

Study of Pre-Handwriting Factors Necessary for Successful Handwriting in Children

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Abstract—Handwriting is essential to academic success; however, the current literature is limited in the identification of pre-handwriting skills. The purpose of this study was to identify the pre-handwriting skills, which occupational therapy practitioners deem important to handwriting success, as well as those which aid in intervention planning. The online survey instrument consisted of 33 questions that assessed various skills related to the development of handwriting, as well as captured demographic information. Both occupational therapists and occupational therapy assistants were included in the survey study. The survey found that the respondents were in agreement that purposeful scribbling, the ability of a child to copy (vertical/horizontal lines, circle, squares, and triangles), imitating an oblique cross, cognitive skills (attention, praxis, self-regulation, sequencing), grasp patterns, hand dominance, in hand manipulation skills (shift, translation, rotation), bilateral integration, stabilization of paper, crossing midline, and visual perception were important indicators of handwriting readiness. The results of the survey support existing research regarding the skills necessary for the successful development of handwriting in children.

Keywords—Development, handwriting, occupational therapy, visual perceptual skills.

I. INTRODUCTION

OCCUPATIONAL therapy practitioners have an important role while practicing in a school-based setting. According to the American Occupational Therapy Association (AOTA) [1], therapists are responsible for supporting academic outcomes such as reading and writing, as well as non-academic outcomes such as self-help skills. Therapists are concerned with the active participation of their clients across a variety of settings, not only in school but at home and during extracurricular activities [1]. An important function of occupational therapists, mentioned above, is to remediate academic difficulties such as handwriting. This poses the question: “What types of pre-handwriting skills are necessary for the development of successful handwriting in children?” Also, “What skills do occupational therapists perceive as the most essential to the development of successful handwriting?”

Current research explains that 31% to 60% of a student's academic day in elementary school is spent on fine motor tasks, such as handwriting [2]. Thus, the acquisition of handwriting skills is vital to a child's successful educational

performance. The connection of the occupational therapist and handwriting in the school setting is one of many facets. Therapists traditionally use a direct approach in determining the needs of a specific client, coupled with intervention sessions outside of the regular classroom [3]. Therapists in a school-based setting work with a variety of disciplines, as well as with the client and their families, in order to improve participation in daily occupations.

School age children are eligible to receive occupational therapy services when certain circumstances or difficulties arise [4], such as if the child were to experience difficulties with handwriting. Handwriting is an important skill to learn, not only for the occupation of education, but also for many other areas of occupation, such as play, leisure, and social participation. For most children, learning to read and write can be considered a “rite of passage” that promotes independence. It encompasses a variety of skills including motor function, cognition, and visual perception, in order to be carried out. Yet, handwriting is an activity that for some is difficult to master. While teachers are the primary instructors for handwriting, occupational therapists evaluate children to determine underlying pre-handwriting skill deficits that could possibly interfere with the successful development of handwriting [3].

II. LITERATURE REVIEW

Children begin to attempt writing by scribbling, which occurs by the age of two [5]. While early scribbling may lack features of traditional writing, literature suggests that scribbling that is purposeful actually contains common elements necessary for the formation of letters, such as directionality [6]. At the age of two, children begin imitating vertical lines, six months later they proceed to horizontal lines, and finally moving to circles at age three [7]. Trying to reproduce or imitate a perpendicular line or cross typically emerges at age four, followed by a square at five years, and finally a triangle six months later [7]. The ability to first imitate and then copy such geometric shapes, as well as the ability to cross midline seen when making a cross, are important indicators of preparedness for writing [7]. Appropriate prerequisite skills are necessary to prevent discouragement and the development of poor handwriting habits that can be difficult to eliminate [8].

The ability of the child to copy the first nine forms (vertical line, horizontal line, circle, cross, right oblique line, square, left oblique line, oblique cross, and triangle) on the Developmental Test of Visual-Motor Integration (VMI) is a great indicator and predictor of a child's ability to copy more

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letters [9]. Recommendations of appropriate instruction state that the child should not receive handwriting remediation until the oblique cross is mastered [10]. Naidoo, et al. [10] further reported that the VMI is a helpful tool in evaluating handwriting readiness and reported a significant correlation between VMI scores and letter formation.

Fine motor skills are one of the most important elements a child needs to have for successful handwriting. The maturity of grasp patterns contributes to competence in the use of a writing utensil [11]. Younger children tend to have immature grasp patterns because of the difficulty in finger isolation and grading movements of the hand [7]. These difficulties encourage compensation strategies in order to stabilize their writing utensil, ultimately leading to an incorrect grasp pattern. Four grasp patterns are described in the literature as being conducive to writing. These are dynamic tripod, dynamic quadrupod, lateral tripod, and lateral quadrupod [11]. As we age, our grasp becomes more dynamic, often moving from the conventional tripod grasp into something of our own creation. The movement of joints is seen to be most functional via the dynamic tripod grasp, due to its lack of laxity at the joints [12]. In many cases children with poor handwriting had laxity at their distal interphalangeal joint of the index finger and the interphalangeal joint of the thumb with passive extension of 30 degrees or greater [12].

Finger function has a substantial role in the acquisition of writing [13]. One major fine motor skill involving finger function is in hand manipulation. In hand manipulation is essential to the development of handwriting because it allows the writer to move the writing utensil if necessary to erase or adjust. In hand manipulation is “the process of adjusting objects within the hand after grasp” [7, p313]. In hand manipulation includes translating, shifting, and rotating an object, all of which are achieved at different periods of development from 12 months to roughly 7 years of age [14]. Other studies support this time frame for in hand manipulation, observing that six year olds show continued development and room for growth [2]. The first emergence of in hand manipulation appears at 12 to 15 months of age, as seen in finger to palm translation when an infant picks up an object with the fingers and moves it to the palm of their hand [15]. A more complex skill for the child is palm to finger translation due to the need to isolate and control the thumb [15]. Palm to finger translation and simple rotation are observed in children 2 to 2.5 years of age, whereas complex rotation occurs around 2.5 to 3 years with moderate difficulties [15]. Children in the age range of 3.5 to 5 years are able to shift a writing instrument into an ideal position for writing, however prior to this age, shift is relatively inconsistent [15].

Motor function, such as the stabilization of paper, involves larger muscle groups thought to have an impact on successful writing [16]. In a study by Naider-Steinhart and Katz-Leurer [16] contraction of the trapezius muscle of the shoulder and the thumb muscles were measured and recorded via EMG in order to determine if there were any correlations between proximal and distal muscle activity. Results found that the

more diverse the writing task, the more variable the muscle activity became in both the shoulder and thumb region [16]. Although proximal muscles displayed less variability than the distal muscles, no statistically significant relationships were found with quality of writing and muscle activity [16]. Handwriting necessitates the ability to perform asymmetrical movements in order for the child to stabilize the writing material with their non-dominant hand; therefore, bilateral integration is a skill essential to the development of handwriting [18]. Bilateral integration is defined as the ability “to perform symmetrical or asymmetrical movements of the body during an activity” [16, p313].

Hand preference or hand dominance is an essential aspect in the development of fine motor skills and can later impact areas of education, such as handwriting [17]. A child’s inability to cross the midline of the body is an indicator that the child may lack hand preference. The promotion of hand dominance can be achieved by “encouraging activities that utilize the upper extremity in crossing midline” [17, p5].

Children with mild motor difficulties are one of the most frequently served populations in school-based occupational therapy. Mistakenly noted as “clumsy” these children often have impairments such as dyspraxia, developmental coordination disorder, and dysgraphia [18]. Regardless of the specific diagnosis of disability, a child’s skills are likely to be impaired [15]. Some skills that are noticeably affected are “isolation of movements, poor grading of movements, insufficient force to attain adequate grasp patterns, poor timing of movements, limited variety of movement patterns, bilateral integration, and trunk stability” [15, p292]. These skills are integral parts of developing successful handwriting during the school years.

Since handwriting is a complex process, children not only need motor skills to be successful, but must also coordinate a variety of cognitive and visual tasks. Handwriting is taught primarily through copying letters and words, which involves visual motor integration [19]. However, very little is known about how the visual and motor systems work in the handwriting process [19]. Maldarelli, Kahrs, Hunt, and Lockman [19] utilized eye-tracking technology to gain a better understanding of the role that the visual system plays during this complex phenomenon. Children were found to ‘re-fixate’ on a visual stimulus several times while completing a handwriting activity making them less mechanically fluent when compared to adults. The study by Maldarelli et al. [19] revealed that successful handwriting can only be attained when certain skills, such as the visuomotor process, are mastered.

Copying letters and symbols is thought to engage higher executive functions of the brain involved in the processes of self-regulation, attention, impulse control and working memory [20]. Motor learning is “a set of internal processes associated with practice or experience leading to relatively permanent changes in the capability for motor skill” [21, p264]. Therefore, motor learning is an essential skill to the acquisition of handwriting.

Perceptual-motor processes and cognitive skills are foundational components of handwriting [22]. Perceptual-motor skills in handwriting include the ability to perceive visual or auditory information and integrate fine motor and visual-motor input. Cognitive skills, on the other hand, include planning and memory. The ability to know and recall a letter, such as remembering the shape, name, and sound of the letter, are important skills to the development of handwriting [23]. Absence or impairment of perceptual-motor processes and cognitive skills results in poor quality, slow speed, and illegibility of handwriting [22].

The ability to integrate the visual image of letters or shapes, along with the appropriate motor response, is a construct we see in the development of handwriting [24]. Children with slow and normal handwriting reacted to handwriting needs through different perceptual-motor systems [25]. Tseng and Chow [25] found that children with normal handwriting speed relied on upper-limb speed and dexterity, whereas children with slow handwriting responded better to interventions that incorporated memory and visual-motor integration skill development. Children with slow handwriting may benefit by concentrating on improving memory for visual form and sequence [25].

The development of adequate perceptual-motor and cognitive processes contributes to successful handwriting [26]. Praxis is the “ability of the brain to conceive of, plan, organize, and carry out a sequence of unfamiliar motor actions and enables adaptive interaction with the environment” [26, p555]. While ideation, a fundamental concept of praxis, is the “cognitive ability to conceptualize and generate motor actions” [26, p.555]. Furthermore, Ivey, Lane, and May-Benson [26] reported that poor motor praxis skills often result in difficulties with motor planning, motor coordination, and ideation.

Successful handwriting is achieved after the development and integration of perceptual-motor performance components, such as kinesthesia, motor planning, eye-hand coordination, and visuomotor integration [27]. Kinesthesia and proprioception impact pencil grasp, the force exerted on the writing instrument, the directionality of letters, and the ability to write within boundaries, making them important components to the development of successful handwriting skills [7]. Visual perceptual skills, such as “visual-motor integration, visual closure, visual memory, and form constancy,” are skills necessary to the development of handwriting [7, p314]. Feder and Majnemer [7] defined visual closure as the ability to identify if a letter has been completely formed and form constancy as the ability to discriminate between similar letters. Visuomotor integration is essential to the success of handwriting skills because it greatly influences “one’s ability to copy and transpose text” [27, p734].

Motor planning “influences the child’s ability to plan, sequence, and execute letter forms and ordering of letters in words” [7, p314]. Similarly, emphasis on motor planning as a performance component of handwriting is seen to impact “letter planning, letter sequencing, and letter formation” [27, p733]. Forming and producing letters necessitates prerequisite

skills of planning, sequencing, and executing the required movements necessary to write letters, which is preceded by writing words. Sequencing skills are necessary for successful handwriting. For a child to be successful in handwriting, he or she needs to know his or her birth date, days of the week, and other information that requires sequential memory since writing letters is ultimately a sequence of movement patterns [23]. In the beginning stages of writing, sequencing is especially important because the child is required to know, memorize, and execute each smaller movement to write a letter [23].

In the occupations of children, handwriting is one of the most important. Handwriting plays a vital role in effective personal communication and successful academic achievement. Having the ability to write is a source of self-esteem as well as a key way that a child can succeed in school [7]. Children are often referred to occupational therapy services to help restore function when difficulties are noted in this area. Occupational therapy practitioners implement many strategies in order to help children in resolving these difficulties [15]. Many factors play an important role in assuring student success in handwriting, including the identification of prewriting skills that are not yet present, but important to the attainment of successful handwriting in school. Therefore, more consistent research on the identification of prewriting skills is necessary to ensure appropriate remediation by occupational therapy practitioners.

III. METHOD

The research design utilized a mixed method descriptive survey with both a qualitative and a quantitative approach. The study was completed by three graduate students, in conjunction with their faculty research committee chair, interested in research about pre-handwriting skills.

A. Participants

The participants of this study included Certified Occupational Therapy Assistants (COTAs) and Registered Occupational Therapists (OTRs). The participants had at least one year of experience working with the pediatric population who have difficulties with handwriting. The authors contacted the American Occupational Therapy Association (AOTA) to recruit a random purposive sample of occupational therapists and occupational therapy assistants. Upon discovering that email information is not distributed by AOTA other options were explored. Social networking websites, such as Facebook and Twitter, were used to inform respondents about the availability of the survey. Another method of recruiting participants was by searching Intermediate Unit websites and contacting directors of special education, as listed on the websites. Supervisors of occupational therapy services were also contacted. Personal contacts with a background in pediatric occupational therapy were emailed an invitation to participate in the research survey. Also, Board of Education and Department of Education members were contacted to distribute email lists and contact information about current occupational therapy practitioners in their specific districts.

Once obtained, this contact information was used to distribute the survey link in hopes that respondents would participate in the survey.

B. Instrument

The study utilized an internet-based survey that was posted on the Web using Survey Monkey. The survey was developed in several stages. An initial draft of the survey was created based on information obtained from previous studies that investigated different skills needed for pre-handwriting success. A draft of the survey was sent to a pilot group, which reviewed the survey and provided validation, as well as comments and suggestions, to better implement this topic. The survey included demographic information questions and questions pertaining to the topic investigated.

The survey collected the following information: demographic characteristics of the respondents and a Likert scale rating of the importance of certain skills necessary for developing successful handwriting. Motor, cognitive, and visual perceptual skills were also addressed in this fashion. Demographic information included age, gender, geographic location, level of education, years of experience, practice setting, and areas of board certification. Open-ended questions were utilized to describe any additional skills occupational therapists felt were important factors in the development of handwriting. The survey became available Wednesday, August 5th, 2015. The survey was left open for approximately six weeks. Closing of the survey took place on Wednesday, October 19th, 2015.

C. Procedure

Prospective respondents received initial invitation by email to participate in the survey after searching for contact information. Respondents were also sought via social networking websites, such as Facebook and Twitter, and information was posted on each of the 50 states occupational therapy web pages, as well as the AOTA webpage, respectively. The PA Board of Education was asked to provide contact information regarding practicing occupational therapy practitioners throughout the United States. The Survey Monkey website provided an informed consent statement, which stated that completion of the survey indicates the respondents' informed consent to participate in the study. Once initial contact was made, respondents were sent out a reminder via email to complete the survey after a period of one month. To further increase chances of a response researchers provided respondents with the SurveyMonkey link in the body of the email for easier access.

IV. DATA ANALYSIS

The research utilized descriptive statistics to present the demographic information about participants, as well as their responses to the online survey. This included frequency counts, percentages, and means. Tables and figures were provided accordingly. Item to item content analysis was used to analyze open-ended qualitative information. Researchers

also completed a content analysis of responses to the closed ended questions asked in the online survey.

V. RESULTS

The survey was opened on August 5th, 2015 and was anticipated to be open for a period of two months. The survey timeline was extended by two weeks, in anticipation of reaching more respondents. The survey was closed on October 19th, 2015. The total number of practitioners who responded to the survey was 538. Three responses were not included in the results, bringing the total to 535. The specific geographic locations of the survey respondents have been outlined in Table I located in the Appendix.

The results of our survey study found that an overwhelming majority (95%) of respondents felt that the ability of a child to copy vertical lines, horizontal lines, circle, squares, and triangles was a good predictor of handwriting readiness. Imitating an oblique cross was largely agreed upon as a precursor to handwriting readiness. Respondents felt that imitating, as well as copying, an oblique cross alluded to the important developmental milestone of crossing midline, which 98% of respondents taking our survey identified as critical to handwriting readiness. Imitation in general was looked upon as a necessary visual component to handwriting. In fact, visual perceptual skills were also identified by respondents as important in the complex process of handwriting. The most important of which was agreed upon as visual motor integration at 68%.

Survey respondents reported that the ability of a child to stabilize their paper with the non-dominant hand was greatly important for handwriting development at 83%. Furthermore, a large majority (74%) reported that the establishment of hand dominance is necessary for successful handwriting. Aside from this, the grasp pattern used by children, which was found to be most conducive to handwriting was identified by respondents as the dynamic tripod grasp (67%). The remainder of the survey study results have been summarized in Table II located in the Appendix.

VI. DISCUSSION

The development of successful handwriting is dependent on "the integration of the visual, motor, sensory, and perceptual systems" [28]. Current literature suggests that cognitive processes, such as self-regulation, attention, impulse control and working memory, engage the higher executive functions of the brain necessary for copying letters and symbols [20]. Consistent with the findings of McClelland and Cameron [20], more than half of the survey respondents (56%) agreed that cognitive skills are very important to the development of pre-handwriting skills. The survey respondents identified attention, praxis, and motor learning as the most important cognitive processes. Moreover, difficulties with praxis may result in motor planning problems. Nearly three quarters of participants (73%), indicated that motor planning is very important to the development of pre-handwriting skills. Current research explained that certain visual processes,

predominantly the visuomotor process, must be mastered before successful handwriting can be attained [19]. Over three quarters of survey respondents (77%) agreed that visual perceptual skills were very important to the development of pre-handwriting skills. The respondents identified visual motor integration as the most important visual perceptual area in the development of handwriting skills. Nearly half of the survey respondents (45%) indicated that kinesthesia and proprioception are very important in the development of pre-handwriting skills.

Poor body part awareness was identified as a factor that can delay the development of handwriting skills by over half of the survey respondents. Additionally, over three quarters of respondents agreed that poor body scheme might delay the development of handwriting skills. This result in particular, in comparison to survey results was quite surprising. A majority of survey respondents (82%) indicated that body scheme had a very important role in the development of successful handwriting. However, body scheme was not largely discussed in the research obtained for the literature review for this survey study as conducive for the successful handwriting of children.

Existing literature explained that hand dominance is an important motor skill that greatly impacts areas of education, such as handwriting [17]. The results of the survey were consistent with the findings of [17]. Almost half of respondents (44%) agreed that the emergence of hand dominance is very important to the development of handwriting. Furthermore, nearly three quarters of respondents (74%) indicated that hand dominance is an important factor regarding the development of functional grasp patterns. Consistent with prior research, over two thirds of the survey respondents (67%) indicated that the dynamic tripod grasp was the most conducive to successful handwriting [11]. Moreover, nearly half of the survey respondents (56%) agreed that immature scissor grasp patterns would result in the development of ineffective pencil grasp patterns. More than half of the survey respondents (55%) indicated that purposeful scribbling was very important to letter formation. Consistent with the findings of [6] two thirds (66%) of the respondents reported that purposeful scribbling fosters letter directionality. Additionally, nearly half of the respondents indicated that sequencing skills are important to letter directionality. Almost all survey respondents (95%) agreed with prior research, which explained the ability of a child to copy vertical lines, horizontal lines, circles, squares and triangles was a good predictor of handwriting readiness [9]. Nearly all survey respondents (83%) indicated that the ability to first imitate, then later copy, an oblique cross was a good predictor of handwriting readiness. The results of the survey indicated that almost half of the respondents (43%) agreed that in-hand manipulation skills were very important to the development of pre-handwriting skills. These results are consistent with existing literature, which explains that in-hand manipulation skills were essential to the development of handwriting because they allow the writer to adjust, reposition, or move the writing instrument [13]. The survey respondents identified that

shift was the most important aspect of in hand manipulation; however, it is the last to emerge at 3.5 to 5 years of age [15].

Over three quarters of survey respondents (83%) agreed that stabilizing the paper with one hand, while writing with the other, is necessary for successful handwriting. Although only half of survey respondents (50%) believe bilateral integration of the body is important to the development of handwriting, this skill is necessary when stabilizing the paper during writing. Over three quarters of respondents (83%) agreed that the ability to cross midline was necessary for the development of successful handwriting. Finally, the majority of survey respondents identified central postural control as the initial area of concern, when compared to other areas such as proximal joint stability, intrinsic hand strength, and the arches of the hand.

According to the Bureau of Labor Statistics [29], occupational therapists accounted for 110,520 jobs across the nation. Out of this national total, 14,370 practiced in an elementary or secondary school setting, which was given as the highest area of practice for the respondents in the current survey study (75%). Other areas of practice, educational level attained, and additional board certifications of the survey respondents were identified in Fig. 1 located in the Appendix. We cannot say with certainty that the respondents of our survey were a true representation of all practicing occupational therapy practitioners throughout the United States.

VII. LIMITATIONS AND ASSUMPTIONS

This research study used social networking websites (Facebook, Twitter, and blogs/forums) to recruit participants. Therefore, it cannot be said with certainty that all respondents actually practice in a pediatric occupational therapy setting. Also, there was no way to accurately determine if the respondent filling out the survey had professional credentials and were occupational therapy practitioners. The study solely relied on self-report and the responses of participants were assumed to be honest and accurate to the best of their abilities. Another possible limitation was the misinterpretation of survey questions by the respondents, thus evoking a different outcome.

VIII. SUGGESTIONS FOR FUTURE RESEARCH

Future research should investigate the pre-handwriting skills identified within this research study as being necessary to the successful development of handwriting in children. The overall project itself could be modified to make the focus of the study more specific to one area of handwriting, such as the cognitive processes or visual perceptual areas involved. While identifying pre-handwriting factors, it was evident that there was a large range of skills necessary for its success. Having a more specific reference point may be beneficial in future research. The existing literature examined for this survey study was found to be lacking current, updated information about handwriting. Another suggestion would be to expand on our research to develop or locate an evaluation method to

quickly and practically assess a child's handwriting issues. Additionally, future research should concentrate on creating recommendations for handwriting curriculum.

IX. CONCLUSION

In conclusion, more consistent research is needed on these skills to help guide occupational therapy practitioners during pre-handwriting and handwriting based interventions to better support children's ability to successfully participate in school-based activities.

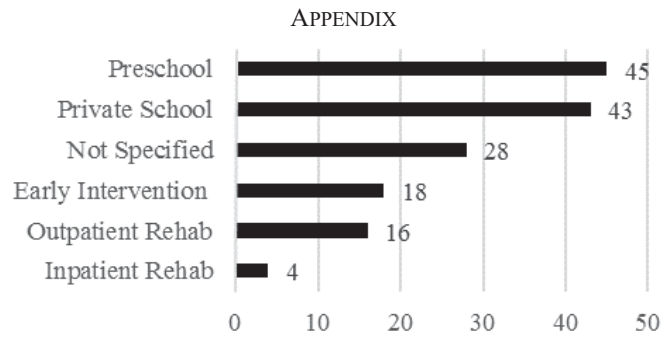


Fig. 1 (a) Respondents by practice area

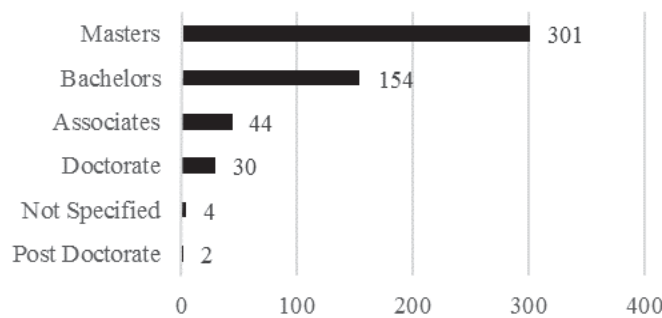


Fig. 1 (b) Respondents by education level

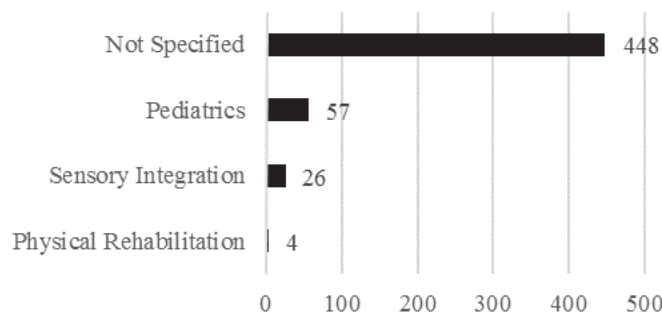


Fig. 1 (c) Respondents by board certification

TABLE I
 GEOGRAPHIC LOCATIONS OF RESPONDENTS

Regions	States	% of Respondents	# of Respondents
Midwest: East North Central	IL, IN, MI, OH, WI	28.01%	149
South: South Atlantic	DE, FL, GA, MD, NC, SC, VA, WV, Washington D.C.	26.32%	140
Northeast: Mid-Atlantic	NJ, NY, PA	17.86%	95
West: Mountain	AZ, CO, ID, MT, NV, NM, UT, WY	7.14%	38
Northeast: New England	CT, ME, MA, NH, RI, VT	6.77%	36
South: West South Central	AR, LA, OK, TX	4.51%	24
West: Pacific	AK, CA, HI, OR, WA	4.14%	22
South: East South Central	AL, KY, MS, TN	3.38%	18
Midwest: West North Central	IA, KS, MN, MO, NE, ND, SD	1.88%	10

TABLE II
SURVEY DATA

Questions	Level of Importance	Yes/No	% of Respondents	# of Respondents
1. How important is purposeful scribbling to letter formation?	Very Important		55.33%	296
2. In your opinion, does purposeful scribbling foster letter directionality?		Yes	66.36%	355
3. Do you think the ability to copy vertical lines, horizontal lines, circles, squares, and triangles are a good predictor of handwriting readiness?		Yes	95.14%	509
4. Do you think the ability to successfully imitate an oblique cross is a precursor to handwriting readiness?		Yes	82.99%	444
5. Do you think the ability to successfully copy an oblique cross is a precursor to handwriting readiness?		Yes	82.24%	440
6. How important are cognitive skills in the development of pre-handwriting skills?	Very Important		55.83%	297
7. What cognitive processes do you think are the most important in the development of successful handwriting? Please rank the following cognitive processes in order of importance, where 1 is the most important and 6 is the least important.	Attention		29.53%	158
	Praxis		27.29%	146
	Self-regulation		19.07%	102
	Motor Learning		13.64%	73
	Memory		6.54%	35
	Impulse Control		3.93%	21
8. In regards to letter directionality, how important is sequencing to the development of pre-handwriting skills	Very Important		41.68%	223
9. Which grasp pattern used by children (5 years and younger) do you think is the most conducive to successful handwriting?	Dynamic Tripod		66.73%	357
	Dynamic Quadrapod		25.98%	139
	Lateral Tripod		3.93%	21
	Lateral Quadrapod		3.36%	18
10. Do you think hand preference/hand dominance is an important factor regarding the development of functional grasp patterns?		Yes	74.02%	396
11. How important do you think the emergence of hand preference/hand dominance is in affecting handwriting development?	Very Important		44.49%	238
12. How important are "in-hand manipulation" skills (including shift, translation, and rotation) to the development of pre-handwriting skills?	Very Important		43.18%	231
13. What area of "in-hand manipulation" do you think is the most important to the development of handwriting skills? Please rank the following areas of in-hand manipulation in order of importance, where 1 is the most important and 3 is the least important.	Shift		48.22%	258
	Translation		30.09%	161
	Rotation		21.68%	116
14. Do most of the children (5 years and younger) that you work with have "in-hand manipulation" skills?		No	76.82%	411
15. How important is bilateral integration in the development of pre-handwriting skills?	Very Important		49.53%	265
16. Do you think stabilizing the paper with one hand while writing with the other is necessary for successful handwriting?		Yes	83.36%	446
17. Do you think the ability to cross midline has an effect on the development of successful handwriting?		Yes	97.76%	523
18. How important is motor planning in the development of pre-handwriting skills?	Very Important		72.52%	388
19. How important are visual perceptual skills in the development of pre-handwriting skills?	Very Important		77.01%	412
20. What area of visual perception do you think is the most important to the development of handwriting skills? Please rank the following areas in order of importance, where 1 is the most important and 5 is the least important.	Visual-Motor Integration		68.79%	368
	Visual Memory		14.02%	75
	Visual Spatial Relationships		10.47%	56
	Visual Closure		3.55%	19
	Form Constancy		3.18%	17
	21. How important is kinesthesia in the development of pre-handwriting skills?	Very Important		45.05%
22. How important is proprioception in the development of pre-handwriting skills?	Very Important		45.23%	242
23. Do you think poor body part awareness (ability to name and point to body parts) delays development of pre-handwriting and handwriting skills?		Yes	62.43%	334
24. Do you think poor body scheme (awareness of body parts in relation to each other) delays development of pre-handwriting and handwriting skills?		Yes	82.43%	441
25. How important is the controlled use of a mature scissor grasp pattern to the development of successful handwriting?	Somewhat Important		36.07%	193
26. Do you think immature scissor grasp patterns (flexor-extensor patterns) result in the development of ineffective pencil grasp patterns?		Yes	55.51%	297
27. In regards to the development of handwriting skills, please rank the following areas in order of priority, where 1 would be addressed during the initial intervention and subsequent areas would follow in order.	Priority 1	Central Postural Control	69.16%	370
	Priority 2	Proximal Joint Stability	14.95%	80
	Priority 3	Intrinsic Hand Strength	10.65%	57
	Priority 4	Arches of the Hand	5.23%	28

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REFERENCES

- [1] American Occupational Therapy Association. (2010). *Occupational therapy in school settings*. (Online). Available: www.aota.org.
- [2] R. Humphry, K. Jewell, and R. Rosenberger, R. "Development of in-hand manipulation and relationship with activities," *Am. J. of Occup. Ther.*, vol. 49, no. 8, pp. 763-771, Sep. 1995.
- [3] C. Bayona, J. McDougall, M. Tucker, M. Nichols, and A. Mandich, "School-based occupational therapy for children with fine motor difficulties: Evaluating function outcomes and fidelity of services," *Phys. and Occup. Ther. in Pediatr.*, vol. 26, no. 3, pp. 89-110, Jul. 2006.
- [4] G. Frolek-Clark, J. Polichino, and L. Jackson, "Occupational therapy services in early intervention and school-based programs," *Am. J. of Occup. Ther.*, vol. 58, pp. 681-685, Nov-Dec. 2004.
- [5] L. H. Dinehart, "Handwriting in early childhood education: Current research and future implications," *J. of Early Childhood Literacy*, vol. 15, no. 1, pp. 97-118, Mar. 2014.
- [6] J. E. Gombert, and M. Fayol, "Writing in preliterate children," *Learn. and Instr.*, vol. 2, pp. 23-41, Mar. 1992.
- [7] K. Feder, and A. Majnemer, "Handwriting development, competency, and intervention," *Dev. Med. and Child Neurol.*, vol. 49, no. 4, pp. 312-317, Apr. 2007.
- [8] L. L. Lamme, "Handwriting: In an early childhood curriculum," *Young Children*, vol. 35, no. 1, pp. 20-27, Nov. 1979.
- [9] M. Weil, and S. J. Cunningham-Amundson, "Relationship between visuomotor and handwriting skills of children in kindergarten," *Am. J. of Occup. Ther.*, vol. 48, no. 11, pp. 982-988, Nov-Dec. 1994.
- [10] P. Naidoo, A. Englebrecht, S. Lewis, B. Kekana, "Visuomotor integration (VMI) - a predictor for handwriting in grade 0 children," *S. Afr. J. of Occupat. Ther.*, vol. 39, no. 2, pp. 18-21, Aug. 2009.
- [11] H. Schweltnus, H. Carnahan, A. Kushki, H. Polatajko, C. Missiuna, and T. Chau, "Writing forces associated with four pencil grasp patterns in grade 4 children," *Am. J. of Occup. Ther.*, vol. 67, no. 2, pp. 218-227, Mar-Apr. 2013.
- [12] J. Summers, "Joint laxity in the index finger and thumb and its relationship to pencil grasps used by children," *Australian Occup. Ther. J.*, vol. 48, pp. 132-141, Sep. 2001.
- [13] V. W. Berninger and J. Rutberg, "Relationship of finger function to beginning writing: Application to diagnosis of writing disabilities," *Dev. Med. and Child Neurol.*, vol. 34, no. 3, pp. 198-215, Mar. 1992.
- [14] M. Visser, M. Nel, J. de Vries, E. Klopper, K. Olën, and J. van Coller, "In-hand manipulation of children aged four and five-years-old: Translation, rotation and shift movements, in bloemfontein," *S. Afr. J. of Occup. Ther.*, vol. 44, no. 2, pp. 22-28, Aug. 2014.
- [15] C. Exner, "Evaluation and interventions to develop hand skills," In *Occupational Therapy for Children*, J. Case-Smith, Ed. Maryland Heights: Mosby Inc, 2010, pp. 275-325.
- [16] S. Naider-Steinhart, and M. Katz-Leurer, "Analysis of proximal and distal muscle activity during handwriting tasks," *Am. J. of Occup. Ther.*, vol. 61, no. 4, pp. 392-398, Jul-Aug. 2007.
- [17] J. M. Naus, "Helping hands: A world of manipulatives to boost handwriting skills," *Teaching Exceptional Children*, vol. 32, no. 4, pp. 64-70, Mar-Apr. 2000.
- [18] T. Malloy-Miller, H. Polatajko, and B. Anstett, "Handwriting error patterns of children with mild motor difficulties," *Canadian J. of Occup. Ther.*, vol. 62, no. 5, pp. 258-267, Dec. 1995.
- [19] J. E. Maldarelli, B. A. Kahrs, S. C. Hunt, and J. J. Lockman, "Development of early handwriting: Visual-motor control during letter copying," *Dev. Psychol.*, vol. 51, no. 7, pp. 879-888, Jul. 2015.
- [20] M. McClelland, and C. Cameron, "Self-regulation in early childhood: Improving conceptual clarity and developing ecologically valid measures," *Child Dev. Perspectives*, vol. 6, no. 2, pp. 136-142, Jun. 2012.
- [21] T. Howe, K. Roston, C. Sheu, and J. Hinojosa, "Assessing handwriting intervention effectiveness in elementary school students: A two-group controlled study," *Am. J. of Occup. Ther.*, vol. 67, no. 1, pp. 19-27, Jan-Feb. 2013.
- [22] M. Volman, B. van Schendel, and M. Jongmans, "Handwriting difficulties in primary school children: a search for underlying mechanisms," *Am. J. of Occup. Ther.*, vol. 60, no. 4, pp. 451-460, Jul-Aug. 2006.
- [23] J. Taylor, "The sequence and structure of handwriting competence: Where are the breakdown points in the mastery of handwriting?" *British J. of Occup. Ther.*, vol. 48, no. 7, pp. 205-207, Jul. 1985.
- [24] J. Case-Smith, L. Weaver, and T. Holland, "Effects of a classroom-embedded occupational therapist-teacher handwriting program for first-grade students," *Am. J. of Occup. Ther.*, vol. 68, no. 6, pp. 690-698, Nov-Dec. 2014.
- [25] M. H. Tseng, and S. K. Chow, "Perceptual-motor function of school-age children with slow handwriting speed," *Am. J. of Occup. Ther.*, vol. 54, no. 1, pp. 83-88, Jan-Feb. 2000.
- [26] C. K. Ivey, S. J. Lane, and T. A. May-Benson, T. A. "Test of Ideational Praxis (TIP): Preliminary findings and interrater and test-retest reliability with preschoolers," *Am. J. of Occup. Ther.*, vol. 68, no. 5, pp. 555-561, Sep-Oct 2014.
- [27] H. Cornhill and J. Case-Smith, "Factors that relate to good and poor handwriting," *Am. J. of Occup. Ther.*, vol. 50, no. 9, pp. 732-739, Oct. 1996.
- [28] J. Case-Smith, and J. Clifford-O'Brien, *Occupational Therapy for Children*. St. Louis, MO: Mosby, 2015.
- [29] Bureau of Labor Statistics. (2014). *Occupational employment and Wages* (Online). Available: <http://www.bls.gov/oes/current/oes291122.htm#nat>