Re-shaping of Writing in the Digital Age

a Study of Pupils’ Writing with Different Resources

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ABSTRACT

This article explores how resources used in test situations shape pupils’ writing and to some extent their possibilities to represent their knowledge. Two conditions (pen-and-paper and digital) are investigated in two subjects. The theoretical underpinnings stem from a design-oriented and multimodal perspective on learning (Jewitt, 2009; Kress, 2010; Selander & Kress, 2010). Findings presented in this article are in line with previous research, which has shown that digital writing technologies have an impact on pupils’ writing process (Haas, 1996; Stapleton, 2012; Genlott & Grönlund, 2013) and that the modes and media used for learning shape communication and to some extent delimit what is possible to represent as knowledge in a given situation (Kress, 2003; Jewitt, 2009; Selander & Kress, 2010).

Keywords
Designs for learning, multimodality, learning, writing, literacy

INTRODUCTION

Not long ago textbooks were regarded as objective mirrors of reality framed in written words or other symbols. The representation of knowledge imposed the ‘truth’ on the reader, and the learner then was obliged to copy the representations as accurately as possible. However, the authority of textbooks has been challenged by the introduction of digital resources in education and to some extent been ‘put out of play’ (Cope & Kalantzis, 2000; Gee, 2000; Lankshear & Knobel, 2003; Rostvall & Selander, 2008; Selander & Kress, 2010; Säljö, 2010). Writing practices have also changed rapidly in the last decades, and writing by hand seems to become ever more rare in daily life (Neef, 2010). In its stead, digital devices are used for scribbling down shopping lists, writing reports, or sending text messages to our loved ones. These technologies are efficient, and they offer us the possibility to store and transmit data, but also facilitate our process of manipulating data in terms of, for example, changing and revising texts, which previous technologies could not. In schools, pupils use computers for writing essays, reports, home assignments and so on (Skolverket1, 2013a). They cut and paste chunks of text, revise and edit, and search for information on the Internet. In digital classroom practices, pupils design...
their learning processes in collaboration with peers, employing different semiotic resources when representing signs of learning in a constant flow, sometimes without the teachers’ direct control (Kjällander, 2011). There is awareness on a national level in Sweden about the increased use of computers for writing (Skolverket, 2013), however, there still remain differences between learning practices and the way pupils are formally tested. During tests, knowledge is typically represented individually and often by delimited resources, in contrast to digital learning practice where technologies enable re-design with a broader mix of written text, images, colours, graphs etc. (Lankshear & Knobel, 2003; Kress, 2010). According to Blikstad-Balas & Hvistendahl (2013), students frame formal and informal tasks differently and, “[…] the literacy practices the students develop when working on informal tasks are described as irrelevant when working on formal tasks, as these require other literacy practices.” (Blikstad-Balas & Hvistendahl, 2013, p. 44). One could ask if there are tensions between today’s designs for learning with different digital knowledge resources and views on learning in the past where textbooks were seen as the dominant source of knowledge (Selander & Kress, 2010; Blikstad-Balas & Hvistendahl, 2013).

TENSIONS AMONG AND BETWEEN PRACTICES

Tensions among and between practices can also be seen as a resistance to the integration of new technologies in schools, especially in relation to test situations where knowledge is often seen as something that can be easily measured and quantified (Collins & Halverson, 2009). This can be traced to an epistemology that has dominated Western education for a long time, where learning has been based on the core content of subjects (Lankshear & Knobel, 2003) and has often been tested without reflecting upon which resources the pupils are allowed to use to represent their knowledge about the subject matter. However, this is partly starting to change. In Norway and Denmark, students in upper-secondary school have access to digital resources, even during exams (Søby, 2013) and challenge ‘standard’ Western epistemology, as the use of digital resources changes the conception of knowledge as well as what counts as knowledge among and between practices (Lankshear & Knobel, 2003; Selander & Kress, 2010; Aagaard & Lund, 2013).

Even if research regarding assessment practices is an emerging field, there are still few studies that address these practices concerning the increased use of digital resources in schools (Erstad, 2008) and how the resources used in a test situation might shape pupils’ writing and possibilities to represent their knowledge. I use the term resources to emphasise my interest in investigating the technologies used for writing as well as the layout of the tests, as it says somet-


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hing about how the communication and interaction should proceed (Kress, 2010).

**OBJECTIVE**

The aim of this article is to explore how resources pupils use shape writing. The underpinning theoretical approach and assumption is that modes and media have an influence on the ways that communication and learning is carried out (Jewitt, 2002; Stein, 2008; Jewitt, 2009; Mavers, 2010; Kress, 2010; Selander & Kress, 2010). My hypothesis is that the resources pupils are allowed to use for writing during a test situation shape their writing and, to some extent, their possibilities for representing their knowledge. My claim in this article, based on this hypothesis, is that there seem to be tensions between writing in classrooms with different resources at hand compared to writing in test situations, often with a de-limitation of resources. From my perspective, it is important to investigate how the different resources that pupils are allowed to use during classroom activities, and later in test situations, shape the conditions for learning as well as assessment practices.

The design of the study can be described as a micro-comparative survey investigating two conditions: 1) Pen-and-paper; and 2) digital forms (screen, keyboard and a word processor). The purpose is to explore these conditions with a focus on the relationship between writing and layout in relation to the resources used, on the one hand, and how these relationships shape the pupils’ possibilities for representing their knowledge in test situations on the other. The study will address the following research questions: 1) How does the writing process unfold when pupils use different resources?; 2) In what ways do the layouts of tests and the use of different technologies shape pupils’ possibilities for representing their knowledge?

**BACKGROUND**

In the Nordic countries pupils have easy access to computers and most classrooms are connected to the Internet (EUN, 2013). How computers and the Internet are used in a classroom varies between the Nordic countries, schools, and sometimes even between classes in the same school (EUN, 2013; Skolverket, 2013a; Fleischer, 2013). Yet, another question that needs further investigation is which digital resources pupils are allowed to use during test situations and how these might shape their possibilities for representing their knowledge. This might change over the next few years, however, as most of the Nordic countries have initiated projects for implementing digital exams. In Denmark this is already the case (Søby, 2013) and in Norway this is also true to an extent as the ‘Knowledge Promotion Reform’ means digital skills are

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2. Iceland is not included as the response rate was insufficient for analysis (EUN, 2013, p. 9).
3. See also the PISA 2015, Draft Reading Literacy Framework.
given a central role but “[…] forms of assessment rarely include digital tools […]” (Søby, 2013, p. 4). In Swedish schools pupils are allowed to use computers for writing during the national tests. The Swedish National Agency for Education (Skolverket), which organises and constructs the national tests in Swedish schools, is aware of the increased use of computers in schools. It also recognises that pupils often use word processors when writing and therefore states that pupils should be permitted to use computers during tests as well. Yet, Skolverket also requires schools to guarantee that their pupils do not use irregular aids such as spell- and grammatical checks in test situations and that computers are offline and unable to communicate with the Internet or other computers (Skolverket, 2013b). In 2014 there is no current data showing the number of schools in Sweden that allow pupils to use computers in test situations. Skolverket recently began an investigation to explore how grading could be facilitated and made more efficient if national tests were digital (Larsson, 2014). Whilst this is important, the pupils’ writing process, as an issue to investigate further, was not mentioned. In Finland ‘The Finnish Matriculation Examination’4 will be digital by 20195. However, there has been very little research carried out on the topic of digital exams as regards layout and the resources pupils are allowed to use. Although there are initiatives to digitalize exams in most of the Nordic countries, there are only a handful of studies that investigate the impact of the resources used for writing. In addition to those, there are studies that have investigated the impact of writing technologies on writing on a more general level. As such this study addresses an area that has been previously left untouched.

Writing technologies

Writing has taken various forms and been created through different technologies and media. These resources are part of the definition of writing, and most of the time they are in the background, wherefore they have, in some sense, become transparent. This transparency is useful since it would be very hard to pay attention to our writing tools all the time. Haas (1996) argues that most of what has been written about writing technologies has been built on this notion of transparency. Nevertheless, it tends to treat the technologies used in a superficial way and rarely investigates them in a systematic manner. The relationship between technologies and writing is what Haas (1996) refers to as the ‘technology question’, and it is far more nuanced. This article addresses the ‘technology question’ and treats technologies as more than a means to produce text. This implies that my interest is to investigate the use of technologies in schools and how these are part of shaping and challenging established practices.

Research from predominantly linguistics (Miller, 2000) and the cognitive perspective (Haas, 1996; Stapleton, 2012) has been conducted concerning the use of different writing technologies and its affect on writing. The methodology used in these studies has often been the so-called “think-aloud” protocols (Haas, 1996) and studies have used specially designed software to log pupils’ writing (Miller, 2000). Haas (1996) has done extensive studies about different writing technologies and their consequences for the writing process. In her study she explored the amount and kind of planning under three conditions: pen-and-paper, word processing alone, and word processing with pen-and-paper allowed (Haas, 1996). She found that writers using a word processor planned less for their text than pen-and-paper writers and also relied on the possibility of revising their text to a greater extent. In a more recent study carried out by Stapleton (2012), the students’ composition process was followed from the moment they received an assignment until its submission. The process was followed by using a quantitative and open-ended questionnaire about the students’ use of computers and the Internet as resources for composing a text. The findings indicate differences in the planning process in a digital environment: it was faster and more targeted and encompassed a much larger scope in comparison to a pen-and-paper and book environment. Stapleton (2012) found that the students relied on spelling and grammar checks as well as translators for the revision of their texts. He argues that this kind of work involves a different set of skills and that students in a digital environment learn to compose texts in different ways. Although these studies address writing with digital technologies, there are still few studies that examine the dissimilarity between the uses of different resources (technologies and layout) and how these shape writing in test situations in a more fine-grained way.

Resources and representations

The notion of transparency, or what Haas (1996) refers to as the ‘technology question’, has been further investigated and explored in the field of multimodality, where the resources used are seen as a part of shaping representations of knowledge. Kress (2005) emphasises this by arguing that technologies used for representations (modes), and those of dissemination (media), are “[…] always both independent of and interdependent with each other.” (Kress, 2005, p. 7). Jewitt (2006, p. 53) points out that […] technologies, ‘old’ or ‘new’ always shape knowledge in distinct kinds of ways.” Kress et al. (2001; 2004) have studied meaning-making in science and English classrooms, and draw attention to not only the relation between modes and how these shape knowledge, but also the importance of recognizing this link (Kress et al., 2001).

Kress (2003) emphasises that the screen re-shapes “[…] the possibilities of the arrangement of knowledge, information, and ideas. The screen offers entirely different possibilities of arrangements, formal and therefore conceptual, to those of the page.” (Kress, 2003, p. 20). Kress (2005) argues that the screen and written/printed page are profoundly different in terms of ordering and points of entry. In the project Gains and Losses (Kress, 2003; Bezemer & Kress, 2008)
compared the *London University Institute of Education* prospectus from 1992 with their webpage from 2004. He found, among other things, that the printed text prospectus had one entry point while the webpage had thirteen entry points. He argues that these media are built on different ordering principles as the webpage offers different reading paths.

Multimodal studies focus on studying modes and media and how they work and function together in social practice. Nevertheless, there seems to be a lack of research concerning the mode of writing at a more detailed level and how writing unfolds in test situations when using different resources, as addressed in the present study. The focus in earlier studies has mostly been on classroom interaction and compositions with different modes such as image, written text, and moving images (Kress et al., 2001; 2004; Lindstrand, 2006; Stein, 2008; Öhman-Gullberg, 2008; Insulander, 2010; Mavers, 2010; Kjällander, 2011).

**DESIGNS FOR LEARNING – A MULTIMODAL PERSPECTIVE**

My theoretical understanding draws on a multimodal perspective (Jewitt, 2009; Kress, 2010) and a design perspective on learning (Rostvall & Selander, 2008; Selander, 2008; Kempe & West, 2010; Selander & Kress, 2010; Elm Fristorp & Lindstrand, 2012). The multimodal framework is used as an analytical framework to study pupils’ writing beyond the linguistic meaning of language (Hodge & Kress, 1988; van Leeuwen, 2005). The design perspective focuses on practices and expected actions within these, as well as on how resources are used. These are framed by traditions, norms, and cultures of recognition (Selander & Kress, 2010).

“Mode is a socially shaped and culturally given resource for making meaning.” (Kress, 2009b, p. 54). Examples of modes are images, graphs, sound, writing, and layout. The modes and media used in a social practice (or those allowed to be used) shape communication and meaning (Jewitt, 2009). Kress (2010) emphasises the importance of discussing and reflecting upon what mode is used to communicate meaning, “Whether for science or for everyday issues, it matters which mode is used to ‘fix’ meaning. Scientific conceptions as much as everyday ‘common sense’ are shaped by that decision” (Kress, 2010, p. 95). The organisation of elements through the mode layout says something about how communication and social interaction should proceed. The way we present and organise information through layouts has social, ontological, and epistemological consequences and (implicitly) frames what is possible to communicate in a situation (Kress, 2010). The modes investigated in this study, writing and layout, are resources that are culturally and socially shaped for meaning-making, and these are commonly used in schools and in test situations. This study contributes a fine-grained analysis of how pupils’ writing with different resources unfolds in test situations.
DESIGN OF THE STUDY

In this study I explore two conditions: 1) pen-and-paper; and 2) digital conditions (keyboard, screen and the word processor Word). This study also addresses how the principle of composition in a mode of writing, in relation to the layout of the tests, can be described. My interest in the layout of the tests is concerned with the writing space provided in both conditions and how this might shape pupils’ writing, since the use of layout is also seen as a resource for how the communication should proceed (Kress, 2003).

In order to investigate pupils’ writing in test situations, three classes (two classes in history and one class in chemistry) were selected in two different schools in a suburb of Stockholm, Sweden. The pupils in the three classes had had their own laptops since they started secondary school in year 7 and regularly used them in school, although this was the first time they used their computer to perform a test with open-answer questions. In similar tests taken before, they mainly used pen-and-paper. The tests were based on homework except for one of the tests in history (Layout 2, both conditions), which was more extensive and was conducted at the end of the subject area. The investigation of the two conditions took place at the schools in the pupils’ classrooms or in a connected room.

The pupils were at the end of year 9 at the time of the study and their grades were becoming more important for their choice of upper-secondary school, which called for ethical considerations. This was why I chose to observe these smaller tests, instead of their final exams. Information regarding the study was sent out by e-mail to the pupils and their parents before the study was conducted.

Two different test layouts

In this study, two different test layouts were used in order to investigate if the layout had an impact on the pupils’ writing and, if so, in what way. The tests in both subjects had two different layouts, here called Layout 1 and Layout 2, which were designed by the author of this article in collaboration with the teachers in history and chemistry6.

History Layout 1 consisted of seven questions, which were presented on two sheets of printed paper (pen-and-paper condition) and in a Word file (digital condition). Questions 3–7 were essay questions while 1a, 1b, and 2 were “short-answer questions”. After questions 3–5, the teacher had written (in brackets) that the pupils’ answers should be written in bulleted lists. Underneath each question there were lines to support pupils’ handwriting. Chemistry Layout 1 had the same design and consisted of six questions, of which two were essay questions in both tests. History Layout 2 consisted of eight questions, where two of them were short answer questions. The rest were essay ques-
tions. Layout 2 in history and chemistry was different compared to Layout 1, insofar as all questions were gathered on one page and the pupils were allowed to use as many blank papers or as much space in Word as they needed to write their answers. These two different layouts allowed investigations on how the space provided, through the layout, shaped the pupils’ writing.

Empirical data

The empirical data includes the test sheets completed by the pupils and video recordings of pupils writing. The data includes video recordings of a total 23 pupils: twelve pupils in the pen-and-paper condition and eleven in the digital condition (Tables 1 & 2). Pupils in the chemistry class were only tested with pen-and-paper, except for the pupils that were part of the investigation concerning the digital condition.

<table>
<thead>
<tr>
<th>TABLE 1. PEN-AND-PAPER CONDITION</th>
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<tbody>
<tr>
<td>Pen-and-paper condition (Layouts 1 &amp; 2)</td>
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<tr>
<td>Subject in focus for the test:</td>
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<tr>
<td>Numbers of pupils recorded:</td>
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<tr>
<td>Total time of recorded data:</td>
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<td>Total tests collected:</td>
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<tr>
<th>TABLE 2. DIGITAL CONDITION</th>
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<tbody>
<tr>
<td>Digital condition (Layouts 1 &amp; 2)</td>
</tr>
<tr>
<td>Subject in focus for the tests:</td>
</tr>
<tr>
<td>Numbers of pupils recorded:</td>
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<tr>
<td>Total time of recorded data:</td>
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<tr>
<td>Total tests collected:</td>
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</tbody>
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Tables 1 and 2 show the subjects in focus for the tests, the numbers of pupils, the total time of recorded data, and the number of completed tests collected in both conditions. Both layouts (1 and 2) were tested in both conditions and in the subjects of history and chemistry.

Pulse Smartpens were used to record pupils’ writing with pen-and-paper, and these pens recorded the pupils’ pen movements, including their editing, and in what order they answered the questions or if they added text to previous questions already answered. This was later played back in the software LiveScribe Desktop as an animated movie sequence. To record pupils’ writing when using
Word, Auto Screen Recorder was used. The software is freeware and records activities on the computer screen while it’s running. A video camera was also placed behind the pupils to grasp a wider context, and functioned as reference material for the Pulse Smartpen and Auto screen recordings (Figure 1).

The unit of analysis was the pupils’ use of resources while writing. In the fine-grained analysis of the video recordings, my focus concerned the pupils’ writing and how they used their time. The time aspect was investigated to see if there were any differences in the pupils’ writing patterns between the two conditions.

A systematic analysis was conducted through three categories. The construction of the categories was an iterative process where the video recordings were viewed at several different times. The focus of categorisation was pupils’ writing when they completed the tests. By doing so, pupils’ writing and their use of time in the test situation could be detected and unfolded. The data was coded in ELAN, and the categories were constructed as a way to investigate the mode of writing in greater detail. The categories were defined as follows:

- Pen movements/keystrokes – when the pupil writes in Word or with the smart pen, constructing new letters, words, sentences, and parts of sentences or paragraphs.

- Editing – when the pupil erases/deletes words and/or letters, copies and pastes text or adds text to a previously answered question, corrects of spelling mistakes or changes words in a sentence and uses different tools in Word.

- Pause (Not pen movements/keystrokes nor editing) – Pauses longer than three seconds have been marked.

On some occasions a pupil’s writing was categorised as both pen movements/keystrokes and editing. This two-fold categorisation was made when they moved back to a previously answered question and added new letters, words, or whole sentences. These are marked as editing because they revised their text and pen movements/keystrokes when they produced new text. Two additional categories were added in the digital condition: Word AutoEdit and Key-stroke mistake. While coding the data, I noticed that Word changed words without the pupils actively changing them. For example, if a pupil forgot to use a capital letter at the beginning of a sentence, Word did an auto-correction, depending on the pupil’s software settings.
EMPIRICAL FINDINGS

In the following sections I present my empirical findings of how the pupils’ writing processes were shaped by the use of different resources (technologies and layouts). In the first section, findings from the analysis of the pupils’ writings that are related to the test layouts (1 and 2), in both conditions and subjects, are presented. After that, findings from the analysis of the coded video-recorded material in both conditions and subjects are presented. Finally, I make a comparison between the two conditions, focusing on the time spent on each of the categories and how many times the pupils changed between the categories (pen/key stroke, editing and pauses).

Layouts 1 and 2

The pupils used various approaches to the two layouts of the tests in the pen-and-paper condition. The space provided in the printed version of the tests shaped the pupils’ writing in different ways. The findings are inconclusive in relation to the two different subjects, chemistry and history, as the majority of the pupils in history used more space than provided, and in chemistry this group was in the minority. In spite of this, some findings were quite clear in Layout 1 of the history test-sheets. The majority of the pupils (14 of 21) in the pen-and-paper test in history (Layout 1) used more space than the layout offered. The pupils in history used different strategies to handle the limitation of the space. They often used a blank sheet of paper to continue their answers and used arrows, numbers, or stars to indicate where they had continued their answers. One of the pupils decided to write some of his answers directly on a blank sheet. Some of the pupils also used the narrow space between two questions or wrote in the margin. In chemistry, Layout 1, it was the opposite; the pupils...
who used more space were in the minority (2 of 13). These two pupils in chemistry also used the margins to manage the limitations of space (Figure 2).

In both subjects, some of the pupils in the pen-and-paper condition, Layout 1, did not use more space than provided, and seemed to estimate the expected length of their answers by the number of lines or spaces provided by the layout. In a sense they ‘fixed’ their answers to fit the provided space (Figure 3). When the pupils used a word processor, the space was unlimited, as most of the pupils also removed the lines in the layout before starting to write or used as much space they needed. They were not constrained by the lines or by the provision of paper. In a sense, they manipulated the test in Layout 1 in order to fit their writing. Therefore, in the pen-and-paper condition, the layout was more fixed and limited compared to the digital one, whereas the latter condition was more flexible and open for manipulations.

Layout 2 had a more ‘open’ layout and was not as restricted in terms of writing space as Layout 1. The majority of the pupils did not use the margin or other spaces for writing their answer (18 of 21). Similar findings to those of Layout 1 were that some of the pupils who used pen-and-paper seemed to estimate their answers according to the size of the paper. As they reached the area halfway down or at the end of the paper, their answers ended. When pupils used a word processor, they opened up a blank Word document and used as much space as they needed.
Figures 3 and 4. The picture on the left shows Layout 1 in history and how the pupil used and adapted his/her answer to the number of lines provided by the layout. On the right, the pupil has also adapted his/her answers according to the size of the paper and number of lines (Layout 2).

As stated earlier, the comparison of different layouts in both subjects showed inconclusive findings in regard to the pupils’ use of space. On the one hand, Layout 1 constrained the pupils’ writing in the pen-and-paper condition, as the pupils adapted their writing to the space provided. On the other hand, 14 out of 21 pupils in history used more space than provided, which means that they were not constrained by the space. Instead, they utilized a more flexible strategy by using the space provided in the margin or elsewhere to express their knowledge, in spite of the limited space provided by the number of lines.

**Video recordings**

**Pen-and-paper condition**

The most frequent annotations made in these video observations were pen movements and pauses. Editing was less common. The pupils’ writing was linear in the sense that they started with question one and worked through the test to the last question. The shift and sequencing of the writing followed a rhythm that could be illustrated in the following way.
In the pen-and-paper condition for history (Figure 5), the pupils moved their pen for 14 seconds, took a pause that lasted 24 seconds and then edited their text for 8 seconds before continuing to move their pen for another 14 seconds. In chemistry there was a similar pattern (Figure 6). However, there was a slight difference in the shifts of activity, which refers to how many changes of activity the pupils made between the categories (pen movements/keystrokes, editing, pauses). In history there were 2.747 shifts of category/minute, and in chemistry there were 2.53 shifts of category/minute.

Pen movements and pauses were the most frequent categories annotated. In chemistry, 40% of the annotated categories were marked as pauses, compared to 19% in the digital condition. In history there was a similar result. As shown in Figures 7 and 8, the pauses and pen movements are rather equally distributed along the timeline. Pauses often occurred when the pupils came to an end of a sentence or had finished answering a question.

Pupils that used pen-and-paper rarely edited their text. When they did edit their text they were either deleting a word by crossing it out with the pen or adding text to a previous answer. One of the pen-and-paper pupils edited his/her text eight times during a session that lasted forty-six minutes, while another pupil who used Word edited the text two hundred and eleven times in a session that lasted 35 minutes. Activity marked as editing in chemistry was 13%, in contrast to 37% in the digital condition. In history, 7% of the activity was marked as editing, compared to 39% in the digital condition.

7. The shifts of annotated category per minute for both subjects are based on the total time for all the pupils used for conducting the tests in history and chemistry, divided by annotation in the three categories: pen movements, editing and pauses. Please note that the lengths of each segment are based on an average of the time used by the pupils.
Digital condition

The two different test layouts showed similar patterns in the digital condition. The most frequently annotated categories in the digital condition were keystrokes (44% chemistry, 42% history) and editing (37% chemistry and 39% history). The pupils took pauses but not as often as the pupils in the pen-and-paper condition. The sequencing of the annotated categories followed a rhythm that could be illustrated in the following way.

Figure 7. Typical sequencing of the pupils’ writing in the digital condition for history. Shifts per minute were 5.61. The scale on the horizontal axis is 60 seconds.

Figure 8. Typical sequencing of the pupils’ writing in the digital condition for chemistry. Shifts per minute were 9.49. The scale on the horizontal axis is 60 seconds.

In the digital condition for history (Figure 7), the pupils used the keyboard for 8 seconds, and then edited their text for 12 seconds. After that, they started to strike the keyboard again for 10 seconds, and so forth, as illustrated in Figure 7. A comparison between the two conditions indicates a different sequencing of activity between the annotated categories. There is also a marked difference in the writing sequencing between the two subjects in the digital condition (Figures 7 and 8).

Keystrokes represent about half of the activity in both subjects (44% chemistry, 42% history). Pauses represent a minor part (around 19%) in both subjects. Pauses that are over one minute (in total three instances) were often taken at the end of the test. In the pen-and-paper condition, the number of activity segments marked as pauses were 386 compared to 297 in the digital condition. In relation to time spent on pauses there are no differences between the two conditions (Figures 11 and 12).

Pupils in the digital condition edited their text frequently. They usually went back to a recently written sentence and added or changed text. It was also common that they wrote “in a flow” where they did not seem to care about the spelling or grammatical faults. These faults were either auto-corrected by Word, by the pupils right away or after they had written a paragraph. Most of the pupils took advantage of the option to go back to a previously answered
question and add or change words or sentences. Occasionally, they formatted their text, for example, by adding a bullet list.

**Comparison between the pen-and-paper condition and the digital condition**

The findings show a difference between the two conditions. Pupils using pen-and-paper take more pauses, while the pupils using Word edit their texts more frequently. The pupils’ use of time in the two conditions shows differences, but also similarities. The most striking finding in relation to time is that, despite the fact that they took fewer *pauses* in the digital condition, pupils used the same amount of time for *pauses* as the pen-and-paper pupils (Figures 9 and 10). In the digital condition, the pupils often took a longer pause before handing the tests in.

![Figure 9. Percentage of activity segments marked as keystrokes/pen movements, editing and pauses in history, Layout 1 and Layout 2.](image1)

![Figure 10. Percentage of activity segments marked as keystrokes/pen movements, editing and pauses in chemistry, Layout 1 and Layout 2.](image2)
The pen-and-paper pupils seldom edited or changed their text. This was more common among the word processor users, which can also be seen in the time differences. In history, there is even a greater difference; these pupils used 20% of the total time for editing their text, compared to pen-and-paper pupils who used only 2% of their total time.

As mentioned earlier, the pupils in the pen-and-paper condition worked their way through the tests in a linear manner, while the pupils in the digital condition had the tendency to jump back and forth in their work. It is also apparent that the pupils in the digital condition wrote more text than the pupils in the pen-and-paper condition even though they did not use more time (Figures 11 and 12).

**DISCUSSION AND CONCLUSIONS**

Findings show that pupils in the digital condition spend more time editing their texts and jumping back and forth between the questions (Figures 7-8).
This might indicate that the pupils’ writing process moves from linear writing to a composing process, where the linear logic is, in some way, put out of play and replaced with a more spatial and simultaneous way of writing text. These findings relate to the argument raised by Kress (2003) that the logic of writing (linear/spatial) is re-shaped by the logic of image (spatial/simultaneous), as the screen provides several entry points compared to the printed-paper. Evidence presented in this article shows that the modes of writing and layout, and the use of different resources, shaped the pupils’ writing in a test situation and therefore, to some extent, also their possibilities to represent their knowledge. Pupils in the digital condition:

- Move towards a composing process;
- Are not constrained to the same extent by the layouts of the tests;
- Externalise their thoughts and use the screen as a “tool for thinking.”

I will further elaborate on these aspects below.

Towards a composing process

As I have shown in this study, pupils in the digital condition sometimes ‘write in a flow’ where they do not seem to care about grammatical faults or misspellings. They are more focused on writing down what they know about the subject matter and using the screen to elaborate upon their knowledge. With the aid of the word processor they adjust grammatical faults (or the word processor sometimes adjusts it for them) at a later stage. These opportunities are limited in the pen-and-paper condition, as the technologies used do not offer these possibilities. As mentioned by Kress (2003), Selander (2013), and Stapleton (2012) the writing process seems to move towards a composing process in the digital condition where pupils seem to use the logic of images when they write texts rather than a linear logic, as is the case in the pen-and-paper condition. This study also confirms Selander’s explanation that writing is also about design and re-design of texts (Selander, 2013), as the pupils in the digital condition frequently edit their work. The ordering principles differed between the two conditions, as the pupils that used Word had, for example, several entry points as they often jumped back and forth between the questions (Kress, 2005).

Layout as a mode for communicating meaning

The two different test layouts provide different affordances. The design of Layout 1 provided limited space for the pupils in the pen-and-paper condition to express their knowledge, as it communicated through the numbers of lines ‘how much’ written text the teachers expected them to write. Some of the pupils seemed to be constrained and adjusted their answers to the number of lines provided (Figures 3 and 4), although a majority did not care and used the
margin or other spaces for writing. In the digital condition this was not an issue for the pupils, as most of them deleted the lines before starting to answer the questions. In a sense they manipulated the layout of the test. This means that directions that are implicitly communicated through the layout of the tests are to some extent ‘put out of play’ in the digital condition, since the pupils can re-organise the elements in the layout and change what becomes possible to communicate in the test situation (Kress, 2010).

**Externalisation of thoughts**

Pupils that use pen-and-paper had limited options to edit and format their texts. This might constrain the pupils in test situations, as they would generally need to formulate complete sentences in their head before starting to write. This can be seen in the findings, as the pupils in the pen-and-paper condition more frequently took short pauses before starting to write, and they also rarely edited their text in comparison to the pupils in the digital condition. They, the pupils writing in the digital condition, seemed to use the screen and keyboard as ‘tools for thinking’. They often wrote a sentence, erased it, and started again. The screen in these cases seemed to function as a space for externalisation of their thoughts, and they used the screen and keyboard to organise them. As previous research has shown, the planning process of the text seems to be different when using a word processor (Haas, 1996; Stapleton, 2012). This might indicate that certain strategies to form sentences and paragraphs change when pupils use word processors or other digital devices for writing. If these are used on a daily basis, their writing process might change. An indication of this can be seen in the findings, as the pupils sometimes ignored the limited space in the pen-and-paper condition and used more space than provided. This can be interpreted as the pupils using ‘digital strategies’ with analogue technologies.

Previous research has shown that resources are of importance for individual learning processes and can be seen as an extension of their opportunities to act and reason in learning situations (Scholtz et. al., 2001; Ivarsson, 2004; Säljö, 2005; Ivarsson et al., 2009). The marked differences in the pupils’ writing patterns between the two conditions (Figures 5-6 and 7-8) can be viewed as an extension of their opportunities to reason about their knowledge, since they have the possibility to externalise their thoughts to a greater extent with digital resources. On the other hand, these constant and frequent shifts in activity might – from a qualitative perspective – be viewed as a distraction from the subject at hand (Fleischer, 2013; Nordmark, 2014). The word processor indicates and marks misspelled words and draws the pupils’ attention to areas other than that of the subject, which might interrupt their writing flow and focus. The difference between the shifts of activities for subjects in the digital condition is noteworthy despite the fact that the same resources were used. This could be related to traditions and norms associated with writing practices in history and chemistry, which also need further investigation.
CHALLENGES AND FURTHER RESEARCH

The mode of writing faces a new environment, from printed text, which is based on linear/spatial logic, to the screen, which based on the mode of image and spatial/simultaneous logic (Kress, 2003). Kress (2003) argues that, as writing appears more often on the screen, the logic of writing will be reshaped by the logic of image, which some of the findings in this study confirms. The swift implementation of new technologies in schools challenges contemporary assessment practices. In turn this has implications for teaching and learning in schools. I especially want to address these implications on a more general level in relation to my findings, which has to do with possible tensions among and between practices as I mentioned earlier. When pupils have the possibility to express meaning by using various resources in the classroom, the concept of literacy expands (Godhe & Lindström, 2014). On the one hand, the educational system, and how it is organised to measure pupils’ knowledge, seems to stay in a tradition where knowledge is seen as first and foremost individual and memory based. Here it can be retrieved at a certain time and place, often with pen-and-paper. On the other hand, teachers seem enthusiastic and open towards testing digital resources for writing on a regular basis in classrooms. Writing in schools often takes place in diverse multimodal activities, which shape knowledge and the way pupils write (Kress et al., 2001; Jewitt, 2006). Tests, on the other hand, are often designed and carried out without reflection upon what resources pupils are allowed to use to represent their knowledge about the subject matter, which can be connected to teachers’ assumptions about learning and knowledge. A recent study conducted by Aagaard & Lund (2013) shows that teachers had a tendency to perceive pupils’ use of external resources in test situations as not being counted as valid representations of knowledge (Aagaard & Lund, 2013). To know something from this point of view is often based on how much pupils remember about certain facts, figures, reasoning, discussion, etc., which can be seen as a “…historically rooted view of learning as an individual and cognitive effort” (Aagaard & Lund, 2013, p. 235). Their findings also showed that some teachers talked about emerging assessment practices where their interest was to support both individual and shared learning processes rather than have a focus on controlling individual learning outcomes (Aagaard & Lund, 2013).

Findings presented in this article are in line with previous research, which has shown that new technologies have an impact on pupils’ writing process (Haas, 1996; Stapleton, 2012; Genlott & Grönlund, 2013) and that the modes and media used for learning shape communication, and to some extent delimit what is possible to represent as knowledge in a given situation (Jewitt, 2002; Stein, 2008; Jewitt, 2009; Kress, 2010; Mavers, 2010). Findings from this study also show how writing changes when pupils use a word processor while conducting a test, and that they partly use the screen and word processor as a resource for reasoning about their knowledge. Removing these resources can risk reducing pupils’ possibilities to represent their knowledge in test situations. There is also a risk that if schools and policy makers ignore contem-
emporary forms of communication it “... will lead to misrecognition of learners’ capacities and actions” (Kress, 2009a, p. 38). The shift from a pen-and-paper environment to a digital one does not seem to permeate all the way through to the test situations (Åkerfeldt et al., 2013). Svärdemo-Åberg et al. (2013) discuss the relations between the course plan, criteria, and pupils’ multimodal representations, and found that, on the one hand, the course plan encourages pupils to work with and learn through multimodal representation but, on the other hand, they are obligated to represent their knowledge first and foremost in written and spoken language. Our contemporary society is based on communication as a multimodal activity, where moving images and other forms of communication are as valid knowledge representations as spoken and written form, and if we keep ignoring this in test situations we might hinder pupils’ possibilities to represent their knowledge, since there seem to be tensions among and between practices in schools (Aagaard & Lund, 2013; Godhe & Lindström, 2014). There is a need for further research concerning writing with different resources and how these form pupils’ possibilities to represent their knowledge. Further research is also needed concerning the quality aspect of writing with different resources and in different subjects. Finally, there is also a need to look further into assessment practices; what is assessed and how it is assessed needs further research.

REFERENCES


