UTILIZING THE AFFORDANCES OF DIGITAL LEARNING MATERIALS

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Abstract

Due to the all-pervasive digital transformation of education, learning materials have developed considerably in terms of their form, function and content over recent decades. This development from print-based to digital formats carries with it a corresponding transformation of materiality that may not be apparent, yet plays an important role in shaping contemporary learning environments. Obviously, this transformation is of relevance for the design of learning materials and has implications for how we assess and study digital learning materials. However, the process of designing learning materials with a view to utilizing the many possibilities of contemporary digital technologies is no trivial task. Consequently, a focal point in the study of learning materials must concern the utilization of these new possibilities. For that purpose, we develop a framework for analyzing digital learning materials based on the notion of affordance. We use this framework to study how six courses from a widely used digital form of Danish L1 learning material integrate different kinds of affordances into their learning designs. Based on the results of our analysis, we also discuss the implications of this material transformation.

Keywords: digital learning materials, affordances, digitization, digital transformation, learning environments, materiality

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1. INTRODUCTION

Since the sixteenth century, learning materials in the form of textbooks have been the dominant medium in formal European education (Sammler, 2018). This, however, has changed dramatically over the last few decades due to the all-pervasive digital transformation of education. As in all other school subjects, this development has led to an extensive integration of digital technologies in the teaching of Danish L1. The tendency has been a threefold focus on digital technologies either used as *practical aids* (digital dictionaries, encyclopedias, access to media content etc.), or in the form of *content* (basic ICT skills, critical thinking in relation to social media etc.), or as a *means* of developing new modes of learning through digital production (digital film production, digital presentations, computer programing etc.). Consequently, digital learning materials have developed considerably in terms of their form and function, serving in connection with all kinds of activities from individual repetition and memorization to new types of complex and collective learning activities (Gee, 2003).

In addition, the transformation of learning materials from print-based to digital formats carries with it a corresponding transformation that is less apparent, yet very important: the transformation of the materiality of the learning environment caused by substituting digital devices for books, blackboards and paper and pencils. This transformation provides not only new affordances, but also new restrictions on teaching and learning activities (Hutchby, 2001; Kolbeck & Röhl, 2018). For instance, digital technologies shape our modes of meaning making (The New London Group, 1996; Cope & Kalantzis, 2009), frame learning and teaching activities (Lye & Koh, 2014), and make it more feasible for users to communicate and access information regardless of time and space. In other words, teachers and students are no longer constrained by school walls (Edwards-Groves, 2011; Knight, 2015).

Obviously, these transformations are of great relevance for the design of learning materials and have direct implications for how we assess and study digital learning materials. However, the process of transforming learning materials in a way that intelligently utilizes the many affordances of contemporary digital technologies is no trivial task. Consequently, a focal point in the study of learning materials must concern the utilization of these new possibilities.

The purpose of this study is to examine how the digital transformation of education affects learning materials. As a point of reference, we examine six courses from a digital learning material designed to be used in the Danish lower secondary school (for a more thorough description of the Danish educational system, see Rasmussen & Werler, 2015). To examine these courses, we make use of the notion of affordance (Gibson, 1979; Hutchby, 2001; Norman, 2013) in order to develop a tentative framework for analyzing and understanding how digitization affects different dimensions of learning materials. The present article is divided into five main sections. First, we outline on the methodological underpinnings of the study as well as defining and contextualizing our research object. Second, we present a brief review of research

literature dealing with the digitization of learning environments in the L1 subject in order to frame the present study within the research field. Next, we develop our theoretical framework, elaborating on the notion of affordance and relating it to the structure of observed learning outcome (SOLO) model (Biggs & Tang, 2011). Based on our theoretical framework, we then analyze the learning designs of the six courses in order to examine how the learning material integrates and utilizes different types of affordances. Finally, in light of the analysis, we discuss the implications of the digital transformation of learning materials with a special view to the relation between materiality and learning activities as well as to how the material transformation challenges the teacher's role as a designer of learning activities.

2. RESEARCH OBJECT AND METHOD

2.1 Case and context

The present study is a case study (Yin, 1994) in the sense that we examine in detail six related Danish L1 courses that illustrate an emerging class of digital learning materials which we will call *digital learning portals* (DLPs). We define DLPs in relation to five distinct features:

1) A DLP is didactic in nature (see also Fougt, Bremholm & Buch, 2020). In other words, it consists of different learning designs.
2) A DLP includes a wide range of different online courses that are ready for the teacher to use, and together the courses aim to meet all aims of the National Curriculum of the Danish L1 subject.
3) The courses and content of a DLP are designed by different authors, but the courses are published on the same platform by only one publisher.
4) The courses on a DLP are coherent and consist of both individual and collective group or class activities. Consequently, most courses require facilitation and scaffolding by the teacher.
5) A DLP provides not only courses, but also digital tools which can be used by teachers for the purpose of planning.

Our choice of research object is motivated by the fact that in recent years DLPs have become predominant in Danish primary and lower secondary school—so they are now an important part of most students' everyday learning environment. This rapid digital transformation is mainly due to an agreement in 2011 under which the Danish government and Local Government Denmark, which is an interest organization representing the Danish municipalities, agreed to allocate substantial funding to primary and lower secondary school in order to strengthen the use of ICT in the classroom (The Danish Government, Danish Regions & Local Government Denmark, 2011). Consequently, schools have invested heavily in digital technologies, including DLPs; and as shown by Bundsgaard, Buch & Fougt (2020), this development is also evident in the Danish L1 subject. Particularly in lower secondary school there is a

tendency to use digital learning materials more frequently than paper-based materials. The choice of courses is further motivated in section 5.

2.2 Online research

Although this is not an ethnographic study, our method of data collection resembles in many ways that of virtual ethnography, and we have conducted our data collection along lines which are commonly used in contemporary ethnographic approaches to online research (Hine, 2015; Caliandro, 2018; Light, Burgess & Duguay, 2018). In practice, this meant going through the different parts of the six courses meticulously and documenting them through screenshots and field notes. In the data collection process, we focused mainly on describing content, features and affordances as well as following hyperlinks and trying out interactive components of the learning design.

In one important respect, however, our data collection process did not resemble that of virtual ethnography. As described by Light, Burgess & Duguay (2018), the exploration of software applications often involves immersing oneself in their everyday uses. We did not do this since the everyday use of DLPs unfolds in school contexts involving teachers and students engaging with and through DLPs. Nor did we look at how students and teachers engage with the DLP in practice. Doing these two things would have meant conducting a radically different investigation. Instead, we have approached the six courses from a document analysis perspective (Bowen, 2009) in order to describe and understand the limitations and potentials of DLPs as learning environments.

2.3 Analytical approach

In order to analyze the six courses, we outline a theoretical framework for studying digital learning materials by relating an elaborated notion of affordance to the SOLO taxonomy. We introduce a distinction between *physical*, *virtual*, and *social* affordances in order to show how the digital learning material provides ways of interaction. On this basis, we describe a range of concrete opportunities for students to interact with and through the DLP, and we use the SOLO taxonomy to assess the extent to which the students are provided with meaningful learning opportunities.

Within each affordance category, we identify a number of ways to interact with the DLP, e.g. moving the mouse (physical) or scrolling (virtual). These subcategories are data driven in the sense that they were generated as a result of going through the six courses as described above. We use these subcategories in combination with the affordance categories to show how students are invited to interact with the DLP. Since the categories are data driven, they reflect what is possible within DLPs. Just as importantly, however, they also provide us with important information regarding ways of interacting with the DLP that are not possible. We describe the framework in more detail in Section 4.

3. LITERATURE REVIEW

As suggested in a comprehensive review of Scandinavian research on technology in the L1 subject, technology is currently altering the form, content and actions made possible within the subject in many ways (Elf et al., 2015, p. 36). These major changes are reflected in the growing and increasingly varied field of research aimed at exploring different aspects of digital learning environments in L1. However, although some aspects have been studied to a great extent, there are relatively few studies that adopt an affordance-centered approach to studies of educational technology. In the following, we point to the dominating tendencies in order to position the present study within the research field.

There are currently two major tendencies within this field. The first focuses on the educational *consequences* of digitization, whereas the second focuses on the educational *potentials* of integrating digital technologies in the L1 subject. The studies that focus on consequences tend to be based on ethnographic accounts of different classroom practices. For example, Juvonen et al. (2019) and Asplund, Olin-Scheller & Tanner (2018) focus on how different hardware technologies affect teaching and student learning processes; while Blikstad-Balas (2012) examines the unintended individual literacy practices that may occur in digital learning environments. Similarly, Hultin & Westman (2013) study how digitization affects different aspects of literacy teaching in the early years of schooling. A slightly different angle is found in a range of studies by Erixon (2014; 2016; 2018; Erixon et al., 2012), who relates classroom findings to a more general discussion on whether the changes taking place in the classroom affect the more fundamental and paradigmatic understandings of the L1 subject.

The second dominant tendency focuses on the educational potentials of integrating digital technologies in L1 teaching. Often framed as action research or design-based intervention studies, this group of studies tends to focus on how digital technologies can be integrated into learning designs in a way that promotes specific teaching practices or learning outcomes (e.g. Sousa & Soares, 2009; Sessions, Kang & Womack, 2016; Sørensen & Levinsen, 2014; Godhe, 2013; Yamac & Ulusoy, 2016). These studies typically adopt a pragmatic and utility-oriented approach to digital technologies. A subgroup within this type of studies focuses on how technologies can facilitate new modes of social participation and inclusion of at-risk students (e.g. Hanghøj, Lieberoth & Misfeldt, 2018; D'Agostino et al., 2016; Berthelsen, 2019).

Within these dominant tendencies, the concept of affordance has only been applied sporadically to empirical research. Some studies have adopted the concept as a means of examining the educational potentials of specific technologies, for instance mobile technologies (Cochrane & Bateman, 2010; Suarez et al., 2018), tablets (Petersen, 2015), or blogs (Deng & Yuen, 2011; Robertson, 2011). Other studies have provided more generic descriptions of different affordances within education (Conole & Dyke, 2004; Bower, 2008; Evans, Pearce, Vitak & Treem, 2017). The pre-

sent study adopts the concept of affordances in an analysis of a digital learning material, thereby relating to a small subgroup of studies that focus on assessing and analyzing digital technologies as artefacts in their own right. In other words, these studies focus not on pedagogical applications of technology in the classroom, but rather on the different learning designs or material qualities of the technologies involved (e.g. Rogne, 2010; Carlsen, 2017; Berthelsen & Tannert, 2017).

4. THEORETICAL FRAMEWORK

In this section we elaborate on the notion of affordance. More specifically, we introduce a distinction between physical, virtual and social affordances. As a starting point, we show how the notion of affordance goes from being applied to the relation between agents and objects in general (Gibson, 1979) to being applied to technological artefacts (Hutchby, 2001) and finally ending up in the vocabulary of designers (Norman, 2013).

Utilizing the affordances of a given digital learning material does not, in itself, guarantee the desired learning outcome. It is equally important that the learning material provides students with affordances that support relevant and meaningful learning activities. Consequently, we link the analysis of affordances to Biggs and Tang's (2011) SOLO taxonomy in order to evaluate the extent to which the digital learning material actually provides students with genuine learning opportunities

4.1 Affordances of physical objects

The term *affordance* was first introduced by psychologist James Gibson (1977, 1979) in order to explain how our perception of the physical world is shaped by our ability to interact with our surroundings. According to Gibson, we do not perceive the physical world as brute facts or mere physical matter. Rather, we perceive it relative to ourselves as an environment with which we can interact. An environment, thus, differs from physical reality in that it provides organisms, such as humans, with a wide range of possibilities for interaction. These possibilities for interaction are what Gibson refers to as 'affordances'. One important point in this connection is that affordances are relative to the organisms perceiving them, i.e. they are objective in the sense that they exist in an environment independently of actually being perceived and utilized by a specific organism, but subjective in the sense that they depend on the constitution of the organism perceiving them. As an example, Gibson (1979, p. 127) mentions the surface of water, which is 'walk-on-able' for water bugs, but 'sink-into-able' for humans. Affordances are also neutral in the sense that they exist in the environment relative to its inhabitants for better or for worse. Thus, the affordance of water of being sink-into-able for humans might be beneficial on a warm summer day, but disastrous if you cannot swim.

Even though Gibson's focus is placed on understanding how we make sense of our physical surroundings and perceive the environments in which we live as meaningful and manageable, his theory of affordances has had a great impact in other areas as well. In relation to studies of human-technology interaction in particular, the notion of affordance has played a major role. An important contribution in this area is made by sociologist Ian Hutchby, who applies the notion in his analysis of the cultural practices that emerge when new technologies enter our everyday lives. Arguing against a social constructivist approach to technology, Hutchby (2001, p. 444) talks about the 'constraining, as well as enabling, materiality of the technology as a worldly object'. He stresses that technological artefacts are not mere byproducts of cultural practices, because once they are brought into existence, they also shape the cultural and social practices in which they are embedded. More precisely, technologies, understood as material objects, belong to our environment and therefore provide us with different affordances for better or for worse. For instance, both corded phones and mobile phones afford long-distance communication, but only mobile phones afford walking around while talking. This might be an advantage if you are in a hurry, but a disadvantage if it prevents you from watching the traffic.

Having noticed that affordances are provided not only by our natural environment but also by artefacts, the question of proper design arises immediately. Cognitive scientist Donald A. Norman has addressed this question by suggesting a so-called 'user-centered' approach to the design of everyday things, including technologies (Norman, 2013). The main idea of user-centered design is that knowledge of affordances imposes an obligation on designers to design artefacts that provide users with relevant, perceptible and accessible affordances. A classic example of this approach is the so-called skeuomorphic interface design of the calculator app for Apple's first smartphone, the iPhone 1. Plain handy objects such as smartphones afford tapping and swiping as an easy way to engage with the applications that they contain. Thus, users can operate the virtual calculator implemented in their phones by tapping and swiping the touch screen. However, at the time, interacting with technologies through a touchscreen was a new experience for most users, which led Apple's software designers to create an interface that resembled the design of Braun's iconic EC66 calculator in order to provide users with immediate and unambiguous information on how to use a virtual calculator.

4.2 Affordances of digital technologies

Following this line of thought, we will take as the starting point of our analysis the assumption that technological artefacts, such as digital learning materials, have affordances, and that designers of digital learning materials should strive to utilize these affordances in order to provide the users, i.e. learners, with meaningful learning opportunities. However, as we saw with the calculator app example, digital technologies are complex artefacts that cannot be described exhaustively in terms of ma-

teriality and physical affordances. Digital technologies are, of course, material objects (e.g. laptops and smartphones) with physical affordances (e.g. drop-able and move-able), but the functionality of the software that is used cannot be reduced to utilizing the affordances provided by the material object. For instance, multiplying 4,765 by 876 on the calculator app cannot be reduced to tapping and swiping the surface of the phone. We are also doing something else: we are making the app embedded in the physical device perform a calculation by means of tapping and swiping.

This leads us to the assumption that virtual artefacts, i.e. software, just like physical artefacts, have affordances in the sense that they provide users with certain possibilities for action. The distinction between the affordances of an artefact and the features of an artefact is disputed to some extent (Norman, 1999; Pols, 2012; Evans, Pearce, Vitak & Treem, 2017). We will follow Evans, Pearce, Vitak & Treem (2017) and distinguish between the *features* of an object, e.g. the sharp edges of a piece of glass; the *affordances* of the same object, e.g. that it is step-on-able; and the outcome, e.g. the cut you get from stepping on it. If we apply this distinction to virtual artefacts, e.g. a drawing program, we can say that it has certain features, e.g. a tool bar on the right-hand side of the screen; certain affordances, e.g. that drawn objects are moveable and resizable; and certain outcomes, e.g. a printed version of the drawing.

Finally, in addition to the physical and virtual affordances, technologies sometimes provide what we will call virtually mediated *social affordances*. By this we mean virtually mediated affordances that provide users with possibilities for social interaction. Gibson (1977, 1979) pointed to the fact that other humans in an environment, just like rocks and water, provide certain affordances, e.g. communication. We will build on this idea and define virtually mediated social affordances in relation to the utilization of virtual affordances as opportunities to interact with other users by means of virtual artefacts. Sharing content and sending messages are two examples of virtually mediated social affordances, and they differ from e.g. performing calculations on a calculator app in that they require a recipient in order to be meaningful and successful. Obviously, we do not need virtual artefacts in order to communicate, and many physical objects, such as flags or bugles, provide social affordances. However, the social affordances of virtual artefacts are of special interest in relation to the discussion of digital learning materials, since learning and teaching by and large are social phenomena that require interaction.

An overview of the affordance categories is given in Table 1 below:

Table 1. Overview of affordance categories

Affordances of physical objects
• **Gibson**: Affordances emerge as possibilities of action and interaction between agents and object in the surrounding environment. • **Hutchby**: The notion of affordance also applies to artefacts. Therefore, when new technologies are created, they shape our lives by providing some rather than other possibilities of action and interaction. • **Norman**: Good design provides users with relevant, perceptible and accessible affordances.
Affordances of digital technologies
• **Physical affordances**: From a hardware perspective, all technologies are part of the physical environment and provide users with certain possibilities of physical action and interaction. • **Virtual affordances**: From a software perspective, all digital technologies provide users with certain virtual possibilities of action and interaction that cannot be reduced to the corresponding physical actions. • **Virtually mediated social affordances**: Some digital technologies provide users with virtually mediated possibilities of social action and interaction.

4.3 The SOLO taxonomy

Although affordance is a useful concept for identifying the potential for action within a learning material, it is in itself insufficient in terms of addressing the normative issue of instructional quality. This is because affordances are didactically neutral. In other words, it is not intrinsic to the concept to ascribe any specific values or hierarchical classifications to the different actions that are made possible. Therefore, we will connect our affordance analyses to the levels of the SOLO model (Biggs & Tang, 2011).

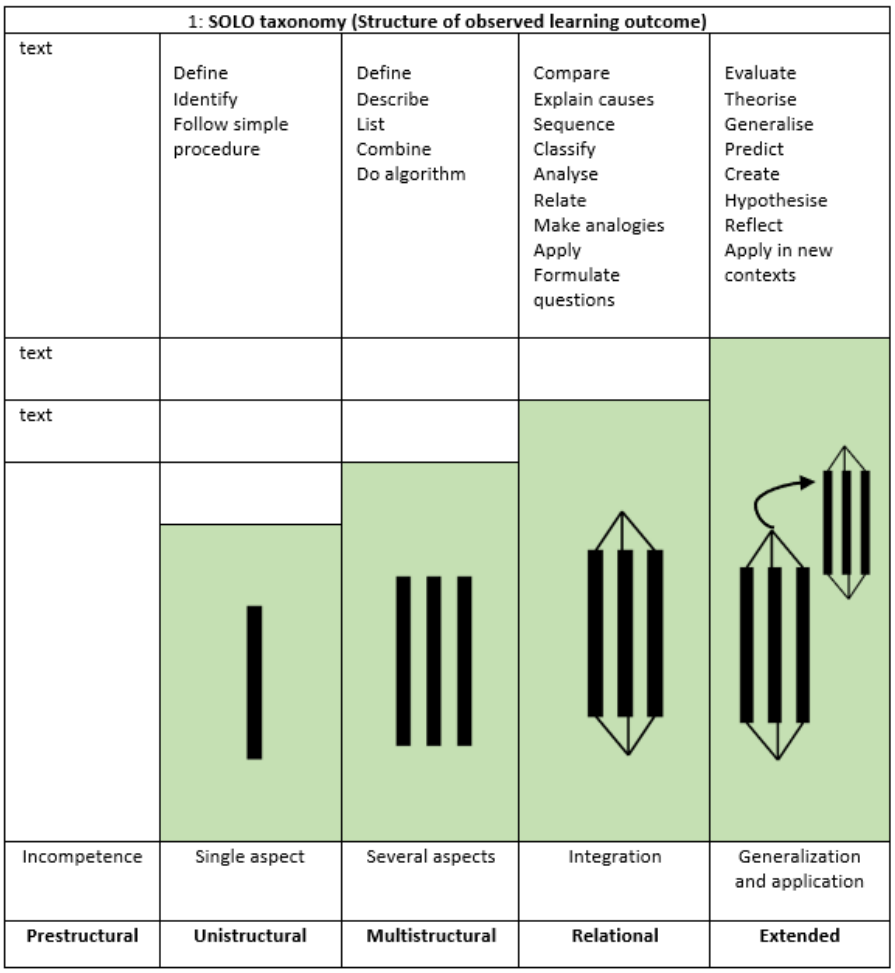
A distinct quality of the SOLO taxonomy is that it connects the levels of uni- and multistructural cognitive processing with specific outcome and student activity. As such, it provides a conceptual basis for understanding the intertwined dynamics of cognitive processing and its indicators in the classroom (performances of understanding). The model distinguishes between different levels of understanding in terms of complexity, cf. Figure 1:

1) *The prestructural level*: At this level the student fails to perform an action or misses the point.
2) *The unistructural level*: At the unistructural level the student is merely identifying and/or naming objects and following simple procedures. It is a merely quantitative level in the sense that there is no deep understanding or relation to other relevant aspects of knowledge.
3) *The multistructural level*: At this level the student understands more, but the aspects are still unrelated. The increase in complexity is thus merely a quantitative increase. The student is able to describe and combine aspects, but still only at a level at which he/she is reciting or merely identifying.
4) *The relational level*: At the relational level there is a qualitative change in the understanding of knowledge, as the different aspects are integrated

into a common structure. The student is thus able to compare, explain, relate, apply and analyze what has been acquired.

5) *The extended abstract level*: At the deepest level of understanding, the student moves beyond what has been acquired. This instills an ability to generalize, hypothesize and reflect, and thereby deepens the qualitative complexity of understanding.

Figure 1. The SOLO taxonomy (Biggs & Tang, 2011)



Although the levels of the model serve as a normative scaffold for relating the different actions enabled by affordances to the levels of complexity in understanding, it is

important to stress that the model instantiates a progression. In other words, affordances that initiate actions related to the lower levels of the model are not bad *per se*. Instead, complex learning activities include activities on all levels. It is, however, of interest to examine what relation, if any, exists between the different levels of the model and the types of affordances that are present in the courses.

5. ANALYSIS

The objects of our analyses are six Danish L1 courses from the DLP *dansk.gyldendal.dk* [danish.gyldendal.dk], which is one of the most commonly used online DLPs in Danish lower secondary school (Bundsgaard, Buch & Fougt, 2020). As mentioned in section 2, it is a distinct feature of many DLPs that they are comprehensive and address a significant part of the curriculum. In other words, they intend to cover most (if not all) content areas of the national curricula of the individual subjects. The DLP called *danish.gyldendal.dk* covers a variety of content areas such as literature, grammar, writing, multimedia production, reading, oracy etc. (Bundsgaard, Buch and Fougt, 2020). DLPs have a potentially very significant influence on classroom practice (Warren, 2000; Watt, 2015; Horsley & Sikorová, 2014). The structure of the analyses will be as follows. First, we will briefly present the courses and then go on to make some general remarks about the DLP that apply to all the courses, after which we will focus on each of the three main affordance categories in separate sections.

5.1 The courses

The six courses chosen for analysis (see Table 2) cover six different content areas: writing, reading, literature, multimedia production, oracy and grammar. Together the courses cover the main content areas of the National Curriculum for Danish L1 (Undervisningsministeriet [Ministry of Education, forthwith abbreviated UVM, 2019), 2019). We have chosen this thematic scope in order to avoid biased results from the analyses. In addition, in order to increase the validity by constructing a critical case (Flyvbjerg, 2006), we have chosen courses in which we believed the students had a chance of achieving the higher and qualitative levels of the SOLO taxonomy. Hence, courses that mainly consist of fragmented and repetitive training exercises have been excluded. All the courses are designed to be used in lower secondary school (7^{th}-10^{th} grade).

5.2 General remarks

Students trying to access the courses on the DLP in class have to take a series of steps, including everything from opening the computer to clicking through the different web menus on the user interface of the DLP. For students navigating a course about spelling, the process looks something like this:

> Pushing the power button on the computer → Typing in the password → Opening a web browser → Typing the url address for the DLP → Logging on to the platform → Choosing a course.

This process requires the student to interact with the keyboard, mouse and screen (hardware) and with the webbrowser and DLP (software). Thus, gaining access to the courses on a DLP is potentially a time-consuming task with no apparent learning potential that results in less time being available for other activities.

Table 2. Courses

Course	*Title*	*Content area*	*Main aim*
1	Skriv en novelle [write a short story]	Writing	The students are introduced to the genre characteristics of the short story and write one themselves.
2	Faglig læsning 1 [academic reading 1]	Reading	The students acquire reading strategies and tools for reading and understanding non-fiction texts.
3	Lejren [The Camp]	Literature	The students read, analyze, interpret and discuss a graphic novel.
4	Multimodale tekster [Multimodal texts]	Multimedia production	The students learn about multimodality and produce a multimodal text themselves.
5	Fremlæggelse [Oral presentation]	Oracy	The students learn about the characteristics of a good oral presentation and present one themselves.
6	Sætninger [Sentences]	Grammar	The students learn key concepts about syntax and use this knowledge to do sentence analyses themselves.

All the courses consist of a series of steps. Virtual buttons are listed on the right side of the screen. These work as hyperlinks functioning as the central structuring of the courses providing virtual navigational affordances, e.g. moving back and forth in the virtual learning environment. Each course also has a series of digital tools that the students can access directly or through hyperlinks within the different steps of the course. It is also possible to access the texts of specific courses directly without having to click through the steps of each course.

5.3 Physical affordances

As shown in Table 3, the physical actions that are afforded in the courses are the same. The students switch between interacting with the computer, which affords opportunities for basic actions such as typing on the keyboard, moving and clicking the mouse, and doing more collective activities (group work, going to the library etc.). We distinguish between affordances that are actual properties of the DLP and affordances that are initiated in another physical environment (see section 5.7 for further details). We refer to these affordances in the table as “Physical affordances

in another physical environment". It is also worth mentioning that only course 3 includes the use of a physical book (in this case a novel). All the other courses use texts and worksheets in a digital format within the DLP.

Table 3. Physical affordances

Physical affordances	*Course 1*	*Course 2*	*Course 3*	*Course 4*	*Course 5*	*Course 6*
Typing	x	x	x	x	x	x
Clicking	x	x	x	x	x	x
Moving the mouse	x	x	x	x	x	x
Moving the device	x	x	x	x	x	x
Physical affordances in another physical environment	x	x	x	x	x	x

5.4 Virtual affordances

As can be seen in Table 4, the courses all share three simple virtual affordances: navigating between webpages using a hyperlink structure, navigating within the individual websites by scrolling, and watching images, graphics etc. Furthermore, five of the courses contain writeable elements in the form of digital worksheets that mirror well-known paper worksheets in terms of both form and function. These are often designed in the form of tables with questions in the left column and students' answers in the right column. Three of the six courses also integrate videos. In courses 2 and 5 the videos serve as a short, informative introduction to the topic of the course; whereas the videos in course 5 consist of interviews with Danish authors who are to be the subjects of student presentations. These are the most common categories of virtual affordances in the six courses. The rest of the affordance categories (audio, sharing content etc.) are only present occasionally in one or two of the courses.

It is worth noticing that many of the virtual affordances offered in the courses support the receptive skills of the students. For instance, the reading of many (but not all) of the texts that are part of the courses is scaffolded by enabling virtual affordances such as listening to audio, altering text formatting and resizing elements. More specifically, in courses 1 and 2 some of the texts can be opened in a special browser window that supports student decoding processes. The students can have the text read out loud to them, and they can change the typography, background color, letter size and the length of the lines. Such affordances are made available to support struggling readers (Stetter & Hughes, 2010). But there are very few virtual affordances within the limits of the DLP that enable the students to be producers of content. This does not necessarily mean that the courses in general do not promote the productive skills of the students. What it means is that the virtual affordances that support these productive skills are primarily made available in another virtual

environment. For instance, many of the activities in which the students actively produce content link to an external web application called Skoletube.dk, which is a repository for 23 different online and easy-to-use tools. For instance, there are tools that allow the students to produce digital mind maps, blogs, videos, cartoons etc. The affordances made available by these tools are slightly more varied and diverse than those made available within the limits of the DLP. However, it is beyond the scope of this analysis to examine the affordances of all of these tools, as such affordances are not actual properties of the DLP.

Table 4. Virtual affordances

Virtual affordances	*Course 1*	*Course 2*	*Course 3*	*Course 4*	*Course 5*	*Course 6*
Navigating between pages (hyperlinks)	x	x	x	X	x	x
Navigating within page (scrolling)	x	x	x	x	x	x
Watching static virtual objects (screen content, pictures)	x	x	x	X	x	x
Watching dynamic virtual objects (video)		x		x	x	
Resizing elements	x (optional)	x (optional)				
Listening to an audio file	x	x				
Writing	x	x	x	x	x	
Sharing digital content with peers	x					
Enlarging objects				x		
Printing				x		
Altering formatting of text (e.g. changing typography, font size etc.)	x (optional)	x (optional)				
Virtual affordances in another virtual environment		x	x	x	x	x

5.5 Virtually mediated social affordances

All of the courses provide students with the option of some sort of social interaction. However, as shown in Table 5, these social affordances are accessible in other physical environments (e.g. discussing and comparing text drafts in groups). This means that social interactions unfold in an environment that is not directly mediated by the digital device. Instead, they are initiated and scaffolded by means of text descriptions within the individual courses, e.g. through directives such as “Discuss the development of the main character in groups”. As such, most of the social affordances of the

courses are not properties of the DLP, in the sense that they are not related to any of the virtual affordances of the courses.

There are, however, a few examples of activities that enable social interaction by interacting with the computer. For instance, in course 4 the students must share their individual multimodal products with the class on a blog. However, it is again the case that this affordance is enabled in another environment—in this case a virtual one. The DLP links to another external website (skoletube.dk) that provides the affordances needed to carry out the action. Yet, in course 1 we see an example of a social action that can actually be carried out within the DLP itself. The students write short stories and are asked to give feedback on the drafts produced by their classmates. This is done using a digital worksheet that the students can then share with each other digitally. Such an act is social and communicative in that it takes into account a recipient. Similarly, in course 4 the students are asked to write explanations/definitions of some of the key words from the course, which must then be printed and memorized with a classmate.

Table 5. Virtually mediated social affordances

Social affordances	*Course 1*	*Course 2*	*Course 3*	*Course 4*	*Course 5*	*Course 6*
Producing text for other recipients	x			x		
Social affordances in another physical environment	x	x	x	x	x	x
Social affordances in other virtual environments				x	x	

5.6 Relations to the SOLO taxonomy

The affordances provided on the DLP are generally very limited. The analysis of virtual affordances, for instance, shows that the most common virtual affordance categories made available in the courses are either related to very simple acts of navigating within or between webpages, or to filling out worksheets with simple analytical questions such as “Does the short story begin in medias res?” or “Is the conflict of the story resolved?” In such cases, the students are merely identifying independent text features and following a heavily scaffolded procedure. A similar situation applies in course 3 when the students are asked to fill out lexical flash cards with new words that they encounter when reading a novel. Again, such an activity only affords writing very basic and unrelated pieces of knowledge. In addition, the analysis of virtually mediated social affordances quite clearly shows that the opportunities for social interaction made available within the DLP are very basic and simple. On this basis, the affordances offered in the courses seem to follow a certain pattern. Activities in which the students work individually with tasks and tools within the DLP are

largely connected to the lower levels of uni- and multistructural cognitive processing in the SOLO model. By contrast, activities that are connected to the qualitative levels of the model take place when the students leave the DLP and interact within different virtual or physical environments. For instance, when they give each other feedback in groups, or when they produce more advanced multimodal products using tools from the external web application skoletube.dk.

Consequently, the question is whether this is a satisfying way of utilizing the affordances of contemporary digital technologies. Digital technologies have the potential to engage students in much more complex activities than those afforded by *Danish.gyldendal.dk*. Calder (2011) points out that a digital environment affords the opportunity for students to interact with and manipulate multiple modes of representation (e.g. graphs, 3D models, games) in ways that support their understanding of the subject matter. Similarly, Patwardhan & Murthy (2015) show that interactivity features are important for visual modes of representation to enhance higher learning; and Wan Ng (2015) stresses that digital technologies have the potential to engage students in collaborative processes in which they create, share and manipulate content. Such complex activities that relate to the higher and qualitative levels of cognitive processing require a variety of different types of affordances. Such a variety is seemingly hard to make available within the restricted format of *Danish.gyldendal.dk*. However, it is crucial that learning materials—especially when they are as large and comprehensive as DLPs—provide students with the affordances needed to progress beyond the stages of displaying merely disjointed pieces of knowledge, towards the more connected and complex levels of learning activities.

5.7 Limitations of the study

In studying learning materials in isolation from their application in the classroom, we are studying an artefact that is yet to be interpreted by teachers and students. In other words, we are analyzing what van den Akker (2003, p. 3) calls an "intended curriculum" (see also Fougt, Bremholm & Buch, 2020). In other words, a formal and materialized specification of the ideas, norms and visions of the ideal curriculum. As such, an analysis of a learning material says something about the potentials that it offers for student and teacher action and can only plausibly, but never say something definitive about classroom practice. In addition, an affordance analysis says something very specific about the potentials for action that are made possible by learning material, but does not provide a general and holistic analysis of the qualities of the content or the specific learning designs.

In the analysis, we have refrained from quantifying the observations of affordances by counting the number of times a particular affordance is made available in the courses. This is because a number of the identified affordances cannot be meaningfully quantified (e.g. scrolling, clicking) or validly inferred from our data material. Such a quantification would require another research design altogether. Instead, the nature of our study is explorative and aimed at identifying and describing

the existing affordances within the DLP. We acknowledge, however, that in another type of study a frequency count of some of the affordances (e.g. writing, sharing digital content) could possibly lead to more in-depth understandings of the nature of DLPs.

Another limitation in the study concerns the distinction between the DLP and the other virtual or physical environments related to the learning designs. This distinction is, however, necessary for two particular reasons. First, we have, as mentioned before, not examined how teachers and students perceive and make use of the DLP. As such, it is beyond the limits of the present analysis to speculate as to what types of opportunities for action are afforded during group work, for instance. Such an analysis would require a different methodological approach involving, for instance, classroom observations. Second, we cannot examine the affordances of the related virtual environments because they are not didactic in nature. This means that there is no propositional content to guide our walkthrough descriptions of what the students are actually supposed to do in these environments.

6. DISCUSSION

In the following we will focus on some of the implications of our analysis. We start by discussing the benefits of adopting an affordance perspective when analyzing learning materials. Then we discuss the challenges of digitizing learning materials. And finally, we will briefly discuss how large-scale DLPs challenge the teacher as a designer of learning activities.

6.1 Benefits of an affordance perspective on digital learning materials

As we have described in the literature review, research on digitization in the L1 subject centers around two overall tendencies. Studies are concerned with either questions about the educational consequences of digitizing learning environments, or questions about the potentials of digital technologies to promote specific classroom practices and/or learning outcomes. Both of these focal points are mainly concerned with different applications of technology in authentic classroom settings. However, what an affordance approach to the study of educational technology means is a shift in focus towards what Kolbeck & Röhl (2018, p. 405) call “the material qualities of the book itself”. The point is that the material qualities of a learning material shape its use in the classroom. As such, the material properties of the resources that enable different types of action (i.e. the affordances) must be considered when evaluating the qualities of learning materials (Macgilchrist, 2018). This is particularly true of digital learning materials with virtual affordances, since they are used on laptop computers, tablets and smartphones that all differ radically in terms of their materiality and physical affordances from traditional learning materials such as books, paper and pencils.

In the analysis above, we saw, for instance, that only very few and very basic virtual affordances were made available within DLPs, and that these affordances mostly allowed actions related to the lower levels of the SOLO taxonomy. Such aspects would not have been as clear if we had only looked at the content or the different learning designs of the courses. What an affordance perspective implies is the question of whether a learning material provides the affordances that are enabled by its materiality (paper, digital etc.), in ways that allow the students to carry out actions with different levels of complexity. For instance, you might question what the reasoning behind digitizing learning materials is, if they do not provide affordances that are distinct for digital technologies.

6.2 The digitization of learning materials

We saw in the analysis of the six courses, that they in many ways represent digital replications of traditional learning designs or what Meier (2015, p. 5) coins as "merely digitizing the status quo". This shows that digitizing learning materials so that they align with the educational potentials contained in digital technologies is no trivial task. In other words, digitizing learning materials is by no means a quick fix leading to more progressive educational practices. This would require a distinctly user-oriented and *pedagogical* approach instead. In other words, an approach to the design of digital learning materials that is based on criteria for instructional quality and strives to utilize virtual affordances in order to increase learning outcome. As pointed out by Clark (1983) more than three decades ago, it is pedagogy rather than media that influences instruction. As such, it continues to be the design of learning materials that is the essential issue, and the argument for digitizing learning materials must concern the different kinds of affordances enabled by different kinds of digital technologies.

An example of an approach that in fact do provide students with higher level learning opportunities was proposed by Papert (1980) and later elaborated by Resnick (2017). Here digital technologies are thought of not merely as learning aids, but as powerful vehicles for learning. However, the playful and project-oriented approach of Papert and Resnick rarely serves as the basis of digitally mediated courses and DLP content.

One subsequent consequence of digitizing learning materials concerns the material changes brought about by substituting digital devices for paper and pencils. Many of the activities in the courses that we looked at could have been carried out without using any digital technologies. For instance, a digital worksheet affords precisely the same affordance as a paper worksheet, namely writing. Similarly, drawing a timeline using a web-based online tool affords the same thing as performing the same action using a paper and pencil, namely drawing. The main difference is the restriction of physical affordances that digital technologies provide. As we saw in the analysis, using a computer affords a very limited amount of physical actions (typing, clicking, moving the curser etc.); whereas interacting with a range of other tactile

elements (paper, pencil, rubber, ruler etc.) potentially affords a wider range of actions. As such, digitization (in the extreme case) might result in a general deficiency of materiality in the classroom.

6.3 Who are the primary designers of learning activities?

Another important question that arises when digitizing learning materials concerns the role of the teacher, when he/she is faced with large, comprehensive DLPs. As we have mentioned earlier, it is the case in Denmark that many DLPs aim to cover most content areas of the subjects in the Danish primary and lower secondary school. The sheer comprehensiveness of these DLPs gives them considerable potential for influencing classroom practice. Teachers, on the other hand, might lose agency and be reduced to mere facilitators of learning activities, leaving them with restricted opportunities for compensating for the limitations and inadequacies of the learning materials. This is a key issue that needs to be addressed in the future development of digital learning materials.

7. CONCLUSION

In this study, we have examined the way in which the digital transformation of education affects learning materials. The contributions of the present study are twofold. First, we have outlined a framework for conceptualizing affordances in educational technologies. By elaborating on the notion of affordance from Gibson (1979), Hutchby (2001) and Norman (2013), we have distinguished between physical, virtual and social affordances. These categories were then related to the SOLO model (Biggs & Tang, 2011) in order to provide them with a pedagogical scaffold. By applying the framework in a case study, we have shown how a DLP integrated and utilized different types of physical, virtual and social affordances.

Second, the analysis showed that the courses on the DLP were very similar in terms of the affordances that were made available. In addition, it was shown that very few affordances related to student activity on the high levels of the SOLO model. As such, we have questioned whether the digitization of learning materials has actually resulted in any substantial pedagogical changes to the Danish L1 subject.

Further studies of affordances are needed if we are to gain a better understanding of digital technologies and have a thorough and critical discussion about their educational potentials. In addition, there is still a need for further empirical studies on the use of digital learning materials in the classroom with special emphasis on how students actually utilize the different affordances that digital learning materials make available. In addition, although we have approached the question of digitization in the L1 subject from the perspective of learning materials, one of the key rationales behind the digitization of learning environments in general concerns issues relating to data-driven education (Berthelsen & Tannert, 2019). This represents an important direction for future research.

LEARNING MATERIALS REFERRED TO IN THE ARTICLE

Course 1

Bojsen, J. & Godsk, R. (n.d.). *Skriv en novelle* [Write a short story]. dansk.gyldendal.dk. Retrieved from https://dansk.gyldendal.dk/Indgange/forloeb/~/link.aspx?_id=1C17AC9FA-CAF4CC291072A375456E2BA&_z=z (10.01.2019)

Course 2

Schultz, M.F. (n.d.). *Faglig læsning 1* [Academic reading 1]. dansk.gyldendal.dk. Retrieved from https://dansk.gyldendal.dk/Indgange/forloeb/laesning/faglig_laesning_1.aspx (10.01.2019)

Course 3

Brandt, K.L.S. (n.d.). *Lejren* [The Camp]. dansk.gyldendal.dk. Retrieved from https://dansk.gyldendal.dk/Indgange/forloeb/hovedvaerker/lejren.aspx (10.01.2019)

Course 4

Nielsen, S.A. (n.d.). *Multimodale tekster* [Multimodal texts]. dansk.gyldendal.dk. Retrieved from https://dansk.gyldendal.dk/Indgange/forloeb/kommunikation/multimodale_tekster.aspx (10.01.2019)

Course 5

Skyt, A.F. (n.d.). *Fremlæggelse* [Oral presentation]. dansk.gyldendal.dk. Retrieved from https://dansk.gyldendal.dk/Indgange/forloeb/mundtlighed/fremlaeggelse.aspx (10.01.2019)

Course 6

Hagen, J.Z. (n.d.). *Sætninger* [Sentences]. dansk.gyldendal.dk. Retrieved from https://dansk.gyldendal.dk/Indgange/forloeb/sprog/saetninger.aspx (10.01.2019

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