



Nordic Journal of Digital Literacy,
volume 11, no 2-2016 p. 101–117
ISSN online: 1891-943X

DOI: 10.18261/issn.1891-943x-
2016-02-02

PEER REVIEWED ARTICLE

The potential of digital tools for enabling the observation of comprehension in the classroom

Lisbeth M Brevik

Associate Professor, Department of Teacher Education and School Research,
University of Oslo, Norway
l.m.brevik@ils.uio.no

Chris Davies

Director, Kellogg College Centre for Research into Assistive Learning,
University of Oxford, United Kingdom
chris.davies@education.ox.ac.uk

ABSTRACT

This article examines findings about the role of digital tools in supporting teachers in the challenging task of observing student comprehension in upper secondary school. These findings indicate that digital tools can provide valuable information to teachers about students' uses of comprehension strategies, as well as enabling the students to demonstrate or reflect on their own uses of these strategies. Based on interviews, narratives, and observations in four classrooms, these findings suggest that digital tools potentially afford rich information about student processes of learning, in the course of being used for a variety of specific pedagogical purposes in the classroom.

Keywords

Digital Tools, Classroom Observation, Comprehension, Strategies, Upper Secondary School

INTRODUCTION

The focus for this paper emerged from an investigation into ways in which student comprehension may be observed in the classroom – a finding that was not anticipated or sought in the initial design of the study. It became increasingly evident, though, during the process of analysing the cases where digital tools had formed part of lesson activities, that they also helped the teacher to observe and make sense of students' use of comprehension strategies, as well as enabling the students to demonstrate or reflect their own uses of these strategies. In this paper, we submit this emergent finding to closer examination, in order to identify any characteristics of the various digital tools used in four upper secondary school classes that might offer the specific (and perhaps incidental)


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benefit of gaining access to abstract or hard-to-observe aspects of student cognitive processes such as comprehension. Given the unanticipated and non-systematic nature of this topic's emergence, any conclusions are necessarily tentative, but nonetheless point to what will potentially constitute a fruitful hypothesis for further research.

The context of the study

The focus of assessment guidelines has shifted over the past decade (e.g. Norwegian Ministry of Education and Research [KD], 2009), highlighting the responsibility that teachers must elicit and interpret evidence of what their students comprehend, and use this evidence to identify students' future learning needs and make decisions about instruction (e.g. Black & Wiliam, 1998, 2009). Although these guidelines do not require the use of digital tools in observing student comprehension, studies suggest that such tools are used in classroom practices and assessment processes (e.g. Blikstad-Balas, 2012; Blikstad-Balas & Hvistendahl, 2013), as well as in self-assessment practices where students use them to reflect on their comprehension processes (Kirk & Pitches, 2013).

A core challenge of observing student comprehension in the classroom is the inescapable fact that comprehension is unobservable. When we observe a student looking at a text with an expression of concentration, we assume this is reading. However, we cannot know through observation only whether the student understands the letters on the page or screen and, if so, whether this signifies comprehension. If it does, we must ask: comprehension of what?

In Norway, abstract concepts, such as skills, strategies, and comprehension, are explicitly stated in the Education Act (KD, 2011) and the National Curriculum (Norwegian Directorate for Education and Training, 2013). Teachers must stimulate students and offer opportunities to develop their comprehension; in addition, they must give feedback on mastery and provide suggestions for further development. The question then arises of how teachers are expected to know what their students comprehend. Some teachers may say they can "see" whether their students have understood a task. Others may talk about their search for "evidence" of student learning, for example, by eliciting student thinking during instruction (Grossman, Hammerness & McDonald, 2009). However, we must acknowledge the difference between what we observe and how we interpret our observations. Grossman et al. (2009) stated that "teaching is complex work that looks deceptively simple" (p. 273). It is timely to discuss these issues that continue to pose challenges for researchers and teachers alike, when trying to determine what students comprehend.

Consequently, researchers and teachers must understand what characterises an abstract concept like comprehension, and how it is manifested as an observable behaviour or utterance; in other words, they must know what comprehension looks like in a classroom. Because of the complexity and challenges uncovered

by these studies, it is tempting to suggest that the abstract and invisible (e.g., student comprehension, concepts in a book, and classroom learning) should be made concrete and visible (e.g., in the form of students, books, and classrooms). It is not easy to draw distinctions between these items even though the abstract/concrete notion is fundamental in literacy research. Abstraction in this paper refers to invisible, unobservable concepts at one extreme of a continuum, while concrete describes the other extreme. In particular, it appears possible – on the basis of the evidence of the cases reported in the present paper – that digital tools used in the classroom might be seen as possessing certain properties that render them as particularly effective in filling the space between abstract and concrete manifestations of cognitive activity such as comprehension. Digital tools have transformed the subject matter and ways of communication (Blikstad-Balas, 2012; Säljö, 2010; Schofield, 2014); as a result, students meet multimodal hypertexts, enabling them to read in various ways and communicate across time and space (Lund, Furberg, Bakken, & Engelen, 2014; Lund & Rasmussen, 2008). These new modes of reading require students to use reading strategies in new ways, or to develop new strategies (Brevik, 2015; Frønes, Narvhus, & Aasebø, 2013; Roe, 2014). Similarly, using word processing tools has changed text writing from a linear process into a cyclical one, in which the student's comprehension might manifest itself through writing, rewriting, and revising – or, perhaps, in taking shortcuts by reproducing information from accessible sources (Blikstad-Balas & Hvistendahl, 2013). As teachers grow more confident in their use of these digital tools in their work with students, and as these uses become more integrated and normalised within classroom practice, so the wider implications and benefits of their use become more evident. The research presented in the following sections provides one aspect of this.

The scope of the article

As indicated in the Introduction, this paper focuses on four cases chosen out of eight studied for this research, in which digital tools of various kinds were utilised in the course of the lesson observed to support the intended learning. In order to develop the focus of this paper, as outlined above, we shall consider the classroom affordances (Gibson, 1979) of these tools in each case, as a basis for considering ways in which they may have contributed to the observation or communication of students' comprehension strategies. This study addresses this issue by asking: *In what ways might affordances of digital tools enable teacher observation of students' comprehension strategies in the classroom?*

Here we refer to affordances associated with very many classroom uses of digital tools: the display on screens of content for discussion and study; certain operations carried out by both teacher and students with respect to that content, such as notes, observations, and interpretations; new content created by students, feedback from the teacher in relation to these, and interaction between teachers and students in front of screens (see Davies & Birmingham, 2002; Davies & Eynon, 2013; Birmingham, Davies, & Grieffenhagen, 2002).

Such encounters and interactions, via screens of various kinds, enable some degree of visualisation of ongoing processes of comprehension, interpretation, evaluation, speculation and reflection as modelled by the teacher, or as carried out collectively or individually. Whilst the display of lesson content has long formed part of classroom activities in earlier eras, through pre-digital tools such as blackboards, overhead projectors, and non-electronic whiteboards, digital tools enable the teacher to move beyond a convenient or attractive enhancement of previous resources in enabling dialogue between students, and between students and teacher, as well as participation in meaning making processes within the classroom. The field of computer-supported collaborative learning (CSCL) has been particularly influential in developing such understandings of the role of digital tools in classrooms, for instance, in the work of Scardamalia and Bereiter (1994), Crook (1994), and Lehtinen (2003). The latter pointed out that:

ICT has played an important role in many attempts to create powerful learning environments for supporting higher order learning and the development of metacognition and self-regulation. (Lehtinen, 2003, p. 52)

Discussions of this kind are primarily concerned with the ways in which new technologies propagate the creation and sharing of new knowledge in the classroom, especially through collaborative activities, and do not appear to address ways in which digital tools afford insights to the teacher about the students' hard-to-observe cognitive processes, such as their decisions about comprehension strategies. This paper, therefore, aims to do just that in relation to four classes in which quite regular classroom uses of digital tools formed part of the activities of the lesson.

THEORETICAL PERSPECTIVES

The article is informed by socio-cultural thinking on the importance of tools and social interaction in learning (e.g. Daniels, 2005, 2008; Vygotsky, 1986) with the use of digital tools to observe comprehension. Transparency in the nature and purposes of digital tools in the classroom would therefore seem a worthwhile aim. Since learners are not passive receivers of information (Daniels, 2005; Derry, 2008; Duke, Pearson, Strachan, & Billman, 2011), they actively engage with the activities, making personal connections between the task and other topics within and beyond the classroom while using digital tools in this engagement. Thus, building on the Vygotskian notion of the active, sense-making learner (Vygotsky, 1981), Claxton (2007) pointed out the importance of developing metacognitive awareness in learners to foster conscious and active learning. Building on his argument, we suggest a need to include instructional attention to the purposes of using digital tools in the lives of upper secondary students to help teachers see how they gain information about their students' comprehension by using such tools in the classroom. We link Claxton's (2007) argument to the notion that abstract concepts (e.g., metacognitive awareness of comprehension) share some closely related characteristics.

Based on the theories of Popper (1975), Cartwright (2012), and Hanson (1958), we build our argument on three shared characteristics of vital importance to researchers or teachers who intend to observe the abstract concept of comprehension in the classroom: (1) abstract concepts can be observed only indirectly, (2) any observation can be a realisation of multiple abstract concepts, and (3) all observations are theory laden, building on our prior knowledge and world view.

Indirect observation

Indirect observation poses complex challenges for researchers and teachers alike. Popper (1975) distinguished between observation and theory, separating the empirical from the non-empirical, and argued that observations “are always *interpretations* of the facts observed” (original emphasis; Popper, 1975, p. 107). For example, when a teacher asks a question, the direct observation is the students’ responses. The indirect observation is related to whether these responses signify something more abstract, like comprehension. Acknowledging the difference between direct and indirect observations is relevant, considering the challenging tasks of observing, interpreting, and validating student responses (Creswell, 2013).

Multiple abstract concepts

A related challenge is that *any observation can be a realisation of multiple abstract concepts*. For example, two students’ giving the same answer might indicate that both have understood the task. However, this answer might be a manifestation of comprehension for one student, but a simple guess for the other. This difference aligns with Cartwright’s (2012) argument that a change from one abstract state of mind (e.g. lack of comprehension) to another (e.g. comprehension) may not lead to a change in the observed action (e.g. a correct answer).

Since any observation can be a realisation of multiple abstract concepts, it is necessary to interpret to what extent an observed action or response indicates comprehension. In line with Cartwright (2012), we argue that observing students’ comprehension is more difficult than we might believe, especially if we fail to recognise that our observations might not mean what we believe they mean on a more abstract level.

Theory laden observation

This leads to a third challenge, namely that *all scientific observation is theory laden* (Hanson, 1958). Several persons may observe the same action and see different things, indicating that “seeing is an experience” (Hanson, 1958, p. 6).

In education, Miller and Zhou (2007) identified such differences in observation among student teachers in China and the United States, who systematically noticed different things when watching the same classroom videos. This

difference reminds us that observation is never neutral, and depends on context and experience. Similarly, Grossman et al. (2010) found that teachers’ awareness of what they did during lessons differed from researchers’ observations of the same lessons. In other words, saying that two persons see the same thing because they observe the same action or phenomenon is what Hanson (1958) described as an elementary mistake.

METHODS

This study was designed around methodological triangulation with a multiple methods design (Creswell, 2013) involving data collected through classroom observations, teacher narratives, and student interviews. The first author was a participating researcher during each observed lesson and took field notes (Creswell, 2013). Immediately after each lesson, the teacher wrote a description of the lesson (written teacher narrative), while the first author conducted audio-recorded group interviews with all the students in the class.

Participants

In 2011, 21 teachers participated in a teacher professional development (TPD) course facilitated by the first author that addressed reading comprehension in upper secondary school (Brevik, 2014). Six months later, she asked the teachers if they would allow her into their classrooms to observe a lesson concerning reading. Of the 20 positive responses, eight were chosen for classroom observation one year after the TPD course (Brevik, 2015). We have included four of these in this article (Table 1).

Aiming for both student and teacher perspectives, all the students (aged 16–17 years) present in the observed lessons were invited to participate. All consented and are the student participants in this article. The observations took place at three rural schools, in four English classes in Years 11 and 12, in general and vocational programmes.

TABLE 1. OVERVIEW OF THE SCHOOLS, THE CLASSROOMS, SCHOOL YEAR, AND STUDY PROGRAMME

| Classroom observation | | | | Participants | |
|-----------------------|--------------|-------------|-----------------|-----------------------|----------|
| School | Case (class) | School year | Study programme | Teachers (pseudonyms) | Students |
| A | 1 | 11 | General | Magne | 9 |
| B | 2 | 11 | Vocational | Petter | 9 |
| D | 3 | 12 | General | Ruth | 19 |
| D | 4 | 12 | Vocational | Andreas | 7 |
| Total | | | | | 44 |

Data collection

Being present in the observed lesson, the first author took structured *field notes* in a template (see Appendix A), including activity descriptions and teacher and student responses as direct quotations. The teacher used the same template to write a *narrative* immediately after the classroom observation. This provided records from the teacher's perspective on the observed lesson (Table 2).

TABLE 2. PRIMARY AND ADDITIONAL DATA

| Data collected during classroom observation | |
|---|--|
| Field notes | The researcher's field notes from each observed lesson using a template (see Appendix A) for structured observation. |
| Data collected post classroom observation | |
| Written teacher narratives | Four teacher narratives written on the template, one from each teacher, describing the observed English lesson immediately following the lesson. |
| Student group interviews | Four semi-structured, audio-recorded, and transcribed group interviews with 44 students, ranging in size from 7–19 (see Table 1), immediately after each observed lesson. The template served as the interview guide. The average interview length was 18 minutes. |

Talking to the students methodologically validates the observations by member-checking (Creswell, 2013). To elicit the students' views on their comprehension processes, the first author conducted *group interviews* immediately after the observed lessons (Creswell, 2013). She used the template as an interview guide, covering them in any order (Brevik, 2014, 2015).

Data analysis

We analysed the data in three steps involving readings of: (1) the field notes, (2) the narratives, and (3) the transcribed interviews (Table 3).

TABLE 3. STEPS OF ANALYSIS.

| Readings | Aim | Tools of analysis | Research question |
|----------------------------------|---|--|--|
| 1st step (field notes) | To identify the researcher's observations of student comprehension. | Students' actions or utterances in the classroom indicate comprehension. Digital tools are used as resources in the comprehension process. | In what ways might affordances of digital tools enable teacher observation of students' comprehension strategies in the classroom? |
| 2nd step (narratives) | To identify the teachers' observations of student comprehension. | Teachers' explicit descriptions of student comprehension based on actions or utterances in the classroom. | |
| 3rd step (student interviews) | To identify the students' metacognitive awareness of their own comprehension. | Students' explicit descriptions of their own comprehension. | |

Table 3 shows the three steps of analysis used to identify how student comprehension was observed in each of the classrooms from three perspectives: the researcher's, the teacher's, and the students'. First, the field notes were used to identify instances where the students' actions or utterances had indicated comprehension processes, and searched for evidence of digital tools being used as resources in the comprehension process. Second, each teacher's narrative was used to identify explicit descriptions of how they had observed their students' comprehension. Third, the transcribed interviews were used to identify student utterances commenting on their own comprehension.

Validity, reliability, and ethics

A number of steps were taken to assure the validity and reliability of the data (Creswell, 2013). First, since self-reported data might reflect intentions rather than practices, the narratives and the interviews were triangulated with the field notes. Second, talking to the students validated the classroom observations by member-checking, where the students commented on the first author's immediate analysis. Third, the template served as a methodological tool across all data collection situations; using the same template with the same headings made the comparison across the narratives, interviews, and observations more reliable.

FINDINGS

Two patterns emerged across the classrooms. First, the teachers frequently asked the students to express their comprehension in the lessons, and digital tools were part of the process; the use of online word-cloud software (Case 1), digital searches for information (Case 2), word processing software in order to write summaries (Case 3), and digital co-production of text (Case 4). Second, while the classroom observations, the teachers' observations as expressed in their narratives, and the students' information in the interviews overlapped, the students provided vital details on their own comprehension that were not captured in the classroom. The main difference between the classrooms was not whether digital tools were used as resources, but whether the observations concerned student comprehension.

Case 1 – Mundane use of digital tools enhancing comprehension

In Magne's English lesson in general studies, he interpreted several group discussions as manifestations of his students' lack of comprehension. The teaching sequence was designed around a multimodal text he had prepared. To illustrate the American author Ernest Hemingway, he had used a Wikipedia text and deleted all references to the author's name, before using the text to create a word cloud¹. In the word cloud, the most frequent words in the text were

1. See www.wordle.net

visualised as the largest ones. The students were asked to search for clues in the word cloud and draw inferences about who the American author might be. We observed the following discourse in one of the groups:

Student M1: It says that he is American.

Student M2: It's a guy. He's tall. Definitely hair. Maybe facial hair.

Magne: It's a difficult task. I don't know what you know about American authors. Anyone who want to guess who this is? Ernest...

Student M3: Hemingway!

The question is what is this observation a manifestation of: comprehension or lack of comprehension? Based on the observations alone, it was impossible to determine whether the teacher elicited student understanding or if the students used his hints to make a guess. In his narrative after the lesson, Magne indicated how he had interpreted this sequence to indicate lack of comprehension:

No group managed to guess the correct author based on the word cloud, but the most important [thing] here was that they worked with words that were related to Hemingway, and when they learn the name, they will unconsciously link many of these words to his name.

In the following interview, the students revealed comprehension. First, student M1 said: "Like the word cloud. I just learned a lot of words about the author". Student M3 elaborated, saying that using the word cloud had activated his prior knowledge, and enabled him to recognise the author in question as Hemingway. He explained how he had first associated the word cloud with the Norwegian author Hamsun, which reminded him that he had once compared Hamsun and Hemingway, and had found the authors and their texts to share several characteristics. This, he revealed, made him realise that the American author illustrated in the word cloud might be Hemingway. Interestingly, while Magne interpreted his students' answers as lack of comprehension, this particular student expressed that the process of reading and reflecting on the word cloud had made him search for clues and make inferences that led to comprehension.

The contribution of digital tools in this case relates to the students' own processes of comprehension rather than to the teacher's observation of those processes: digital tools were not utilised in ways that displayed the students' thinking. Nonetheless, this quite mundane and low-key use of such tools appeared to play a significant role in the process of providing both an individual and a collective experience of comprehension.

Case 2 – Observing comprehension of digital texts

In his English lesson in vocational studies, Petter observed his students' active digital searches for information and subsequent recall of facts as comprehension of multiple texts. He asked them to search for information on three topics each about the USA, before presenting these in class. The aim of the activity was to enable the students to choose one of the topics for an oral presentation in a later lesson.

During the lesson, the students presented a broad spectrum of information from American cars to the US election process. Although the intellectual challenge was restricted to rote learning by reproduction of facts, they also analysed multiple digital sources to identify relevant information. In his narrative, Petter observed three aspects of his students' comprehension: their use of English, their active participation, and their ability to choose a topic:

[It was a] positive experience to see that students who are reluctant to speak English participated. The lesson had high learning pressure, which contributed to the students working efficiently and concentrating. At the end of the lesson, everyone had chosen a topic for their oral presentation.

In the subsequent interview, the students reflected on their comprehension process, echoing several aspects of their teacher's observation. They acknowledged that the open task of searching for information in English on the Internet was easy. One of the boys revealed that he actually preferred English: "I just find English easier for me to read. I actually know many more words in English than in Norwegian ... even though I'm from Norway", while another boy explained that he read English digital texts on a daily basis: "I read the text in anime. [...] It is an animation style they use in Japan. [...] They have English subtitles".

The combination of perspectives in this case points to what the observer sees: while Petter observed their active participation as manifestation of comprehension, the students' explanation that the digital aspect of reading in English had promoted their comprehension offered additional information about what the observations indicated.

Case 3 – Observing digital text production

In Ruth's English lesson in general studies, she observed and pondered a lack of engagement among her students. At home, the students had used a word processing program to produce individual summaries of a text about the environmental policy of the USA. In the lesson, Ruth asked her students to read their summaries aloud, using the summaries as manifestations of comprehension. She responded to each summary, stating the importance of using their own words: "This is a good summary because you have used your own words to sum up the content of the text", and "You have summed up the same text in other words. Thank you". Afterwards, in her narrative, she focused on the

length of the original text and the teaching sequence, suggesting that it had probably lasted too long for her students:

A long and (for some) demanding text. The listening part was too long. It should have been cut shorter as we lost some of the listeners [students] towards the end.

However, in the following interview, no students mentioned the sequence being too long. Instead, they revealed satisfaction at understanding how to write summaries: “You go through the text once more and write it in your own words so that you understand it”. They also expressed the benefit of summarising a text: “We grasp the content”. This lesson involved a digital tool first for text production outside the classroom and then, crucially, as a screen for reading their texts aloud to one another in class. In contrast to the students in Petter’s class, none of these students mentioned the computer as a digital resource in their comprehension process. Their responses implied that using word processing to write, rewrite, and revise their summaries was their standard approach to writing.

Case 4 – Observing student reflection through digital co-production of text

In Andreas’s English classroom in vocational studies, he was able to observe how his students understood a technical drawing of a tractor shovel. He asked the students to interpret the drawing together, to formulate an oral description of what to do in which order, and then to co-produce an installation instruction on the classroom computer, which projected the text on the wall. During this interactive process, Andreas observed his students’ collective comprehension of the drawing, reflecting, discussing, and formulating their comprehension.

Throughout the learning sequence, Andreas guided his students in their comprehension process, asking questions like, “Can you see what that is?” and “What is the first thing we need to do?” He encouraged the students to build on what other students said, and asked follow-up questions without introducing anything new. Each time they had formulated a new step, a student wrote the step on the computer. Throughout the lesson, the discourse moved from interpreting the drawing and discussing details to looking at what they had already written, orally formulating a new step, and writing their instruction. In his narrative, Andreas commented on the students’ search for clues in the drawing, and noted how each student, through helping each other understand the installation process, enabled the entire class to create a set of instructions as a collaborative product to be used in the workshop the next day.

In the following interview, the students expressed similar reflections on their comprehension process; specifically, they noted that reading the technical drawing together and co-producing an installation instruction was useful both in the workshop and at their workplaces.

Summary: The role of digital tools

Each of these four cases involved a different use of digital tools of one kind or another, using Internet-based resources and computer software in various ways, but all with certain key aspects of how digital tools are characteristically used in classrooms to support student learning and comprehension. In each case, it is possible to identify ways in which the tools used – either peripherally or centrally – contributed both to fostering processes of comprehension and to making these processes visible to the teacher and, to some extent, to the students themselves.

In Case 1, Magne's choice of the simple and popular classroom device of the online word-cloud software transformed the somewhat uninviting nature of Wikipedia texts into something that was immediately vivid and accessible to the whole class, effectively engaging them in a process of collective comprehension. As a pedagogical tool, this appeared to be effective, and to some extent it proved effective also in providing a shared point of reference by which the students were able to articulate their developing comprehension of the topic to the teacher.

In a similar way, Case 2 shows how the teacher, Petter, skilfully utilised a digital tool by having his students carry out active digital searches for information they were then to present to the class orally. Again, the role of the digital tool might be seen as quite minor here, given that the information collected was subsequently shared orally, but interviews with students indicated that some at least felt their opportunity to carry out their own Internet explorations was liberating and stimulating and, as far as the teacher was concerned, generally encouraged and demonstrated the use of active comprehension strategies.

The third case reports the use of word processing software in order to write summaries of a demanding text at home which Ruth, the teacher, was able to draw on subsequently in class by reflecting on the work of individuals in order to review and validate processes of comprehension collectively. The effectiveness of how the use of this digital tool had previously engaged student thinking and comprehension on an individual basis, and was then augmented collectively, attests to the way in which the ostensible purpose of using a particular tool (e.g. word processing) can be matched by the incidental benefit that might follow from that (the display of individual and collective comprehension strategies).

This is most strongly evident in the fourth case, in which the teacher, Andreas, had his students co-produce technical instruction on the classroom computer which he was then able to project in front of the whole class. As a result, he was able to observe a process of collective comprehension taking place, involving a cycle of reflection, discussion, and formulation of understanding. Thus, the use of digital tools in Case 4 enabled active processes of comprehension by individuals and groups in the first instance, resulting in the co-construction of understanding within the class as a whole that the teacher was able to observe in process.

DISCUSSION

Initially, this article posed the question: *In what ways might affordances of digital tools enable teacher observation of students' comprehension strategies in the classroom?* Our main argument is that the researcher's or the teacher's observation of student comprehension alone is not enough. The analyses of the classroom observations, teacher narratives, and student interviews suggest that the key to observation of student comprehension lies in the integration of the students' active engagement and reflections (Daniels, 2005, 2008; Derry, 2008; Duke et al., 2011; Vygotsky, 1981, 1986), made visible partly by using digital tools in the classroom (Davies & Eynon, 2013). Some challenges highlighted by these findings are discussed below.

Although the teachers and the students in these classrooms often agreed on what the observed responses indicated, the students' reflections offered relevant nuances about their comprehension process, in line with Brevik's (2015) argument in a previous study. In the first three cases, the group interviews alone revealed these reflections, while they were also included in the lesson in the last case. If we address the contradiction between the teacher's observation and the students' perspectives, it becomes apparent that having information about their students' reflections on their comprehension would have changed the teachers' interpretations of their observations.

In the above cases, the teachers' observations of their students' responses seemed to be realisations of multiple abstract concepts (Cartwright, 2012), such as comprehension or lack of comprehension. Comparing the teacher's interpretations with the students' reflections indicated the difference between these explanations could be observed only indirectly (Popper, 1975), and that the teachers' observations were theory laden in that prior knowledge of their students as learners influenced the teachers' interpretations (Hanson, 1958).

First, using Andreas's lesson in Case 4 as a model requires conscious planning as his entire lesson was designed around the use of digital tools as resources during the comprehension process, in line with arguments by Davies and Eynon (2013). In addition, Andreas's engagement of all his students in reflections of their comprehension resembles Grossman et al.'s (2009) notion of eliciting student thinking, which differs from observing their answers to a question requiring recall of facts.

Second, considering how to capture student reflection after the lessons, we might build on the group interviews, which were effective observational arenas where students reflected on their comprehension. It should come as no surprise that students are able to reflect metacognitively on their own comprehension process (Brevik, 2015). Asking the students to do the same on their own, for example, by using their mobile phones to audio record their reflections at home, is manageable, particularly if they are asked to make a one-minute recording and submit this to their teacher. This could be a rewarding way of integrating the available digital tools when eliciting students' self-assessment

of their own comprehension. We argue that including the student's view is vital in order to assess whether their students have comprehended the task at hand (Brevik, 2015; Davies & Eynon, 2013).

CONCLUDING REMARKS

Whilst it would be rash to argue on the basis of the small number of cases reported here that digital tools are in all circumstances effective in enabling students to reveal their comprehension strategies, or supporting the teacher's observation of these, it appears that they did indeed contribute usefully in the quite varied cases reported. We suggest that the incidental nature of this finding points us to certain ways in which digital tools offer potentially valuable general benefits to teachers and learners alike, beyond the specific pedagogical or curriculum purpose which they are intended to fulfil. It appears that the engaging and markedly visual nature of screen-based technologies has the potential to make learning *content* and student engagement with that content visible and accessible, as well as constituting powerful means for making *processes* of learning more visible to teachers and learners alike. On the basis of the research reported here, we therefore hypothesise that such visualisation of content and its exploration in the classes is capable of rendering crucial but largely abstract processes of cognition more accessible than otherwise. In order to test that hypothesis, we suggest that valuable understandings about the wider benefits of using digital tools in the classroom might emerge through extended case studies of the kind reported in this paper. We believe that further research of this kind would be valuable in assessing the extent to which teachers are able to access information about their students' processes of comprehending and analysing lesson content through drawing on the wider affordances of classroom technologies.

APPENDIX A

Template: Teacher narrative form used to describe a best practice reading instruction. The teachers could use or cross out any of the headings (Brevik, 2014).

| |
|--|
| <p>Subject & year:</p> <p>Comprehension strategies:</p> |
| <p>School:</p> <p>Teacher:</p> <p>Topic:</p> <p>Duration:</p> |
| <p><i>Learning aim</i></p> <p><i>Preparations</i></p> <p><i>Instruction</i></p> |
| <p>Before reading:</p> <p>During reading:</p> <p>After reading:</p> |
| <p>Didactic reflection</p> |

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