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Pros and Cons: Handwriting Versus Digital Writing

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ABSTRACT

This study compares three different writing conditions – pen and paper, tablet, and tablet with access to speech synthesis – within a class of fourth graders in Sweden. The aim was to examine if these different conditions for writing had any impact on students' creation of narrative text. The empirical data consists of students' texts, composed under these three conditions, completed with data from participant observations. The theoretical model, the Wheel of Writing, in combination with a process analysis described in Systemic Functional Linguistics, served as a basis for analysis of the texts. Observations were analysed using content analysis. Findings presented in this article are partly in line with previous research. Speech synthesis seemed to play a crucial role in improving students' writing. The texts were affected in terms of increased text length, spelling, structure, and content when using digital resources. These results were most obvious for students with Swedish as their second language. One core finding, which was true for most students, was that processes describing action verbs increased when students wrote digitally. Contradicting this, when students wrote by hand they used more processes, describing feelings and verbal processes.

Keywords
handwriting, digital resources, writing, narrative text

INTRODUCTION

The ability to read and write is fundamental for virtually all student learning in all subjects. Therefore, reading and writing education lays the foundation for student learning and opportunities for students to achieve their goals, develop their skills, achieve their potential, and participate fully in society (OECD, 2016: UNESCO, 2004:13). Swedish students'

reading results have decreased according to PISA studies, and the issue of skills in reading and writing has been heavily debated. However, in the latest report on PISA (Skolverket, 2016), student results have once again increased. This has initiated a discussion regarding the relationship between the use of digital resources in education and PISA's results. This is also the first time the test was digital (Skolverket, 2015). There is a need to extend classroom reading and writing education with varied methods, including the use of digital tools (Liberg, 2007; Kress 2010; Edwards-Groves, 2011; Åkerfeldt, 2014). More varied reading and writing methods can both increase motivation and interest as well as providing all students opportunities to improve their skills (Agélii Genlott, & Grönlund, 2013). To combine handwriting and digital writing in early writing instruction could be a way to prevent possible negative effects on motor control, which can occur if handwriting is lost completely (Mangen & Balsvik, 2016).

Reading and writing are two abilities that depend on each other in the early grades. Research on reading has a long tradition, yet writing research is considerably newer. Writing is considered more difficult to control and measure than reading, which means that society knows less today about writing compared with what is known about reading (Wengelin & Nilholm, 2013). Writing in this study is defined as a key competence in school. Writing is also seen as a cultural, individual and intentional act, a communicative event. Writing acts are made by the use of different resources or tools for writing (Berge, Evensen, & Thygesen, 2016). Adoption of digital resources is an important part of our lives today, when the use of digital resources is increasing. Children learn to write on a screen by touching tablets or smartphone screens before they can write by hand. As writing is a central cultural skill and an important prerequisite to success in school, differences in digital writing compared with handwriting is an issue to investigate and discuss. The governing documents also require students to master modern technology use as "a tool of knowledge, communication, creativity, and learning" (Skolverket, 2011, p. 16).

Schools are facing conflicting messages regarding the relationship between writing achievement and digital resources. One argument leans towards research where the results show increased performance (Agélii Genlott, & Grönlund, 2013; Hultin & Westman, 2014; Agélii Genlott & Grönlund, 2016), while others argue that digital resources in writing decrease performance (Mueller & Oppenheimer, 2014). Also, there are messages to schools on how digital writing tools can improve the skills of struggling writers, which can increase accessability and equity (Stone, 2002; Liberg, 2014; Agélii Genlott & Grönlund, 2016). In contradiction to this, Mangen (2016) and Mangen and Balsvik (2016) report on danger in the transition from handwriting to typing, because of the lack of evidence on the effects this may have on students' cognition and fine motor skills. Studying the impact of digital resources on student texts also includes reflecting on technological gains and losses. Important questions to ask include why use new technology, what can bring, and what knowledge will be generated (Mitcham, 1994). It is important neither to stigmatise technology nor to have overconfidence in it. Most important is to describe the opportunities and barriers in different environments, where digital technology can be seen as an environment (Kress, 2010).

Writing is also not just a skill which can be measured in one analysis. It can be seen more as a complex set of skills (Berge et al., 2016). In this study, we take a step in the direc-

tion towards analysing students' texts from more than one dimension: the form, the structure, *one* dimension of the content, and the mediated tools used for creating texts with the purpose of narration. In previous research, the age groups found are younger children (Agélii Genlott & Grönlund, 2013) and older students (Grönlund, 2014; Grönlund, Andersson, & Wiklund, 2014; Muller & Oppenheimer, 2014). Middle school classes seem to be the forgotten grades for research in this field. This target group is particularly interesting because the learning outcomes of the curriculum are higher and more precise compared with the earlier grades, and the students are no longer young children but, rather, have developed in many ways over the years socially, biologically, and mentally (Gidlund & Boström, 2017).

A research gap is therefore evident concerning the impact of digital resources on students' writing in middle school, focusing on students' texts. Our ambition with this study was to explore this impact. The aim was—by implementing digital resources as mediated tools for writing—to examine if different conditions for writing had any impact on students' creation of narrative text. The question was asked: how do various mediated tools for writing affect student texts when students create text by hand compared with digital writing? To answer this research question, previous research and conceptual frameworks are presented followed by the empirical and methodological basis. Finally, the concluding section of the article discusses the results, and both pedagogical and practical implications.

PREVIOUS RESEARCH

This overview focuses on previous research related to the study, such as the use of different resources for writing, handwriting compared with digital writing, and students' text creation.

When comparing writing by hand to using digital resources, there have been conflicting and paradoxical results regarding what impact the revised terms for writing have on students' text creation. Digital writing impairs students' memories, according to Muller and Oppenheimer (2014), who conducted a study on university students' writing with different resources wherein students were assigned to different conditions and instructions. Those who wrote by hand produced the least number of words but could best describe the content. However, the students who wrote digitally produced much more text and did so very literally. Muller and Oppenheimer's conclusions were that students remember better when they write by hand and that digital writing can affect students' performance negatively. The students who wrote digitally seemed specifically to compose rich content with a wide range of meaningless depreciation (for example, a student essay which contains many words, yet lacks substantial content). These results seem to be relevant in all age groups from pre-schoolers to adults. The perspective of learning and remembering better while taking notes was also found in a Norwegian case study, where the participants were in the same age group as the present study. Even though the findings on a general level showed that the use of tablets made writing easier, some of the students related that they learned better if they wrote by hand (Kongsgården & Krumsvik, 2016).

Similar results were reported by Longcamp, Zerbato-Poudou, and Velay (2005), and Longcamp et al. (2008). These researchers conducted studies on pre-schoolers and adults,

with the aim of investigating which method produced the best results concerning people learning to write new, unfamiliar symbols. Those who had to learn by hand showed better results than those who did so digitally. Longcamp et al. (2008) concluded that the combination of physical action and memory makes people remember better. To encourage teachers to use keyboards instead of pen and paper in early writing instruction is, according to Mangen (2016), ill advised. She argues that we still know too little about how the effects of transition from pen and paper to writing with digital tools will affect the close connection of motor action, perception and cognition (Mangen, 2016; Mangen & Balsvik, 2016). Handwriting, in addition to writing with digital tools, may be a solution for preventing long-term negative effects on motor control skills, and may prevent the ongoing marginalisation of handwriting in writing instruction (Mangen & Balsvik, 2016). This is also highlighted in a Norwegian study, where the authors suggest that at times, as now, when there is a change in early writing instruction, at least in Scandinavian countries, there is a need for studies of effects to provide answers on how to combine handwriting and digital writing instruction, with the aim of improving students' writing skills (Wollscheid, Sjaastad, Tømte & Løver, 2016).

Furthermore, using digital tools for writing can increase comprehension of subject content, provided the writing is well integrated into an educational thought, according to Agélii Genlott, and Grönlund (2016), and increases availability and equivalence. The authors argued—like Mueller and Oppenheimer (2014)—that by introducing technology alone, however, there is a tendency towards negative effects on writing and its contents. Liberg (2014), like Agélii, Genlott, and Grönlund (2014), pointed out the advantage of using word processing software in combination with speech synthesis in the development of early reading and writing skills. All students in grade 1 cracked the written code when they used digital resources for writing; this was probably due to using speech synthesis, which gave direct feedback on correct letters and spelling. A similar relationship was also found by Hultin and Westman (2014). The ability to hear how letters and words sound in combination with the writing gives students a functional connection. Combining form with functionality is favourable for the construction of an internal dictionary of the written word and the orthographic lexicon, which is favourable for writing development (Hultin & Westman, 2014; Liberg, 2014; Myrberg, 2007). The use of speech also means, according to Liberg's (2014) study, that students can be supported on an individual level, and that any motor difficulties in shaping letters are alleviated.

The foray of digital resources into classrooms can be understood as a meeting between students' prior knowledge and established teaching methods (Liberg, 2014; Sofkova, Hashemi, & Spante, 2016). Nyström Höög (2010) described writing development in grade 5 and grade 9 student texts in Swedish schools. The texts were analysed quantitatively and qualitatively regarding several linguistic variables, including text length and content. One part of the content analysed was through process analysis, which is part of Systemic Functional Linguistics. This was done in both grades. Strikingly, Nyström Höög (2010) found many relational and mental processes. This result is remarkable because material processes, according to Holmberg and Karlsson (2013), are most common. A process analysis of informal texts written on computers in students' early schooling years showed similar results: most texts contained a majority of relational processes (Liberg, Wiksten Folkeryd, & af Geijerstam, 2014).

How parts of Systemic Functional Linguistics can be used as a tool for analysing students' narrative texts was discussed by Correa and Domínguez (2014) regarding tools for helping students develop their narratives. For example, Correa and Domínguez (2014) analysed what kind of processes the students used in their texts in terms of action verbs, how students constructed action, and what the characters said, felt, and thought. The researchers found that the text makers included hardly any action verbs (material processes), which meant the students had failed to achieve the purpose of the narrative. This means that if teachers know how to analyse texts in this way, these results can be used to help students develop the texts, according to Correa and Domínguez (2014).

In conclusion, the results are contradictory, showing that digital writing impairs students' memories, and makes text become meaningless depreciation, but can increase understanding and availability while writing. However, some research commonly found that speech synthesis can play a crucial role in students' writing: the ability to write and crack codes earlier, to more easily find the interplay of form and function in the text, and to gain support in the writing process. Research on how the contents of students' texts are affected by digital resources remains in its infancy.

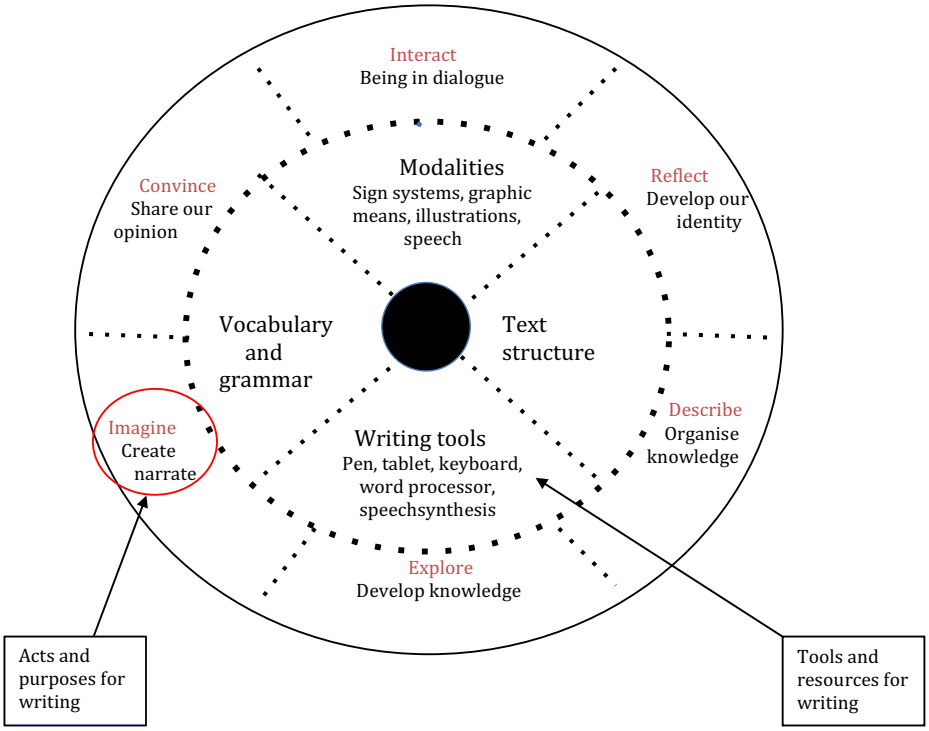
CONCEPTUAL FRAMEWORK DRAWING ON PARTS OF THE WHEEL OF WRITING AND SYSTEMIC FUNCTIONAL LINGUISTICS

Two conceptual frameworks inspired the present study: the Wheel of Writing, the theoretical model that places writing at the focus, and one part of Systemic Functional Linguistics (SFL).

The Wheel of Writing

In an attempt to define what writing is, a theoretical model has been developed with the aim to be a tool for conceptualising writing (Berge et al., 2016). In this study, we use parts of the model to motivate the choice of taking different aspects of writing into consideration when analysing the texts.

A basic assumption for this theoretical model is that writing is an act and that the writer has a purpose when writing. Another assumption is that the writer creates meaning when using mediated tools, which include technology. The purpose of writing, which is mediated through semiotics in combination with the different acts which we use to express ourselves, composes the intentionality of writing. The wheel shows six different acts of writing and six different purposes of writing, all which correlate with each other. This is visualised in the outer ring in Figure 1. One of these acts, the act of imagining with the purpose of creating and narrating, is one of the focuses in this study.



The wheel of writing, inspired of Berge, et al. (2016).

Figure 1. The Wheel of Writing, with a focus on the semiotic mediation of writing.

To carry out a certain act with its certain purpose, semiotic resources are seen as meaning-making tools. The theoretical model includes tools and resources for writing. This is visualised in the four different fields in the inner ring of the model.

The physical tools used in the writing process are as important as the mental and motor conditions. According to this theoretical model, writing is seen as the use of different sign systems available. In this study, the sign systems of writing and speech are taken into consideration.

Lexico-grammatical resources are another example of resources for writing, as well as text structure and writing tools. Writing is composition. Using the different resources, one composes the text (Berge et al., 2016).

Systemic Functional Linguistics (SFL)

SFL can be described as a holistic approach to language. It is a socially focused, text-focused, and meaning-focused theory. Language is seen as a gigantic social semiotic system (Halliday & Matthiessen, 2013). This theory can serve as a tool in practical work with language, such as writing as a tool for text analysis (Holmberg & Karlsson, 2013). In this study, only parts of this complex theory are used as a tool to determine if different conditions for writing can affect how content is created in terms of processes.

SFL is used to assume that texts are utterances created in social contexts and that all texts contain three meta-functions (Halliday & Matthiessen, 2013; Holmberg & Karlsson,

2013). These are: the *interpersonal* function, related to the relationship between text creator and reader; the *ideational* function, which deals with the content; and the *textual* function, which affects how text elements are related to each other. In this study, we proceed from the ideational meta-function when we analyse how students express their experience of the world in their texts. This meta-function can also be called the *experiential function*. The core descriptions are called the processes and expressed acts of "doing", "sensing", "talking", and "being". These meanings are considered the central experiential meanings in the language (Holmberg & Karlsson, 2013). How these meanings are expressed in student texts is analysed through the different process types described below in Figure 2.

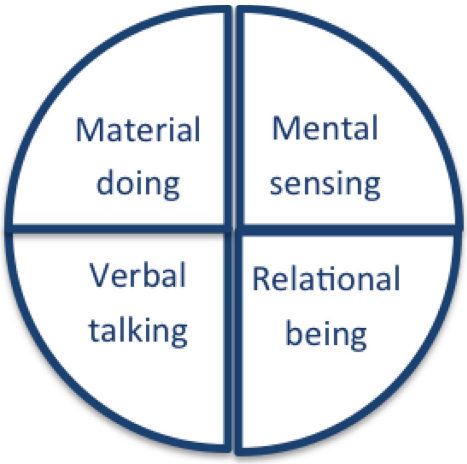


Figure 2. The ideational function and four different process types.

Material processes are the most common process type of narrative text (Holmberg, Grahn, & Magnusson, 2014). The term *material* means that this process changes something in the outer world. Simply put, something happens. If the material is about processes that occur in the physical and material world, *mental processes* express the opposite: what happens within people, such as feelings. *Verbal processes* indicate someone saying something with signs, or verbally. *Relational processes* describe how people or things are related to each other.

In conclusion, this study is inspired by two theoretical concepts. The Wheel of Writing is used to justify the importance of seeing writing as something multidimensional. The study does not address all parts of the model. The focus is on the purpose of imagining and narrating and the use of pens, tablets, and speech synthesis as mediated resources for writing, using the sign systems of writing and speech. To analyse how students use language resources when creating narrative, one part of Systemic Functional Linguistics theory is used. By analysing how the students expressed the verbs of "doing", "sensing", "talking", and "being", we attempted to see if the content was affected by the use of different resources for writing.

DESIGN AND METHODOLOGY

The purpose of the study was to implement digital resources as mediated tools for writing and to examine if different conditions for writing have any impact on the students' creation of narrative text. The design was explorative using qualitative and quantitative methods.

The class included in the study was selected because it fulfilled the criteria set in advance to answer the research question (cf Grey, 2013). The criteria were a) the students would be of an age group, the middle years, that already knew how to write, as we were not focusing on the best way to learn to write, b) the students would have experience of writing both with digital tools and pen and paper, and could therefore handle the options, and c) the students would be both boys and girls with varied access to digital tools at home.

The school is a primary school with approximately 300 students, located on the outskirts of a medium-sized city in a low socio-economic status area. The class consisted of seventeen fourth-grade students, but one student moved during the year, with sixteen students remaining. Six students had Swedish as a first language (L1). Ten students had Swedish as a second language (L2). The class had not used digital resources during their narrative-writing activities. Three different writing tasks were included involving three different conditions for writing as the basis of the study. Each time, the class teacher gave the same instructions: the students were to write a narrative text in which something happens with a beginning, middle, and an end. There should be an expected, given structure in the narrative (Johansson, 2005; Johansson & Sandell Ring, 2010). The style of the narrative text was chosen because it is the most commonly used genre in the Swedish curriculum for students' middle education years.

Initially, participant observations were conducted while students created a narrative in the way in which they were accustomed: with pen and paper. A writing assignment was then introduced, and the students wrote the first text by hand. Then, the students used digital resources in the form of tablets to write a narrative in order to form the habit and the technique of writing on tablets. During that time, observations were carried out to determine whether something in the writing process changed. Another task was then performed with similar instructions to the first task. This time, the conditions of writing changed to writing on tablets in a programme that also had a speech synthesis function. Students could choose to have the text they wrote read aloud. The third condition for writing was based on a similar task as in the first two occasions, but this time, students wrote on tablets without speech synthesis.

Data

The empirical data gathered in the study consist of student texts and participant observations. The texts that were compared were three texts written by the same student under three different conditions. The conditions for the intervention, the subject, the number of students, and the time allotted for writing are shown in Table 1 below.

Table 1. Overview of intervention students' texts

Occasion	Time	Conditions	Theme	Students
1	60 min	Pen and paper	An exciting event	17
2	60 min	Tablets with speech	A different day	17
3	60 min	Tablets	Something unexpected	16

Analysis of Student Texts

The text analysis was based on the assumption that writing is complex and cannot be seen as a general competence (Berge, et al, 2016). To compare students' text creation, different dimensions of writing were taken into consideration. The four dimensions in the Wheel of Writing theoretical model, the resources for writing, and with a process analysis as described in Systemic Functional Linguistics (Halliday & Matthiessen, 2013; Holmberg & Karlsson, 2013) served as a base for the analyses of the texts. As the purpose of the study was to implement digital resources as mediated tools for writing and to explore if different conditions for writing have any impact on the students' creation of narrative text, the tools for writing were broadly analysed on different levels. Three different tools for writing were included in the analysis: a) pen and paper, b) tablet together with speech synthesis, c) tablet. The modalities, or sign systems, taken into consideration in this study were writing and speech when using the speech synthesis. How vocabulary and grammar were used and how the text structure was affected by different resources were analysed in the texts. In order to be able to analyse one dimension of the content in the texts, a process analysis was performed. This makes it possible to analyse different processes that are dominant in the texts, such as "doing", "sensing", "talking", or "being" in the texts (see Halliday & Matthiessen, 2013; Holmberg & Karlsson, 2013).

Variables in the concept of vocabulary and grammar included linguistic correctness and text length. The linguistic correctness was inspired by the National Agency for Education requirement level for storytelling in the national tests for grade 3 (Skolverket, 2011). Because the students in the writing studies were older than students in grade 3, and in order to better match the research question, small adjustments were made. To find the total number of linguistic errors, the text was divided by the number of words in order to obtain a relationship between the number of errors and the text length. The variable length of the text is highlighted in the study because the length of students' texts has traditionally been a measure of writing ability. Results from previous studies have shown that text length and rating are correlated (Hultman & Westman, 1977; Larsson, 1984). To review the structural elements of the texts, Knapp and Watkins's (2005) terms (based on the Labovs and Waletskys study, 1967) for a narrative were used. More specifically, these terms include *orientation*, a *sequence of events* or *complication*, an *evaluation*, a *resolution*, and a *coda*.

The data were processed using a statistical descriptive method of frequencies, thus providing an overview of the information in the material.

Observations

To analyse how students' writing processes may be affected by different resources for writing, the observations of the situations when students created the texts were made in two rounds: first, when they created the text by hand and second, when they created the digital text. Participant observation is one of the key tools in qualitative research (Creswell, 2014). Four days were spent in the class. The observations were documented using a protocol where predetermined observation categories were designed. This empirical study consists of eight protocols of two pages each, which when condensed, totalled sixteen A4-pages in 11-point Calibri.

The categories for observation referred to differences in the writing process when students wrote with different tools for writing. If and how students used speech synthesis was observed, and if the interaction was different, the different conditions for writing were also observed. If there was a difference in how much help students needed, this was observed as well.

The contents of the observations were analysed using a thematic content analysis (Ahuvia, 2008). The themes that emerged in the content analysis were: speech synthesis, interaction and participation on more equal terms.

The research was conducted in accordance with the Swedish Research Council's (Hermerén, 2011) ethical requirements, involving special considerations as students were under the age of fifteen.

Methodological Questions

Because this is a small study with a class of sixteen students, the results cannot be generalised. Thus, it applies only to this group of students. Since the strategy of methodology is abductive, the research process has moved between theory and empiricism, and we have attempted to find the most likely explanation. Concerning the credibility of the results of the study, we have tried to achieve it in part through transparency in the research and partly through both the researchers' gathered data and the long experience of the specific educational practice. To ensure reliability in the study, two researchers independently analysed the results and then worked together to reach a consensus. One critical question is whether the time between writing sessions influenced the results of the text writing. What are the real linguistic improvements, and what is maturity? On an individual level, this is impossible to answer. However, on the group level it is not of importance, because all students were measured at the same time. Another question is if and how textual themes affected the quality of the texts. Because the themes were quite similar, we believe that they did have a decisive effect. Furthermore, one can ask whether the order of the experiment played a role in the outcome (i.e. write by hand [1], using tablets with speech synthesis [2], and using only tablets [3]). Further studies are needed to answer these questions.

RESULTS

The theoretical model the Wheel of Writing, supplemented with one part of Systemic Functional Linguistics, is the conceptual framework for this study. The act of imagining with a purpose to narrate was the focus of the students' text creation. The four dimensions were taken into consideration: writing tools; text structure;: vocabulary and grammar; and modalities. Below, the results of the analyses of the different variables in student texts are presented, namely linguistic correctness and length, structure, and process analyses of content. The students were divided into two groups: Swedish as their first language (L1, N=6) and Swedish as their second language (L2, N=10). This was not the intention initially. However, in the analysis, a difference emerged according to this variable. The observations are also reported below.

Writing Tools and Modalities

The impact of the three different writing tools on student texts were analysed according to grammar and vocabulary, text structure, and process analysis, and are presented under each heading below. The sign systems (modalities) used in the study were writing and speech. In the study, multimodal analysis is not included, but the results indicate that the sign systems and speech were used and played a crucial role in the text making for the L2 students, as presented under each heading below.

Grammar and Vocabulary

First, the text length was examined. The words were counted in the students' texts. In Figure 3, the length of each text on three occasions is shown.

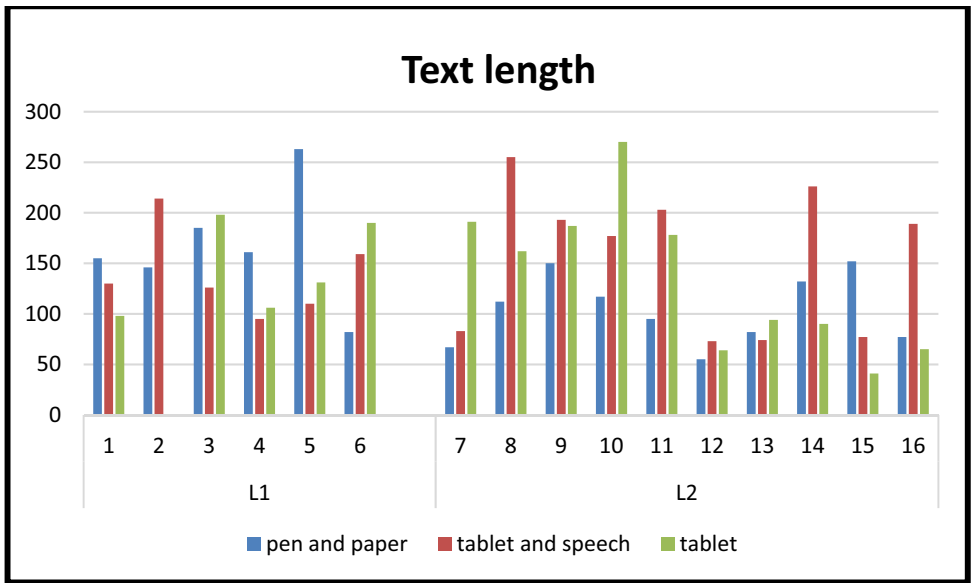


Figure 3. Text length in three texts per student.

The results show that the L2 group wrote much longer texts digitally, and even longer when they also had access to speech synthesis. This trend was not found for the L1 group, for which the result was the opposite. The mean values for the two groups are presented in Table 2.

Table 2. Mean values for the two groups, Students (L1) and students (L2) text length/number of words.

Conditions	**(L1) M**	**(L2) M**
Text 1: pen and paper	165.3	103.9
Text 2: tablet and speech	139	155
Text 3: tablet	144.6	134.2

All the texts were then examined on the basis of the National Agency for Education requirement level of narrative in the national tests for grade 3 (Skolverket, 2011). The language errors were based on three main factors: vocabulary, spelling, and "other" language faults. The number of errors in the text was divided by the number of words in order to obtain a relationship between the number of errors and text length.

The number of errors, expressed as a percentage of the text, for the first, second and third text creation activities are shown in Figure 4 below.

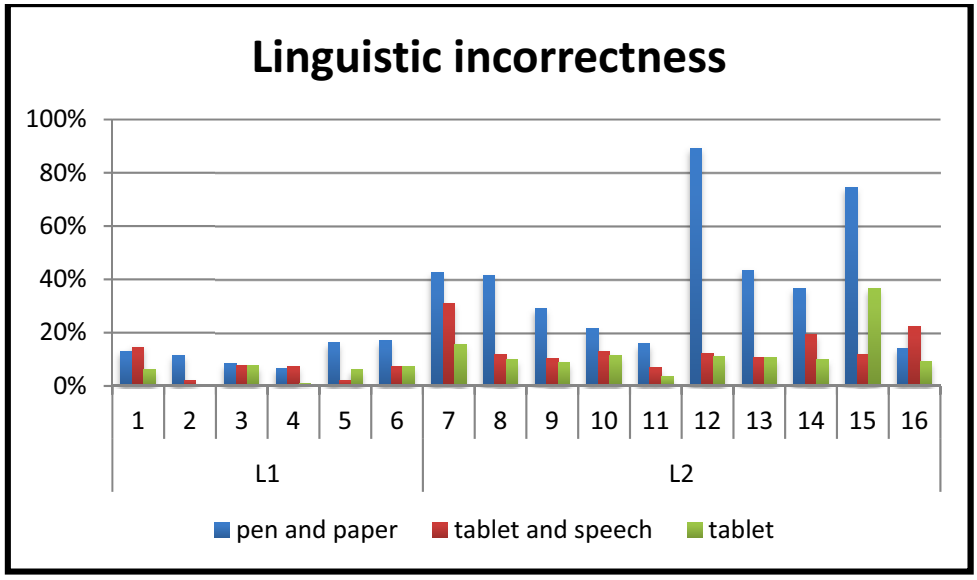


Figure 4. Linguistic incorrectness/number of words in percentage.

The results show that the majority of students wrote texts with increased linguistic correctness when writing on tablets. This result were shown in both groups of students, but, as shown in Table 3, the L2 group increased the correctness in the digital conditions the most.

Table 3. Mean values for the two groups, Students (L1) and students (L2), linguistic incorrectness.

Conditions	**(L1) M**	**(L2) M**
Text 1: pen and paper	12.08	40.8
Text 2: tablet and speech	7	15
Text 3: tablet	5.6	12.6

Text Structure

The criterion for the national tests is to have a structure with a chronological sequence of events in which the plot is clear. To review structural elements of the texts, we used Knapp and Watkins's (2005) terms for narrative (i.e. orientation, a sequence of events or complication, an evaluation, a resolution, and a coda) with the aim to find variations in the structures in the texts. Based on the five criteria, the texts were analysed using a point-based

matrix.

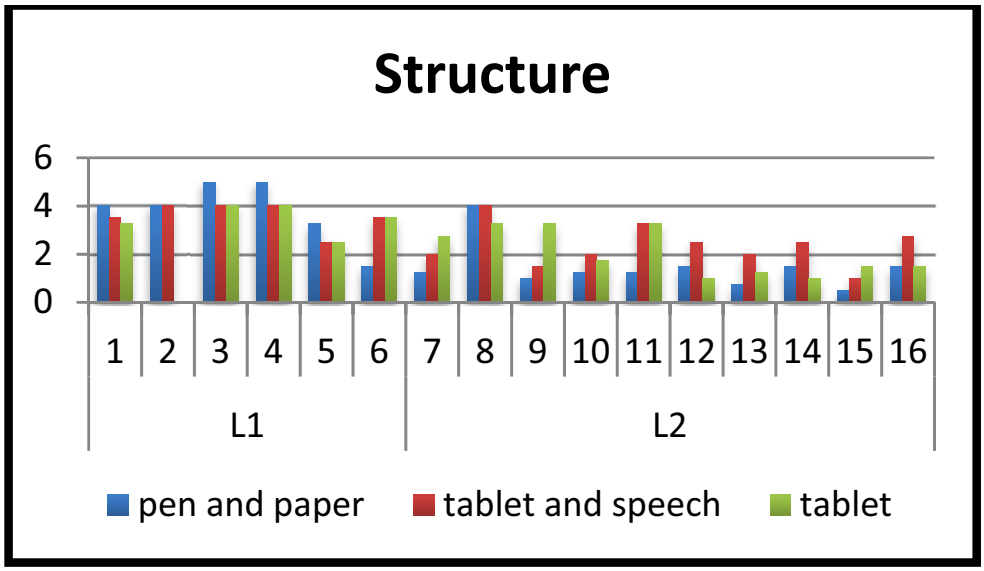


Figure 5. Assessment of the structure of the texts.

As shown in Figure 5, most L2 students improved the texts' structural content using tablets with speech synthesis. This did not occur for the L1students. The results of Table 4 shows that, the L1 students, in general showed the best structure when writing with pen and pencil.

Table 4. Mean values for the two groups, Students (L1) and students (L2), evaluation points

Conditions	**(L1) M**	**(L2) M**
Text 1: pen and paper	3.8	1.45
Text 2: tablet and speech	3.6	2.35
Text 3: tablet	3.5	2.05

Processes

Process analyses were used in order to see how different processes ("doing", "sensing", "talking", or "being") were dominant in the texts. This is one method of determining whether the content in texts changes when using different resources for writing. In general, the texts mainly contain material processes, which is the most common type of process in narrative text. However, this differed sharply between the different writing sessions. When students wrote on tablets with speech synthesis, more material processes were seen. That is, the students expressed "doing" in a large portion of the texts. The opposite result was true when it came to the mental processes, which were expressed most frequently in the texts which were created by hand. Also, the verbal and relational processes were expressed the most when students wrote by hand, but there was not as big a difference as in the case with the mental processes.

To exemplify how the processes can be distributed in a text, two short examples are presented. The same student wrote the two texts under different conditions. This first text, text 1, is created by hand and contains the most mental processes.

> Mom says he has to hurry up. He feels scared. It's very cold and dark outside.
> It looks like someone has blood on him self, that does not make me feel any better.

Below is a short excerpt from when the same student wrote text 2 digitally. This example illustrates a text which contains many material processes.

> There were no mental processes included in this text.
> After I had eaten up, I brushed my teeth and went to the toilet but the paper was out. I had to get more in the basement. It was now 6.30 pm, the school starts at 8.00, someone knocked on the door.

A difference between the L1 and L2 learners could only be discerned for the verbal processes. L2 students generally expressed more verbal processes in their texts when compared with L1 students.

Observations

Three areas could be identified where there was a clear difference depending on the various conditions for writing, including how the students used speech synthesis, interaction, and participation on more equal terms.

Most students, all but three of the students, used the speech synthesis. Some students used it the entire time that they wrote. Others wrote without speech and listened to their text occasionally. Some students did not want to rewrite a text that they were unhappy with, because they thought that they had to rewrite everything. The students wanted to let classmates listen to their stories. More students interacted with others when they wrote digitally, whereas they worked more individually in silence when they wrote by hand.

Some wrote only when a teacher was sitting nearby so they always could get spelling feedback when writing by hand. When they wrote digitally, a change was observed where students listened again and again to the words they wrote and could hear what was wrong in order to correct themselves. This suggests that these students were able to participate on more similar conditions in the writing activity.

Summary of Results

The analysis revealed differences in some areas, and differences were found within the dimensions of vocabulary and grammar (language accuracy), text length, text structure, and abundance of material processes. L2 students wrote much longer texts, and they used more accurate and structural language when using tablets with access to speech synthesis. This also applied to students with L1 in terms of language accuracy but not the length of the text or the structure. The result of this section show that material processes dominated when students wrote digitally and that mental, verbal, and relational processes dominated when they wrote by hand. The observations indicate that students used speech while spelling, which resulted in less need for help. There was more interaction between students when they wrote digitally.

DISCUSSIONS AND CONCLUSIONS

The aim of the study was to find out how students' narrative texts were affected by writing with different resources—handwriting compared with digital resources. The results show that different resources for writing in middle-school students' text creation have impact on different areas.

One area is grammar and vocabulary (language accuracy and differences in text length) and text structure, and another area is how students describe the content of the text in terms of what process types dominate the texts. A difference in the results, depending on whether the student was an L1 (N=6) or L2 (N=10) language speaker, turned out to be the core finding. Initially, this research aspect was not taken into consideration, but it was a result that emerged. L2 students wrote longer texts with greater linguistic correctness and better structure when they used tablets with access to speech synthesis. For students with L1, no clear results could be found. Above all, the possibilities of using speech synthesis as a resource when writing seemed to be a positive variable (cf. Agélii et al., 2014; Liberg, 2014) for L2 students. Using various types of scaffolding tools, such as speech synthesis and word processors, can create opportunities for students to participate and produce texts on more equal terms. This includes students with L2 as well as students who struggle with writing in different ways. Similar research results have been reported for both of these student groups (Stone, 2002; Agélii Genlott, & Grönlund, 2013; Liberg, 2014; Hultin &Westman, 2015). However, this did not apply to students with L1. The text length may have increased for the L2 student group due to the possibility of transforming the text (cf. Elmfeldt & Erixon, 2007; Nordmark, 2014; Åkerfeldt, 2014). However, it could also be that the range of redundant words increased for students who wrote longer texts digitally (cf. Muller & Oppenheimer, 2014). This is supported in the process analysis, which indicated that material processes increased when students wrote digitally. Another explanation may be the increased motivation students who needed a lot of teacher support when they wrote by hand. When writing with speech synthesis, some students wrote more on their own, and they could listen to how words sounded, which could give students an understanding of both form and function simultaneously. The combination of form and function has been proven to be beneficial for students' writing skills according to previous research (cf. Hultin & Westman, 2014; Liberg, 2014; Myrberg, 2007). The fact that language accuracy in the students' texts is improved when they use digital resources is seen clearly in this study for L2 students. However, this does not say anything about whether or not they master language accuracy. The explanation may lie in the use of word processors and speech synthesis resources. When using this resource for writing, students compose texts that are more linguistically correct. However, the question remains: is this about mastering the technique or learning linguistic correctness? The analysis of the narrative structure of the texts showed that the digital resources (particularly combined with speech synthesis) had a positive impact on student texts written by L2 students. If the use of digital resources is of decisive significance for early writing development based on the established requirements in Swedish for the age group, can, however, not be determined from this study.

As an indication of whether the contents of student texts were affected by the intervention of digital resources, the presence of different process types, as presented in Systemic Functional Linguistics (Halliday & Matthiessen, 2013; Holmberg & Karlsson, 2013), was

analysed. The results showed that the contents of the texts changed when digital resources were used. The most evident was that most students used material processes ("doing") when writing with digital resources, especially in combination with speech synthesis. These processes are also common in narrative texts (Holmberg et al., 2016). When students wrote by hand, mostly mental and verbal processes were used. In some of the student texts, when students wrote digitally, there were no processes involving emotions, thinking, and talking. Could this be an expression of the link between hand and brain, motor embodiment, and memory (cf. Longcamp et al., 2008, Mangen, 2016, Mangen & Balsvik, 2016)? This is remarkable, especially if we add the results of observations showing that some students interacted more when they wrote digitally, whereas they sat by themselves more when writing by hand. One possible explanation could be the tendency for digital writing to become more of a description of things that happen, whereas the slower bodily process of writing by hand allows for more thought in writing. Another interesting finding was that L2 students expressed more communication between people. Otherwise, there were no direct differences revealed between L1 and L2 students in how they expressed themselves in terms of different processes. One educational implication may be that to help students develop text content in narratives, teachers could conduct process analyses in order to see if certain processes are lacking (cf. Correa & Domínguez, 2014). In this case, teachers could encourage students to add more mental, verbal, and relational processes when writing digitally.

More research on writing with digital resources, combined with the quality of the texts, is needed in the field (cf, Åkerfeldt 2014). This study has taken a step in this direction. With the support of Berge et al.'s (2016) definition of writing and the Wheel of Writing, the study has focused on an overall assessment of student texts regarding writing tools, grammar and vocabulary, text structure, and processes. Based on the positive results in Norway (see Berge et al., 2016), our country has much to gain from a common definition of writing skills, based on a model such as the Wheel of Writing. This could give teachers opportunities to design teaching that prepares students for the society of which they are part. The results of our study indicate that students with L2 have much to gain from the use of digital resources in their text creation (cf. Agélii Genlott & Grönlund, 2016). Therefore, there is a need for research, which highlights the relationship between students writing in a second language and gains from using scaffolding tools for writing.

According to the Wheel of Writing, writing is seen as the use of different sign systems (see Berge et al., 2016). This study was limited to the use of writing and speech, where access to the sign system speech (speech synthesis) turned out to be of great importance for a certain group of students. An important future research area for this particular group of students could be to analyse texts, created with the use of multiple sign systems.

For example, creating narrative texts using audio, image, and video combined with writing is a matter of accessibility and equity. What will be valued as necessary knowledge in the future, is a relevant question to ask in order to equip students for the society in which they will work.

How can all of the linguistic processes in students' writing be developed? What happens to the textual content when writing by hand is replaced with digital writing? Here we see the need for broader research about writing as well as the use of digital resources. The focus on students with Swedish as a second language (L2) seems to be particularly important.

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