

indicate, there were significant gains scores on both the hard copy and PS tests. The authors also investigated the effects of attention on between pre and posttests. Although there was an increase in attention, it was not statistically significant. The authors were also interested in looking specifically at performance and attention differences between males and females. Consistent with previously mentioned research (Dubois et al., 2004), the females seemed to outperform their male counterparts as evidenced by their gain scores being significantly higher than the males. Even though the average attention gain on PS and gains on the hard copy were also higher for females, they were not statistically significant. These results also confirm the results in the previous research (Hernandez, Field, Largie, Mora, Bornstein, & Waldman, 2006).

Limitations in the Present Study

As with any research, there were a number of limitations in this study. The first limitation was with the technology itself. The technical team in this study inevitably encountered a few bugs in the software that required software “patches” to remedy. The fix on these bugs were troublesome and required a fair amount of work and time to get all 14 computers running the way they were supposed to. Once the patches were installed, the program seemed to work fine.

Second, there was such a wide range of learning disabilities associated with the participants that the outcomes could be completely different for different disabilities. Although an investigation of the effects on each population would have been beneficial, there were not a significant amount of children in each special needs category to gain a true understanding of the effects on specific disability. The number of participants in this study was a fairly small number (n=65), especially when compared to the previous study which had over 100 participants. Therefore, as with many small-scale studies, this study could certainly benefit from a larger sample in terms of detecting statistically significant results between disability categories.

Third, the variation of time exposed to the program for each child varied substantially. This is natural however, because each child’s IEP is also varied for their time in occupational therapy. Regarding the OTs involved in the study, a fourth limitation was that there appeared to be a considerable degree of variance among the therapists helping us with this study. Although much of this was beyond the control of the study, the authors did observe distinct differences across the sample. As a precursor, in order to minimize variation in therapist teaching techniques, standardized training sessions were held for all the therapists at the beginning of the eight week study. However, due to unforeseen circumstances, a few therapists were unable to attend the initial training and therefore had to rely on another therapist at their school to provide them with the training. This in itself could have led to small differences in protocol implementation.

After the study, it was noted by the authors that while some therapists were able to work more exclusively with the children on a weekly basis, others had to rely on paraprofessionals or classroom aides to work with the children. A third area in which the therapists varied was in their “comfort level” with technology. For some of the OTs, not only was it a “new” technology to

work with but a new pedagogy of teaching writing. According to the feedback received after the study, it appeared that while some OTs were quite comfortable using the stylus and tablet computers, other OTs were somewhat uncomfortable. Another limitation that was not controlled in the study was the physical setting in which the testing took place. For example, some schools had a special technology room or a special education room where the PS program was set up whereas other schools used the PS computers in the proximity of the classroom (e.g., adjoining room next to the classroom). Although these rooms varied from school to school, the common factor was that all the testing took place in rooms that were separate from the regular classroom where the students normally learn.

The authors of this study hope that these limitations can lead to future investigations on much larger participant pools having a common disorder. These investigations can potentially show if the PS program is more adept at helping certain children over others (e.g., visual attention disorders). Overall, a future study would benefit by teasing out the software bugs completely before implementation, increasing the sample size (to help detect differences between sub-samples), standardizing the time that each child has practicing PS, reduce OT variation by implementing a day-long formal training to help everyone become more comfortable with the software and hardware, and controlling the training and testing environments better.

In conclusion, there is considerable evidence in both this study and the pilot study that the PointScribe writing system is beneficial to children with learning disabilities in developing their handwriting abilities. Getting these children to have high attention scores and a sense of motivation to engage in the program is a success in itself. However, it is only the beginning steps, but if they do indeed enjoy and benefit from working with the PointScribe program, then the chances for them to build the foundations of writing are greatly improved. With additional feedback and improvements, this system can continue to help children with disabilities increase their learning motivation and writing skills.

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Table 1.

Breakdown of Primary Diagnoses

<u>Primary Diagnosis</u>	<u>Frequency</u>	<u>Percent</u>	<u>Cumulative Percent</u>
ADD/ADHD	6	9.0	9.0
Autism	11	16.4	25.4
Cerebral Palsy	3	4.5	29.9
Developmental Delay	10	14.9	44.8
Down Syndrome	6	9.0	53.7
Hearing Impairment	3	4.5	58.2
Hydrocephalus	1	1.5	59.7
Multiple Developmental Delay	3	4.5	64.2
Other (preschool, IEP pending)	8	11.9	76.1
Other Disability (un-specified)	3	4.5	80.6
Primary Communication Disorder	2	3.0	83.6
Speech & Language Disorder	3	4.5	88.1
Significant Limited Intellectual Capacity	4	6.0	94.0
Visual Attention Deficit	4	6.0	100.0
Total	67	100.0	

Table 2.

ANOVA Gain Scores on PointScribe Posttest

		Sum of		Mean		
		Squares	df	Square	F	Sig.
Gain Scores on PointScribe Posttest	Between	338.469	1	338.469	5.165	.026
	Groups					
	Within Groups	4259.862	65	65.536		
	Total	4598.331	66			
Average Attention Gain on PointScribe	Between	650.354	1	650.354	1.791	.185
	Groups					
	Within Groups	23597.47	65	363.037		
	Total	24247.76	66			
			1			

Table 3.

Attention Score Gain on Hard Copy Posttest

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Pretest Score (Hard Copy)	16.387	66	.000	36.68806	32.2179	41.1582
Posttest Score (Hard Copy)	16.728	64	.000	41.60769	36.6386	46.5768

Table 4.

T-Test of Gender Differences

	t	df	Sig. (2-tailed)	Std. Error Difference
Gain scores on Hard Copy posttest	-.145	63	.885	1.85527
Average Attention Score Gain on Hard Copy Test	1.148	62	.255	3.29835
Gain Scores on PointScribe Posttest	-2.273	65	.026	2.01635
Average Attention Gain on PointScribe	-1.338	65	.185	4.74571

Appendix A

PointScribe Screenshot



Practice Mode

Session Settings

Student: [Create/Edit Student](#)

Tracking Mode:

Repeats:

Graphics Settings

Theme:

Background Color:

Character Color:

Ink Color:

Shape Settings

Shapes

- Capital A
- Capital B
- Capital C
- Capital D
- Capital E
- Capital F
- Capital G
- Capital H

[Create New Shape](#)

Character Size:

Skill Level:

Time Limit:

Sound Settings

Background Music:

Positive Sound:

Negative Sound:

[Start Practice Session](#) [Main Menu](#) [Save Current Settings](#) [Load Saved Settings](#)



Appendix B
Grading Rubric

Design: Straight Lines (Vertical, Horizontal, and Diagonal)

Score 3

No score 3 may be recorded for this design

Score 2

Lines are on the dotted lines for the majority of the pattern

Score 1

Lines are on the dotted lines for part of the design

Score 0

Lines are not on the dotted lines or only intersect the dotted lines throughout the pattern

Design: Letters (C, L, and M)

Score 3

Lines are on the dotted lines for the entire pattern, very few deviations can exist

Score 2

Lines are on the dotted lines for the majority of the pattern

Score 1

Lines are on the dotted lines for part of the design

Score 0

Lines are not on the dotted lines or only intersect the dotted lines throughout the pattern