STUDENT WORK AND THE MULTIMODAL CHALLENGE

A mixed methods study of students' productive work in L1, science and mathematics

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Abstract
Students' productive work constitutes an essential part of the various learning activities students are involved in while in school. However, empirical research on students' productive work in schools is quite sparse, and thus, we only know little about what kind of products the students make in different subjects, and how they relate to learning. This article presents a mixed methods study on students' productive work in the subjects L1, science and mathematics in primary and lower secondary school in Denmark with a particular focus on the students' use of multimodality. By combining a quantitative scoring of a large sample of tasks and student products (n = 451) and qualitative classroom studies in L1, science and mathematics, the mixed methods study provides a picture of the practices related to students' productive work in Danish schools. This picture shows, on the one hand, that there is obvious potential related to students' multimodal productive work, and, on the other hand, that this potential is difficult to realize due to a number of barriers that overall point to the tenacity of conventional approaches to students' productive work in Danish classrooms.

Keywords: student work, task, multimodality, mixed methods, L1, science, mathematics.

1. INTRODUCTION

The school is, among other things, a place of production. An important part of the activities children and adolescents are involved in across the different subject areas while in school includes productive work of various kinds. They write texts, fill out work sheets, draw up reports on experiments, make posters, put together power

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point presentations, make drawings and other art products, produce movies and design homepages just to mention a few examples of "things" produced by students in school. In this sense, students' productive work is an important and regular element of teaching in most subject areas in school, which is also indicated by the fact that productive activities constitute a more or less mandatory component in textbooks and learning materials produced for teaching (Bremholm, Slot & Hansen, 2017; Hansen, 2012). Add that the Danish School System has a high degree of formalized digitalization organizational and didactical strategies which among others means that teachers and students subject content work on a daily basis is supported with ICT.

At the same time, scholars from different fields of research have repeatedly pointed out that students' products hold a high pedagogical value inasmuch as they are a source of insight into the students' thinking and learning (Khoh & Luke, 2009; Kress, 2010; Matsumura & Pascal, 2003; Newmann, Bryk & Nagaoka, 2001; Skjelbred, 2009). Baron (2008) puts it this way in his advocacy for the students' products (or students' work) as a teacher tool: "Students' work […] demonstrates students' efforts to understand and master the nature, possibilities, and challenges of particular genre or media. It demonstrates their understanding of significant ideas and concepts" (p. 66). Considering the pedagogical importance of student products, it is remarkable that the empirical knowledge of students' productive work in schools is quite sparse. This is the case internationally and in particular in a Danish and Nordic context. A considerable amount of prescriptive research exists on aspects such as the design of tasks for students' productive work, the assessment of students' products and the pedagogical framing of students' productive work, but surprisingly little is known about the productive work the students actually do in schools. What kind of products do the students make in different subjects, what characterizes the different kinds of products and how do they differ, how do the different kinds of tasks and student products relate to learning, and what are the differences and similarities between different school subjects regarding their productive practices?

In this article, we address some of these questions by presenting and discussing findings from a mixed methods study of students' productive work in L1, science and mathematics carried out in primary and lower secondary schools in Denmark (Bremholm, Slot & Hansen, 2017; Bremholm, Hansen & Slot, 2016a). We center our presentation on the question of multimodality in the students' productive work, and we have chosen this pivotal point for two reasons. First, multimodality plays a prominent role in modern communication. Gunther Kress and others have pointed out that the importance of multimodality in meaning making and communication have intensified throughout the 20th century, and not least in the last 20-30 years with the advances in digital technology, so that today multimodality is an essential part of the way we communicate and create meaning (Jewitt, 2009; Kress, 2010; van Leeuwen, 2005). This also includes disciplinary domains and school subjects where the use of different modalities is considered to be an intrinsic aspect of the way you represent and communicate about disciplinary content (Bremholm, 2014; Cazden et al., 1996; Hansen, 2010; Lankshear & Knobel, 2011). In particular, this is the case for the three school subjects in question in the study (Maagerø & Skjelbred, 2010; O'Halloran, 2005; Smolkin & Donovan, 2004; UVM, 2015a and 2015b; Wellington & Osborne, 2001). Second, the question of multimodality encapsulates a number of the main findings and insights of the above-mentioned study.

We address the following research questions in this article:

- What are the differences and similarities in the students' use of multimodal resources in their productive work in L1, science and mathematics?
- To what extent do the use of multimodality in the student products support subject-specific communication and the students' subjects-specific learning?

We use the term *task* to denote the description made by a teacher (or a textbook / a learning material) that sets out the guidelines for the students' productive activity. The term assignment is often used synonymously with what we call task in the article. We use the term *student product* to denote the result of a student's productive work initiated by a task. Finally, we propose the concept *task-based pedagogy* as a term for the specific aspect of pedagogy that regards students' productive work in an instructional context.

2. RESEARCH ON STUDENTS' PRODUCTIVE WORK

Empirical and descriptive research on classroom-based productive practices of teachers and students are surprisingly limited. A methodologically interesting example of descriptive research has been done by Khoh and Luke (2009) in their comprehensive quantitative study of tasks and student products in Singapore School in the subjects English as L1, social science, mathematics and science. In the study, they collected a large number of tasks and student products (n = 6529) in 5^{th} and 9^{th} grade in 59 different schools. The study examines what Khoh and Luke term "the authentic intellectual quality" of the tasks and the student products and their interrelation. They evaluated this quality using criteria such as "depth of knowledge", "knowledge manipulation", "connections to the real world" and "student control". Khoh and Luke (2009) found strong correlations between the quality of tasks and student products in both grade levels as well as significant differences between the four subjects regarding the quality of both tasks and student products. Furthermore, the study shows that a significant majority of tasks were short in-class tasks as compared to homework tasks, extended tasks/projects or teacher made tests (p. 11, 17). In a less comprehensive North-American study, Matsumura and Pascal (2003) combined a quantitative analysis of tasks and students' products in English as L1 with qualitative classroom observations to examine the interrelations between tasks, student product and learning environment. Over the course of four years, tasks and student products were collected from a total of 109 English teachers in third, fourth, seventh and tenth grade. The quality of the tasks was evaluated and scored according to criteria such as cognitive challenge, clarity of goals and alignment of goals and activities. The study shows that not only the quality of tasks is strongly associated with the quality of the student products but also with the quality of the observed instruction, and

Matsumura and Pascal (2003) state that tasks might serve as an indicator of classroom practice (p. 37).

The large majority of research on student work consists of prescriptive studies examining different aspects of students' productive work. Specifically, the designing of tasks has been the object of certain research interest. A number of studies have pointed to the connection between task design and students' learning and particularly their opportunity to construct knowledge (Newmann, Bryk & Nagaoka 2001; Peterson, 2001; Rademacher, Cowart, Sparks & Chism, 1997). Similarly, several studies have examined how certain task designs might support specific approaches to teaching and learning, such as "deep tasks" for deep and independent learning (Fullan & Langworthy, 2014), "co-learning tasks" for inquiry-based teaching (Gunckel & Wood, 2016) and "authentic tasks" for teaching that connects the students' activities and learning to the out-of-school world (Faircloth & Miller, 2011; Bures, Barcley, Abrami & Mayer, 2013; Yelland, Cope & Kalantiz, 2008). Other studies that have examined the aspect of student influence show that task designs that allow students a choice on various aspects of the productive work have a positive impact on student motivation and learning (Capobianco, Nyquist & Tyrie, 2013; Perry, Phillips & Dowler, 2004).

The work process related to student products has also been the object of interest in a number of studies. Several studies have examined how the collaborative organisation of the students' productive process using different group structures and formations might support students' productive work and learning benefits (Fuchs et al., 2000; Johnson, Johnson & Skon, 1979; Thornborrow, 2003). Furthermore, studies have pointed to the importance of scaffolding of the productive process with regard to the quality of the students' productive work (Capobianco, Nyquist & Tyrie, 2013; Fuchs et al., 2000; Parsons, 2008).

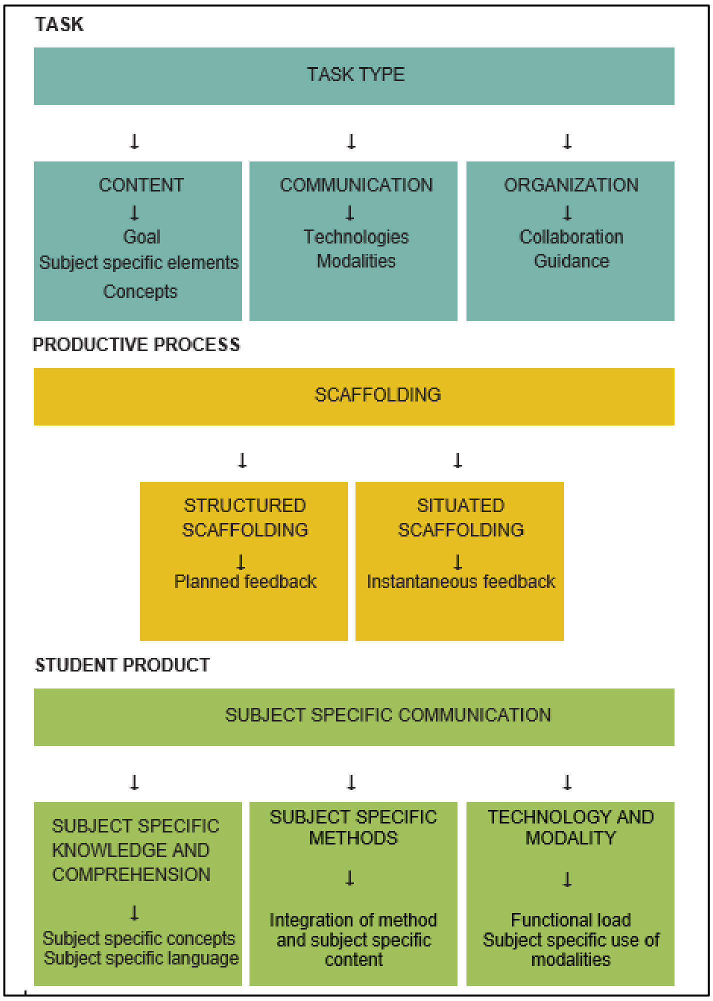
Concerning the student product itself, the research has in particular directed its attention to questions about the assessment of student products and the students' use of technologies and digital ressources in their productive work. For instance, studies have shown that including a varied selection of student products, e.g. by using portfolios, form the basis for a deeper and more valid assessment of the students' learning than standardised testing (Bures, Barcley, Abrami & Mayer, 2013). Likewise, studies have pointed to the important role of communicative and digital technologies and shown how they might enhance the quality of the students' productive work (Chandler-Olcott, 2009; Tay, Lim, Lim, Khoh, 2012).

3. THEORETICAL FRAMEWORK: A MODEL OF TASK-BASED PEDAGOGY

Task-based pedagogy can be described as the dynamic interplay between three elements: 1) *The task* which can be defined as the framework for students' productive activity as described by the teacher and/or the learning material. The task constitutes the framework for the students' intended learning related to the activity, inasmuch as it is based on a more or less deliberate intention about the learning the students will obtain from the activity in question. 2) *The productive process* which we define as the students' work process in order to carry out a given task. The productive process can be quite short (e.g. a single lesson) or extend over a longer period of time (e.g. several weeks) and, besides the task itself, it is conditioned by the instructional framing and organization of the students' work in the classroom. 3) *The student product* defined as the end result of the students' productive process. The student product constitutes the manifest representation (or sign) of the actualized learning the student has obtained from working with the task and, as such, it can be regarded as the realized version of the intended learning represented by the task. This approach to task-based pedagogy is inspired by several theoretical sources. First and foremost social semiotics and multimodal theory (Kress, 2010; Kress & van Leeuwen, 2006; Martin & Rose, 2003; van Leeuwen, 2005), but also learning material theory (Bundsgaard & Hansen, 2011; Hansen & Bundsgaard, 2012; Hansen & Gissel, 2017), pedagogical concepts such as scaffolding, organization and framing (Bernstein, 1981; Wood, Bruner & Ross, 1976), performance-oriented classification of student products (Greenstein, 2012; Mueller, 2008; Shear, Hafter, Miller & Trinidad, 2011), and Nordic didactical research on students' productive work (Hedeboe, 2002; Skjelbred, 2009).

These three elements and the interplay between them constitute the basic groundwork upon which we developed the model of task-based pedagogy used as our analytical framework in the study (see Figure 1). The limited length of the article does not permit a detailed description of the various categories in the model (see Bremholm & Slot, 2018, and Slot, Bremholm & Hansen, 2016, for a thorough explication of the model). In this study, we use the model as our analytical framework. The three main categories in the model, *Task Type, Scaffolding,* and *Subject-Specific Communication*, each represent the manifest counterpart of the three basic elements described above. By this, we mean that the teacher's choice of a specific type of task should be seen as the concrete manifestation of the task as a framework for the students' intended learning. Likewise, the degree to which a student demonstrates subject-specific communication in his or her work is a manifestation of the student's actualized learning represented in the concrete student product. Furthermore, in the same manner, the scaffolding that the teacher provides for the students' work is the concrete manifestation of the instructional framing of the productive process. In the section about qualitative findings in this study, we will elaborate further on some of the other categories in the model.

Figure 1. Model of task-based pedagogy



4. A METHODOLOGICAL DOUBLE PERSPECTIVE ON STUDENT PRODUCTION

Based on our theoretical conception of task-based pedagogy we designed the study as a mixed methods study consisting of a quantitative and a qualitative part. In the quantitative part of the study, we focused on tasks and student products in Danish, science and mathematics, whereas the qualitative part permitted us to include the productive process as analytical dimension as well (cf. Figure 1). Furthermore, we conducted the mixed methods study as an explanatory sequential design (Creswell

& Clark, 2011) which meant that the qualitative part followed from and elaborated on the results of the quantitative part of the study.

4.1 The quantitative part of the research design

The quantitative part of the study consisted of the collection, categorization and analysis (scoring) of a large number of student products and related tasks from Danish, mathematics, and science (*N* = 451).

The tasks and student products were collected in 14 schools from different regions of Denmark. The schools were technology-oriented schools chosen to participate in a large national project about the use of technology in education. The strategic selection of schools in our study is based on the idea that they could produce more insight into our research questions on student's use of digital multimodal resources than a random sample of schools could provide. Given this bias, it is possible that the quantitative study represents a slightly more positive picture of the digital task-based practice in Danish schools than what is actually the reality.

The collection was conducted in 2014/2015 in randomly selected classes (from grade 1 to grade 9) in the subjects Danish, mathematics and science. The data collection process was as follows: Teachers in the selected classes and subjects were at a given time asked to upload student products (with associated task) from four randomly selected students in the class (selected by us by means of a random number generator). The teachers were told to choose the last product these students had made in the given subject. Student products and associated tasks were uploaded to a web platform developed within the research project. This procedure helped to ensure that the data collection represents a realistic and broad picture of the teachers' actual practice regarding tasks and students' productive work.

Based on the collection of tasks and student products, we generated a dataset that contains a total of 451 unique student products and related tasks. Students are distributed relatively evenly on the three levels that characterize the organization of the Danish primary and lower-secondary school. There are 157 student products from grade 1-3, 166 student products from grade 4-6 and 128 student products from grade 7-9 (see figure with details regarding the distribution of tasks and student products in Appendix 1).

We did the categorization and analysis of the student products and related tasks using a digital set of scoring rubrics with a corresponding coding guide developed for the purpose of the project. The scoring rubrics are based on the theoretical framework presented in the section on task-based pedagogy. The tasks were scored according to the following rubrics: Type of task, Mode, Scaffold, Organization, Framing, and Differentiation. The student products were scored according to the following rubrics: Use of ICT, Multimodality, Functional dominance, Content domain, Organization, and Process. In Appendix 2, two figures are included that show the different categories of the scoring rubrics for the tasks and the student products respectively. The scoring was done by us. 20% of the tasks and the student products were scored by two coders with an inter coder reliability of 90% (see Hansen, Slot & Bremholm, 2016 & Slot, Hansen & Bremholm, 2015) for a detailed description of the scoring rubrics, coding guide and the methodical procedure regarding the scoring of tasks and student products).

In the following sections, our results will be presented in bar graphs of frequencies for the different category variables. In order to determine if there is a significant difference between two category variables we use a precautionary principle. Statistically, the analysis utilizes that proportions and mean both provide an approximative normal distribution in large random sampled samples and a confidence interval is established. We conclude that there is a significant difference if the confidence intervals do not overlap. If the two confidence intervals overlap, we cannot identify a significant difference.

4.2 The qualitative part of the research design

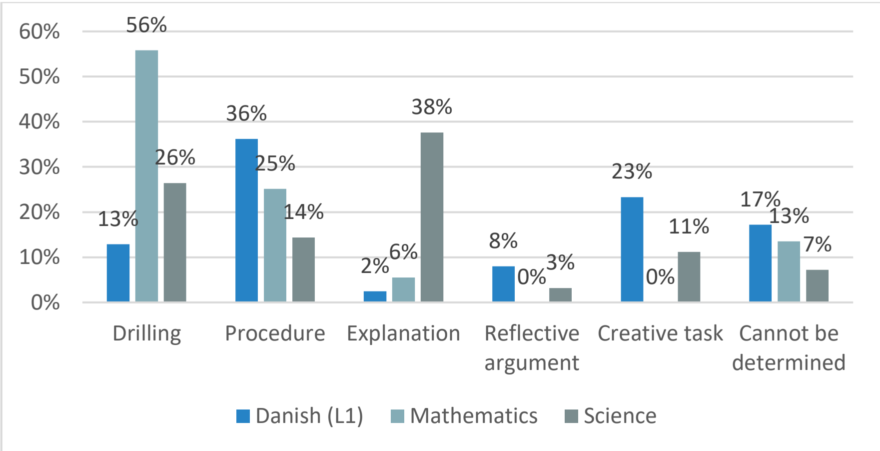
The qualitative part of the study consists of three case studies of classroom teaching in Danish, science and mathematics. In these case studies, we focused in particular on the work process and the students' learning outcome from their productive work within the instructional context (Bremholm, Hansen & Slot, 2016b).

In the case studies, we did classroom observations in three teaching units in which students' productive work was an important element. The units represented the three subjects in the study, Danish, mathematics and science and took place in three different schools during the autumn of 2014. Methodologically, the cases are classroom studies inspired by an ethnographic approach and we conducted them with a special analytical focus on the students' productive work in the actual teaching context in order to gain an insight into what skills and competencies, general as well as subject-specific, the productive work process supports. We collected a variety of data to permit in-depth analyses of the students' work processes: observation notes, video and audio recordings of lessons, classroom documents (tasks, student products, learning materials, unit plans) and interviews with selected students about their product and their work process (18 interviews in total).

5. STUDENT PRODUCTION AND MULTIMODALITY QUANTITATIVE FINDINGS

As an introductory background for the study's results regarding multimodality, it is pertinent to point out that the quantitative analysis offers an interesting overview of the task types used in the subjects Danish, mathematics, and science (see Figure 1). *Explanation, creative production* and *reflective argument* are types of tasks that have a potential to support the students' independent knowledge construction, whereas *drilling* and *procedure* (recipe for answering and solving a task), to a large degree, invite students to approach knowledge in a reproductive and fact-oriented manner (Bremholm, Slot & Hansen, 2017). As illustrated in Figure 2, the study shows that a significant part of the tasks used in the three subjects does not support the students' independent knowledge construction. This said, there are also some interesting differences between the three subjects worth noting. Danish has a significantly higher proportion of creative tasks than mathematics and science, but it has very few in the categories of *explanation* and *reflective argument*. Danish (*N* = 163) also has a relatively high proportion of reproduction tasks (*procedure* 36% and *drilling* 13%). Mathematics (*N* = 163) stands out as having by far the highest proportion of drilling tasks (56%), whereas science (*N* = 125) is the only subject of the three where *explanation* (38%), *creative task* (11%) and *reflective argument* (3%) taken together constitute more than half of the collected tasks.

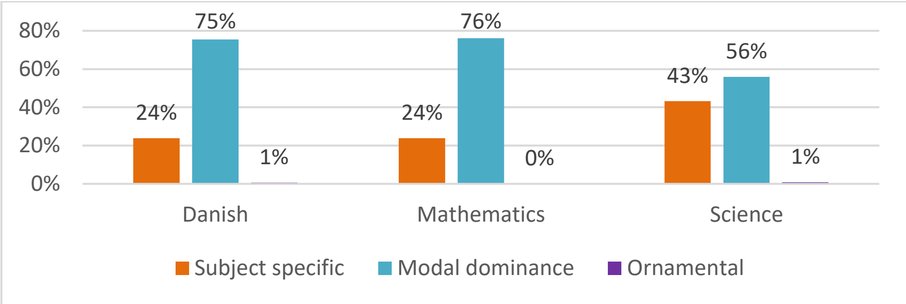
Figure 2. Task types distributed on subjects. N = 451.



5.1 Students' use of multimodality

With regards to the category *multimodality*, we scored the student products in the following manner. If the different modalities used in the student product support the representation of the subject-specific content, it was scored as *subject specific*. If they are used predominantly as decoration and without real relevance to the content, it was scored as *ornamental*. If one single modality dominates the meaning making in the student product, it was scored as *modal dominance* (cf. Appendix 2, Figure B). Among the collected material (*N* = 451), there is a predominance of student products with modal dominance (70%), which indicates that multimodality is not the usual means of expression for students in Denmark when doing productive work in school. However, a number of interesting differences between the three subjects in question are hidden behind this general picture as indicated by Figure 3 below.

Figure 3. Multimodality distributed on subjects. N = 451.



Danish (*N* = 163) and mathematics (*N* = 163) both have a high proportion of student products with *modal dominance* (Danish 75% and mathematics 76%). This could lead one to believe that Danish and mathematics are similar regarding the students' use of multimodality, but a deeper analysis reveals a different picture and show that they differ considerably. In Danish, the student products are characterised by modal dominance consistently throughout all the grades in primary and lower-secondary school (73% in Grade 1-3, 75% in Grade 4-6 and 78% in Grade 7-9). In mathematics, on the contrary, there is a significant drop in the proportion of *modal dominance* when distributed on grades (85% in Grade 1-3, 81% in Grade 4-6 and 46% in Grade 7-9).

The student products were also examined with regard to the use of specific modes of representations (the categories "functional dominance" and "secondary functional dominance", cf. Appendix 2, Figure B). Further analysis of the data shows that the vast majority of student products with modal dominance only uses a single modality and may therefore be termed mono-modal. Thus in Danish (*N* = 163), we found that the written language dominates the vast majority of student products (74% of all the student products in Danish). Put together these results paints a picture of Danish with regard to students' productive work as a mono-modal subject dominated by the written language (see Figure 4).

This may not come as a surprise for members of the L1 community as the written language is a key component in L1. Nevertheless, we maintain that the limited use of multimodality is quite remarkable, at least in a Danish perspective, since multimodality, as an essential element of modern communication, is actually an integrated part of the Danish National Standards for L1 as mentioned in the introduction.

Figure 4. A typical example of a mono-modal student product in Danish. In the text, the student describes Denmark. The title means "The beauty of Denmark".

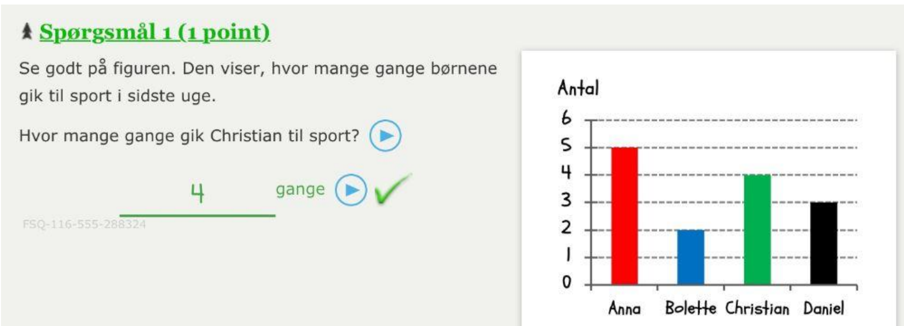
Det smukke ved Danmark

Jeg synes, der er mange smukke ting ved Danmark. Og en af tingene er… At her er jeg født. Det er mit hjem, og det er her, jeg føler mig allermest hjemme. Det er her, jeg har mine venner og familie. Det er her, jeg kan tænke over tingene, og det er her, jeg kan sidde, og kigge ud ad vinduet, og ikke kunne lade være med at smile, fordi det er så smukt. Vi har den smukkeste natur, som skifter udseende efter årstid, vi har rettigheder, men allervigtigst friheden. Friheden til at være sig selv og friheden til at kunne have sin egen mening. Noget af det vigtigste for mennesker, eller i hvert fald for mig, er frihed, og det kan man finde i dette lille helt fantastiske land, Danmark. Man har brug for frihed til komme igennem sit liv, og man har brug for at kunne komme ud med sine holdninger og værdier. Ja, det smukke ved Danmark er friheden. Vi er heldige med at vi har frihed i Danmark, for jeg kender en masse lande, hvor mennesker lever i diktatur. Det synes jeg ikke er okay, alle lande, alle mennesker skal have ret til frihed. Så er det fair over for de mennesker, der ikke selv må bestemme over deres egen liv? Så tak Danmark, fordi vi har så meget frihed.

Når jeg løber min sædvandlige søndagstur og tænker ”hvad er egentlig det smukkeste ved Danmark” kan jeg se alt, lugte alt, høre alt. Fuglene synger de smukkeste sange, vandets bølger

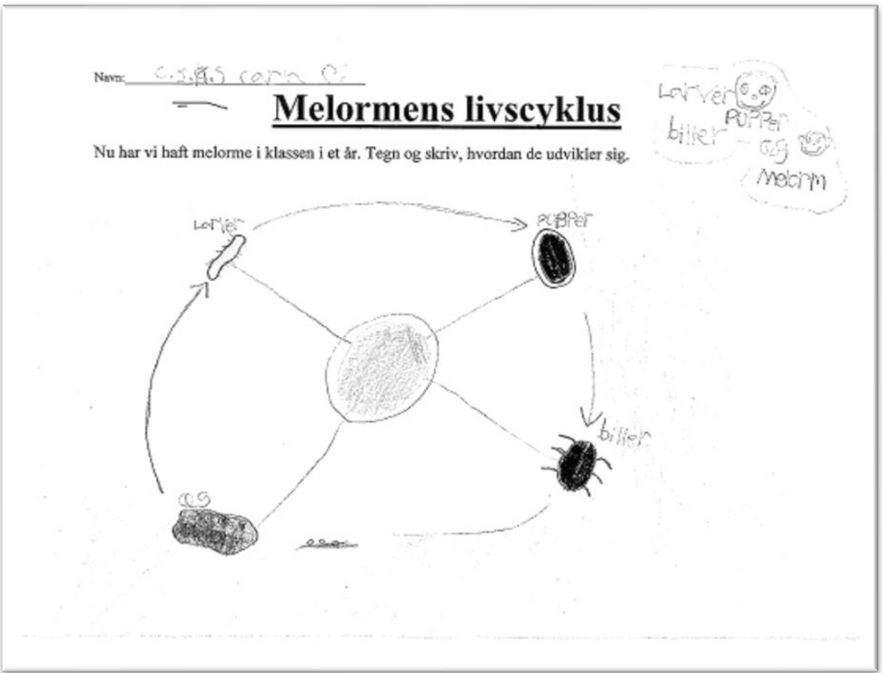
In mathematics, the large number of mono-modal student products is to a great extent related to the high proportion of drilling tasks (cf. Figure 2) because these are tasks where the students must insert their answer in a predefined template with limited opportunities for a varied use of modalities (see Figure 5). The proportion of drilling in mathematics in Danish schools is a noteworthy result in itself. At the same time, apart from drilling, the use of multimodality is quite frequent in the other types of student products in mathematics.

Figure 5. A typical example of a drilling task in mathematics. The Figure shows the number of times four children have participated in sports activities. The students are asked to enter the number of times the boy Christian has participated in sports activities.



In science, as compared to Danish and mathematics, this study shows a more consistent use of multimodality in the student products throughout the grade levels. The student product reproduced below in Figure 6 is an example of a multimodal student product in science. It shows the life cycle of a meal worm and the student has sketched the cycle from egg to larva, from larva to pupa, and from pupa to beetle.

Figure 6. A student product in science titled "The life cycle of the meal worm"



In this example, the visual mode (drawing of egg, larva, pupa and beetle), the diagrammatic mode (the cyclic model with rounded arrows connecting the various stages of development) and the mode of writing (the names of the various stages) support and complement each other in the student's explanation of the life cycle of the meal worm. The example may serve to illustrate that in science the use of multiple modes of representation of subject-specific content is an integrated aspect of the subjects' discourse and epistemology (Maagerø & Skjelbred, 2010; Smolkin & Donovan, 2004; Wellington & Osborne, 2001). With the exception of the products related to drilling, the student products in mathematics illustrate a similar point regarding the use of multimodality as an inherent aspect of mathematical discourse (Maagerø & Skjelbred, 2010; O'Halloran, 2005).

The scarceness of multimodal student products in Danish can, by comparison, be interpreted as an indication that multimodality is not at this point an integrated element in the subject-specific epistemology of Danish as L1. This sheds a certain paradoxical light over the fact that in the Danish National Standards, that have recently been revised, multimodality is specifically related to the subject of Danish (UVM, 2015a).

5.2 Multimodality and functional learning materials

Subject-specific use of multimodality supports competent subject-specific communication. Hence, the obvious question is which pedagogical conditions support the subject-specific use of multimodality? The quantitative study offers some interesting answers to this question in relation to the students' use of various learning materials (or technologies) when doing productive work.

The study shows that particular kinds of digital learning materials have potential in terms of supporting students' subject-specific use of multimodality. We have named these learning materials *functional learning materials*, inspired by a typology of learning materials developed by Hansen and Gissel (2017). This type encompasses learning materials used as a tool or an instrument to produce content and which do not present a specific content. (Examples of functional learning materials are *Movie Maker* for movie production, *Prezi* for presentation, *Word* for word processing and *GeoGebra* for geometric construction.) Regarding the question of multimodality, the data indicates that functional learning materials support the use of subject-specific multimodality in student products (see Figure 7).

Figure 7. Multimodality distributed on functional learning materials or non-functional learning materials. N = 451.

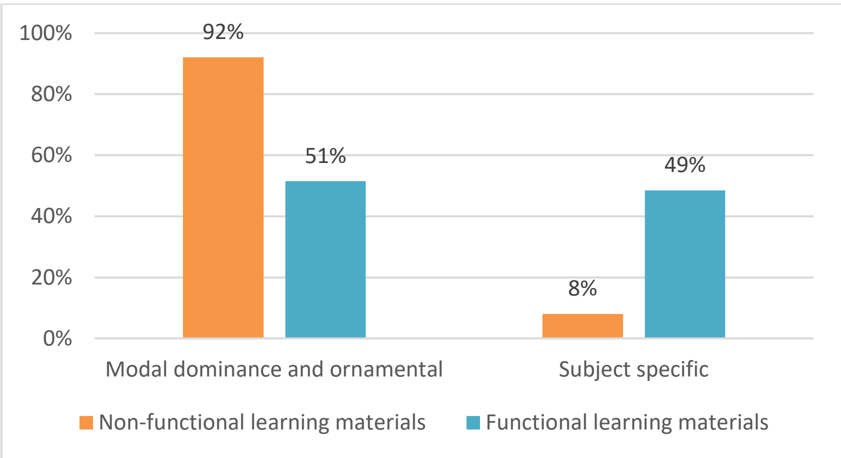
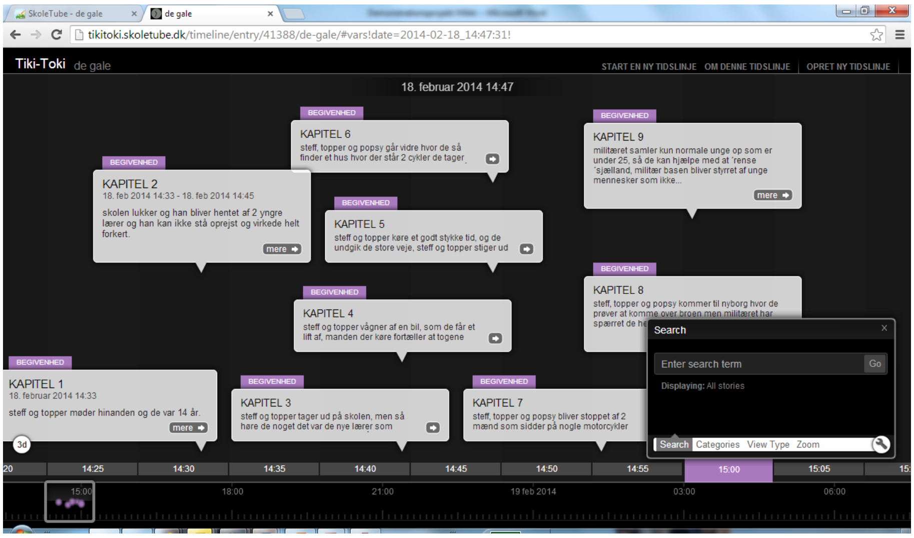


Figure 7 shows that the students' use of subject-integrated multimodality is significantly higher when the students employ a functional learning material than when they do not. An example may illustrate the interaction between functional learning materials and the students' use of subject-specific multimodality. The example is from Danish grade 9 and illustrates how students use a functional learning material (*Tiki-Toki*) to represent the composition of a novel, in this case the novel *De gale* (*The Crazy Ones*) by the Danish author Kim Fupz Aakeson (see Figure 8). In this example, the students employ the functional learning material *Tiki-Toki* to create a timeline linking the ten chapters of the novel with the development of the characters. Every chapter frame contains links to pictures and, in some cases, also sound bites that supplement the written description of the chapter. Thus, the functional learning material permits the students to make a multimodal representation of their interpretation of composition of the novel.

Thus, the results here indicate that functional learning materials support the students' subject-specific use of multimodality. Furthermore, it is interesting to note that the quantitative study also points to a connection between the use of functional learning materials and students' use of subject-specific terminology and procedures. In combination, these results indicate that the use of functional learning materials supports subject specific communication on the part of the students.

Figure 8. Screenshot of a group of students' use of the functional learning material Tiki-Toki to create a timeline for a novel.



6. STUDENT PRODUCTION AND MULTIMODALITY QUALITATIVE FINDINGS

As mentioned earlier, the purpose of the qualitative part of the study was to examine whether and under which conditions in an actual teaching context the learning potentials indicated by the quantitative study are actually manifested in the students' subject-specific learning. As pointed out in the previous section of the article, these learning potentials relates to task types, specifically *explanation*, *reflective argument* and *creative task*, and to the use of functional learning materials. In the qualitative part of the study, we did classroom observations in three thematic units in Danish, science and mathematics, and a basic criterion for selecting the classes/thematic units were that the students would be using functional learning materials and working with the above-mentioned task types. In the unit in Danish, the task was a creative task, in mathematics an explanation and in science a reflective argument. The Danish unit was carried out in 6th grade, the mathematics unit in 5th grade and the science unit in 8th grade.

An important result of the classroom studies is that it is difficult to realize the learning potential of the above-mentioned task types and learning materials due to a number of different barriers that arise in the teaching situation. In this section of the article, we will describe the three most important of these barriers. The multimodal aspect of the students' productive work will be the pivotal point of the description and we will include and compare examples from all three classroom studies (Bremholm, Hansen & Slot, 2016b).

6.1 Key barrier 1: Technology displaces the content

In all three cases, the digital production and use of multimodal forms of expression tend to displace the focus in the productive process away from the specific content and towards more formal and technical aspects of the productive work. This is the case for the students as well as for the teachers. The absence of a clear subject-specific focus is manifested by a limited degree of subject-specific use of multimodality in the products. As a result, the three subject units are all characterized by the dilution, and in some instances, even the depletion of the subject matter content in the students' productive work.

The Danish unit may serve as the first example. In this unit, the students work with poetry. They are introduced to and work with different poetic genres (expressive poetry, nonsense poetry, haiku), and in the final task they are asked to compose a poem of their own generic choice and to present it in a multimodal form to be shown at an in-school exhibition for the 4th and 5th graders. The students' compositional criteria when working on the multimodal presentation of their poems illustrate the point above (see Figure 9 below). At this stage of the productive process, the students devote most of their time and attention to the search for pictures on the website *Candy Wallpaper* and they are particularly occupied by the technical qualities of the pictures (number of pixels, etc.). Neither during class nor in our interview with them, do the students reflect on the role and function they want the pictures to have in relation to their poem. In other words, they do not reflect on the multimodal meaning making in their product. Thus, it is questionable if these student products qualify as subject-specific use of multimodality.

Figure 9. An example of a multimodal poem made by a student in the Danish unit. The poem depicts the movement of different kinds of sweets in a child's stomach.

The students' lack of focus on the content dimension of their multimodal production corresponds to the teacher's feedback during the productive process. Thus, like the students, the teacher is preoccupied with the technical aspects of the students' productive work as demonstrated when she gives her final evaluation of the students' products just before the exhibition. Here she does not address the interplay between modalities as a key aspect of multimodal meaning making. Instead, her focus is solely on the ornamental function of the pictures as illustrated by this short extract (our translation):

Teacher: NN [Student's name], now it is your turn to perform your poem… Did you do this all by yourself?
Student A: No, my mum helped me…
Teacher: Oh, your mother helped you… This is really good… It is very, very good. It looks a bit like patterns made by American Indians. Very good, NN [student's name]

In the mathematics unit, the students produce small films in the form of screencasts (so called pocket films) on the construction of geometric figures using *GeoGebra* (a functional learning material for mathematics). In this case, the technological displacement of the content matter takes place, for example, when a group of students chooses to add background music to their film. The music has no relevance to the geometric explanations in the film, but rather undermines the subject-specific communication in the film. This happens partly because the music is a kind of muzak, which constitutes a confusing breach of genre in the film, and partly because the background music drowns out the voice-over with the students' geometrical explanations in some stretches. When questioned about their use of background music, the students did not offer any other reason or intention than the fact that it was a technical possibility, as the following excerpt from our interview with one of the students illustrates (our translation):

Student B: That is because that way we could try it ourselves. First, we tried to listen to some music, and then we found some good music, and we thought that we would put it in because then you also have something to listen to, sort of.

In both of these examples, the multimodal resources are not used in a subject-specific way but rather as a kind of ornamentation or embellishment.

Both examples also illustrate another important point: That the dilution or weakening of the content matter in the student products may be explained, in part, by the lack of scaffolding of the students' productive process. The students hardly receive any feedback in the course of their work and as a consequence, they are not urged to reflect on and to monitor their work in progress, including the subject-specific focus of their product. The lack of scaffolding leaves them free to wander off into purely technical or decorative pursuits, so to speak. In the following section, we will describe this barrier in more detail.

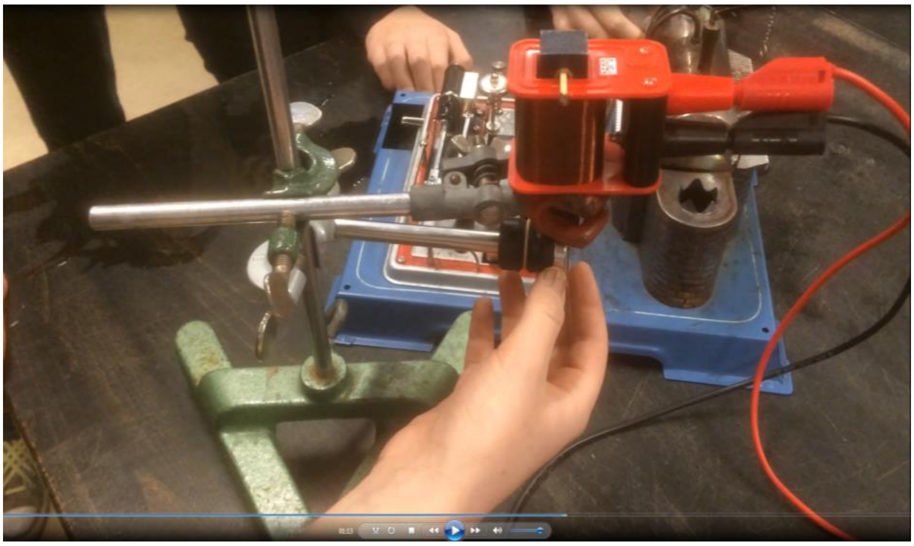
6.2 Key barrier 2: The absence of scaffolding

The students' productive process is strongly influenced by the way the process is organized and framed, or in other words by the degree of scaffolding which supports it. An essential aspect of scaffolding consists of feedback regarding the students' preliminary product and work process (Christensen, 2015; Hattie & Timberlay, 2007; Sawyer, 2006) and in the model of task-based pedagogy (cf. Figure 1), we operate with two main types of scaffolding, structured and situated scaffolding.

We understand structured scaffolding as planned teaching sessions focusing on feedback (e.g. teacher guidance, group conferences or peer-to-peer response), whereas situated scaffolding represents the kind of scaffolding that takes place when the teacher *in situ* and based on a quick diagnosis of the students' need for support regarding their productive work offers the students instantaneous feedback (Bremholm & Slot, 2018; Brush & Saye, 2002).

Both structured and situated scaffolding of the students' productive process is virtually absent in the three cases. As a consequence of this absence, there is no subject-oriented guidance of the students' productive work during the work process and this constitutes a serious barrier to the realization of the above-mentioned learning potentials related to multimodal productions and certain task types. The following example from the science unit illustrates how a lack of situated scaffolding has an important impact on the quality of the students' subject-specific communication and on their understanding (and learning) of the scientific phenomenon in question.

Figure 10. Screenshot from student documentary on "Electricity at home".



In the science unit, "Energy—now what?", the students are inquiring about a problem related to energy and energy consumption in their local community and based on their inquiry they are required to produce a short documentary. One of the groups is working on the topic "electricity at home" and their documentary includes a sequence with an experimental set-up with a steam engine, which has the purpose of explaining the principle of energy conversion (see Figure 10 above).

This sequence is interesting because it is an example of a causal explanation of a scientific phenomenon (kinetic energy converted to electricity) using a multimodal form of representation (primarily image and spoken language). The voice-over of the student is reproduced below. The student supports his explanation by pointing to different parts of the experimental setup (i.e. the gestural mode).

> [Voice-over by student]:
> So, this is the way that electricity is being produced. It is being heated using this gas burner. And in here there is a lot of water. And then it changes to steam. And then a massive pressure is created down here. And then we have to open this one so that the pressure can get out and set this one in motion. And then there is kinetic energy up here. And so, this is the core of it all because it is a magnet, and when it starts turning, it sends electricity down through the wires, kind of, so that we get light in the light bulb. And then over here we can see how many volts of energy that are actually there. (our translation)

On the surface, the sequence appears to be an almost exemplary use of subject specific multimodality on the part of the students. The students use the possibilities of the technology to activate different modal resources (speech, image and gesture) in a meaningful interplay that both represents and supports subject-specific communication using relevant scientific terms and concepts. In this sense, the sequence appears to be an example of independent construction of scientific knowledge on the part of the students.

However, the relevance of situated scaffolding presents itself when we scrutinize the situation a little closer. The oral explanation in the film (i.e. the students' articulated understanding) which at first seems to be quite adequate, actually turns out to have a serious 'gap'. This 'gap' occurs at the point in the explanation identified by the voice-over as "the core of it all". That is, around the electromagnet and the conversion of kinetic energy generated by the steam engine into electricity (flow of electrons). At this point, the student voice-over leaves the scientific explanation in favor of an almost magical explanatory model when establishing that the magnet as it rotates, sends current through the wires (note that the student does not use the more accurate term "electromagnet"). Judging from the sequence, the students in the group have not acquired a basic understanding of this essential aspect of the process. Our subsequent interview with the student who did the voice-over confirms this conclusion.

Furthermore, the science teacher was present in the science lab and watched the students' experiment, both the trials and the final recoding. Thus, the teacher had the opportunity to direct the students' attention to the gap in their explanation and to discuss the phenomenon of electromagnetism with them or ask them to investigate it further. In other words, the situation presents an opportunity for situated scaffolding and presumably the students would have profited considerable in terms of learning if they had received instantaneous feedback from the teacher about the scientific phenomenon they are striving to understand and explain. However, the teacher chooses not to use this opportunity—or maybe he does not notice it at the crucial moment in the situation. Whatever the case, the lack of situated scaffolding becomes part of the reason why the full learning potential of the students' productive work is not realized in this example.

6.3 Key barrier 3: The students' perception of school subjects

Especially in the units in Danish and mathematics, it turns out that the students' perceptions of the school subjects also constitute a barrier to the realization of the learning potential related to multimodal production. The students' perception of what counts as 'real Danish' (as L1) and 'real mathematics' tends to hamper their learning benefits from doing productive work with a focus on multimodality and independent knowledge construction.

In the Danish case, many of the students do not regard working with images and other visual modalities as valid content in the Danish L1 classroom. When interviewed, several students explain how they spend a lot of their free time at home making different kinds of digital productions, such as photo editing, product designs, film and digital narratives on snapchat. However, they find it difficult to see the connection between these activities and the skills relevant in the Danish classroom they are accustomed to, as illustrated by this extract (our translation):

Interviewer:	Do you think you'll improve your skills in Danish when you work with editing photos and films at home?
Student C:	No.
Student D:	No, I don't think so.
Interviewer:	Why don't you think so?
Student C:	I don't know. Well …
Student D:	It hasn't got anything to do with Danish that we just sit there editing films. Perhaps we'll be better at those presentations that we are going to do. Digital presentations and that kind of thing. Like that, we might improve our Danish skills.
Interviewer:	What are Danish skills in your opinion?
Student D:	That is how well you read, and how well you write.
Interviewer:	Right. So, being able to edit a film, and knowing which background is the best, that isn't really Danish?
Student C and D	(simultaneously): No!

Although the students all agree that the unit with multimodal digital production has been interesting and amusing, their comments imply that they do not consider these kind of activities to be as serious and valuable as reading and writing which in their view represent the real "Danish skills". A review study on empirical research on the use of technologies in L1 in the Scandinavian countries supports this result as it flags up that Nordic students develop a wide palette of multimodal productive skills outside school, but that these skills are difficult to integrate in the L1 subject in school (Elf, Hanghøj, Skaar & Erixon, 2015).

In the mathematics unit, the students demonstrate a similar restricted view of mathematics as a school subject. Their perception of and approach to mathematics tend to be primarily related to facts and basic skills and less to comprehension and competences, which impedes the benefits they might obtain from doing multimodal productive work in terms of independent knowledge construction and in-depth comprehension. The students' geometrical pocket film (described earlier) illustrates the problem quite clearly. In the pocket film, the students explain the geometrical concepts of reflection, rotation and parallel shift, as shown in the following transcript of a sequence of the film (our translation):

> Voice-over by student: [reading out from the task] Draw an arbitrary pentagon and a vertical mirror line [the student chooses a function on the menu-bar and starts constructing the figure while commenting]. At first you just draw the pentagon, and then you go to the menu [moves the mouse to the menu bar] and click on line segment, and you make a mirror line [draws a line segment]. And then you click reflection in the menu, and then you click first on the figure and then on the mirror line, and then it moves to the other side [points with the mouse to the pentagon that has now appeared].

The task requires the students not only to show how to construct reflections, rotations and parallel shift using Geogebra, but also to explain in their own words what characterizes these geometric concepts and to reflect on their possible use. In the transcript, we see that the students focus on the purely skill-based elements of the task, while ignoring the more cognitive demanding elements (explaining and reflection) that would involve independent knowledge construction on their part, and that would, at the same time, provide an insight into their deeper understanding of the mathematical content. The mathematical students' orientation towards basic skills also manifests itself in the fact that, like the Danish students, they do not perceive their productive work as 'real mathematics'. When interviewed, they point out that when this experimental unit is over, they are certain their class will return to "normal math". By this, they refer to teaching based on textbooks or web-based teaching portals and centered on predefined tasks (cf. the dominance of *Drilling* in mathematics as mentioned previously).

6.4 The barriers are not the whole story

Based on the close analysis of three subject units—that on the surface constituted exemplary cases regarding students' subject specific communication—we have presented and described three important barriers regarding students' multimodal productive work. By throwing light on these barriers, the qualitative part of the study adds nuance and complexity to the quantitative part inasmuch as it identifies a number of factors that influence the extent to which the potentials related to students' productive work are in fact realized in actual teaching.

As a final remark in this qualitative section of the article, it is fair to mention that, notwithstanding the various barriers, all three cases also include situations where the students through their productive work show tendencies to integrate and combine 21st century skills and subject-specific competences. The example from the mathematics case presented above may serve as a quick illustration. In spite of the described deficiencies of the product, the students show in their pocket film how they are able to use multimodal forms of representation to communicate mathematical content. Thus, the productive work the students are doing supports the development of important mathematical competences (i.e. communicative competence in mathematics and technical competence in mathematics, cf. the National Standards in Mathematics (UVM, 2015b). Similar examples occur in the Danish case as well as in the science case.

7. CONCLUDING REMARK

In this article, we have presented findings from the mixed methods study *Tasks and student products in the 21st century* focusing on the students' use of multimodality in their productive work. The study is based on a large sample of tasks and student products across grades in Danish, mathematics and science in primary and lower secondary schools in Denmark and thus it provides an interesting picture of the actual task-related practices in Danish schools at the time of the sample. This picture reveals that there is obvious potential related to students' multimodal productive work as a means to support the students' subject-specific communication and learning. However, as illustrated repeatedly throughout the article, the study also points to considerable challenges regarding the realization of these potentials and to sum up, we would argue that the challenges dominate the overall picture of the task-related practices in Danish schools. The challenges specifically relate to the research questions set forth in the article:

a) Regarding the question how do students use multimodal resources in their productive work in L1, science and mathematics, the study shows that multimodality is not an integrated aspect of students' productive work in Danish as L1. A very small proportion of student products in Danish make use of multiple modalities and this study shows Danish to be largely a mono-modal subject dominated by the written language. This is not the case to the same extent in science and mathematics (in the upper grades), where the students are more prone to apply multimodal forms of expression in their student products. This could indicate that in science and mathematics multiple modes of representation of subject-specific content are to a larger degree an integrated aspect of the subjects' discourse and epistemology than in Danish as L1. If so, it appears paradoxical that the Danish National Standards specifically links multimodality to the subject of Danish.
b) We also asked to what extent the use of multimodality in the student products supports subject-specific communication. Regarding this question, an important result from the quantitative part of the study is that functional learning materials appear to hold particular learning potentials, and the same is the case for the task types "explanation", "creative task" and "reflective argument". However, the classroom analyses from the qualitative part of the study show that it is quite difficult to realize the learning potential of

these learning materials and task types, in particular when the students' subject-specific learning is also brought into the equation. This is due to a number of barriers in the instructional setting, among which the most important are: The fact that the digital technologies tend to displace the subject-specific content in the students' productive work; the insufficient scaffolding of the students' productive processes; and the students' traditional perceptions of the school subjects (focusing on rote learning and a restricted and conventional use of modalities), which is indicative of a traditional task-related practice in the subjects. Existing research confirms the importance of scaffolding for the quality of student products (Capobianco, Nyquist & Tyrie, 2013; Fuchs et al., 2000; Parsons, 2008). Likewise, both the studies of Khoh & Luke (2009) and Matsumura & Pascal (2003) mentioned earlier point to conventional task-related practices as an impediment to the implementation of more meaningful and intellectually challenging approaches to students productive work.

In summary, our empirical study of what one might term the productive practice in schools in Denmark indicates that conventional approaches to students' productive work tend to dominate in Danish classrooms. Furthermore, and as a consequence of this situation, the obvious possibilities and potentials of students' productive work as a supportive vehicle for the students' subject-specific communication and learning are far from being exploited.

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APPENDIX 1: DISTRIBUTION OF COLLECTED TASKS AND STUDENT PRODUCTS ACROSS GRADE LEVELS

Student tasks and products		
Grade 1-3	Danish	45
	Mathematics	67
	Science	45
Grade 4-6	Danish	59
	Mathematics	57
	Science	50
Grade 7-9	Danish	59
	Mathematics	39
	Science	30
Total		451

APPENDIX 2: SCORING RUBRICS

Figure A. Scoring rubrics for tasks

Type of task	Mode	Scaffold	Organization	Framing	Differentiation
• Drilling • Procedure • Explanation • Reflective argument • Creative task • Cannot be determined	• Written • Oral • Cannot be determined	• Step-by-step • Method • Content criteria • No scaffold • Cannot be determined	• Individual • Group (without defined roles) • Group (with defined roles) • Cannot be determined	• High • Low	• Yes • No

Figure B. Scoring rubrics for student products

ICT	Documentation of process	Multimodality	Functional dominance	Secondary functional dominance	Content domain	Organization	Process
• No use of ICT • Production • Communication • Searching • Data gathering • Analysis • Calculation • Drill and practice	• No documentation • Screen cast • Sound recording • Video recording • Other documentation	• Modal dominance • Content specific • Ornamental	• Visual • Diagrammatic • Linguistic – written • Linguistic – oral • Symbolic • Sound • Layout	• Visual • Diagrammatic • Linguistic – written • Linguistic – oral • Symbolic • Sound • Layout	• Terminology • Procedure • Method	• Individual work • Group work	• Meta-communication • Transparency