

Revisiting Cultures of Inscription

Digital Pencils in Swedish Compulsory Schools

Anders Björkvall, Fredrik Lindstrand and Ida Melander





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Table of Contents

- How to read this report 4**
- Four main recommendations 5**
- Introduction 6**
- Previous research on digital pencils 9**
- Research design 11**
- Bridging the analog and the digital worlds of inscription 16**
- Making use of digital potentials 23**
- Conclusions and detailed recommendations 29**
- References 32**

How to read this report

This research report presents the results of two studies of uses of digital pencils in Swedish compulsory schools. Digital pencils are used for writing, drawing, and pointing, usually on the screens of tablets such as iPads. First, four main recommendations are presented, based on some of the main findings. These recommendations are then matched with more specific recommendations and conclusions in the final section of the report (*Conclusions and detailed recommendations*). The rest of the report presents the research conducted, and it does so in a manner that aims to be accessible to readers without any previous knowledge of the research field. The most direct way to grasp the content of the report is to focus on the sections *Four main recommendations* and *Conclusions and detailed recommendations*. For an extended understanding, it is recommended to read the full report.

Four main recommendations

Digitalized schools should consider introducing digital pencils as a way to bridge the digital practices of writing and shaping by hand (screen and digital pencils) with their analog counterparts (writing and shaping with pens and pencil on paper). This recommendation is based on the main observations presented in the report. In relation to analog pencils, the digital pencils can be used as providers of ‘digital ink’ for manual inscription, as a cognitive and embodied tool for thinking, and as a tool for creative practices to test out and play with different shapes.

Dichotomizations between digital and analog pencils should be avoided and a combination of digital pencils (and screens) and analog tools should be encouraged in the classrooms, based on the principle of aptness: the most apt tool for a specific learning task should always be used, whether it is analog or digital. Our studies have shown how learners and teachers appreciated the potentials of digital pencils for some tasks but analog tools for others, in order to maximize learning.

Before digital pencils are introduced in digitalized classrooms, teachers and school management should set up strategies and pedagogic plans for how teachers and students can receive basic training with the pencils, including setting up inventories of accessible apps that are compatible with the digital pencils. The analysis presented in the report points to how some apps were less compatible with the digital pencils, which caused some confusion. The analysis also showed that some of the functions of the digital pencils were left untapped in classroom practice.

Representatives of the hardware and software industry – including designers – and educational policymakers should collaborate in order to facilitate charging of the pencils as well as extending the compatibility with a wider array of apps used in schools. The studies identified issues with uncharged pencils, especially when younger children (here, in fourth grade) are responsible for charging, along with a lack of freedom regarding use of the pencils across the main apps available on the iPad.

Introduction

In Swedish compulsory schools, almost every learner has access to their personal digital device, typically a tablet or a laptop (Skolverket, 2022: 42–43). In other words, what is sometimes referred to as ‘one-to-one’ computing – one device per learner – is now a completed reform in the Swedish educational system. It is fair to say that the Swedish school system is largely digitalized.

Paradoxically – or as an expected consequence of this high level of digitalization – ideas of *de-digitalization* now prevail, not only in the fields of educational research but also in Swedish society at large. At the political level, decisions have been taken to bring back printed textbooks as well as pencils and paper into Swedish schools (Utbildningsdepartementet, 2024). It is fair to say that, to some extent, the ways of thinking and talking about digital devices – in schools and in Swedish society at large – are changing, from generally being positive – presenting digitalization as a means for economic, political, intellectual, and educational progress – to being more skeptical and pointing to the risks associated with spending too much time in front of screens.

Such debates about the pros and cons of digitalization are often both productive and a key component of democratic dialog. However, it can be argued that, in the context of education and compulsory schooling in Sweden, both the debate and the larger processes of digitalization and de-digitalization have been characterized by rather stiff positions of being either pro or against the use of digital tools in schools. Still, there are researchers as well as educators in Sweden who maintained a more balanced idea of *aptness* (Kress, 2010; Bezemer and Kress, 2016): the most apt tool or device should be used for every educational challenge or task. For instance, many learners tend to prefer a printed book when they do mathematics, just as many math teachers prefer a traditional blackboard or a whiteboard when teaching. Such analog devices may then be the most apt tools. However, when writing a longer essay to be distributed to other learners in a class or to be published online, the use of a keyboard for typing may be the most apt tool. And if images are to be inserted into

the text, the use of a digital photo-editing app may be motivated and more apt than trying to do the same thing in an analog photo studio.

The contemporary dichotomization of digital vs. analog tools for teaching and learning has a history. In the early 2010s – when ideas of ‘one-to-one’ computing were really picking up – laptops and tablets were sometimes introduced as devices that would totally transform teaching and learning. Sometimes teachers and learners were positive and explored the potentials; sometimes they perceived the uses of laptops and tablets as something imposed on them from above. But quite soon, both practitioners and researchers in fields such as technology in education pointed to the problems of introducing new technology without the support of matching educational designs and pedagogies in the classroom or, as mentioned, with using digital tools even though other tools may have been more apt. Questions were raised regarding whether reading on screen could impair the learners’ abilities to read and interpret longer, linear texts. In digitalized schools, the importance of pens and pencils – previously key tools for inscription and learning in schools – was often downplayed in favor of keyboards and, in the case of tablets, pointing and writing with the index finger.

Swedish schools are now in a situation where digital technologies are present and accessible in the classroom; teachers and learners can use them; and their potential for teaching and learning may be increasing with the large-scale introduction of generative AI. At the same time, the message is clear from politicians and to some extent from researchers: digital devices should be replaced by analog tools for teaching and learning. The research presented in this report is a direct result of this situation. It looks at a specific tool – the digital pencil – that may have the potential to make use of the technology that is present in schools. The research also points to other practices that, to some extent, have been downplayed during the past decade: shaping and writing by hand. A digital pencil is a pencil that can be used for writing, drawing, and pointing on a digital screen, usually a tablet but sometimes a laptop.

This report details the results of two studies of how digital pencils are used in two classes in Sweden: one fourth-grade class and one eighth-

grade class, where each student has their own iPad that is used to access the digital learning platforms and teaching materials, and to complete tasks and assignments. The report aims to empirically describe the potentials of the digital pencils as tools for writing by hand and drawing, but also for performing tasks other than those that are possible with analog pencils, such as moving objects around on a screen or designing texts in layers. In other words, the extended aim is to discuss the potential of digital pencils in schools with regard to reconnecting with analog cultures of inscription as well as pointing to ‘new’ potentials of the digital pencils. The results presented come from the research project *Connecting digital and analog literacy: The potential of the digital pencil for text creation in schools (DigiPen)*.¹

The report primarily targets teachers, teacher students, school management, and educational policymakers, as well as representatives of the hardware and to some extent software industry. It is therefore written in a style that is accessible to readers without any previous knowledge of the specific research fields – *social semiotic multimodality* (Kress, 2010; Hodge and Kress, 1988; Van Leeuwen, 2005) and *designs for learning* (Björklund Boistrup and Selander, 2022; Selander and Kress, 2021) – within which the studies were performed.

¹ The project was financed by Örebro University and the University of Arts, Crafts and Design (‘Konstfack’) in collaboration with Logitech. Logitech contributed by providing the digital pencils that the learners in the two classes were using and co-financed the salary of the researcher who performed the main part of the fieldwork in the study of grade eight. Logitech has had no influence over neither the specific aims and research questions formulated nor over the methods and theories applied, which was agreed upon at the start of the project.

Previous research on digital pencils

Digital pencils do not solely have a digital presence: they are analog in the sense that they have material shape and form similar to that of an analog pen or pencil. It is primarily the traces of inscription that digital pencils produce on a screen that are digital. Previous research on digital pencils can be divided into two main groups. The first group includes accounts of how digital pencils have been used for various purposes in educational contexts. The second group comprises studies of the physical properties of specific types of digital pencils along with the type of use that they invite. Let us start with the first group.

Some research on the use of digital pencils in education focuses on academic practices in higher education (Huang et al., 2017; Siddiqui and Muntjir, 2017), but more relevant to this study is, for instance, Simonnet et al. (2019), who focus on children's 'shaping' of letters with digital pencils, and Lubke and Dabney (2017), who study children's annotations with digital pencils in and out of school. Lubke and Dabney show how learners used the digital pencils in ways that the teachers did not expect. For instance, they created clearer annotations than with traditional pencils (2017: 51). Interestingly, they also managed to make relevant and motivated decisions regarding whether to use digital or analog tools for inscription when faced with specific tasks.

Further, 'the digital pencil' is sometimes used as a metaphor for all digital literacy devices: laptops with keyboards, touchscreen devices, and so on (Lei et al., 2008; Wollscheid et al., 2016; Farinosi et al., 2016). The research presented in this report focuses on digital pencils that look like an analog pencil, which is something else.

Turning to specific disciplinary literacy practices in subjects such as Swedish and visual arts in Sweden and the Nordics, we have not identified any studies that target digital pencils in particular, except for that by Björkqvall et al. (2025), which presents one of the studies reported on here. Instead of analyzing shaping by hand in the digital environments, digital literacy practices in general, most often exemplified through the keyboard, have been compared to the analog pencil with regard to writing strategies, literacy genres, correctness, and

quality (e.g., Hultin and Westman, 2013; Erixon, 2018; Dahlström and Boström, 2017; Åkerfeldt, 2014, Spilling et al., 2022). Andersson and Sofkova Hashemi (2016) – focusing on primary school – show how young learners already make use of digital technologies in the creation and designing of texts, but that these activities are often “restricted to the use of the keyboard mainly as a substitute for the pen” (p. 94).

The second group of research has a focus on the design of the pencils in relation to the uses they invite. Here, the work by Riche et al. (2017) is highly relevant to the study presented here as it focuses on the design and multifunctionality of the digital pencil. A distinction is made between the digital pencil as a provider of ‘digital ink’ for writing on a tablet and as a tool for an array of tasks: moving items, framing, using lasso functions, and clicking. These distinctions are further explored in our own studies.

Another strand of research within this group approaches the digital pencil as a tool for helping older users of handheld devices to reproduce shapes and thus handle new technology by connecting the new surface/device to knowledge of the analog pencil (Hourcade and Berkel, 2008; Valentine et al., 2017). This includes becoming acquainted with the physical properties of the smooth writing surface on the tablet (cf. Alamargot and Morin, 2015; Guilbert et al., 2019; Park et al., 2012; Hochhauser et al., 2021). Here, research shows that the difference in screen surface and the kinematics of writing with a digital pencil on a tablet influence writing practices. The lack of friction has consequences for both letter legibility and letter size compared to writing on paper, and this specifically affects young learners – something that resonates in the voices of learners studied here. Further, Osugi et al. (2019) demonstrate that familiarity with the digital pencil matters, and that experienced users might benefit from writing with it compared to writing with an analog pencil. In the aforementioned work by Björkvall et al. (2025), the way of holding the pencil also stood out as a factor that needs to be considered when introducing digital pencils to young learners.

In sum, it is clear that even though the digital pencil has been researched to some extent, its uses and potentials in higher education have been more analyzed than those compulsory school. In particular, there is an obvious research gap regarding what we know about its uses, potentials, and challenges in Sweden and Scandinavia. This research report will fill part of that gap.

Research design

Two theoretical perspectives form the foundation for the research presented in this report: multimodal social semiotics (Kress, 2010; Hodge and Kress, 1988; Van Leeuwen, 2005) and a related design-oriented approach to learning and designs for learning (Björklund Boistrup and Selander, 2022; Selander and Kress, 2021). In social semiotics, the interest of meaning-makers – for example, someone creating or annotating a text or a drawing – is at the core of investigations. Based on their interest in, for example, highlighting the most important words in a text, which tools do they choose, and which properties of those tools are regarded as most apt for performing the highlighting?

A key concept in social semiotics is that of *affordance* (cf. Kress, 2010; Gibson, 1979): “The history of semiotic use of a specific materiality produces *semiotic affordances*: what a sign-maker does is shaped by what other sign-makers have done before her or him, in response to similar social and semiotic needs” (Bezemer and Kress, 2016: 31, italics in original.) In relation to digital pencils, this means that users of the pencils – guided by their interests and needs for making specific meanings – will find uses for the digital pencils based on the material design of the pencils and their knowledge of previous uses of both analog and digital pencils and related objects. Affordance is a key concept for the analysis presented in this report: we investigate the affordances of the specific digital pencils that we study when they are put to use in different practices in the classrooms.

The designs for learning approach helps us to think about teachers and learners as designers *for* learning and *in* learning. The former has to do with how teachers prepare for use of the pencils when tasks are designed for the learners. For example, the teachers can design for

learning when they prepare a task in which the learners are to both write and draw an end to a story that they have read. Learners are then designers in learning when they make use of the pencils for finishing the story, based on their own interests and how they perceive the affordances of the digital pencils in this specific context.

The application of these theoretical perspectives can be further explained by the illustration in Figure 1 (from Björkvall et al., 2025).

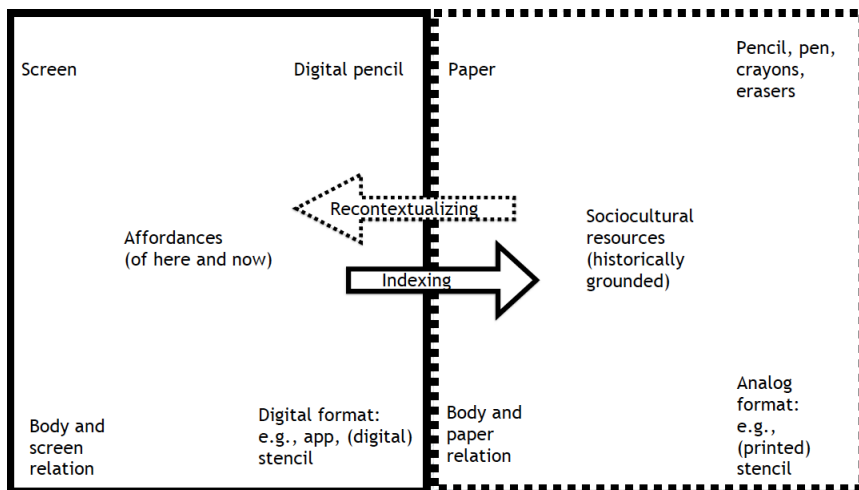


Figure 1. Designs for and in learning with digital pencils (Björkvall et al., 2025).

The box to the left in Figure 1 represents the digital aspects of the classrooms in which the present study has been conducted. Here, we typically find (represented in the top right of the box) digital pencils and, to the bottom right, digital apps in which the digital pencil is used. There will also be learners’ bodies, which – when using an iPad – is oriented toward a screen in one way or another. Finally, there will be screens, here in the shape of iPads. The box to the right represents the analog aspects of classrooms. Starting from the top right, there are analog pens and pencils and (bottom right) printed stencils and writing booklets. Here, the learner’s body in relation to paper is just as relevant as its relation to the screen in the left box. Finally, there is paper – the analog counterpart of the screen.

Now, from the perspective of theory, in the left-hand box where we find the digital pencils there is opportunity for a teacher to use the affordances of the digital pencils to connect this tool for inscription to other such tools – what in Figure 1 are called other *sociocultural resources*. In other words, the teacher can potentially design the activities in the digital classroom so that learners can simultaneously learn about how paper, crayons, stencils, and so on work. That is, the affordances of historically grounded sociocultural resources other than digital pencils and their uses can be brought into the digital classroom through the use of digital pencils. The teacher designs *for* learning about analog tools for inscription through the use of digital pencils. We call such processes *recontextualizations* (Linell, 1998), as indicated by ‘recontextualizing’ in the arrow that points from the ‘analog’ box to the ‘digital’ box in Figure 1.

From the perspective of the learners, located in the left-hand box working with their digital pencils, they are active in designs *in* learning, guided by their interests in relation to the digital pencil. As part of such activities, they will explore the affordances – the potentials and limitations – of the digital pencils in relation to the screen, apps, and their own bodies. Two aspects of this design in learning are particularly interesting for this study. First, the learners may have some knowledge of the analog sociocultural resources in the box to the right in Figure 1 – especially if the teacher managed to design for learning in a way that the properties of such resources were recontextualized into the digital pencil context. In such cases, the affordances of digital pencils may point to – or *index* (Silverstein, 2003; Scollon and Scollon, 2003) – the affordances of analog resources for inscription, from the perspective of the learner. That is, on a generic level, the learner will recognize the pencils as related to analog crayons, pencils, and pens, and connect their use of the digital pencils to uses of their analog counterparts.

However, in their designs in learning with the digital pencils, the learners will also explore affordances that will not index the sociocultural resources found in Figure 1. As Riche et al. (2017) pointed out, the design of a digital pencil usually makes it multifunctional, including many functions that are not found in analog pencils. Such

explorations are not captured by Figure 1, but they are in focus in the studies presented.

The overall methodological framework of the two studies is *multi-modal ethnography* (Björkvall, 2012; Flewitt, 2011). This methodology makes use of tools and techniques from ethnography (Green and Bloome, 1997) in combination with analyses of the pencils' designed potentials. Initially, we analyzed the pencils – in this case, Logitech's first-generation Crayon pencil – in terms of designed affordances. The ethnographic part of the studies comprised classroom observations (see below) in which we studied how the affordances of digital pencils were picked up or left untapped. Thus, the ethnographic analysis zooms in on observable interests of the learners, their motivated choices of pencils, and the perceived affordances of the pencils, along with the texts, drawings, and other representations that they create.

The methodological tools employed were video-recorded, ethnographically inspired observations (regarded as visual field notes) of situated meaning-making, focusing on learners' work with digital pencils on screens and complemented with still images and written field notes. Focus group discussions with learners and teachers were used in order to identify attitudes to, and experiences of, digital pencils as resources for meaning-making and learning. Finally, texts and drawings created with the pencils were collected and analyzed.

The data collected in grades four and eight are presented in Table 1.

Table 1. Overview of data collected in grades 4 and 8.

Data type	Quantity grade 4/8	Comments
Video recordings	76/75 recordings (9 hours, 42 minutes, 55 seconds/5 hours, 47 minutes, 14 seconds)	The recordings were mostly produced with handheld cameras, sometimes complemented by the use of a fixed camera (documenting work in groups).
Photos	91/43 photos	The photos were mostly of texts and drawings produced by the pencils and of various uses of the pencils.
Field notes	11/11 field notes (11.5 pages, 4,856 words/12 pages, 4,963 words)	The field notes were produced by the three researchers/authors of this report individually.
Group interviews	1 teacher interview (22 minutes, 16 seconds), 2 student focus group interviews (46 minutes, 29 seconds in total)/1 teacher interview (19 minutes, 21 seconds), 1 student focus group interview (33 minutes, 49 seconds)	The group interviews were video-recorded.
Learners' texts	Approximately 25/50 texts	Sometimes these texts were captured by our photos and video recordings, so it is difficult to give an exact number of texts collected.

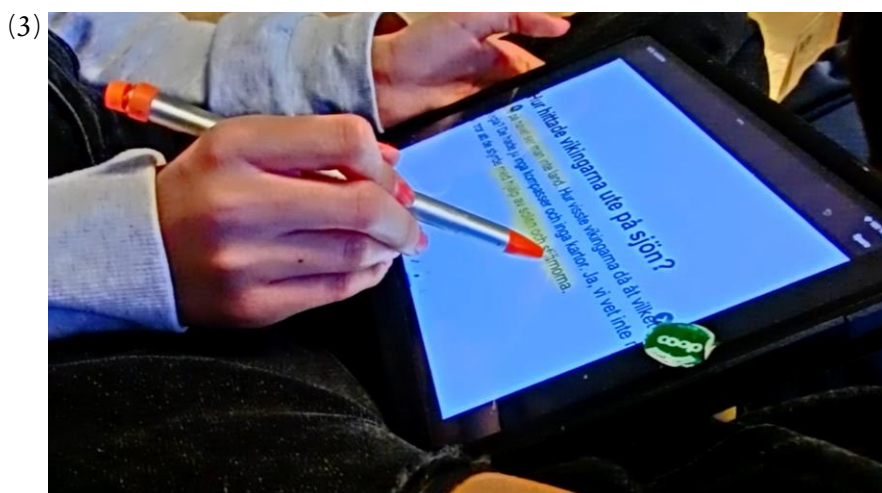
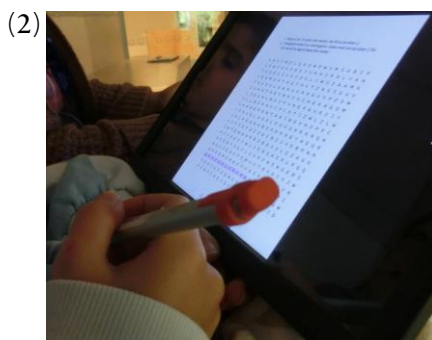
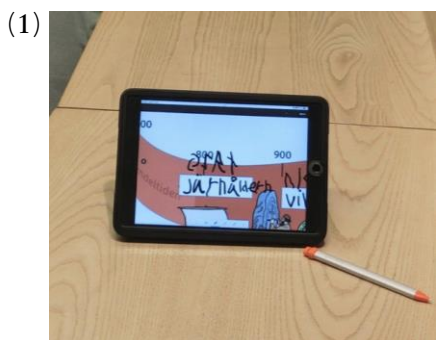
The data were collected in two different schools, each of which is located in the suburbs of a large city in Sweden. Both schools were so-called 'iPad schools,' in the sense that the learners worked with iPads across subjects, although neither of the schools had any previous experience of working with digital pencils. Four teachers – two from grade four and two from grade eight – participated in the study. In grade four, 53 learners participated, and 23 learners took part in the grade-eight study.

Teachers, learners, and guardians were informed, both orally and in writing, about the purpose of the research and what participation would involve for them. Consent was obtained from all participants – only a few choose not to participate. The activities of the latter were simply not documented, which meant that we directed the camera elsewhere or moved to a different part of the classroom if a non-participating learner engaged with the learners that we were documenting.

Each of the studies was carried out during a period of eight weeks. In the fourth-grade class, the study documented a history project in which the learners were introduced to life in Sweden and the Nordics from the Viking Age to the Early Middle Ages. In the eighth-grade class, the study documented the learners' work in the subjects of visual arts and Swedish. In the art class, learners worked with advertising and opinion images. In Swedish, they worked with a blackout poetry assignment and different assignments related to the reading of a novel. In both studies, the topics that we documented were already planned, but the teachers were asked to design activities in which the digital pencil could be a relevant tool.

Bridging the analog and the digital worlds of inscription

In terms of key functions and uses, the two studies demonstrate that learners most often made use of the digital pencil as a provider of 'digital ink' when drawing and writing, similarly to the ink provided by an analog pen. In the fourth-grade class, this entailed using the pencil to fill in words in blank spaces in pdf-documents or stencils, to mark up a historic timeline, or to highlight words, as exemplified in images 1–3.



In the eighth-grade class, learners made use of the digital pencil as a provider of ‘digital ink’ to black out words in the blackout poetry assignment, thereby creating a new poem. They also used the ‘digital ink’ function to illustrate new endings to the novel that they had been reading in class. Images 4 and 5 exemplify the results of these tasks involving the digital pencil.



As mentioned, this use of the digital pencil as a provider of ‘digital ink’ for writing or drawing relates to the functions of the analog pencil and promotes recontextualizations of historically grounded school practices. The dominance of the ‘digital ink’ function in both studies can be traced back to the designs for learning – the tasks, which largely picked up analog pencil functions such as filling in words or sketching. In general, learners tended to make more use of the digital pencils for drawing than for writing. In the focus group with eighth-grade learners, it was even questioned whether the digital pencil is a good tool for writing in school – some of the learners definitely preferred using the keyboard instead. In contrast, the teachers interviewed expressed an interest in really exploring the potential of the digital pencils as a tool for handwriting. Thus, it seems that both the interests and experiences of learners and teachers point in different directions when it comes to handwriting with these devices.

In the fourth-grade study in particular, we also saw evidence of a lack of compatibility between the pencil and some of the software, where the apps used during lessons did not always support the pencil, or only supported certain functions of the pencils. Although the fourth-graders still found meaningful ways to make use of the pencil’s ‘digital ink’, this lack of compatible software may have restricted the

possibilities to recognize and make use of more specific potentials of the pencil. Here, it is also worth mentioning that, although the digital pencil can provide learners with ‘digital ink’ for practices of inscription, the surface of the iPad differs considerably from the surface of paper. When evaluating the digital pencil as a tool for writing specifically, learners complained about the lack of friction and the smooth surface of the iPad.

Another potential compatibility issue was raised in the eighth-grade focus group. Some of the participants mentioned that, when using the digital pencils, the palm of their hands sometimes interfered with the surface and the apps that they were using, with the result that it was difficult to write or draw or that previous inscriptions were partially erased. These issues were never documented by us when we were in the classroom, and they are probably the result of certain selections in the iPads’ settings, but they need to be mentioned as something that teachers and product developers should be aware of.

Both studies demonstrate that there is a creative potential in the digital pencil: it offers the learners an opportunity to test out and play with different shapes. This creative potential of ‘playing with shapes’ was mostly visible during breaks or in between official classroom activities (Björkvall and Engblom, 2010), but there was also creative play going on during learners’ work with tasks, or while the teacher was giving instructions during whole-class teaching. For example, the learners explored the shapes of letters and numbers, drew hearts and flowers, and wrote their signatures. In this way, having access to the digital pencil appeared to provide the learners with a tool for doodling and creativity. Two examples are given in images 6 and 7, showing a fourth-grader (image 6) and an eighth-grader (image 7) engaging in creative play by means of the digital pencil.



In this creative play, the digital pencil appears to share the immediacy offered by an analog pencil, as a tool to use for creative practices without delay. Unlike an analog pencil, it also provides the learners with an opportunity to swiftly erase the traces of their play, and then go on to test out other shapes. This was the case in a task consisting of writing in runic letters, featured in image 8 below. As the learner worked on the assignment of writing the sharp and more angular runes, she was also testing out other, more circular shapes, such as the letter 's' and the number '8'. In the video recording, the learner can be seen repeatedly erasing her drawings to then test out other shapes: first she shapes the number '8', then the letter 's', then she deletes them both and continues with the task, only to go back to testing out other shapes a little while later.

(8)



The creative appeal of the digital pencil was also brought up and commented upon by learners. They would make comments about the esthetic and entertaining qualities of the digital pencil, describing it as a “fun” tool that results in “pretty” handwriting and drawings. These statements are also indicative of the learners’ overall positive attitude toward the digital pencils that we observed during the entire field study in grade four. Similarly, the fourth-grade teachers mentioned seeing progression in the learners’ work in terms of the level of detail and overall esthetics of their drawings. In the case of the learner writing in runic letters, the sequence of her creative play is also coupled with expressions on how she “loves to draw eights with the pencil” and that “it’s really fun.” All of these examples highlight the potential for creative play by means of the digital pencil. Interestingly, in the eighth-grade focus group – which was conducted a few months after the fieldwork was completed – learners mentioned having continued using the pencil at home for similar creative practices, whereas it appeared to have lost some of its function and relevance in their schoolwork.

Similar to an analog pencil, learners also seemed to recognize the digital pencil as an embodied tool for cognition – for instance, by using it to direct their attention when reading or searching for information. In the fourth-grade class, this was evident in their work with a word puzzle. When searching for words in the puzzle, learners used the

digital pencil to focus their reading and follow along in the text, as shown in image 9.



In this case, the learner has her digital pencil directed at the word puzzle on the iPad screen, and the video recording shows her moving the pencil back and forth across the screen, in search of the words featured in the assignment. The other hand is placed on the forehead in a thinking position, which aligns with how she is making use of the digital pencil at this moment. The potential to ‘think with the pencil’ was also mentioned in the fourth-grade focus group, where several learners said that they find it easier to concentrate when they have the pencil in their hand.

In relation to the pencil as a tool for cognition, there were also examples of the digital pencil being used as an object for unloading, or relaxing. Learners would, for instance, use the pencil to scratch the table, tap their leg, twirl their hair, or bite on – uses we recognize from analog pencil use, where the pencil also functions as a tool to unburden or relax, while thinking or taking in information. An example of this is shown in image 10.

(10)

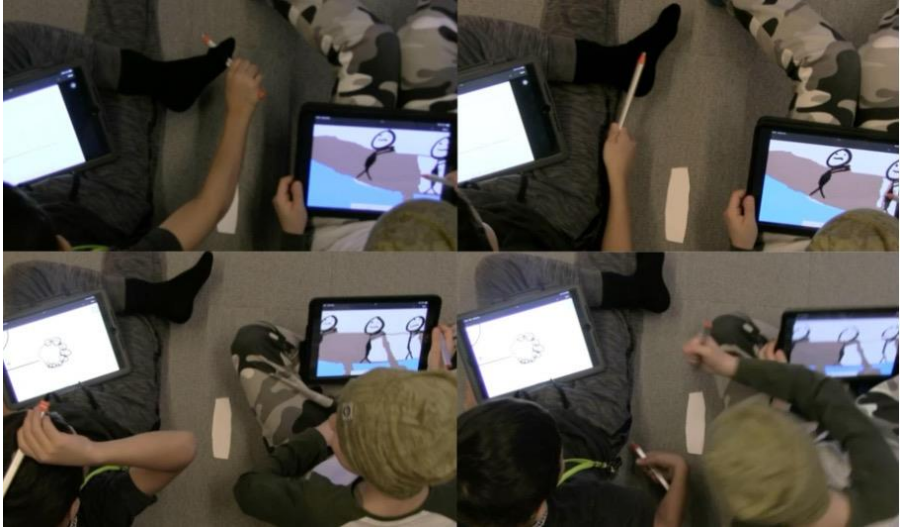


Image 10 shows four still images from a video recording of two fourth-graders working on a task. As can be seen, the digital pencil is moved from in-between the toes in the photo in the upper left corner, to being placed on the foot in the upper right corner. In the lower left corner, the pencil is placed on the learner's head. Finally, in the bottom right corner, the other learner can be seen stabbing his pencil into the carpet. Although these uses of the digital pencil as an object for unloading are not primarily literacy-oriented, we believe that they can have similar cognitive functions and be beneficial for learning in a digitalized classroom, as they pick up a potential that we recognize from analog pens and pencils (including, for instance, breaking a pencil by stabbing it into a floor, which is a more expensive habit if the pencil is digital).

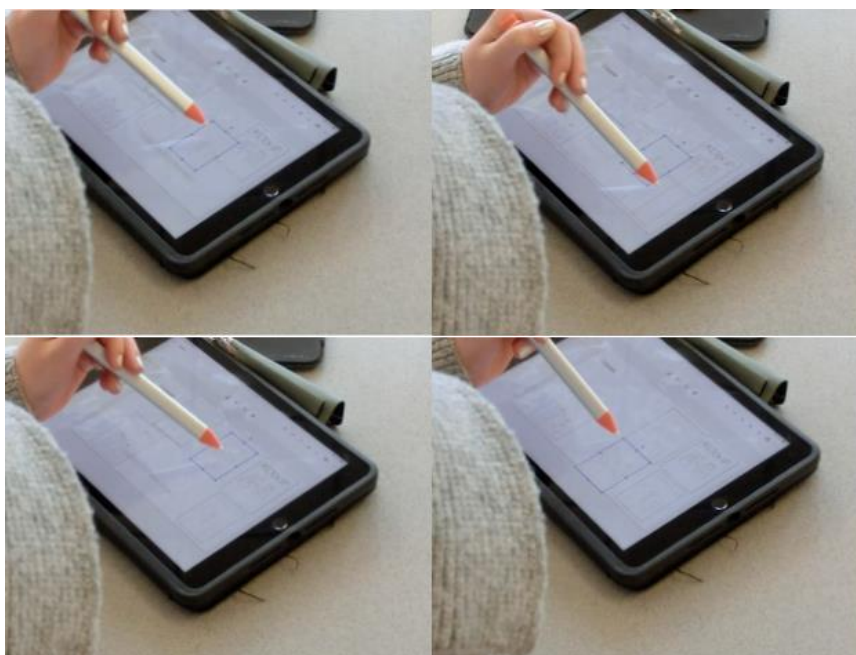
Making use of digital potentials

Although the digital pencils introduced in the two studies have similarities to analog pens and pencils, our studies demonstrate that learners also picked up 'new' or more unique potentials of digital pencils when using them in classroom practices.

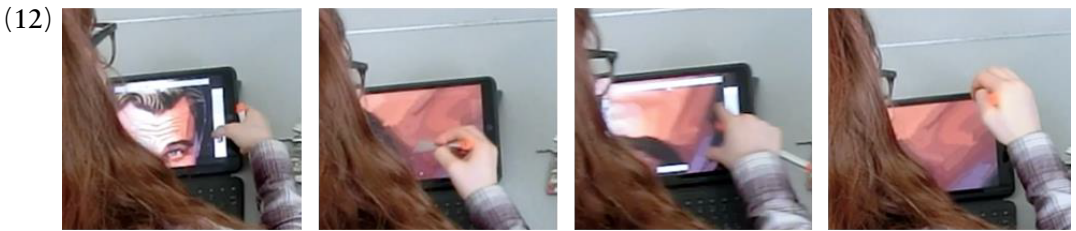
One such potential is recognizing the wider uses of the digital pencil as a multifunctional tool. In our studies, learners made use of the digital pencil as a tool for clicking on apps or pressing on functions within apps. Learners would, for instance, use it to access files and images on the iPad, to scroll or put the iPad in power saving mode, or to press the eraser when writing or drawing. This points to a wide array of functions, which go beyond the functions recognized from analog pen and pencil use.

Another example of the multifunctionality of the digital pencil that we observed was the use of the pencil to copy parts of a text or a drawing and move it to another part of the screen. This is illustrated in the series of images in 11, showing how an eighth-grade learner uses the pencil to move text boxes as part of creating a presentation in the art class.

(11)



The potential to use the digital pencil to move or change the positions of text items was also brought up in the eighth-grade focus group, where learners specifically mentioned the benefit of using the pencil to create and animate presentations, as opposed to using the finger. Another example of this extended use is the potential to use the pencil to design texts in layers. This is illustrated in the four images in 12, which show a learner working on her advertising image in the art class – in this case, re-creating and re-designing a well-known photo of the actor Leonardo DiCaprio’s face.

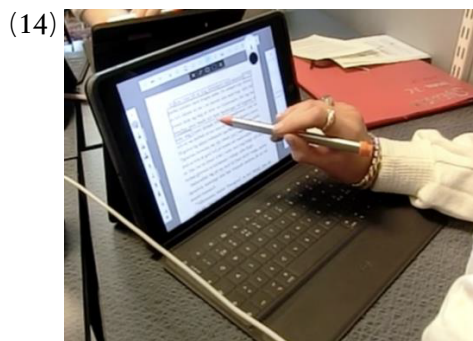
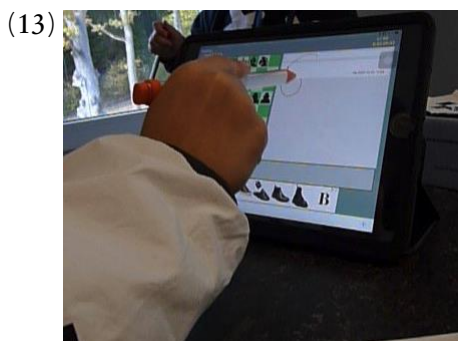


As the series of images show, the digital pencil is used as a tool for focused and detailed inscription and drawing in different layers. In this sequence, the learner switches between working on details in the image, particularly the different shades and contrasts in the actor’s face, to zoom out and shift between layers. In this way, the digital pencil was used in design practices in a way that does not primarily index uses of analog pencils but rather picks up specific affordances of the digital pencil.

As is also visible, the pencil and hand are often used together, as the learner alternates between using the fingers to zoom in and then the pencil to add details. In relation to the choice between finger or pencil, it seems that although the ongoing activity is an important factor when determining whether the pencil is considered an apt tool for the task at hand, previous actions with or without the pencil could also influence this choice. For example, if the previous action had been completed with the pencil in hand, learners tended to also use the pencil for the following action, regardless of the type of action. Similar patterns could be observed but with the finger as a tool. This

suggests that learners make coherent choices of their tool for inscription, which results in the continued use of the pencil or finger.

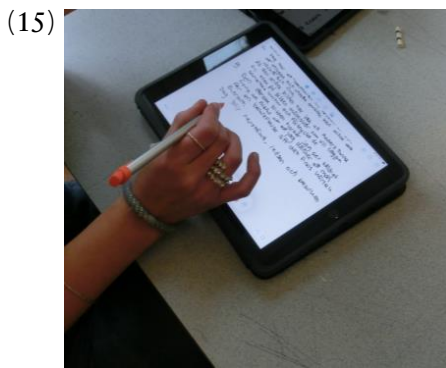
With regards to pen hold and screen position, both studies show that the digital pencil primarily afforded a high pen hold, coupled with a vertical screen position. This pen hold is more similar to the one used for stylus pens, for pressing and pointing, than to the lower pen hold that we recognize from uses of analog pencils. As for the vertical screen position, this meant that the iPad and the digital pencil rarely recontextualized the body and paper relation of an analog pen or pencil – that is, the on-desk position of the paper. This high pen hold and vertical screen position is illustrated in images 13 and 14, which feature a fourth-grade learner doing math (image 13) and an eighth-grade learner doing the blackout poetry assignment (image 14).



This way of performing the practice of writing and drawing with the digital pencil, with the specific pencil grips and spatial orientation of screens as salient features, can be understood as an indication of how learners interpret the tasks and tools that are available to them. Here, they seem not to engage with the digital pencil and iPad screen as if they were analog pen and paper; rather, the digital pencil is perceived as a ‘new’ tool that needs to be tried out in relation to the position and movements of the hand and the well-known iPad screen that is placed in the most familiar position, which is the position offered by the iPad case. In the case of the fourth-grade class, the design of the

classroom, with alternative seating arrangements, meant that the learners often ended up placing the iPad on their laps, which similarly resulted in a more vertical screen position.

Although the high pen hold and vertical screen position dominated in both studies, it is worth mentioning that there were examples of iPads being placed horizontally on the desk and of lower pen holds, which are more indicative of an analog pencil and paper use. Images 15 and 16 exemplify this pen hold and screen position, where the learners' hands can be seen resting on the screen or on the side of the iPad.



The placement of the screen and gripping of the pencil appeared to change depending on the activity, as learners would alternate how they held the pencil and placed the iPad in different tasks. Here, writing tasks seemed to promote a more horizontal position of the screen and a lower pen hold, as a majority of learners tended to place their iPads lying down during these assignments. In the eighth-grade class, one of the teachers also explicitly encouraged the learners to treat the iPad and digital pencil as their analog counterparts when writing, which could have influenced their actions. The practice of drawing did not seem to promote the same position, as overall there was more variation in the learners' choices of pen hold and screen position. Besides choices based on activity, it was also apparent that the learners' own preferences influenced how they positioned the iPad: some

learners always chose to have the iPad lying flat on the desk, regardless of the task at hand.

A final potential to consider is the possibility of using the digital pencil in more collaborative work. In both studies, learners mostly worked with individual tasks, but there were examples of the pencil being shared by two learners during a lesson, or the pencil being used on another person's screen, as demonstrated in images 17 and 18.



In the image to the left, one learner is helping another learner, and using their pencil to point to and show features within the specific software used in the art class. In the image to the right, the teacher is instructing and helping a learner, and both of them are holding their digital pencils. In this specific use, the digital pencil offers both learners and teachers a way to edit and interact with the screens of others, which can be traced back to how analog pens and pencils can be shared and used on the same sheet of paper. However, the specific potential of the digital pencil lies in the possibility to erase these edits without leaving a trace. Specifically in the subject of art, this means that the learner can retain ownership over their own work, but receive suggestions and feedback from the teacher directly onto their drawings.

Conclusions and detailed recommendations

This report has described the potentials of digital pencils as tools for writing by hand, drawing, and thinking, as well as for performing tasks other than those that are possible with analog pencils. In this final section, we provide conclusions and detailed recommendations based on our findings, aimed at teachers, teacher students, school management, and educational policymakers, as well as representatives of the hardware and software industry.

Conclusion 1: Our studies have identified a number of potentials of the digital pencils with regard to a) indexing analog practices of inscription (from the perspective of a learner), and b) recontextualizing analog practices of inscription into the digital classroom (from the perspective of the teacher/designer for learning).

Recommendation: School management and policymakers must make strategic decisions that enable the processes of indexicalization and recontextualization to take place in classrooms. In other words, policies cannot point exclusively to either digital practices or analog practices and tools. These policies should aim to create a classroom environment in which the digital pencil can function more as a general tool for not only writing but also for thinking, drawing, and exploring. A concrete example would be to include both analog and digital inscription in assignments – for instance, by taking notes with the digital pencil while working with printed material, or writing with an analog pencil while working with things on the iPad. Dichotomization of analog and digital tools should be avoided, and a combination based on aptness should be encouraged. This would provide learners with a broad repertoire of ways of learning, and allow them to make motivated choices of apt tools – digital and analog – for shaping, writing, and drawing.

Conclusion 2: Although the digital pencil shares properties with analog pens and pencils, both in terms of functions and its shape and design, shaping by hand with a digital pencil on an iPad screen is different from shaping by hand using pen and paper.

Recommendation: Teachers as well as learners must be trained in using digital pencils, including exploring the potentials and constraints of various apps on the iPad regarding compatibility with digital pencils, and in relation to subject-specific needs and practices.

Conclusion 3: The potential of the digital pencil for drawing was more commonly recognized by learners than its potential for (hand)writing. However, some of the teachers interviewed would like to explore it more as a tool for handwriting.

Recommendation: Teachers need to learn more and develop subject-specific uses of digital pencils (drawing, calculating, writing longer texts by hand) as well as more generic uses (note-taking, annotating). The lack of friction and the smoothness of the iPad screen as a surface for inscription must be taken into account if the pencil is to be used for extensive handwriting. Explicit instruction could be one way forward, especially for younger learners.

Conclusion 4: The uses of the digital pencils were restricted to the time and tasks of our field studies, and no obvious paths forward regarding uses of the pencils were identified by either teachers or learners.

Recommendation: If a school is to introduce digital pencils more broadly, strategies for integrating them in educational practices across subjects must be developed in order to secure long-term uses that go beyond the explorations of yet another ‘new’ digital tool, perceived as a ‘fun’ addition. Teachers, policymakers, researchers, and designers/representatives of the hardware and software industry must collaborate in order to identify possible ways of integrating the digital pencil in education.

Conclusion 5: Both studies identified a number of challenges with the technology, which impact the possibilities to effectively use the digital pencils in classroom settings. The practical challenges of handling the technology were more salient in grade four than in grade

eight, including remembering to keep the pencil charged and to bring it to class.

Recommendation: In terms of design, it should be possible to charge the pencil when attached to the iPad, either directly on the side of the iPad or through a cord while the pencil is still possible to use. There are digital pencils on the market that have this function, but the first generation of the Crayon does not. The battery level could also be displayed on the pencil or on the iPad. This would enable the pencil to always be there for the learner to take action with, as opposed to the pencil being left uncharged and non-functional in a locker.

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This research report presents the results from the project *Connecting digital and analog literacy: The potential of the digital pencil for text creation in schools (DigiPen)*. Digital pencils are used for writing, drawing, and pointing on tablet or laptop screens. So far, they have not been used to any larger extent in Swedish schools. Two studies of uses of digital pencils in Swedish compulsory schools are presented. One was carried out in a fourth-grade class and one in an eighth-grade class. The report describes the potentials of digital pencils as tools in schools for writing by hand, drawing, and thinking, as well as for performing tasks other than those that are possible with analog pencils. A number of detailed recommendations are presented, based on the empirical findings of the studies. The recommendations are directed toward teachers, teacher students, school management, and educational policymakers, as well as representatives of the hardware and software industry.

The authors have long experience of researching literacy practices and uses of digital tools in education. They share an interest in finding innovative ways of combining digital and analog tools for learning and meaning-making in schools. Anders Björkvall is professor of Swedish at Örebro University. Ida Melander is senior lecturer in Swedish language at the same university. Fredrik Lindstrand, finally, is professor of Media Theory in relation to Visual Arts education at the University of Arts, Crafts and Design, Stockholm.