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Embodied Knowledge Construction in Writing

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Abstract

In cognitive and educational sciences, the writing process is an incessantly debated area, particularly when it comes to the newer methods of writing on keyboards and touchscreen devices. Despite controversies, learning through writing with digital devices remains an overlooked area of cognition. To address this gap, in this study, an embodied knowledge construction model that merges Hayes' framework for understanding cognition and affect in writing with Wilson's six aspects of embodied cognition was tested among six 16-year-old adolescents. The data comprised memory tests written with a pencil, laptop keyboard, mobile phone touch screen keyboard and a questionnaire. The purpose was to not only examine the adolescents' recollection after one week of writing stories with these three modalities but also reflect and examine issues affecting the results, which would help develop and validate the embodied knowledge construction model. The results indicate that valuable information was added to the quantitative recollection scores. We have proposed further development of the model.

Keywords: writing, embodied cognition, cognition, embodied knowledge construction model

Introduction

Writing always relies on a medium, whether it is a pencil, a computer or a mobile phone keyboard. Writing fulfils the purpose of communicating messages through visible symbols. The development of these symbols with different tools substantially varies between handwriting and typing (synonym: keyboarding). As Scardamalia and Bereiter (1987) explained the fundamental difference between novice and expert writers is that experts possess the ability to transform and develop knowledge as they write, whereas novices write what they know. This explanation is applicable to any writing method, even in today's world where people are expected to write by hand and use keyboards of various digital devices. The newer writing methods have provided entirely new dimensions, created new writing skills and endless possibilities for expression. Interestingly, automaticity of any given writing tool can influence recollection of written texts as the writer's attention is no longer on the task's execution (Berninger & Swanson, 1994; Klein, 1999; MacMahon & Charness, 2014). Hence, the increased reliance on digital technologies as writing tools for learning situations requires investigation to understand their connection to learning outcomes. However, the theoretical and methodological differences in writing research between the writing mediums have made it problematic to compare any findings (Mangen & Balsvik, 2016).

Firstly, this study is an attempt to bridge the gap in differences between handwriting and typing models used to study the writing process. We used Hayes' framework (1996) for understanding cognition and affect in writing, and Wilson's (2002) model of embodied cognition to create conceptual guidelines for researching affect and knowledge construction in any form of writing. These two models complement each other into an embodied knowledge construction model and help improve our understanding of affects during writing and learning processes. The embodied knowledge construction model has been designed to investigate knowledge construction through writing while considering various aspects that affect writing and subsequent recollection of texts using different modalities.

Secondly, this study examines the model's functioning based on results of an empirical study that was conducted with six 16-year-old adolescents who took part in memory tests after writing down a story using a laptop keyboard, touch-screen keyboard on a mobile phone and a pencil.

Finally, we reflect on the implications and the significance of research in the area of digital writing and cognition. We discuss the strengths and limitations of the embodied knowledge construction model and avenues for future research and development.

Theoretical Context

Researchers studying handwriting (Chenoweth & Hayes, 2001; Flower & Hayes, 1981; Hayes, 1996; Hayes & Flower,1980; Van Galen, 1990, 1991; Van Galen, Meulenbrock, & Hylkema, 1986) and typing (Crump & Logan, 2010; Logan & Crump, 2009, 2011; Rumelhart & Norman,1982) have tried to define the complexity of the cognitive skill for writing, particularly for how letters and words are produced through different writing processes. For example, a psychomotor theory and model by Van Galen (1991) proposes that producing handwritten text follows a hierarchical principle with the functional stages operating in parallel. This model postulates that handwriting is based on parallel processing of psychomotor and biophysical modules through a hierarchical structure that begins with the intention to write and ends with the action of writing. Note that higher levels of processing entail abstract tasks such as spelling recovery and syntax construction, whereas lower levels of processing are responsible for producing letters in the form of motor output, i.e. they produce muscular movements that control a letter's size and shape. To produce text, the processing levels should function along with cognitive functions and memory. The higher level output forms the foundation for the subsequent lower levels of processing (Van Galen, 1990, 1991; Van Galen, Meulenbrock, & Hylkema, 1986).

However, Logan and Crump's cognitive model of typing (2009, 2011) suggests that typing is a hierarchical process—but in two loops with each having its own responsibilities. The outer loop consciously monitors language comprehension and word production before the inner loop strikes the relevant keys to produce words letter by letter through keystrokes. For an expert typist, this action is automated with each finger responsible for striking only certain keys; however, the typist is completely unaware of each keystroke, nor what the left and right hands are doing. This is supported by the idea that both loops are independent and affected by different factors and feedback. However, both the outer and inner loops share a word level interface. The outer loop produces language and provides words to the inner loop for typing one by one. In the inner loop, the words are divided into a series of letters, followed by appropriate keystrokes (Crump & Logan, 2010; Logan & Crump, 2009, 2010).

Although typing and handwriting produce written text, the current models of handwriting and typing view their production from different angles. The above-mentioned cognitive models for typing by Logan and Crump (2009, 2011) and Rumelhart and Norman (1982) consider the process of typing as executing keystrokes to produce words. However, alternative models of handwriting seek to understand handwriting's different processing stages, i.e. unit sizes, motor components, memory storage and retrieval (Chenoweth & Hayes, 2001; Flower & Hayes, 1981; van Galen, 1991). Is there a perspective that supports the investigation of learning through writing using various writing modalities? What elements should be considered when studying writing with different mediums?

Hayes' (1996) framework for understanding cognition and affect in writing

Hayes' (1996) individuo-environmental framework for understanding cognition and affect in writing is a revision of the Hayes and Flower model (1980), a seminal model for writing and a starting point for understanding cognitive approach to writing. This model focused on three focal components: the task environment, the writing process and the writer's long-term memory. The task environment included topics of the text under development, the audience for whom the text was written, the writer's motivation and the length of text produced till date. The general writing process included planning, translating, reviewing and monitoring text production. The writer's long-term memory included knowledge of the topic, target audience and writing plans. Moreover, this model considered the wide range of knowledge required and retrieved during the writing process; however, Hayes (1996) refined it further in the individuo-environmental framework to understand cognition and affect in the text writing process. This framework provided a particularly fitting theoretical framework for developing a model that understands writing—which by any method is a knowledge constructing process—because it considers writing from two dimensions: the individual and the task environment.

The individual dimension focused on multiple aspects of an individual's internal factors that affect the writing process such as the cognitive process, memory functions and motivational aspects (Hayes, 1996). There can be multiple motivational aspects; the individual's predispositions, beliefs, attitudes and goals, together with profitability estimations, may affect the writing outcome. However, the task environment dimension considers external factors influencing the writing process and outcome such as the individual's physical and social environment, the composition medium (writing method), the writer's target audience and potential writing partners (Hayes, 1996).

Hayes' framework (1996) focused on the text writing process by hand. Although this process is different from typing, it provides a well-structured framework that can be extended further using Wilson's (2002) six aspects of embodied cognition, which are not related to writing, to form a model to investigate writing as a knowledge constructing process along with issues that affect this process. Writing is a dual process of motoric action and output perception (MacMahon & Charness, 2014), a sequence that is significant in embodied cognition. The role of hands and the motoric action to write is changing with newer technologies and altering the relation of the writer's body with the text production and produced text (Mangen & Velay, 2010). Hence, embodied cognition provides better viewpoints of the influences of sensorimotor contingencies' and body's interaction with surroundings for cognition (Mangen & Balsvik, 2016).

Embodied cognition

The embodied cognition theory remains to be unequivocally conceptualised (Hommel, 2015; Mahon, 2015); however, work by Varela, Thompson and Rosch (1991) is the starting point for developing a modern embodied cognition perspective. Generally, any aspect or dimension of embodiment requires perception, which connects a person to the outside world and new

knowledge with both consciousness and unconscious sensations and perception of the environment (Roy et al., 1999). Vision and touch provide phenomenological analysis of perceivable bodies along with perceiving bodies, thus creating presentational and kinaesthetic sensations (Heinämaa, 2011). Presentational sensations require two other means of conception: i) sensing and perception of an actual external object and ii) making our own internal sensation of the occasion the epicentre of our attention (Heinämaa, 2011). We are prisoners of our own body, and we cannot completely understand its functions, see them or comprehend our body's capabilities. Moreover, our body's behaviour or emotions are not completely in our control (Heinämaa, 2011). The body is our own personal order in a disordered world; it is filled with concepts like moving, learning, perceiving and feeling. In short, bodily interactions with the changing environment act as a vehicle to gain sensorimotor experiences and acquire knowledge (Borghi & Cimatti, 2010). Hence, cognition extends through the brain, mind, body and environment (Wilson & Golonka, 2013), demonstrating the significance of the mind's learning environment.

Digitization of societies, schools and workplaces has made people use more diverse writing tools, which have changed the sensorimotor processes of writing and writing as a cognitive process too (Mangen & Velay, 2010). The kinaesthesia of handwriting is associated with producing letters, which turns letters into perceivable objects (Mangen, Anda, Oxborough, & BrØnnick, 2015). With the newer technologies, this kinaesthesia is different, with shaping, altering, and knowledge construction occurring through them. The unified and harmonious sensorimotor action and visual perception during handwriting indicate multiple possibilities for embodied cognition (Mangen, 2013). This is further supported by other studies in which motor-perceptual brain areas have been seen to get activated while reading letters after one has experienced writing them but not when letters are studied only by observation (Longcamp, Anton, Roth, & Velay, 2003; James & Atwood, 2009). Furthermore, letters unknown to adult writers when handwritten have been confirmed to be recalled more easily compared to when they were typed (Longcamp, Boucard, Gilhodes, & Velay, 2006; Longcamp, Boucard, Gilhodes, Anton, Roth, Nazarian, & Velay, 2008). A study on children experiencing embodied cognition-based intervention at school reported that children's reading and writing skills, as well as skills in mathematics, improved significantly because of such intervention (McClelland, Pitt, & Stein, 2015).

In this study, to develop the embodied knowledge construction model, the author relied on Hayes' framework for understanding cognition and affect in writing and Wilson's six aspects of embodied cognition in the context of writing. Wilson (2002) identified six different aspects of embodied cognition. First, cognition has to be considered contextually, i.e. this aspect focuses on spatial features of writing in which the writer's cognitive process is continuously affected by processing of perceptual information. Moreover, this aspect encompasses motor activity that may affect surroundings such as writing in a computer room or classroom. Second, lack of time affects cognition, highlighting the temporal feature of knowledge construction with different levels of stress and time constraints. Third, cognitive work often is off-loaded onto the environment. For example,

because of limited information-processing capacity, people tend to maintain calendars or write things as an extension of their memory. Fourth, the surrounding environment is part of the cognitive system that affects knowledge construction, highlighting the potential of interaction and learning by action. Fifth, cognition is activity, emphasising the role of perception and sensorimotor activity in cognition. This feature can be observed in functionality of objects and circumstances. Finally, offline cognition is body-based, indicating the built-in human skills of mental imagery. Note that humans retrieve information, use working memory and 'relive; events using episodic memory. They are able to mentally manipulate events and imagine fictional events in their minds. This sixth aspect of embodied cognition includes automating skills using implicit memory and reasoning and problem-solving skill (Wilson, 2002).

Hayes' (1996) framework and Wilson's (2002) six aspects of embodied cognition provide an ideal foundation for developing newer models for studying embodied knowledge construction through writing. These models provide newer insights and perspectives for both learning and issues that affect the learning moment. These models focus on the significance of perception and episodic memory and report that the foundation of semantic knowledge rests in sensorimotor representations (Barsalou, 1999). This assertion indicates that learning is not abstract but affected by previous experiences, feelings, actions and thoughts. All of these aspects are interconnected in cognition, affecting the learning process and the otherwise seamless teamwork of the brain, mind and body.

Embodied knowledge construction model

The six aspects of embodied cognition (Wilson, 2002) and the individuo-environmental framework (Hayes, 1996) for understanding cognition and affect should not be viewed separately but merged into an embodied knowledge construction model. Before presenting the model, it is important to justify the incorporation of these specific frameworks. The individuo-environmental model (Hayes, 1996) sees writing as a cognitive process that involves internal experiences and perceived interpretations of the outer world. Moreover, the concept of embodied cognition hypothesizes that cognition is embodied and different states of the body and the environment affect cognition (Adam & Galinsky, 2012; Eerland, Guadalupe, & Zwaan, 2011). By applying newer perceptions, such as embodied cognition, to the individuo-environmental model of cognitive writing processing (Hayes, 1996), the foundation of embodied cognition can be enriched. Moreover, the developed embodied knowledge construction model can mediate a writer's inter-individual differences from multiple perspectives.

Note that the development of this model involves both the epistemological objective of explaining the cognition behind writing and seeks to understand its multidimensionality too. The value of constructing an embodied knowledge construction model is dependent on its ability to explain, understand and study writing as a linguistic medium of cognition. Furthermore, this merged model's value is evident by its contribution to writing research and its inestimable value for

understanding the mind's learning environment. By combining these frameworks, we can understand writing to be a cognitive process of perception and action that considers all levels of physical and mental activity, along with context, time, and environmental and cultural surroundings (Figure 1).

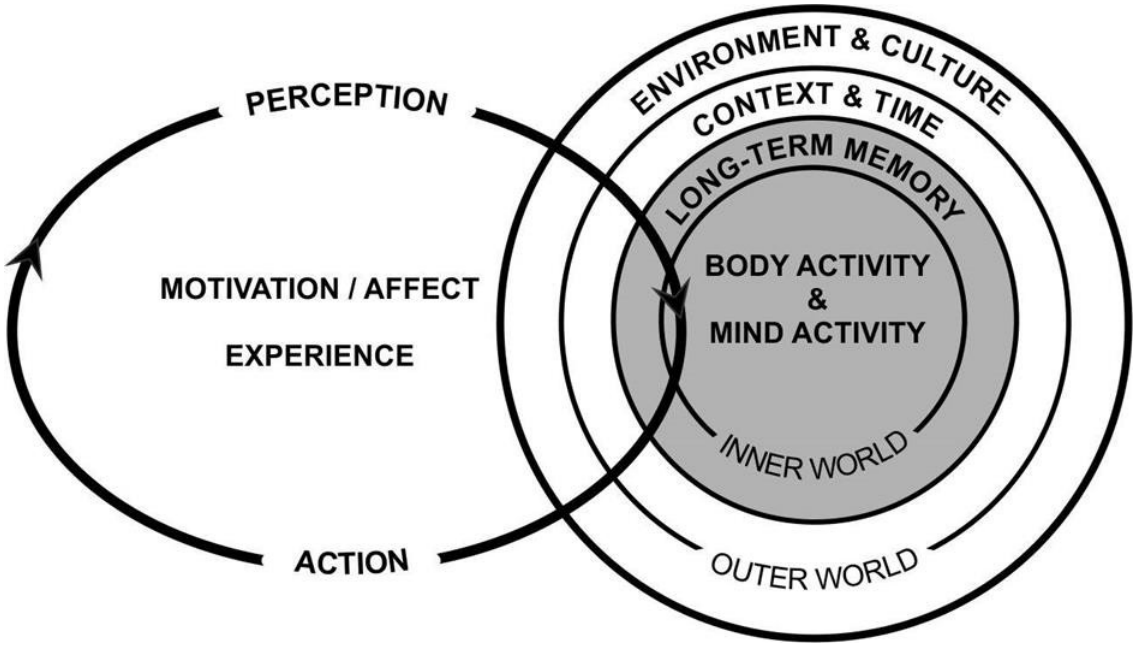

Figure 1. The embodied knowledge construction model

This model combines the six aspects of embodied cognition (Wilson, 2002) into three wider dimensions. The first dimension of environment and culture comprises the third and fourth aspects of embodied cognition concerning the environment. This is represented by the outermost ring encompassing an individual's larger background in Figure 1. The second dimension, i.e. context and time, comprises the first and second aspects of embodied cognition and the second outer ring because they are related to the physical environment and setting of this specific occurrence. Moreover, these two outer dimension rings reflect Hayes' (1996) environment of outer world dimension. The third dimension represents an individual's body and mind activity. It includes aspect five (action) and aspect six (body-based cognition for offline use) of embodied cognition. According to Hayes' framework, the inner dimension ring, along with the dimension ring for long-term memory, represents an individual's inner world. Lastly, Hayes' motivation and affect component is amalgamated with the action and perception experiences of embodied cognition (Barsalou, 2008; Wilson, 2002; Wilson & Golonka, 2013), thus affecting all dimensions of rings and representing their all-pervasive conformation.

In the following section, the embodied knowledge construction model is tested using quantitative recollection tests after writing with different modalities. The following section explains each of the model's dimensions and sheds light on the issues affecting the writing process of participants.

Moreover, it explains how knowledge construction through writing can be explained via the embodied knowledge construction model.

Method

This study is part of a larger design-based study that examines knowledge construction in writing using multiple writing modalities. The overreaching goal of the present design-based research (DBR) (Reeves, 2006; McKenney & Reeves, 2012) is to design and develop a tool for assessing knowledge construction with any writing modality. DBR is a cyclical and iterative methodology that helps researchers develop and improve their practical solutions and theoretical understanding of learning interventions. This study reports one micro-cycle within the DBR process.

The following two interrelated hypotheses were set for this study:

The embodied knowledge construction model will yield valuable information for issues affecting cognition. Second, the above information enhances the understanding of issues affecting cognition.

At the time of testing in 2017, the participants were six 16-year-old Finnish ninth-graders, born in 2001. They wrote down through dictation three short stories by hand, laptop and mobile phone. Stories A and B were from the Finnish version of the Wechsler memory scale-revised (WMS-R) logical memory subtest (Wechsler, 1987), whereas story C of similar length was created such that each writing modality had a different story. All stories had between 421 and 444 characters with a logical story line and required no prior knowledge. Each story had 25 key elements such as animals and incidents that participants could recall after one week. Before the writing tasks, a consent form was signed and a short questionnaire about the participants writing experiences was filled by all participants in the author's presence so that any questions could be immediately answered.

The embodied knowledge construction model was used to understand the questionnaire's answers. This study's confidentiality was brought to the participants' attention who were informed that they will be writing three different short stories with different writing modalities. They were informed that, in the following week, they will be requested to recall the stories. This was done individually without any time limitation. All stories were dictated once and written in a random order at the writer's pace. After each writing task, the story was re-read so that the participants could ensure correctness of the written text. Subsequently, the writing modality and story was changed until all three modalities had been used to write the dictated stories. The participants continued with their normal school activities after the test. One week later, the participants met again to recount the stories. No direct cues were given to refresh the memory, however, questions such as "What happened next?" were asked to encourage participants to speak out as much as

possible. Each recalled key element from the total of 25 was given one point with a maximum recollection score of 25.

Results

The memory tests' results indicated that, for all participants, the mobile phone was the least remembered writing modality; however, there were individual differences for the best writing modality. For three participants, handwriting was the best-recalled modality, whereas for two participants typing on a laptop computer was the best-recalled modality. One participant had equal scores for handwriting and typing on a laptop computer. The quantitative results of the memory tests are shown in Figure 2.

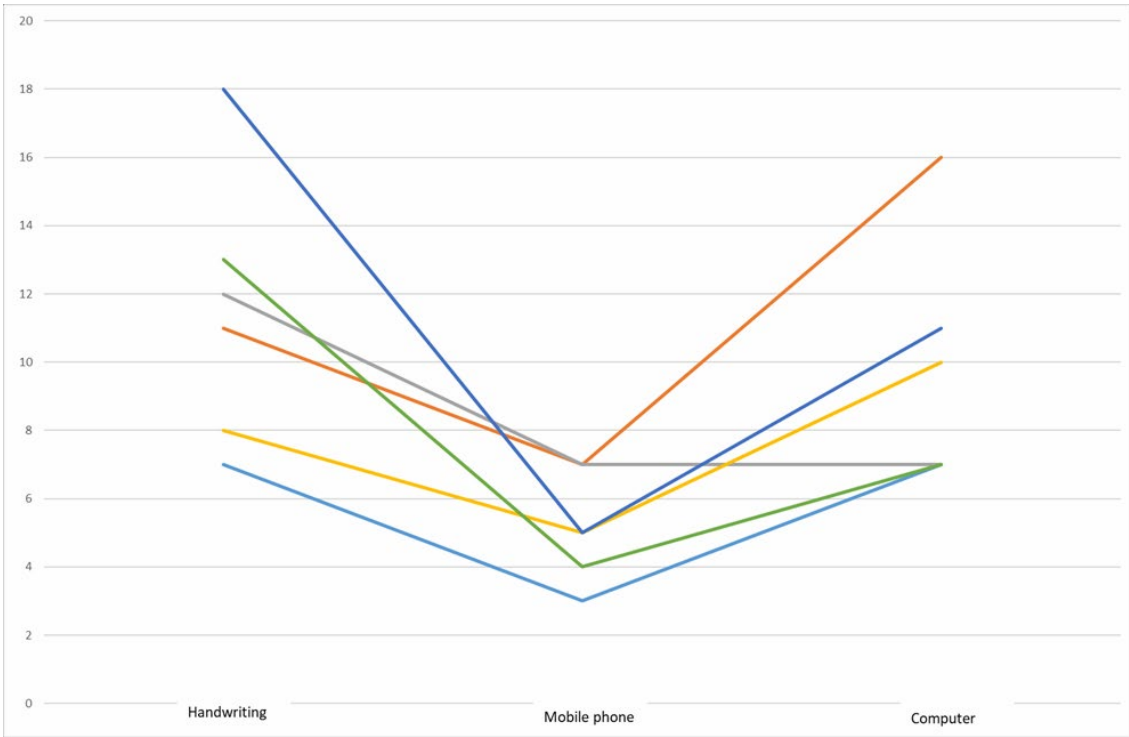

Figure 2. The recollection results of all participants after writing by hand, mobile phone and laptop after one week.

For handwriting, the scores were between 7 and 18 with a mean score of 11.50 (SD 3.94); for the mobile phone, the scores were between 3 and 7 with a mean score of 5.17 (SD 1.60); and, for the laptop, the scores were between 7 and 16 with a mean score of 9.67 (SD 3.56). The low scores and narrow standard deviation for the mobile phone scores indicate that a small touch screen is a relatively bad writing modality for this group of participants. However, their recollection results were quite similar for handwriting and typing on a laptop with even the standard deviation similar for both cases.

Based on these scores, handwriting and typing on the laptop was the best-recalled modality for the participants. However, the scores do not indicate issues affecting these results. To examine

them, the embodied knowledge construction model was used and the answers to the questionnaire were examined. This allowed us to understand aspects that affect cognition because of writing.

When we start examining the outer dimension ring of the outer world, that of environment and culture, we must be remember that the general social and cultural environment may affect the outcome of knowledge construction by writing. How does the social and cultural environment generally perceive writing or how does the social and cultural environment of a specific occasion perceive writing? Is the sociocultural environment motivating or encouraging for writers? Does the society, family or individual have positive or negative experiences with writing? Is the individual writing alone or with someone else? What is the atmosphere of the classroom? All of these factors can affect the general atmosphere for writing.

In this study, the participants were all adolescents from Finland, where education is generally of good quality and teachers are very well educated professionals. The participants were from a school that had high regard for artistic and written expression with encouraging personnel; moreover, they had a positive family background too since they shared similar values. Furthermore, the class atmosphere was positive and accepting individuality. All participants seemed to enjoy the testing and meeting after one week in which they could talk freely about the stories that they wrote as well as their own writing habits.

Note that, in the outer ring of the outer world, the physical environment of writing is integrated with the dimension of context and time. Cognitive activity is situated and connected to the context in which it takes place even if the same physical environment is provided to all of us. Individuals differ in terms of how they observe and perceive writing-related situations. For example, the writing method or medium might be dependent on the general physical writing environment if computers were located in a specific room at school. Furthermore, the writing mediums, digital or non-digital, as well as the text produced can be seen to affect the physical environment of writing. Moreover, the participants' individual levels of automaticity with the writing medium may influence knowledge construction. Time constraints can inherently affect results too; however, not having such constraints can have negative effects. Finally, the time of day can be a factor, e.g. one might be hungry if lunch time is approaching.

In this study, the writing test was performed in the participant's own classroom, as it was the most familiar and convenient place for them with their own desks. The tests were conducted late in spring, just before the summer break, on a Tuesday morning. All of them had their breakfast and nobody was in a hurry. The recollection scores were recorded exactly one week later in a cosy room, opposite the home classroom, that had sofas for group work. The three participants who used all 10 fingers for typing had started to use computers at home at approximately the age of 8; they started using touch-screen mobile phones between the age of 10 and 11. However, their

experience did not seem to affect the recollection of the texts, the first participant scored 7 in typing, 13 in handwriting and 4 with phone; the second participant scored 11 in typing,18 in handwriting and 5 with phone; and the third participant scored 10 in typing, 8 in handwriting and 5 with phone. Furthermore, the participant who used 8 fingers since the age of 6 for typing and had used touch screen mobile phones for three years, scored 7 for both typing and handwriting and 3 with the phone. The participants who used 3 fingers for typing since the age of 6 and touch-screen mobile phones since the age of 11 scored 16 for typing, 11 for handwriting and 7 with the phone. Interestingly, these five participants liked to regularly play games on computer and reported using mobile phones for instant messaging throughout the day. This regular phone usage still did not seem to make it a means for recalling one week later. One participant that had started to use computers at school just 2 years before and used only 2 fingers for typing, and owned but did not use a touch-screen mobile phone regularly, still scored well with both modalities: 7 in typing and 7 with phone. In this case, handwriting scored the best with 12 points, i.e. the participants used mobile phones for communicating quickly with friends and computers for gaming and some school work. For all participants, handwriting was the most regularly used writing modality in which they had considerable experience too.

The individual's inner world dimension ring involves his or her inner world; it represents the individual's mind, body and brain activity while writing. The individual's mind and body, i.e. perceptual and motor systems, form the very epicentre of the embodied cognitive process, indicating that the items to be recalled are encoded and stored in the long-term memory. Moreover, the inner world incorporates an individual's perception of his or her own body and senses. The writer perceives the surroundings during the writing event, including the written text. The written stories are visually perceived, creating an internal representation of the narrated world and occurrences in stories. These occurrences offer an opportunity for kinaesthetic imagery and physical interaction with that imagery. Furthermore, the writing event itself presents an action-perception sequence with motivating and affecting factors such as earlier experiences. Each writing method offers different motoric actions, the result of which is a written text that can be simultaneously perceived. Different writing methods may activate the motor and motor-sensory networks in the brain. Subsequently, these networks could connect to higher cognitive functions, such as long-term memory, and thus knowledge construction.

There are some limitations of this study, and they become apparent particularly for the inner world dimension. Firstly, two participants mentioned that they associated one of the stories with occurrences and experiences of their holidays or somehow with a person with a same name or profession. Naturally, this affects the story's recollection. Secondly, the questionnaire yielded only information about their experiences and not perceptions, which would have been beneficial for this study; however, at the time of testing, it was not known that perceptions should be recorded. Thirdly, it would have been beneficial if, right after each test, the participants could have written down their reflections and feelings about the event. Alternatively, a semi-structured interview right

after the tests could have provided more insights to the innermost perceptions of the participants with more detailed questions. The meeting after one week was necessary for the memory test results; however, an additional meeting right after the writing test would have been better for recording only the feelings and perceptions of the participants, and not the stories' content. Lastly, another limiting factor is the small group of participants and the subsequent inconclusive quantitative results. However, this study encourages development of this data collection method further, even if relation between recollection results and affects could not be objectively proven. Valuable information was still obtained that indicated the usefulness of the embodied knowledge construction model and the affecting factors for the recollection results. In sum, the embodied knowledge construction model yields valuable information for issues affecting cognition, and the obtained information enhances the understanding of issues affecting cognition.

Discussion, Implications and Conclusion

This study offers new insights and contributions to the field of writing research, particularly because the learning process is such a debated area for the cognitive and educational sciences. Moreover, there is lack of research when it comes to newer methods of writing and cognition. However, the model presented in this paper offers grounds for more empirical research on a larger scale on the topic of writing as well as issues that affect the learning process during writing. Further empirical studies could identify the models' limitations more accurately and developmental requirements and refine it to a better model.

An individual's motivation, experiences, inner and outer worlds, cognitive process and long-term memory represent the intertwined components of cognition. One's feelings at any particular moment or one's sociocultural background can affect his or her perceptions of writing and the cognitive process too (Borghi & Cimatti, 2010). Indeed, emotions, pain, hunger, and motivation influence the mobilisation of cognitive processes (Wilson & Golonka, 2013). Under these circumstances, it is apparent that we all have our own individual learning environment in our minds. This fact should be considered when investigating learning process during writing. This can help education professionals evaluate and reflect on their current teaching and learning practices. At the same time, teachers and researchers can use the embodied knowledge construction model for deep reflection and as an assessment tool for the factors potentially affecting cognition through writing. The model also can assist future researchers in investigating the learning process and understanding the multidimensionality and significance of the learning environment in our own minds.

All levels of education currently are integrating technology and multiple forms of writing into teaching and learning. This situation calls for further research and exploration into multiple writing methods and their effects on cognition. Furthermore, as writing on various digital devices is becoming the norm rather than the exception, research and development is necessary in order to

refine existing models and theories of cognition in an effort to develop new guidelines for professionals working in digitized schools.

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