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Writing with Decoding and Spelling Difficulties—A Qualitative Perspective

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Abstract

Writers with decoding and/or spelling difficulties often produce short, lower-quality texts and experience less fluent writing, frequently interrupted by long pauses at the word level. Research suggests that from adolescence onward, such writers become increasingly aware of their difficulties, which influences behaviours such as avoiding difficult-to-spell words and pausing for lexical decisions. The objective of this study was to deepen the understanding of how adolescent students with decoding and spelling difficulties engage in the task of text composition. In this multiple case study, we qualitatively investigated argumentative texts and writing processes produced by three Swedish upper-secondary students with such difficulties. Data were collected through keystroke logging and analyses of texts and keystroke logs provided detailed insights into their individual writing approaches. The results generally align with previous findings but reveal notable differences depending on the severity of the difficulties. Two students with moderate challenges paused extensively to consider spelling, formulation, and word choice, while one student with more pronounced difficulties wrote rapidly and briefly to complete the task quickly. This nuanced analysis highlights the diversity of writing profiles among students with decoding and spelling difficulties and underscores the need for tailored support to help them produce higher-quality texts.

Keywords: reading and writing difficulties; writing process; keystroke logging; written text quality

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1. Introduction

Research has shown that many students with reading difficulties also struggle with writing, and depending on the type of reading difficulty, challenges in writing will look different (Graham et al., 2020; O'Rourke et al., 2018). For students who struggle with decoding, for example, challenges with transcription and spelling can be expected, and activities during composing that require reading, such as searching for information, re-reading text and revision, may pose larger challenges than for students with typical decoding. Research has convincingly shown that some dimensions of text quality are negatively affected in poor decoders' writing (Sehlström et al., 2022), such as length of text (Afonso et al., 2019; Sumner et al., 2013; Å. Wengelin et al., 2024), number of spelling errors, organisation/coherence (Sumner & Connelly, 2020; Tops et al., 2013), idea development (Hebert et al., 2018), and

lexical diversity (Afonso et al., 2019; Sumner et al., 2013; Tops et al., 2013; A. Wengelin, 2007). An increasing number of studies additionally take into consideration poor decoders' writing processes. Earlier studies on group level (e.g., Torrance et al., 2016; Å. Wengelin et al., 2024) provide us with valuable measures of poor decoders' writing processes, such as how fluent text is written, pausing characteristics, and editing and revision behaviour.

This study contributes to the existing body of research by providing a detailed analysis of how students navigate the demands of a writing task, either because of—or despite—their persistent difficulties with decoding and spelling.

1.1. Reading and Writing

Development in reading and writing are closely related, and poor reading and writing skills often co-occur in the same students (Graham et al., 2020). Cognitively oriented research in reading commonly applies the distinction between poor decoders, who encounter challenges in visual word recognition (alphabetic decoding), poor comprehenders, who struggle with oral language and reading comprehension, and individuals experiencing difficulties with both ("The simple view of reading", Hoover & Gough, 1990; Tunmer & Greaney, 2010). These distinct profiles of reading impairments are associated with differing underlying cognitive and/or language deficits. Following shared knowledge theory (Shanahan, 2016), those deficits not only have consequences for reading but will also influence writing processes and texts in distinct ways (Hebert et al., 2018; A. Wengelin & Arfé, 2018).

This study narrows its focus to poor decoders, whose word recognition difficulties can often be explained by underlying difficulties with phonological processing (Hulme & Snowling, 2009; Melby-Lervåg et al., 2012). Phonological impairments can cause difficulties connecting graphemes with phonemes (decoding) but also phonemes with graphemes (encoding/spelling), affecting both accuracy and fluency in decoding and spelling. Students struggling with decoding and spelling face challenges in developing well-established and specific orthographic representations of words in their orthographic lexicon in long-term memory (Perfetti, 2007), which in turn impedes quick and correct activation/retrieval of these units during reading and writing (Brysbaert, 2022; Grainger, 2022).

The degree of orthographic transparency is a decisive factor in how decoding and spelling difficulties manifest across languages (Caravolas, 2004). Swedish is a semi-transparent language and its orthography represents both phonemes and morphemes (Venezky, 1999). For correct spelling it is often, but not always enough to map phonemes to corresponding graphemes—-the morphological structure of words needs to be acknowledged. Further, in Swedish some phonemes can be converted to more than one grapheme, and vice versa (Caravolas, 2004).

For writing, the immediate consequences of decoding and/or spelling difficulties are frequent misspellings and/or slow transcription, while other higher-order text quality criteria may also be affected in the long run (O'Rourke et al., 2018). However, poor decoders can draw on their relative strengths in oral language comprehension to support reading. They may use a text's semantic and syntactic cues (Nation & Snowling, 1998), as well as larger linguistic units, such as morphemes, to support decoding and spelling, partially compensating for deficits in phonological processing (Castles et al., 2018; Deacon et al., 2009; Rastle, 2022).

Hayes and Berninger's model (2014, see Figure 1) of the cognitive processes in writing is an adaptation to previous versions of the model, taking into account areas of difficulty for struggling writers, such as poor decoders and/or spellers. The model consists of three levels: resource, process and control level. Advanced writers succeed in activating these levels simultaneously and integrate them when writing.

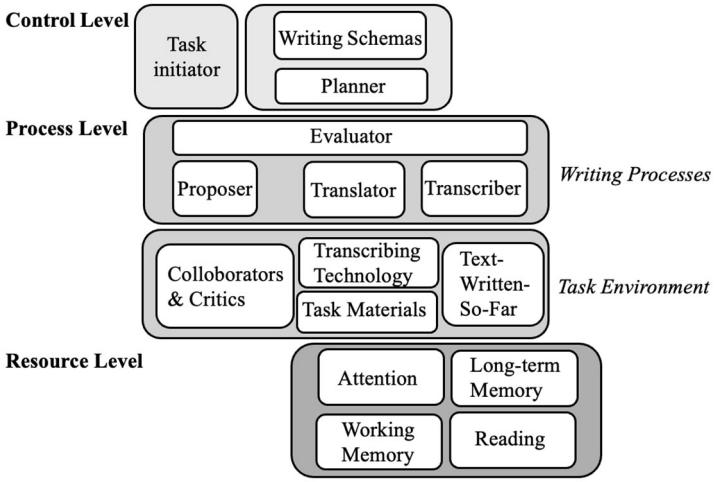

Figure 1. Model of cognitive processes in writing. Adapted from Hayes and Berninger (2014, p. 4).

As an adaptation to the particular prerequisites of struggling writers, Hayes and Berninger's (2014) framework assigns the cognitive resources for writing (attention, working memory, long-term memory, reading) an increased role for understanding the dynamics of the writing process. For poor decoders and/or spellers, a core difficulty is fluent and correct spelling due to difficulties with phonological processing, leading to weaker and less precise orthographic representations of words stored in long-term memory. This directly affects the transcriber, a sub-process in which the writer turns pre-planned linguistic strings into written text through handwriting or typing and spelling (Hayes & Berninger, 2014; O'Rourke et al., 2018). For poor decoders and/or spellers, the transcription process becomes effortful, often resulting in a high number of misspellings. Students with poor decoding and/or spelling, however, frequently produce texts with weaknesses that are beyond orthographic inaccuracy. This results from difficulties in coordinating all writing sub-processes (proposer, translator, transcriber, evaluator) simultaneously (Olive, 2014).

As effortful transcription requires large parts of these writers' working memory, cognitive capacities for other processes, such as proposer and translator, are limited (Kellogg, 1999). Alternatively, students with poor decoding and/or spelling may struggle to find words which they feel comfortable to spell, also resulting in disfluent writing due to "evaluator, transcriber, and translator having to select, deselect, and reselect written vocabulary throughout text generation" (O'Rourke et al., 2018, p. 19). Hence, for students who struggle with spelling, transcription can become a writing bottleneck (Olive, 2014) and affect other sub-processes negatively.

For students with poor decoding, difficulties with *reading* may have a remarkable impact on writing, too. Reading plays a central role in a writer's evaluation and revision of own writing. Struggling with reading hinders writers from monitoring properly how the written text matches the writers' mental representations of the text to be written. If reading is effortful, writers are less likely to notice and quickly correct formal errors and mistakes (Sumner & Connelly, 2020) and they struggle to simultaneously monitor the text's content and organisation while accessing knowledge from long-term memory (O'Rourke et al., 2018). Therefore, weak reading abilities may be a reason for the lack of meaningful text revisions in already written text but also hinder on-line planning of how the text shall be continued, for example, to maintain coherence.

Above all, struggling readers tend to avoid reading, lowering the overall number of encounters with written language. This lack of exposure results in weaker representations of different text genres in writers' long-term memory but also affects the *control level* of writing. In Hayes and Berninger's (2014) model, the *control level* is associated with goal

setting and strategic planning. If writers' genre knowledge and writing schemas are fuzzy due to limited exposure to text, it will impact how genre characteristics can be reproduced in their own writing (Sumner & Connelly, 2020; Torrance et al., 2016).

1.2. Writing Products and Processes of Students with Decoding and Spelling Difficulties

Departing from cognitive models of writing, it is commonly assumed that due to the limited capacity of working memory, there is a trade-off between lower and higher-level processes (McCutchen, 1996; Olive, 2014). Hence, poor decoders'/spellers' increased word-focus limits higher-level processing. This may affect both writing process measures as well as several text quality criteria.

Studies looking for empirical evidence supporting this assumption for adolescents or adults with reading and/or spelling difficulties have shown that these writers produce shorter texts with lower overall quality, characterised by a higher proportion of spelling mistakes, structural difficulties and weaker coherence (Sumner & Connelly, 2020; Tops et al., 2013; Torrance et al., 2016; Å. Wengelin et al., 2014). Several (Torrance et al., 2016; A. Wengelin, 2007; Å. Wengelin et al., 2014), but not all (Sumner & Connelly, 2020) of the reviewed studies noted lower lexical diversity in texts. Tops et al. (2013) also observed less precise capitalization and punctuation. Studies on writing processes show a more scattered picture. Generally, writers with decoding and/or spelling difficulties are less fluent in text production, mostly due to longer transition times between letters, but also extended pausing times before and within words (Torrance et al., 2016; Å. Wengelin et al., 2014). These characteristics have been found to be correlated to lower lexical diversity in texts produced by writers with dyslexia (A. Wengelin, 2007), suggesting that these pauses represent hesitations related to spelling, considerations or strategic behaviour influencing the writer's word choice. Interestingly, in their study on expository writing by 17-year-old Norwegian students with poor decoding skills, Torrance et al. (2016) found the unexpected association between incorrectly spelled words and shorter pre-word interkey intervals, as well as faster production of these misspelled words. As Å. Wengelin et al. (2024) point out, this may be explained either by reading difficulties, or by the fact that Norwegian writers at that age are used to write with spell-checkers and may not pay attention to or overlook misspellings once spell-checking is not available. Torrance et al. (2016) also registered longer pre-sentence pauses for poor decoders, which the authors cautiously interpret as an indicator that poor decoders are less capable of planning the upcoming sentence while writing due to high cognitive load related to spelling. Instead, they are forced to postpone this planning until the sentence currently in production is finished.

Some studies also report more word-level revisions, but these revisions are only partly successful (A. Wengelin, 2007), and only a small proportion of total misspellings are detected (Sumner & Connelly, 2020). In Torrance et al. (2016), however, no increased spelling revision was found among students with decoding and spelling difficulties.

It has been suggested that in adolescent and adult writers, particularly those engaged in higher education, the impact of decoding and/or spelling difficulties may become less evident in the proportion of misspellings within their texts compared to younger writers. For instance, Å. Wengelin et al. (2014) found that among their 15-year-old participants, spelling test scores did not correlate with the proportion of misspelled words in written texts, despite these writers exhibiting longer pausing times and reduced lexical diversity. Tops et al. (2013) observed that university students with dyslexia tended to avoid long words. In contrast, Å. Wengelin et al. (2024) reported robust correlations between spelling test scores and the proportion of misspellings in the texts of 10–13-year-old writers, although writing process measures did not reliably predict spelling difficulties in this younger group. These findings suggest that adolescent and adult writers with reading and/or spelling

difficulties may develop compensatory strategies aimed at minimising spelling errors. Such strategies cost cognitive effort, manifesting disproportionately long word-level pauses during writing.

Further, studies with adolescents and adults have highlighted similar phenomena, such as writers' developing self-awareness (A. Wengelin, 2007) and adaptive changes in writing behaviour, including altered word choice, which are more apparent through longer pauses and disfluencies rather than through overt spelling errors (Torrance et al., 2016). Consequently, for experienced writers aware of their reading and spelling difficulties, a significant portion of cognitive resources may be allocated to avoiding spelling mistakes. However, this increased focus on error avoidance may come at the expense of lexical diversity, writing productivity, and overall text quality, as less attention is available for higher-order writing processes.

1.3. The Current Study

This study contributes to existing research on the writing by students with poor decoding and/or spelling. We conduct a qualitative analysis of the writing produced by three 17–18-year-old Swedish students with typical reading comprehension, but documented decoding and spelling difficulties. The overall aim of this study is to investigate how adolescent students, who, over the course of their schooling, are likely to have developed a self-awareness of their persistent challenges in decoding and spelling, engage with the task of composing text. We are guided by the research question of how writing products and processes of three students with poor decoding and spelling can be characterised. We examine their texts, how they approach the writing process, and whether discernible writing strategies can be identified. Furthermore, we explore the extent to which their difficulties with decoding and spelling manifest during online writing, or whether such challenges remain concealed.

2. Materials and Methods

2.1. Participants

We selected three participants from a larger sample of 159 Swedish students attending their second out of three years of upper-secondary education (Sehlström et al., 2022, 2023; Vandermeulen et al., 2024). Within this sample, we looked for students with pronounced decoding difficulties, moderate to severe spelling difficulties, and typical reading comprehension. Eight students were identified with a composite word reading score (pseudo-word reading and sight word reading) below $z = -1.2$ and with reading comprehension at or above $z = -0.36$. Five of these students had a spelling score at or below $z = -0.6$. Three of these five students were selected for this case study. We call these students Lisa, Niklas and Kalle. All three are Swedish mother tongue speakers, they received their entire education in a mainstream Swedish school system and use laptops for their daily school assignments. Students with decoding and/or spelling difficulties in Sweden often meet a special needs teacher in their primary school years to receive extra training. If the difficulties are persistent despite this training, students are offered compensatory reading and writing tools, such as text-to-speech or spell-checkers.

2.2. Procedure

Students gave their informed written consent. They were informed that they could end their participation in the study at any time without any consequences. The screening procedure (word reading, spelling and reading comprehension) was carried out in February during their second year in the students' classrooms by their teachers and the research team in collaboration. In March to April, the students wrote four writing assignments (one

argumentative and one narrative in Swedish and English, respectively) on their computers with keystroke logging software. The writing took place in the students' classroom during four separate sessions, administered by the research team with support from the teachers. For this study, only the argumentative text in Swedish was used. The three texts in this study were rated within a comprehensive rating procedure of the bigger data sample in Sehlström et al. (2022). The texts were rated by two trained raters, both native speakers of Swedish. To develop a reliable text rating procedure with valid results, a recursive process involving trial ratings, group discussions, and adaptations was carried out.

2.3. Materials: Screening Measures

Standardised screening measures for word reading, spelling, and reading comprehension were employed. Word reading was assessed by using a composite measure of pseudo-word and sightword reading tasks (Olofsson, 1998). Scores were converted to standardised scores (z-scores) using the normative means and SDs in the manual. Cronbach's alpha for the whole sample (N = 159) was 0.79. Spelling was measured through a dictation task requiring students to write target words of varying phonological, orthograpic, and morphological complexity (Järpsten & Taube, 2018). The α reported in the manual was 0.89. Reading comprehension was evaluated through silent reading of three factual texts followed multiple-choice questions targeting literal and inferential understanding (Järpsten & Taube, 2018). The α reported in the manual was 0.74.

2.4. Task

The pupils were given an argumentative writing task, either with the title "For or against a ban on mobile phones during the whole school day?" or "For or against starting school days at 10 o'clock?" They received a short text with contextual information and were instructed to write a letter addressing the school's principal taking a stand on the issue. No word count requirement was given. Pupils were told to not use the internet for the assignment and to finish their writing within 45 min. A considerable difference to the students' usual writing was the absence of automated spell-checking.

2.5. Keystroke Logging

Keystroke logging software records every step of digital writing, such as pressing keystrokes, cursor activities and window switches, together with a time stamp. This allows for a detailed reconstruction of how a text unfolds in real time including those parts that are not necessarily left visible when a writer finishes the task at hand. Fluency, pause and revision measures together create a picture of the dynamic interplay between more fluent and more hesitant writing episodes. In this study, text production was recorded with Scriptlog (Strömqvist & Karlsson, 2002).

2.6. Analysis

For the text analysis, a detailed written instruction was created describing the categories (content, organisation, coherence, vocabulary, language use, spelling and punctuation) and separating each band in the scoring scheme (1 for very poor, 2 for poor to fair, 3 for average to good, 4 for very good to excellent). When assessing the texts, the raters scored one category at a time. Interrater reliability, based on independent double-scoring of 20% of the texts, was good with intraclass correlation coefficients for all seven aspects ranging from 0.88 to 0.98.

The students' writing processes were analysed using Inputlog (Leijten & Van Waes, 2013), which required converting all log files into Inputlog-compatible idfx-files. A total number of ten keystroke logging measures related to production fluency, pausing, and

revision was selected. For three of the process variables, timing was considered (Breetvelt et al., 1994) by dividing the process into three equal intervals (beginning, middle, and end).

Descriptive statistics of these keystroke logging measures were used to get a basic overview of the three students' processes (see Appendix A). For the qualitative analyses, an inspection of the final text was complemented by an analysis of several output files based on the keystroke logging data: the general analysis (a basic log file analysis with the action content, the character position, the time stamp, the action time and the pausing time for every input event), S-notation (a complete record of the insertions, deletions and breaks, shown in a text representation and numbered according to the order of their occurrence in the writing process), and the process graph (a visualisation of the complete writing process, see Appendix B for information on how to interpret the graph). In these files, we looked for instances in the processes that were indicative for pausing and revision related actions. All pauses longer than two seconds were analysed regarding location and potential reasons for pausing (for example, in connection to a revision, within words or between words, between sentences or paragraphs). This two-second threshold is the conventional threshold used in keystroke logging research on pausing as it marks a clear disruption in the writing process (Å. Wengelin et al., 2024).

Since the interpretation of pauses is not unambiguous (Baaijen et al., 2012), we analysed them using a systematic and context-sensitive procedure. In addition to considering the pause itself, we examined the surrounding linguistic and behavioural context to guide interpretation. For example, pauses at grammatical boundaries are usually associated with planning (Baaijen et al., 2012). Thus, a long pause preceding a word such as *till exempel* (for example) may indicate content planning, as the writer needs to formulate an example to continue the sentence. However, because one participant displayed various hesitations (in the form of pauses) and misspellings related to compounding, the pause preceding *till exempel* in this case may also have been related to orthographic considerations. To address such ambiguities and ensure the integrity and reliability of the qualitative analysis, we consistently applied the same contextual criteria across all cases, compared similar instances to check the stability of our interpretations, and documented our reasoning throughout the analytic process. This approach ensured that interpretations were grounded in observable patterns rather than isolated events.

Spelling mistakes were identified both in product (i.e., the final texts) and process. We paid attention to leading-edge revisions and revisions in already written text. In the process, we looked for spelling mistakes which were noticed and then revised, but we also identified spelling mistakes which remained unnoticed.

When presenting examples from the writing process data, we begin by indicating the point in time when the excerpt occurred (e.g., 7:34). We then report the length of any pauses in milliseconds, shown in angle brackets (e.g., <500>). A backspace action is represented as BACKSPACE followed by a number in angle brackets, indicating how many characters were deleted using the backspace key (e.g., <BACKSPACE3>). For longer excerpts we provide an English translation of the original Swedish text.

In our analysis we ignored corrections which are very obviously connected to typos (tcz<BACKSPACE2>ycker, ko<BACKSPACE1>lockan, bar<BACKSPACE2>ra, she<BACKSPACE2>chema, anvö<BACKSPACE>änder). Very short pausing times in the process support our interpretation of these pauses as typos.

3. Results

Three poor decoders' texts and writing processes were analysed qualitatively. Each writer is presented and interpreted individually, with a focus on key observations from both their written text and writing process. Table 1 provides an overview of Lisa's, Niklas' and

Kalle's numerical data, including test results, writing product quality scores, and writing process measures. These data form the basis for the qualitative description and analysis.

Table 1. Overview of participants' test measures, text quality scores and writing process measures.

		Lisa	Niklas	Kalle
Test measures	Phonological decoding (z)	−1.95	−1.64	−2.26
	Orthographic decoding (z)	−1.76	−0.85	−2.05
	Spelling (z)	−0.61	−1.04	−2.19
	Reading comprehension (z)	−0.08	1.03	−0.36
Text quality scores *	Overall quality score (points)	2.5	2.4	1.0
	Content	3.0	2.5	1.0
	Organisation	2.5	2.5	1.0
	Coherence	2.0	2.0	1.0
	Vocabulary	2.5	2.5	1.0
	Language use	2.5	2.0	1.0
	Spelling	2.0	2.0	1.0
	Punctuation	3.0	3.0	1.0
Writing process measures	Total process time (mm:ss)	28:29	32:36	06:42
	Proportion of pausing time	48%	74%	53%
	Number of keystrokes per minute	88.33	39.33	80.66
	Number of pauses per minute	2.32	2.27	2.54
	Mean time of pauses in s	12.42	19.53	12.47
	Mean time P-bursts in s	13.48	7.09	11.20
	Mean characters typed in P-bursts	43.32	20.34	30.35
	Mean time within word pauses in s	0.42	0.38	0.39
	Mean time between word pauses in s	1.19	2.82	1.13
	Revision ratio	0.90	0.98	0.90

* 1—very poor; 2—poor to fair; 3—average to good; 4—very good to excellent.

3.1. Lisa

Tests in word reading and spelling indicated that Lisa showed clear difficulties in phonological and orthographic decoding. Her spelling was located within lower average and her reading comprehension within average (see Table 1).

3.1.1. Lisa's Text

Lisa produced an argumentative text consisting of 492 words (see Figure 2, see also Appendix C for an English translation of all writers' texts). The overall quality of her text was rated as fair to average (2.5 points). The content was assessed as being of average to good (3 points) quality, as Lisa demonstrated some general knowledge of the topic and successfully presented her main ideas. However, the organisation, vocabulary, and language use were rated as fair to average (2.5 points), due to the use of an overly informal register and, in some instances, incomplete sentence constructions.

Lisa's spelling was rated as poor to fair (2 points). In Figure 2, all incorrectly spelled words in Lisa's final text are marked with an asterisk. Different types of misspellings could be identified, such as related to compounding (*tillexempel** [till exempel, for example], *mobil fri** [mobilfri, free of mobile phones]), missing letters (*komisar** [kompisar, friends], *stte** [satte, sat]), redundant letters (*lelktionen** [lektionen, lesson]), metatheses (*sjkuts** [skjuts, car ride], *navänder** [använder, use], *förken** [fröken, teacher]), wrong letters (*tär** [tar, take], *med** [men, but]) and Swedish spelling rules for short and long vowels (*bätre** [bättre, better]).

För eller emot mobilförbud hela skoldagen?
Förslaget om att vi skulle ha en mobil fri* dag i skolan tycker jag inte låter som en bra idé för att mobilen är bra att ha till mycket. Tillexempel* om man måste (A) kolla på vad klockan är så att man hinner i tid till lelktionen* eller kolla när lektionen börjar och vad man har för lektion. Man skulle kunna ha en klocka på sig eller att ni stte*_upp klockor i korridoren och ha ett schema i skåpet med* då tycker jag att det är mycket smidigare med mobilen för det är bara en sak och har allt de där i sig.
Visst kan det kanske vara bra att inte ha mobilen under lektion men jag tycker om man använder mobilen till rätt saker så kan den visst vara nödvändig. Tillexepel* om datorn är sönder eller död och man inte har någon laddare så om man har med sig mobilen så kan man bara jobba på den istället för att inte göra någonting eller måsta jobba med en kompis.
De som behöver skjuts efter skolan kanske måste få tag på dem den ska få sjkuts* av och då måste man också ha mobilen (B) eller kanske kolla upp när busstiderna är om man inte vet när sin buss går hem.
Jag tror inte att någon är för argumentet att ha mobil fri* skoldag eftersom mobilen används till mycket mer saker än vad fröknarna tror, de tror nog att vi bara använder mobilen till att skriva med komisar* och kolla facebook eller instagram eller spela spel. Men om de tär* de dem vill förbjuda så har vi fortfarande datorn och chatta med kompisar, kolla instagram och spela spel och sådant kan vi göra på datorn med. Om dem inte vill att vi ska vara inne på fel saker under lektionen så tycker jag bara att om det är någon som är det borde förken* bara skicka ut honom/henne fårn* lektionen. Då lär vi oss att inte vara inne på fel saker och då kan både mobilen och datorn vara bra att ha på skolan.
Att mobiler skulle ha en negativ effekt på skolresultat tror jag inte stämmer, för att dem flesta navänder* mobilerna till att kolla klockan och schemat och sådant sen på rasterna och om man tar en paus under lektionen så chattar dem flesta med komisar* men då borde dem ha dator förbud* också för man kan chatta med kompisar via datorn också så då borde datorn också ha en negativ effekt på skolresultatet. Att man skulle testa mobilförbud under lektionen ser jag då att det skulle kunna vara en bätre* lösning om fröknarna tycker mobilerna förstör på lektionen men om man inte har någon dator att den är sönder eller död så tycker jag att om man har en mobil så borde man kunna jobba lika lätt på datorn som i mobilen för man kan gjöra* ungefär lika mycket på datorn som i mobilen.(C)

Figure 2. Lisa's final text.

3.1.2. Lisa's Considerations During the Writing Process: Fluency, Pauses and Revisions

As illustrated in the process graph in Figure 3, Lisa wrote her text within 28 min and approximately half of this time she was actively writing. Overall, her writing fluency decreased slightly throughout the writing process, from 97 keystrokes per minute in interval I to 89 in interval II and 79 in interval III, due to longer periods of inactivity in the final stages of writing (see mean time of pauses interval III in Appendix A), most likely related to re-reading the text. However, from all writers in this study, Lisa was the one with the greatest consistency in fluent writing throughout the entire writing process, and had the longest writing bursts both in terms of time and amount of written text (see Appendix A). Further, Lisa's writing is characterised by a linear writing style with few revisions. 90 percent of the typed text remained in the final version of the text (see Table 1). The process graph in Figure 3 shows that her writing is characterised by long and fluent writing episodes, particularly after revision B, where she, apart from one extended pause 20 min into the writing process, continuously produced text until the end of her writing session.

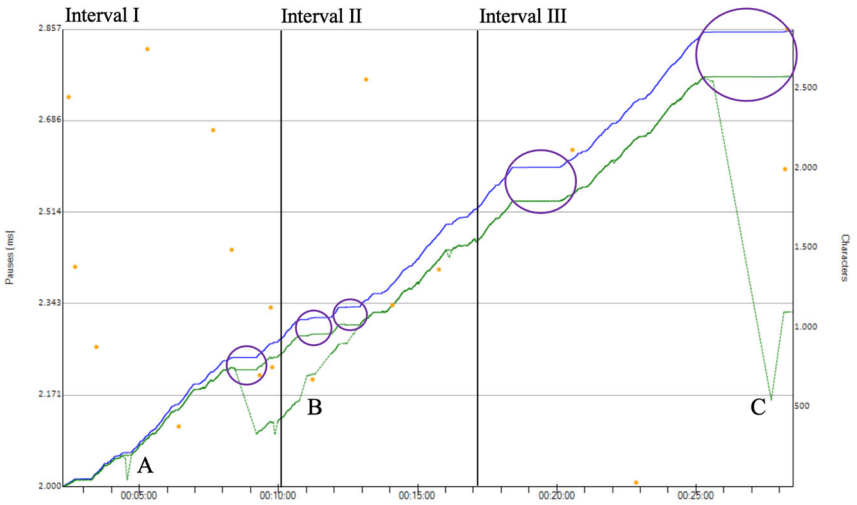

Figure 3. Lisa's process graph.

3.1.3. Planning Next Steps—Pauses

At several instances, Lisa seems to be cognitively engaged with text content, indicated by long pauses. The five longest ones are visible in the process graph through horizontal lines, standing for the writer's inactivity (highlighted by us with circles in Figure 3). The

first three instances take place within the course of cursor move B and can therefore be associated with the revisions in previously written text. The fourth longer period of inactivity takes place between minutes 16:09 and 17:51, right before the final paragraph of the text. Here it seems most plausible that Lisa is planning the next burst of text production or re-reading previous text. However, no revisions were made. The last horizontal line most likely presents a phase of re-reading the whole text after finishing the final paragraph. The cursor move C (Figure 3) associated with this reading phase only results in changes in text layout as Lisa presses the return key three times in order to create visible paragraphs in the text.

Lisa paused 2.3 times per minute on average (see Table 1), often before sentences, but also between clauses, around connectives and prepositions such as *om* (if), *och* (and) or *för att* (because). Two examples are given below (in which editing of typos has been removed for readability). Note, however, that the second pause of 3246 ms after the word *idé* (idea) could be related to the spelling of this word, as it follows a spelling revision of the word, but it could also be related to the continuation of the sentence, or both. Also, the pauses surrounding the word *effekt* (effect) are likely to be related to the spelling of the word.

00:27<35394>Förslaget om att vi skulle ha en mobil fri* dag i skolan tycker jag inte låter som en bra ide<BACKSPACE>é <3246> för att <3312> mobilen är bra att ha till mycket <4874>.

00:27<35394>The proposal that we should have a mobile-free day at school doesn't sound like a good idea <BACKSPACE> <3246> because <3312> the phone is useful for a lot of things <4874>.

17:51<101914>Att mobiler skulle ha en negativ <5425>effekt<2631> på skolresultat tror jag inte stämmer<5006>, för att <7787>dem flesta [. . .].

17:51<101914>That phones would have a negative <5425>effect<2631> on school results—I don't think that's true<5006>, because<7787> most [. . .].

3.1.4. Content- and Language-Related Revisions

In the process, we found indications of content-related considerations as well as few traceable content-related revisions. The longest and most central content-related revision happens during cursor move B (see Figure 3). Right before this cursor move, Lisa starts a new sentence but seems hesitant about how to continue. As shown in the examples below, she deletes the already written sentence beginning except for the very first word *På* and then decides to read previously written text instead of continuing to formulate the sentence. This step is indicated by a long pause of 46 s, preceding cursor move B.

5:46<5903> på <BACKSPACE3>På rasterna om<BACKSPACE3>så <BACKSPACE14> <46237>(cursor move B begins).

5:46<5903> During <BACKSPACE3>During the breaks if <BACKSPACE3>so <BACKSPACE14><46237>(cursor move B begins).

The following sequence consists of three revisions in previously written text. First, Lisa adds a sentence at the end of the first paragraph *Man skulle kunna ha en klocka på sig [. . .]* (You could wear a watch [. . .]), introducing a counterargument and at the same time expressing her own opinion towards this counter argument. In this way, Lisa improved her text by showing an awareness about the different positions regarding the discussed topic. The second and third change happened in the second sentence of paragraph two, as shown in the example below. First, Lisa adds *Tillexepel** (*Till exempel*, For example) in the beginning and then she adds *för att inte göra någonting eller måsta jobba med en kompis* (instead of doing nothing or having to work with a classmate) in the end of the sentence. In both instances longer pauses are preceding the additions, indicating that Lisa is planning text content.

8:47<16016>Tillexepel* **4:04** om datorn är sönder eller död och man inte har någon laddare så om man har med sig mobilen så kan man bara jobba på den istället **9:03**<33873> för att inte göra någonting eller måsta jobba med en kompis.

8:47<16016>For example **4:04** if your computer is broken or dead and you don't have a charger, then if you have your phone with you, you can just work on that instead **9:03**<33873>of doing nothing or having to work with a classmate.

Both changes add to the content of the sentence by making clearer that Lisa is bringing up an example for when a mobile phone is useful at school, and by showing that using a mobile is still the better alternative to doing nothing when the computer does not work. At this point, Lisa continues to work on the text at the leading edge. She decides to delete the word *På* which she had ended with before her revision episode and instead continues the previously finished sentence, as shown in the following example.

4:58 De som behöver skjuts efter skolan kanske måste få tag på dem den ska få sjkuts* av och då måste man också ha mobilen **10:39**<13069>eller kanske kolla upp när busstiderna är om man inte vet när sin buss går hem. (the underlined text was added after deleting *På*).

4:58 Those who need a ride after school might need to contact the person who's picking them up, and then you need to have your phone **10:39**<13069>or maybe check bus times if you don't know when your bus is leaving.

Further language-related revisions in the form of reformulations were indicated by text changes at the point of inscription. The first example below shows an instance when Lisa decided to re-formulate her text, possibly as an attempt to avoid the word *göra* (make). In the second example (final sentence of the text), Lisa develops the argument that mobile phones and computers have similar functions and that, in case a computer doesn't work, the mobile phone might be used instead. She decides to tone down this thought by replacing the adjective *exakt* (exactly) with *ungefär* (approximately).

14:31 Om dem inte vill att vi ska göra fel saker<BACKSPACE17>a vara inne på fel saker.

14:31 If they don't want us to (do the wrong things) be involved with the wrong things.

22:33för att man kan gjöra* exakt li<BACKSPACE8>ubn[BACK][BACK]ngefär lika mycket på datorn som i mobilen.

22:33 Because you can do (exactly) about the same things on a phone as on a computer.

Overall, only a small number of content- and language-related changes were observed. Given that Lisa's text received relatively high scores for content (3 points) and organisation (2.5 points), it is clear that she largely succeeded in structuring her text effectively—possibly aided by strategies such as longer pauses during writing.

3.1.5. Noticing Spelling

With few exceptions, the incorrectly spelled words underlined in Figure 2 remained unnoticed by Lisa, as there are no indications in the writing process that she either hesitated or revised before, within or after the words. Some of these spellings reflect insecurities regarding words' phonological and orthographic representation, such as cases in which letters are redundant, left out, or confused, and double lettering. An interesting example is the spelling of the common verb *gjöra** (correctly spelled *göra*, make), which is pronounced /jø:ra/. In Swedish, the phoneme /j/ can be represented, for example, by the grapheme <g> or by the grapheme <j>. Lisa wrote the word with both graphemes, which leads to the assumption that she has an idea of the possible phoneme-grapheme-correspondences here, but that her word-specific orthographic knowledge did not suffice to make the correct spelling choice <göra>. A contributing factor to the fuzziness around this word is the fact that the past tense and past particple forms of the verb *göra* are in fact spelled with <gj> (*gjorde*, *gjort*). In another instance described earlier Lisa avoided the word by replacing it.

Besides the visible misspellings in the final text, the analysis of Lisa's writing process revealed additional spelling-related issues she faced when writing. These were instances when Lisa noticed and corrected misspellings during the writing process or when she paused extensively in relation to the spelling of words, which then resulted in correct spelling. For example, she paused for 5.4 s before and 2.6 s after the correctly spelled word *effekt* (effect), paused in two out of three instances before writing the anglicism *chatta* (to chat), and deleted and re-wrote the word *korridoren* (corridor), both times with correct spelling.

7:23korridoren<2336><BACKSPACE8><2224>rridoren.

However, in total there were few indications of potential spelling-related considerations. The majority of local, language-related issues in Lisa's writing were linked to insecurities about orthographic rules, such as compounding, prepositional phrases and capitalising sentence beginnings.

3.1.6. Monitoring Orthographic Rules

In Swedish, compounds are written as one word whereas prepositional phrases are not. There are instances in which Lisa hesitates regarding these rules shown by extended pausing, but there are also instances in which she seems to be unaware of any potential difficulty. For example, before the nominal compounds *mobilförbud* (mobile phone prohibition) and *skolresultat* (school results), Lisa pauses 2.7 s and 2 s, respectively. In both these correctly spelled cases it can be assumed that Lisa considers whether to have a space between the nouns or not. The word *dator förbud** (correctly spelled *datorförbud*, computer prohibition), belonging to the same grammatical category, is spelled incorrectly, but no prolonged pauses or revisions indicate hesitations when writing. The insecurity regarding this rule is also confirmed by the incorrect spelling of the compound *mobil fri* (correctly spelled *mobilfri*, free of mobile phones) in two cases. The first time Lisa pauses for 2.7 s before the word, but no pausing can be observed the second time. The issue with spacing can also be recognized when Lisa uses the prepositional phrase *tillexempel** (correctly spelled *till exempel*, for example). In two cases Lisa introduces the sentence with this phrase, so it is unclear whether the longer pauses preceding *till* can be associated with planning text content or the spelling of the phrase. However, during the second time typing the word, Lisa pauses 3.4 s within the word, confirming insecurities concerning the spelling of the phrase.

Whereas Lisa's attention to writing rules for compounds and prepositional phrases seems somewhat random, the capitalisation of sentence beginnings is continuously in her focus. In ten instances she starts a sentence with a lowercase letter and shortly afterwards deletes it to turn it into an uppercase letter. Below we illustrate all instances of such revisions.

0:00för <BACKSPACE4> För **0:04**

3:12<1697>visst <BACKSPACE6> Vu<BACKSPACE>isst **3:18**

4:54<10642>sen <BACKSPACE4> Sen **4:57**

5:52<5903>på <BACKSPACE3> På **5:56**

11:27<18383>jag toro <BACKSPACE8> << <BACKSPACE2> Jag **11:34**

13:05<426>men <BACKSPACE4> Men **13:09**

14:23<5414>om <BACKSPACE4> Om **14:32**

15:38<3953>d<BACKSPACE>Då **15:39**

16:09<101914>att <BACKSPACE4>Att **17:55** *(pause most likely also related to starting a new paragraph)*

20:52<9921>att <BACKSPACE4> Att **20:57**

In seven out of these ten instances, Lisa pauses considerably longer than two seconds before beginning a new sentence. That Lisa tends to miss out on capitalising sentence beginnings when she seems considerably engaged into text content indicates that capitalisation is not a fully automatized action by her, most probably because this usually is taken care of by the spell-checker function. As this function was not activated in this writing task, Lisa understood that she had to monitor this rule herself. Also, the first cursor move (A) (see Figure 3) back into already written text is related to a capitalisation revision and shows Lisa's awareness regarding this easily made mistake.

The examples provided suggest that Lisa is indeed a student with insecurities about spelling accuracy and orthographic rules in Swedish. This is evident not only from the remaining misspellings in her text but also from her hesitations and revisions during the writing process.

3.2. Niklas

Niklas had pronounced difficulties in phonological decoding. He scored in the lower average range for orthographic decoding and spelling, but scored remarkably above average in the reading comprehension test (see Table 1).

3.2.1. Niklas' Text

Niklas' argumentative text contained 282 words (see Figure 4), and overall quality, content, organisation, and vocabulary were rated as ranging from fair to average (2.5 points). While the main ideas were identifiable and generally understandable, the arguments were weakly developed and lacked sufficient detail. Coherence and language use were rated poor to fair (2 points). The use of cohesive devices was inconsistent and at times missing, which affected the overall flow of the text. In terms of vocabulary and language, Niklas selected an appropriate register for the genre; however, the lexical range was limited, and sentence structures remained mostly simple.

För eller emot att börja skoldagen kl. 10:00

jag tycker inte man ska börja skoldagen kl. 10:00 för det skulle vara tråkigt att sluta så sent. Jag tycker int* att man behöver ändra tiden som man går i skolan för de* är bra som de* är nu. Om skolan börjar klockan 10 kommer man vilja ha lunch direkt när man kommer till skolan och då blir de* svårt att konsentrera* sig på de* lärarna tycker att man ska göra. De som tycker att de* är bra att skolan börjar sent är bara lata och orkar inte att gå upp tidigt på morgonen. Om den sista lektionen ska sluta klockan 17:30 måste skolan bjuda på midag* varje dag för anars* blir det för sent att äta och då kommer eleverna må dåligt och kanske få problem hela livet. Om man bor långt från skolan och måste åka buss i någon time* kommer man komma hem från skolan när det är väldigt sent på kvällen och då är de* bra* att lägga sig. Jag tycker att man borde börja skolan mycket tidigt tex klockan 6 på morgonen för då skulle man sluta ungefär klockan 1 på efterrnidagen* och då skulle man ha mängder med tid att göra någott* man tycker är roligt. Man skulle kuna* gör* så att skolan börjar tidigt på måndag morgon och sedan går man skola till väldigt sent på kvällen och sedan skulle man göra så tisdag och onsdag också. Om man skulle ha ett schema som var på de* viset skulle man få vara ledig torsdag och fredag och då skulle alla bli glada och lyckliga. Kära rektor du är väldigt klok och snäll hoppas du gör rätt beslut. (A)

Figure 4. Niklas' final text.

Niklas' spelling was rated poor to fair (2 points). The majority of spelling errors is related to the Swedish spelling rules for short and long vowels, such as in *eftermidagen** (eftermiddagen, afternoon), *time** (timme, hour), *någott** (något, something), *kuna** (kunna, can) and *anars** (annars, otherwise). Further, Niklas misspelled the word *konsentrera** (koncentrera, concentrate), spelling it with the letter <s>, which is one of the two possibilities to spell the phoneme /s/ in Swedish. The remaining misspellings *de** instead of *det/dem* (that/them) and *int** instead of *inte* (not) are most likely due to the convention of omitting final letters in words in the spoken local dialect of Swedish. Finally, the text context makes it most likely that the word *bra* (good) was supposed to be *bara* (only).

3.2.2. Niklas' Considerations During the Writing Process: Fluency, Pauses and Revisions

The process graph in Figure 5 illustrates Niklas' writing process, which lasted for 32 min. It was characterised by frequent and long pauses, resulting in an overall pause proportion of 74% and, on average, a low writing fluency. Niklas' mean pausing time lay at 19.5 s and in the second writing interval reached a mean of 45.2 s. These means were considerably longer than those of the other two students (see Appendix A). In the first and most fluent interval, he typed 58 keystrokes per minute, in the two subsequent intervals 28 and 32 keystrokes per minute. In the middle of the writing process, Niklas paused as long as 6.8 min (second circle in Figure 5).

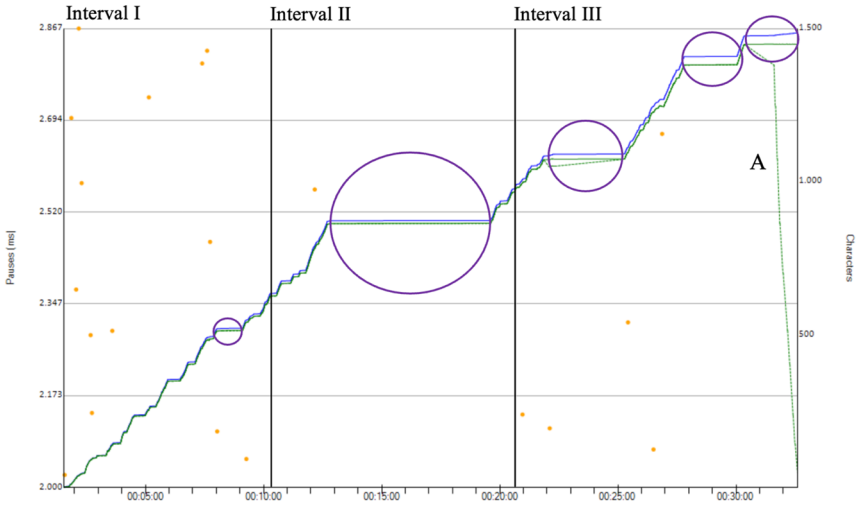

Figure 5. Niklas' process graph.

Comparable to Lisa, Niklas' writing can be described as linear; however, production was much slower, consisting of longer periods of typing alternating with long pauses. However, even during the writing phases, the regular pauses of a couple of seconds becomes visible, giving the graph its stairs-like shape. An example of this writing style is the following sentence, occurring during the first minutes of writing:

7:34<51993>om den sista lektionen ska<2054> s<3574>luta klockan <3705> 17:30 <16114>måste skola <BACKSPACE>n bjuda på middag varje dag <3460>för annars blir det för sent <16370>att äta och då kommer eleverna må dåligt <23842>och kanske få problem <13536>hela livet.

7:34<51993>if the last lesson<2054> e<3574>nds at <3705> 17:30 PM<16114>the school <BACKSPACE> would have to provide dinner every day<3460>otherwise it would be too late <16370>to eat and then students will feel bad <23842> and might end up having problems <13536>for life.

For more than 28 min Niklas kept writing at the leading edge of the text. Revisions in previously written text did not occur until the final stages (see cursor move A in Figure 5). Overall, 98% of typed text remained in the final text version, that is even more than in Lisa's text.

3.2.3. Planning Sentence-Wise

Extensive pausing is a central characteristic of Niklas' writing process. Instead of taking a longer pre-writing pause to plan what the text will be about, he consistently paused during the writing process, that is over 60 times when pauses longer than two seconds are considered. These pauses occur predominantly before words and sentences. The mean pause time between words was 2.8 s (see Table 1), more than double the time compared to the other students. The pre-sentence pauses are from six seconds up to several minutes

long, and indicate the planning of text content sentence-wise and, in some cases, literally resting before continuing to write. Part of these pauses might also have been dedicated to re-reading the already written text; however, the extended frequency and length of these pauses in relation to a rather small amount of already produced text makes it more likely that Niklas' focus lay on planning ahead. In the following, examples of the longest pauses are listed:

03:26<27114>Om skolan börjar [. . .] (If school starts [. . .])

05:16<17299>De som tycker [. . .] (Those who think [. . .])

06:42<66477>Om den sista lektionen [. . .] (If the last lesson [. . .]) (first circle in Figure 5)

08:18<16114>måste skola [. . .] (the school would have to [. . .])

09:06[. . .] eleverna må dåligt <23842> och kanske få problem [. . .] (students will feel bad <23842> and might end up having problems [. . .])

11:15<409138>Jag tycker [. . .] (I think [. . .]) (second circle in Figure 5)

19:44[. . .]tid att <15290> göra <4661> [. . .] (time to <15290> do <4661> [. . .])

26:15<134080>Kära rektor [. . .] (Dear principal [. . .]) (fourth circle in Figure 5)

The location and length of the pauses indicate that Niklas is engaged—at least partly—with those aspects of writing that he perceives as particularly challenging, such as verbalising ideas and spelling words. The pauses can thus be interpreted both as a sign of difficulty and as a coping strategy.

3.2.4. Revising Typos and Considering Spelling

Revision is almost absent in Niklas' writing. There are no indications of macro-level revisions that consider organisation of ideas. The few traceable instances of change consider spelling and typos. In the following, three examples are displayed which show Niklas' insecurity regarding spelling. In the first example, the revision did not happen at the leading edge, but slightly later. Niklas was unsure whether the word *något* (something) is spelled with <t> or <tt>. The second example shows how Niklas notices and corrects two misspelling in the word *tisdag* (Tuesday). In the third example Niklas did not recognise the (previously mentioned) misspelling of *koncentrera* (to concentrate), but corrected a misspelling in the end of the word.

20:32<2112>någe<BACKSPACE>ott<BACKSPACE><3965<t<BACKSPACE>t <BACKSPACE><4781>t (third circle in Figure 5)

24:52tid<BACKSPACE>sds<BACKSPACE><2072>ag

04:24<31858>konsentra <BACKSPACE>era

In three additional instances provided below, extended pausing indicate insecurities about the spelling of words; however, no revisions were carried out. In the first example, it seems likely that Niklas, just as Lisa, feels insecure about whether a compound noun is written as one word or not. In the second example, Niklas considers whether the word should be written with one or doubled. The cause for the long pause in the third example is not obvious.

00:28skol<2374>dagen

19:19eftermid<2138>agen

07:44 <3574>luta klockan

The process graph shows that Niklas carries out smaller revision in the already written text towards the final stages of the writing process (see cursor move A in Figure 5). Just like Lisa, he needed to capitalise all sentence beginnings in hindsight, and started from the last sentence working backwards through the text.

3.3. Kalle

Among the three poor decoders included in this study, Kalle demonstrated the weakest performance in phonological and orthographic decoding as well as spelling. His reading comprehension score fell within the lower average range (see Table 1).

3.3.1. Kalle's Text

Kalle's argumentative text (96 words, see Figure 6) was rated very poor (1 point) across all quality criteria. It is notably shorter and of lower quality than Lisa's and Niklas's texts. The content lacks persuasiveness, with basic, underdeveloped arguments and weak adherence to argumentative conventions. Coherence is limited, with ideas presented in an illogical order and minimal use of cohesive devices, affecting clarity. Vocabulary is notably restricted, with little lexical variation and an inappropriate register. Language use is marked by overly simple structures and frequent word omissions. Punctuation is problematic, with only two full stops used throughout, resulting in an overly long and syntactically complex first sentence.

För eller i mot* mobilförbud hela skoldagen
hej jag tycker att man inte ska ha ett förbud för att använda mobilen på skolan för att de kan vara bra till vissa lektioner tillexempel* som när vi ska nere på pertionrep* ska kolla efter dela* till en bil eller bara ta fram fakta om en bil så kan mobilen vara bra att ha till hands och se om det händer något så måste man ju kunna få tag i någon tillexempel* sina föreldrar*. Jag siger* att din ide om mobilförbud på skolan kan (A) ta och skrotas ordentligt (B).

Figure 6. Kalle's final text.

Numerous misspellings further suggest uncertainty about correct orthographic forms, particularly in relation to vowel usage, such as *i mot** (emot, against), *föreldrar** (föräldrar, parents) and *siger** (sager, says). The word *händer* (happen) was initially about to be spelled *hender**, but immediately revised by Kalle at the leading edge of the text, indicating some monitoring of spelling. A notable spelling instance is *pertionrep* (*personrep*, an abbreviation for *personbilreparation* [car repair]), which illustrates how Kalle may rely on phonological representations when unsure of spelling. As with Lisa and Niklas, Kalle also demonstrated difficulties with compound words, as evidenced by his writing *tillexempel* (*till exempel*, for example) in two instances.

3.3.2. Kalle's Considerations During the Writing Process: Fluency, Pauses and Revisions

As Kalle's writing process graph in Figure 7 illustrates, he paused for 1.32 min before starting to write—unlike Lisa and Niklas. Including this initial pause, the writing process lasted only 6 min and 42 s, while half of this time Kalle engaged in active writing (see Table 1). Kalle wrote his text very fast within a very short time, but his high fluency stopped in the third interval where longer pauses begin to occur (122 and 94 keystrokes per minute in the first and second interval compared to 26 keystrokes per minute in the third). The most fluent phase of writing takes place between about 2:40 and 3:60, that is approximately between the first two longer pauses indicated with circles in Figure 7. During this time period of 80 s all text between *kan vara bra* (can be useful) and *till exempel sina förelder** (like your parents) is produced. Kalle probably used his pre-writing pause to plan the two main ideas of his text. After having written down these ideas hastily in high writing speed, Kalle pauses again for around 20 s after the full stop, indicating another longer planning phase before finalizing his text with a last short sentence stating that a mobile phone prohibition according to him can "go straight to the scrap heap".

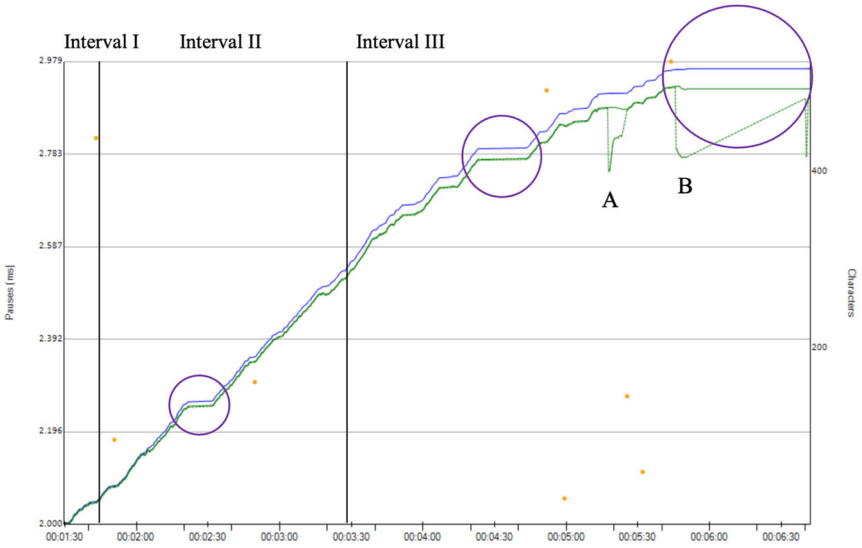

Figure 7. Kalle's process graph. Note that the active writing started after 1.32 min.

2:34få tag i n<BACKSPACE>någon tillexempel* sina föreldrar*.<20248> så jag siger* att din ide om mobilförbud på skolan kan ta och skrotas ordentligt.

2:34contact someone, like your parents.<20248> I'm saying that your idea of a mobile phone ban at school can go straight to the scrap heap.

Overall, only 13 pauses longer than 2 s were registered. Similar to Lisa and Niklas, these pauses are mainly located between words and right before the development of a central idea within a sentence indicating planning text content and word choice.

0:48för att de <10004>kan vara bra till vissa lektioner (. . .) och e<BACKSPACE>se om det he<BACKSPACE>änder något <5263> så måste man ju kunna få tag i (. . .)

0:48because they <10004> can be useful in certain lessons (. . .) and if something happens <5263>you need to be able to contact (. . .)

At two occasions, Kalle pauses for an extended time at the morpheme boundaries of the word *mobilförbud* (mobile phone ban), once in the headline of the text *mobilför<2817>bud* and once in the last sentence *mobil f <BACKSPACE2><2005>förbud<5654>*. The revision in the second example shows that Kalle was considering whether the compound should be spelled as one or two words. Otherwise Kalle does not pause before or after any of the other misspelt words.

The longest pause takes place in the end of the writing process and lasts for about 58 s (indicated by the third circle in Figure 7), most likely to re-read the text. During that last episode Kalle seems to recognise that the first word of his last sentence needs capitalisation. He deletes the first word *så* (so), then capitalises the first letter in the new first word of the sentence *jag* (I) (cursor move B). The three misspellings surrounding the place of revision (*tillexempel* [*till exempel*, for example], *föreldrar* [*föräldrar*, parents], *siger* [*säger*, says]) do not seem to catch his attention.

2:34få tag i n<BACKSPACE>någon tillexempel* sina föreldrar*. så jag siger* att din ide om mobilförbud på skolan kan ta och skrotas ordentligt. (sentence before revision)

4:17få tag i någon tillexempel* sina föreldrar*. Jag siger* att din ide om mobilförbud på skolan kan ta och skrotas ordentligt. (final version of the sentence after the revision)

2:34contact someone, like your parents. så I'm saying that your idea of a mobile phone ban at school can go straight to the scrap heap. (sentence before revision)

4:17contact someone, like your parents. I'm saying that your idea of a mobile phone ban at school can go straight to the scrap heap. (final version of the sentence after the revision)

In general, Kalle's writing is short and faster than Lisa's och Niklas', but in the same linear writing style characterised by few revisions. In sum, 90% of the text remained in the final document (see Table 1). Besides the revisions that were presented already and took place while rereading the text, Kalle revised a few times at the leading edge of the text, predominantly when typos occurred, for example, in *ha till hands och e[BACK]se* (have on hand).

4. Discussion

This study explored the writing of three adolescent students with documented difficulties in decoding and spelling. Previous research has shown that such students often struggle with writing, producing shorter texts (Tops et al., 2013), lower-quality texts overall (e.g., Sumner & Connelly, 2020; Torrance et al., 2016) and experiencing frequent interruptions during the writing process, predominantly on word-level (Å. Wengelin et al., 2014). As they grow older, they appear to develop compensatory strategies to minimize the most visible signs of their difficulties—-misspellings. These strategies include avoiding complex or uncertain words (Tops et al., 2013), planning sentences extensively to ensure grammatical and orthographic accuracy (Torrance et al., 2016), sometimes at the expense of lexical diversity (A. Wengelin, 2007).

We aimed to understand how adolescent students, likely aware of their challenges in the technical aspects of reading and writing, approach text composition to, as Å. Wengelin et al. (2024, p. 1639) put it, "illuminate moments of hesitation, worry, error detection, attempted revisions, the success of revisions and avoidance strategies". Through this qualitative approach, we sought to deepen understanding of how adolescent students with poor decoding and spelling compose texts. By analysing students' written products and writing processes, we found that writers with broadly similar formal prerequisites to poor decoders (Hoover & Gough, 1990), characterized by weak decoding and spelling but relative strengths in reading comprehension, approached writing in diverse ways.

When examining the final written texts, all participants demonstrated very poor to fair performance across the assessed dimensions of text quality. Lisa and Niklas wrote texts of similar overall quality. Both had comparable difficulties in decoding and spelling, and scored within the average range on reading comprehension (Lisa: $z = -0.08$; Niklas: $z = 1.03$). Their relatively stronger reading comprehension likely supported their writing, contributing to higher scores in content, organisation, vocabulary, and, to some extent, language use (see Table 1). Kalle also scored within the average range in reading comprehension, albeit at a lower level ($z = -0.36$) than Lisa and Niklas. Also, he showed the most pronounced decoding and spelling difficulties among the three. These challenges, combined with weaker reading comprehension, likely explain his lower writing performance, reflected in the consistently low scores (very poor) across all text quality categories.

Spelling was challenging for all three students, as shown by numerous errors in orthographic rules, consonant doubling, and vowel usage—patterns typically mastered by students at their age. Consequently, all three received poor to very poor spelling scores. However, the total number of misspellings was not exceptionally high, and spelling did not stick out as a more prominent difficulty than other dimensions, such as coherence and language use. This may relate to the semi-transparent Swedish orthographic system, which can give students with decoding and/or spelling difficulties a relative advantage compared to learners of more opaque orthographies, in terms of phoneme–grapheme correspondence. Another explanation is that misspellings may no longer be the most salient indicator of decoding or spelling difficulties in adolescent writers. As suggested by O'Rourke et al. (2020) and A. Wengelin (2007), these writers may have developed compensatory strategies, reducing the frequency of overt spelling errors.

Pauses to consider formulations and word choice is one strategy for avoiding misspellings. Niklas' writing analysis showed that 74% of his process were pauses. All sentences were preceded by long pauses up to several minutes, and the mean pause time between words was nearly three seconds. Lisas's writing also showed long pre-sentence pauses. This aligns with previous research reporting extended pre-word and pre-sentence pauses instudents with poor decoding (Torrance et al., 2016), suggesting a focus on word-level processing and sentence-level planning rather than parallel processing during writing (Olive, 2014). We assume that both students tried to activate correct spellings of words, or re-considered and reformulated wordings, to avoid difficult-to-spell words. Following Torrance et al. (2016), we suggest that this disfluent writing style, caused by divided attention between spelling and ways to work around spelling mistakes, may result in overall low text quality due to high word-level focus.

In contrast, Kalle wrote very rapidly, but only for a short time. While Niklas' writing suggests deliberate strategic choices in wording and formulation, possibly to avoid spelling errors, Kalle seemed focused on finishing the task as quickly as possible. He may have used his relatively long pre-writing pause to plan most of the text mentally. Once these ideas were written down, he considered the task complete. Given his extended pre-writing pause, rapid one-flow writing, abrupt ending after a few minutes, combined with his significant difficulties in decoding and spelling, it seems likely that Kalle found writing without a spell-checker overwhelming. This led to low motivation and minimal engagement. Our analyses suggest that students aware of their challenges rarely show spontaneous flows of writing down their ideas focusing on content. Instead, they adopt compensatory or avoidance strategies to navigate the writing task in light of their decoding and/or spelling challenges. Such strategies may involve careful lexical selection and attention to spelling, reflecting a meticulous but effortful approach. Alternatively, some students may limit engagement altogether to avoid a cognitively demanding and frustrating task that highlights and reinforces their difficulties.

The texts produced by the three writers were composed in a largely linear fashion, meaning they wrote from beginning to end with minimal restructuring, deletion, or addition of new parts. Revisions were rare and occurred almost exclusively at the micro-level, focusing on typos, misspellings, and capitalization, mostly during inscription. Lisa's insertion of content midway through the process was an exception.

Towards the end of writing, all students showed periods of inactivity, likely due to re-reading the text and/or making minor revisions. These revisions were limited to capitalising sentence beginnings and punctuation adjustments. While these actions indicate an intention to improve texts, the high cognitive demands of reading may have effective monitoring of content and coherence, as well as macro-level revisions. This hypothesis is supported by the low coherence scores observed in all three students.

Misspellings in already written text largely remained unnoticed, even after the final re-reading. Hence, theoretically the students could have engaged in more micro-level revisions than they did. This qualitative observation aligns with previous research by Torrance et al. (2016) and O'Rourke et al. (2020) with larger groups of students, showing that poor decoders perform fewer word-level revisions that typical readers. These writers often have weaker orthographic representations of words and may not easily detect misspellings (Sumner & Connelly, 2020), even during re-reading. Another potential explanation offered by Å. Wengelin et al. (2024), is "overlooking spelling", a phenomenon among writers accustomed to spell-checkers who temporarily disregard spelling to prioritise lexical diversity. This reliance on digital aids may also lead to limited revision when spell-check is absent.

More evidence of spell-check's central role in students' typical writing appears in logged revisions and pauses, particularly those related to orthographic rules such as com-

pound nouns, prepositional phrases, and capitalization of sentence beginnings. In regular school settings, spell-check typically detects and, when enabled, automatically corrects violations of orthographic rules. Students rely on this tool to ensure formal correctness. In this study, however, spell-check was disabled, creating an unusual writing situation and increasing cognitive load associated with spelling and orthographic monitoring. This heightened demand was reflected in writing behaviours. For spelling, students may have employed avoidance strategies, such as lexical planning during pauses to reduce errors. In contrast, orthographic conventions like capitalization and compound formation were harder to circumvent and triggered more frequent hesitations and micro-level revisions, as seen in Lisa's and Niklas' processes. Although we can only speculate about the potential for higher text quality had spell-check been enabled in this study, previous research by O'Rourke et al. (2020) has shown that students with persistent decoding difficulties produce texts with greater lexical diversity when supported by spell-check.

This small-scale qualitative study does not allow generalisation about adolescent students with poor decoding and spelling and their writing. Instead, it provides examples that support or challenge findings from larger studies, adding context and detail to what is known about writing under these conditions. Some results confirmed earlier research, such as a word-level focus reflected in undeveloped and incoherent texts rather than overly large accuracy deficits. Others shed light on new aspects of how students with poor decoding and spelling manage their text production challenges. For students with pronounced difficulties, perhaps combined with other factors such as poor general linguistic ability, interest and motivation, there is a risk of writing refusal, especially when digital writing aids are unavailable. Others with moderate difficulties may adopt compensatory and other strategic behaviour to comply with the demands of writing. Extended pausing at sentence, clause and word level for strategic planning, micro-level revisions and re-reading text during and after writing were observed, showing students' ambitions to produce texts with good quality. Despite their efforts, these students often fail to meet expected text quality standards. However, their varied approaches and demonstrated indications of strategic engagement highlight the need for more nuanced support strategies in educational contexts.

The study contributes to the field by highlighting the diversity of coping strategies and the potential risk factors for disengagement, offering insights that can inform targeted interventions. However, its small scale and qualitative nature limit generalizability, and future research should examine how individual profiles interact with writing conditions across broader samples and settings. Such work could also explore practical solutions, such as adaptive technologies and differentiated instruction, to better support students facing decoding and/or spelling difficulties.

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Appendix A

Table A1. Writing process data by the participants.

	Lisa	Niklas	Kalle
Total process time (mm:ss)	28:29	32:36	6:42
Proportion of active writing time	52%	26%	47%
Proportion of pausing time	48%	74%	53%
Number of keystrokes per minute (overall fluency)			
Number of keystrokes per minute interval 1	97	58	122
Number of keystrokes per minute interval 2	89	28	94
Number of keystrokes per minute interval 3	79	32	26
Number of pauses per minute	2.32	2.27	2.54
Number of pauses per minute interval 1	3.59	3.59	2.24
Number of pauses per minute interval 2	2	1.38	5.37
Number of pauses per minute interval 3	1.37	1.84	0
Mean time of pauses in s (SD)	12.42 (25.27)	19.53 (53.51)	12.47 (22.38)
Mean time of pauses in s/interval 1 (SD)	11.15 (23.84)	12.03 (16.70)	21.39 (34.26)
Mean time of pauses in s/interval 2 (SD)	11.85 (21.72)	45.16 (106.22)	8.75 (13.17)
Mean time of pauses in s/interval 3 (SD)	16.59 (32.32)	14.95 (31.10)	na
Number of P-bursts per minute (P-burst = a period of text production in between two pauses above 2 s)	2.32	2.24	2.54
Mean time P-bursts in s (SD)	13.48 (20.86)	7.09 (7.37)	11.20 (14.30)
Mean characters typed in P-bursts (SD)	43.32 (68.79)	20.34 (22.96)	30.35 (42.22)
Number of within word pauses (relative, per word)	1.64	2.39	2.16
Mean time within word pauses in s (SD)	0.42 (1.60)	0.38 (0.35)	0.39 (0.29)
Number of between word pauses (relative, per word)	0.99	0.97	0.99
Mean time between word pauses in s (SD)	1.19 (6.78)	2.82 (11.98)	1.13 (1.41)
Revision ratio (proportion of text typed during process that ends up in final text)	0.90	0.98	0.90

Appendix B

How to interpret the process graph generated by Inputlog?

The process graph shows you a graphic representation of how you completed your writing process. How do you read a process graph?

- The (horizontal) x-axis represents the duration: the time it took the writer to write the text.
- The blue line is the process line. This line shows the number of characters the writer produced during the task. The steeper the line, the more text the writer produced in a short time. The number of characters produced can be seen on the (vertical) y-axis.

- The green line is the product line. This line shows the length of the text at any time. The number of characters can be seen on the y-axis.
- The graph thus shows how many characters (visible on the y-axis) the writer has already produced (blue process line) and how many of these characters (visible on the y-axis) are still in the text document (green product line) at each point in the process (time visible on the x-axis).
- The greater the distance between the blue process line and the green product line, the more text the writer removed.
- The blue process line and the green product line sometimes go up in one instance (vertically). In that case, a piece of text is added to the writer's text at once. When this happens after consulting a source, a piece of text is copied from the sources and pasted into one's own text. When pasting a piece of text does not happen after consulting a source, it is a piece of text from the own text that is inserted in another place in the text.
- If the green product line goes down at once vertically, a piece of text is removed from the own text at once.
- The green dotted line indicates where in the text the writer was working. If this line overlaps with the full green product line, the writer was working at the end of the text. If the line goes down toward the x-axis, the writer returned to the beginning or an earlier written part of the text.
- Finally, at the bottom you will see an orange line. That shows when the writer consulted the sources and when the writer was working in their own text. When the orange line is at the top, the writer consulted the sources. Each red dot represents a source. When the orange line is at the bottom, the writer is working in their own text.

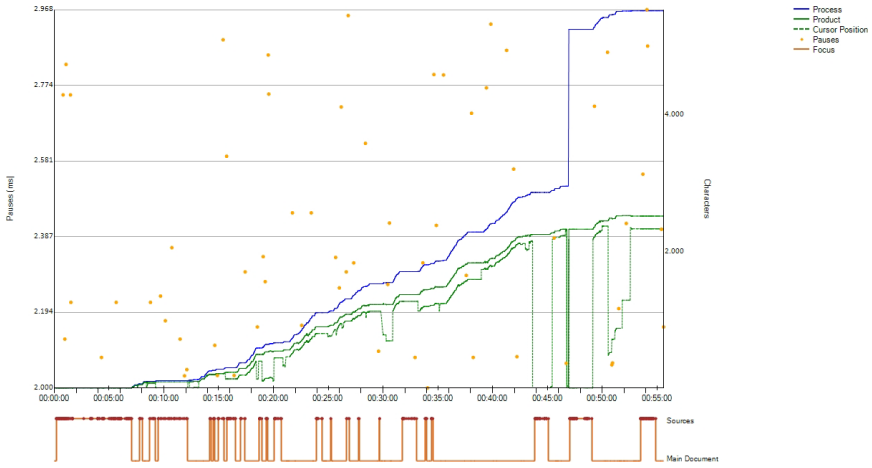

Figure A1. Writing process graph.

Appendix C

English translation of student texts

Appendix C.1. Lisa's Text

For or Against a Full-Day Mobile Phone Ban at School?

The proposal that we should have a mobile-free day at school doesn't sound like a good idea to me because the phone is useful for a lot of things. For example, if you need to check the time to make it to class on time, or check when class starts and what class you have. You could wear a watch or you could put up clocks in the hallways and keep a schedule in your locker, but I think it's much more convenient with a phone because it's just one thing that has all that in it.

Sure, it might be good to not have phones during lessons, but I think that if you use your phone for the right things, it can definitely be necessary. For example, if your computer is broken or dead and you don't have a charger, then if you have your phone with you, you can just work on that instead of doing nothing or having to work with a classmate.

Those who need a ride after school might need to contact the person who's picking them up, and then you need to have your phone or maybe check bus times if you don't know when your bus is leaving.

I don't think anyone actually supports the argument for a mobile-free school day, because phones are used for way more things than the teachers think, they probably think we only use them to text friends or check Facebook or Instagram or play games. But if they take away what they want to ban, we still have the computer and we can chat with friends, check Instagram, and play games on the computer too. If they don't want us to be on the wrong things during class, I just think that if someone is doing that, the teacher should just send him or her out of the classroom. That way we'll learn not to go on the wrong things, and then both phones and computers can be useful to have at school.

That phones would have a negative effect on school results, I don't think that's true, because most people use phones to check the time and schedule and stuff like that during breaks or if they take a short break during class. And if you're going to say that, then you should also ban computers because you can chat with friends via computer too, so then the computer should also have a negative effect on school results. Trying out a phone ban during lessons, I could see that being a better solution if the teachers think phones are disruptive during class. But if you don't have a computer, if it's broken or dead, then I think that if you have a phone, you should be allowed to work on it just as easily as on a computer, because you can do about the same things on a phone as on a computer.

Appendix C.2. Niklas' Text

For or Against Starting the School Day at 10:00

I don't think the school day should start at 10:00 because it would be boring to finish so late. I don't think there's any need to change the time we go to school because it's fine the way it is now. If school starts at 10, people will want lunch as soon as they arrive, and then it will be hard to concentrate on what the teachers want us to do. Those who think it's good for school to start late are just lazy and can't be bothered to get up early in the morning. If the last lesson ends at 5:30 p.m., the school would have to provide dinner every day, otherwise it would be too late to eat and then students will feel bad and might end up having problems for life. If you live far from school and have to take the bus for an hour or so, you'll get home really late in the evening, and then it's straight to bed.

I think school should start much earlier, like at 6 in the morning, because then we'd finish around 1 in the afternoon and have loads of time to do something fun. You could make it so that school starts early on Monday morning and then goes until very late in the evening, and then do the same on Tuesday and Wednesday. If we had a schedule like that, we'd get Thursday and Friday off, and then everyone would be happy and joyful.

Dear principal, you are very wise and kind, I hope you make the right decision.

Appendix C.3. Kalle's Text

For or Against a Full-Day Mobile Phone Ban at School

Hi, I think there shouldn't be a ban on using phones at school because they can be good in certain lessons, for example, when we're down in car repair class and need to look up parts for a car or just find information about a car, then the phone is good to have on hand. And if something happens, you need to be able to contact someone, like your parents.

I'm saying that your idea of a mobile phone ban at school can go straight to the scrap heap.

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