

## AN INTERDISCIPLINARY HANDWRITING FRAMEWORK

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### ABSTRACT

Handwriting is still an important skill especially for school-going children. As a result, it is important to acquire enduring and legible handwriting. Substantial handwriting researches were available before the 19th century. However, the knowledge are fragmented as these research were mostly within discipline-specific boundaries, there is a lack of knowledge transfer. This paper examines an interdisciplinary conceptual framework to guide research and intervention on handwriting. This conceptual framework is the product of an interdisciplinary study focus between educational discipline and occupational therapy discipline. The framework revealed four major factors that influence Malay language handwriting: neuromotor developmental, ergonomic, orthography, and cognitive factors. One important element of this framework is that it takes into account the perspective of language in handwriting. This paper provides a summary description of the framework, the application of the framework, as well as the benefits of utilizing this framework in handwriting assessment and intervention. In conclusion, this paper aims to encourage professionals and researchers who work with or study special population, to adopt this framework, evaluate the adoption and share the results. Such results should extend knowledge of handwriting, particularly among students with special educational needs. It is hope that more effective intervention could be planned to improve handwriting among students struggling with handwriting difficulties.

**Keywords:** handwriting, interdisciplinary framework of handwriting, Malay language handwriting

## INTRODUCTION

Handwriting which is about to be discussed in this article refers to the product of transcribing sound (phonics) to written product (manuscript). This article aims to examine an interdisciplinary handwriting conceptual framework proposed by Lee and colleges (2022). This conceptual framework of handwriting is the product of an interdisciplinary study stems from educational discipline and occupational therapy discipline, the two disciplines which have direct involvement in teaching, diagnosis and provides remedial of handwriting. The framework was said to provide guidance in research and intervention on handwriting. By reviewing this conceptual framework we hope to encourage professionals and researchers who work with or study special population, to adopt this framework, evaluate the adoption and share the results. Such results are believe to extend knowledge of handwriting, particularly among students with special educational needs, hence more effective intervention could be planned to improve handwriting among students struggling with handwriting difficulties.

## LITERATURE REVIEW

In this era of technological advancement, there are various ways to produce texts: keyboarding, type-writing, digital writing, speech-to-text software etc. Handwriting becomes “old fashion” (Hazlina, 2017), and learning handwriting may not be necessary in the future (Graham, 2018). However many of school activities still require handwriting (Collette et al., 2017). Furthermore researches have also found that handwriting brings many advantages such as learning to read, fine motor skills training, improve memory and more (James, 2010; James & Engelhardt, 2012; Lin, 2019; Mangen et al., 2015; Mueller & Oppenheimer, 2014).

School-going children were expected to write as they enter school. However there are students who struggle in handwriting. Many of them have unreadable handwriting, or write too slow and effortful. Handwriting difficulty is expected to be associated with other learning disorder such dyslexia, dysgraphia etc. (Connelly, Dockrell, & Barnett, 2011; Dockrell, 2009). In this article, we consider these problems in light of a recent developed conceptual framework of handwriting (Lee et al., 2022), to illustrate how it can be useful when thinking about the difficulties children might encounter during handwriting. However we are not claiming that this framework we discuss is better than the other frameworks published.

Handwriting is the lower level of writing process. According to Hayes and Berninger’s (2014) writing framework, writing consists of three major elements which are planning, translating and reviewing. Under translating there are two sub-elements which are text generation (translating ideas to words) and transcribing (producing written word). Transcribing consists of handwriting and spelling. This provides us a clear picture of where handwriting is in writing process. It is important to have a clear understanding of what handwriting is and is not in order to review the handwriting framework. The process of handwriting requires tools to execute handwriting and it involved other underlying mechanisms that are related to handwriting, such as visual motor integration, ergonomic and cognitive.

Writing studies was popular during 1980s to 1990s. As described by Brandt (2001), an era of mass writing research. Vast research from various disciplines during that period of time was partly due to the multi-dimensional nature of writing and handwriting. This led to the increase diversity of the knowledge in handwriting, and eventually resulted in a deeper understanding of related processes, mature research methodology, handwriting interventions, and development of

writing models. However these researches are disciplines-specific and discrete which resulted in the lack of cross-knowledge transfer across disciplines, which impedes the practicality of the knowledge. In this conceptual paper, it will be argued that an interdisciplinary conceptual framework on handwriting is needed. Jaakkola's (2020) methodological consideration of a conceptual framework will be used to synthesize the stated interdisciplinary conceptual framework.

## **METHODOLOGY**

According to Jaakkola (2020), a conceptual paper is different from an empirical paper. In general, an empirical paper relies on the research design for its structure and logic in developing new knowledge by detailing variables involved and the approach in handling of the data. However the empirical research method is difficult to apply directly to conceptual research. We shall evaluate the mentioned framework by referring to Jaakkola (2020)'s four approaches in designing conceptual paper. She described four common systematic approaches to develop conceptual research namely, theory synthesis, theory adaptation, typology, and model. These approaches are not mutually exclusive it may occur simultaneously. A conceptual framework may contain aspects of two or more of the approaches described.

The targeted interdisciplinary conceptual framework of Malay handwriting (Lee et al., 2022) was found to contain all four approaches. (1) Theory synthesis: Through summarizing and synthesizing extensive literature of related research from educational discipline and occupational therapy discipline, the key components from both the educational and occupational therapy fields on handwriting were considered in the framework. The framework also introduces new perspective of handwriting. It explained the different terminology issues that commonly occur during interdisciplinary study (for example: the executive function in the framework refers as working memory capacity and executive functioning in different fields. It was explained and a suitable term was suggested). (2) Theory adaptation: The authors described the insufficiency of handwriting theories employed by both disciplines, which justified the needs to produce an interdisciplinary conceptual framework. (3) Typology: the authors of the framework organized the fragmented research handwriting into a combined interdisciplinary conceptual framework (e.g. handwriting performance, underlying factors and sub-factors of handwriting). (4) Models: The framework assembles the related components of handwriting into an interdisciplinary framework (refer Figure 2). We can conclude that in this interdisciplinary conceptual framework, the theory synthesis has led to theory adaptation, and the typology provides the basis for model.

## **INTERDISCIPLINARY CONCEPTUAL FRAMEWORK**

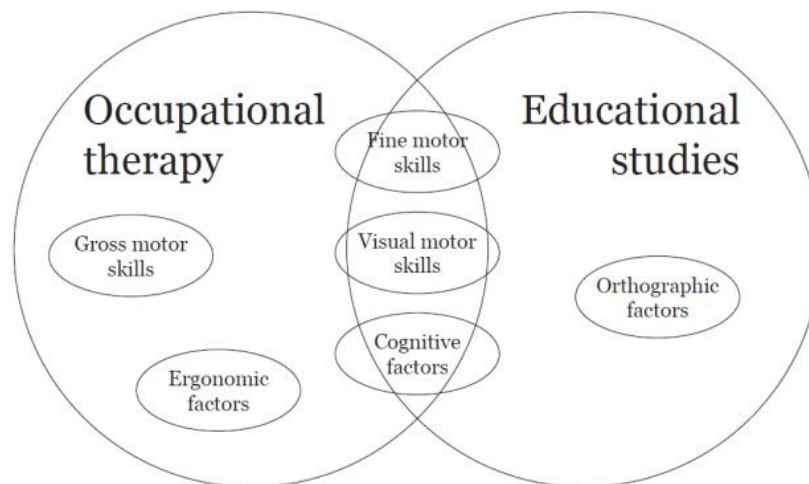
Educators and occupational therapists were two professionals that work directly with individuals to acquire, diagnose, and provide remedial related to handwriting. Generally, handwriting is taught at school by teachers. Students who are struggling with handwriting are identified first by teachers in the school and then refer to occupational therapists for treatment.

Both the educational and occupational therapy disciplines have conducted extensive research on handwriting. To provide a more cohesive view of handwriting, it is necessary to consolidate the accumulated knowledge from the emerging literature of the educational discipline and occupational therapy discipline. Both disciplines work closely with individuals to improve their

handwriting, but they hold distinct beliefs about handwriting. Occupational therapists view handwriting from a prerequisite perspective, whereas instructors tend to view it from a literacy perspective (Lee, 2023). These beliefs do not overlap naturally, indicating a lack of knowledge transfer.

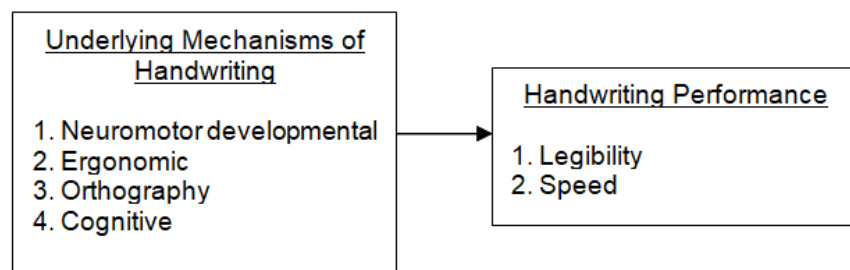
Therefore, Lee et al. (2022) proposed an interdisciplinary conceptual framework for Malay language handwriting based on an interdisciplinary study that considers the relevance of 'educational discipline' and 'occupational therapy discipline' in handwriting assessment and intervention. Lee et al's (2022) conceptual framework on handwriting was formulated from extensive review of literature and past empirical research from both educational and occupational therapy disciplines. In this framework, the authors postulate that handwriting performance which refers to handwriting legibility and speed is influence by four major underlying mechanisms - neuromotor developmental, ergonomic, orthography, and cognitive. In the article, neuromotor developmental factors refer to fine motor skills, gross motor skills, and visual motor skills (refer Figure 1). Figure 1 reveals the primary knowledge sources for the four underlying mechanisms that influence handwriting performance. Figure 2 presents the interdisciplinary conceptual framework of handwriting. The elements involved in the framework presents the connection between the underlying mechanisms and handwriting performance.

**Figure 1:** Mapping of handwriting factors from two disciplines



Source: Lee et al., 2022

**Figure 2:** The Interdisciplinary conceptual framework of Malay language handwriting



The handwriting performance in the framework shows handwriting legibility and speed. Handwriting legibility refers to the readability of a written product. Handwriting speed refers to how fast the handwriting was produced. According to the framework, a proficient hand writer should be able to produce legible handwriting in a certain speed. However a non-proficient hand writer may have problems in one or both of these areas. According to the framework, the four major factors orchestrated in the process of handwriting are the underlying mechanisms that influence the handwriting performance. Table 1 shows an overview of the four major underlying mechanisms of handwriting with sub-factors that are involved.

**Table 1:** *An interdisciplinary conceptual framework of Malay Language*

<b>Factors</b>	<b>Sub-Factors</b>	
Neuromotor developmental	Visual motor integration	
	Fine motor skills	In-hand manipulation
		Motor planning
		Motor precision and dexterity
		Bilateral integration
	Gross motor ability	Postural control
Ergonomic	Pencil grip	
	Pencil and paper positioning/ consistency	
Orthography	Letter knowledge	
	Orthography coding	
	Syllable-size processing units	
Cognitive	Working memory	
	Long-term memory	
	Executive attention	

Source: Lee et al., 2022

Neuromotor developmental factors consist of visual motor integration, fine motor skills, and gross motor ability. During a copying task, the child needs to visualize the word to be copy and make sense of what he is seeing and then manipulate his writing tools (pencil and paper) and coordinate the visual information with the motor response to execute the task of copying the word. Fine motor skills mentioned refer to coordination of finger movements with the muscle in the wrist, elbow, and shoulder to control a writing tool during writing. The four sub-factors in the fine motor skills are in-hand manipulation, fine motor precision and dexterity, bilateral integration, and motor planning. These elements involve process to adjust writing tools with hand and ability to plan and sequence letters in words (refer Lee et al., 2022). Gross motor ability refers to postural control during handwriting. It is understood that trunk stability allows one to adjust the posture to perform fine motor task. Next, ergonomic in the framework refers to pencil grip, positioning of pencil and paper, and consistency of pencil grip and paper positioning.

Three orthographic effects are also proposed in the framework. They are the letter knowledge, orthography coding, and syllable-size processing units. The child needs to master the letters in the alphabet (for language that are using alphabet letters as script) before they can start learning to writing smoothly. Letter knowledge such as letter shapes, names and corresponding phonemes are required to make handwriting fluent. Writing without letter knowledge will be like drawing, just like when one is copying a text in foreign language. Next is the orthographic coding which involves ability to store and retrieve letter, word, cluster of letter from memory. During handwriting, the child requires attention to retain visual information (word to copy) in the working

memory while retrieve related information from the long-term memory. This coding ability could reduce the cognitive load involved and free attention resource hence speed up the handwriting process. The framework was originally designed for Malay language which is a language that is predominantly multi-syllable. The transparency of Malay language encourages the adoption of syllable-size processing units which may reduce cognitive load during handwriting task; however its multi-syllabic characteristic might tax the cognitive components which will be described next.

Three cognitive components in the framework are working memory, executive attention, and long-term memory. During handwriting task, working memory maintain the input from our sensory and then retrieves related information from the long-term memory (letter form, letters sequence, letter writing etc.) and maintains these information until handwriting is executed. The capacity of long-term memory is unlimited (Tse et al., 2014); however poor long-term memory impedes the retrieval of information. Executive attention is required throughout the process of handwriting. It is responsible to allocate attention between multiple tasks. Information in the working memory needs rehearsal which cost the attention resource to avoid information fading. When a child reaches automatisaion in handwriting, (for example, he mastered orthography coding skills) attention resources are freed up so he can focus on higher level process of writing. As mentioned before the Malay language's multi-syllabic characteristic pose challenges to a child in handwriting because it demands more attention. When writing Malay language, the child needs more rehearsal to maintain these syllabics in working memory to avoid information decay before writing.

## **Handwriting Scenario**

Based on the framework, a scenario is presented here to better understand the interactions between the elements in the framework: A child seated on a chair in front of a desk, is asked to copy a sample text in front of him (near-point copying task) onto a piece of lined paper with a sharpened pencil. The child adjusts his posture and position the pencil and paper in front of him. The sensory input from the environment such as the sitting posture, pencil and paper positioning, form the perception for an appropriate action as a response (such as adjustment) to better accommodate the task. This involve gross motor ability, fine motor skills and attention. As he looks at the first word in the sample text to be copied, his visual feedback forms perception, and the perception form concept and action. This is when the working memory works to maintain the image of the word in memory and the orthographic coding ability chunks the word and information from the long-term memory was retrieved and motor commands for writing were decided. Next the child began to execute the motor commands. As the process carries on, the child continues to receive input from the environment such as pencil grip, paper, and motor movement, and making adjustment to execute handwriting. All these happened with the cost of the attention resources. Handwriting performance was affected by all these processes and was presented in the legibility and the speed of the handwriting. Just imagine if the TV was on, the sound and visual from the television might affect the child's attention as this indirectly drawn away some of the attention. Cognitive load might occur and affect the handwriting speed. Another possibility is that, a child with poor fine motor skills will struggle to copy the sample text legibly. On the other hand, a child with poor orthography coding or letter knowledge might struggle with handwriting speed.

## **DISCUSSIONS, RECOMMENDATIONS AND CONCLUSIONS**

### **Discussion and Suggestion**

The interdisciplinary conceptual framework of Malay language handwriting proposed by Lee and colleges (2022) suggested a complex handwriting system that can be influenced and developed in many ways. However the interaction between the handwriting performance and the four underlying mechanisms of handwriting is not yet specified in detail. The framework is useful for identifying components of handwriting process, but not so useful for understanding how these components interact and how these interactions lead to change in handwriting. Therefore, through the handwriting scenario that was created based on the framework, it is hoped to create a vivid picture of the connection of all the components in the framework in order to provide a clearer view of handwriting process proposed by the framework.

In the framework, the authors describe handwriting performance as legibility and speed. Handwriting speed was generally measures by letters written in a given period, normally less than ten minutes. However the measurement of handwriting legibility is not described in details in the framework. Legibility is commonly measured or identified by two methods, namely the componential and the global assessment (Zivianni & Walen, 2006). We suggest componential assessment which provides more details of the handwriting such as letter form, letter size, and word spacing. This method can also avoid possible bias compare global assessment which focuses more on the readability of a written product.

Next, we would also like to suggest including handwriting endurance into the framework. A proficient hand writer not only should be able to produce legible handwriting in a certain speed but must be able to endure the writing task for a period of time. Children need to endure long hours of handwriting activities in school, and this increases with grades. However a non-proficient hand writer would have problems in one or more of this area below: (1) can write legibly but slowly (2) write with speed but with unreadable handwriting (3) write legibly with speed but cannot sustain the activity too long (4) unreadable handwriting, slow and cannot endure long period of writing task.

A unique part of the framework is the aspect of language in handwriting which is uncommon in handwriting study. Each language is unique with its own script and grammatical rules. The framework was based on the Malay language, however it is possible to adapt to the use of other languages. The framework has provided the information to support that handwriting needs to be studies according to different languages (Lee, 2023).

The sub-elements in the neuromotor developmental factor (fine motor skills and gross motor ability) were not yet detail in the framework. We suggest to include other sensory feedback such as tactile, kinesthesia, proprioception etc. in the neuromotor developmental factor as these elements that are related to handwriting (Hepp-Raymond et al., 2009; Ward-Cherrier et al., 2017; Yu et al., 2012). We also would like to suggest adding into the framework the biomechanical ergonomic factors. The biomechanical ergonomic factors refer to ergonomic factors that involved manipulation of tools and body parts when performing handwriting such as sitting posture, pencil grip and manipulation of paper, while ergonomic factors involves writing tools and furniture such as chair, desk, types of pencil and paper during handwriting (Rosenblum et al., 2006).

## **Implication**

Studying the process of handwriting will highlight where hand writers are struggling in handwriting. Using this framework we can surmise that children who have handwriting difficulties may need support in a number of different areas. For example, they may need to be taught letter knowledge, improve fine motor skills, gross motor ability and memory. This is because the framework provides us with possible factors that affect handwriting performance. Handwriting difficulties can be identified through the understanding of these factors. The interdisciplinary conceptual framework as presented in this paper allows researchers to gain deeper understanding and create a child handwriting profile. This framework allows practitioners to identify and understand the specific area of handwriting process that are challenging the writer so that targeted remediation can be developed. Diagnosis tools for handwriting that are guided by a theory based framework can be developed. Early handwriting intervention is possible through such interventions to overcome handwriting difficulties. The framework can be used as a framework for a handwriting assessment. The framework was adapted to develop two Malay handwriting assessment tools (Lee, 2023). Finally, the framework can serve as a guide to develop handwriting intervention.

## **Conclusion**

The development of the conceptual framework presented in this paper took into account the conceptual paper guidelines proposed by Jaakkola (2020). Through an interdisciplinary study, the framework effectively presents a brand-new, pragmatic perspective on handwriting. It has identified significant factors believed to affect handwriting performance. Although the interaction between the components has yet to be specified in detail, the handwriting scenario provides a solution to conceptualise handwriting using an interdisciplinary conceptual framework. This framework is distinctive in that it indicates the influence of language on handwriting. Finally, researchers are encouraged to implement or modify this interdisciplinary handwriting framework for their research and to share their findings. These findings will expand our understanding of handwriting, especially handwriting problems among students with special educational needs. We hope that more effective handwriting programs and interventions will be developed to prevent and treat handwriting difficulties among students with and without special needs that follows the elements of this interdisciplinary conceptual framework.

## REFERENCE

- Brandt, D. (2001). *Literacy in American lives*. New York, NY: Lawrance Erlbaum.
- Collette, D., Anson, K., Halabi, N., Schlierman, A., & Suriner, S. (2017). Core state standards: Teacher, occupational therapist, and administrator perceptions from New York state public schools. *American Journal of Occupational Therapy*, 71(6), 1-9.  
<https://doi.org/10.5014/ajot.2017.021808>
- Connelly, V., Dockrell, J. E., & Barnett, A. (2011). Children challenged by writing due to language and motor difficulties. In V. Berninger (Ed.), *Cognitive psychology of writing handbook: Past, present, and future contributions of cognitive writing research to cognitive psychology* (pp. 217-245). East Sussex, UK: Psychology Press.
- Dockrell, J.E. (2009). Causes of delay and difficulty in the production of written text. In R. Beard, M. Nystrand, & J. Riley (Eds.), *The Sage handbook of writing development* (pp. 489–505). London: Sage Publications Limited.
- Graham, S. (2018). Handwriting instruction: A commentary on five studies. *Reading and Writing*, 31(4), 1-11. <https://doi.org/10.1007/s11145-018-9854-5>
- Hayes, J. R., & Berninger, V. W. (2014). Cognitive processes in writing: A framework. In B. Arfe, J. Dockrell, & Berninger, V. W. (Eds.), *Writing development and instruction in children with hearing, speech, and language disorders* (pp. 3-15). New York: Oxford University Press.
- Hazlina, A. (2017, September 27). Fading art of handwriting. *New Straits Times*.  
<https://www.nst.com.my/opinion/columnists/2017/09/284519/fading-art-handwriting>
- Hepp-Reymond, M. C., Chakarov, V., Schulte-Mönting, J., Huethe, F., & Kristeva, R. (2009). Role of proprioception and vision in handwriting. *Brain Res Bulletin*, 79, 365–370.  
<https://doi.org/10.1016/j.brainresbull.2009.05.013>
- Jaakkola, E. (2020). Designing conceptual articles: four approaches. *AMS Review*, 10: 18-26.  
<https://doi.org/10.1007/s13162-020-00161-0>
- James, K. H. (2010). Sensori-motor experience leads to changes in visual processing in the developing brain. *Developmental Science*, 13, 279–288.
- James, K. H., & Engelhardt, L. (2012). The effects of handwriting on functional brain development in pre-literate children. *Trends in Neuroscience and Education*, 1(1), 32–42.
- Lee, A. S. S. (2023). *Instrument development and assessment of handwriting difficulties among primary school students in Penang* (Unpublished doctoral dissertation). Universiti Sains Malaysia.
- Lee, A. S. S., Lee, L. W., Low, H. M., & Ooi, S. C. (2022). Revisiting handwriting fundamentals through an interdisciplinary framework. *Malaysia Journal of Medical Science*, 29(1): 18-33.  
doi: 10.21315/mjms2022.29.1.3

- Lin, L. Y. (2019). Differences between preschool children using tablets and non-tablets in visual perception and fine motor skills. *Hong Kong Journal of Occupational Therapy*, 32(2), 118-126. <https://doi.org/10.1177/1569186119888698>
- Mangen, A., Anda, L. G., Oxenburgh, G. H., & Brännick, K. (2015). Handwriting versus keyboard writing: Effect on word recall. *Journal of Writing Research*, 7(2), 227–247. <https://doi.org/10.17239/jowr-2015.07.02.1>
- Mueller, P. A., & Oppenheimer, D. M. (2014). The pen is mightier than the keyboard: Advantages of longhand over laptop note taking. *Psychological Science*, 25(6), 1159–1168. <https://doi.org/10.1177/0956797614524581>
- Rosenblum, S., Goldstand, S., & Parush, S. (2006). Relationships among biomechanical ergonomic factors, handwriting product quality, handwriting efficiency, and computerized handwriting process measures in children with and without handwriting difficulties. *American Journal of Occupational Therapy*, 60, 28–39. <https://doi.org/10.5014/ajot.60.1.28>
- Tse, L. F. L., Thanapalan, K. C., & Chan, C. C. H. (2014). Visual-perceptual-kinesthetic inputs on influencing writing performances in children with handwriting difficulties. *Research in Developmental Disabilities*, 35, 340-347. <https://doi.org/10.1016/j.ridd.2013.11.013>
- Yu, T. Y., Hinojosa, J., Howe, T. H., & Voelbel, G. T. (2012). Contribution of tactile and kinaesthetic perceptions to handwriting in Taiwanese children in first and second grade. *OTJR: Occupation, Participation and Health*, 32(3), 87-94. <https://doi.org/10.3928/15394492-20111209-02>
- Ziviani, J., & Wallen, M. (2006). The development of graphomotor skills. In A. Henderson & C. Pehoski (Eds.), *Hand function in the child: Foundations for remediation* (2nd ed., pp. 217-236). St. Louis, MO: Mosby. <https://doi.org/10.1016/B978-032303186-8.50014-9>