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LEARNING TECHNOLOGY AND PATTERNS OF TEACHING

Aprendizaje de la Tecnología y patrones de enseñanza

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Abstract:
There is a statistical correlation between types of teaching methods and types of digital learning materials used in Danish state schools. Especially when it comes to "presentational learning materials", a category which subsume digital textbooks and larger systems and portals characterized by a looser coupling between subjects and courses than the linear progression that characterises the chapter structure of a textbook. This is a finding in a major new study undertaken in 2012-2014 by Rambøll Management Consulting and Boston Consulting Group, within an empirical and theoretical framework developed by Jeppe Bundsgaard and the author. This is partly due to a review of international research in the impact of digital learning materials, and partly due to a theoretical framework with typologies of teaching patterns and digital learning material. This article will present the central parts of the theoretical framework, selected results, and ends with a critique of methods used in the collecting of empirical data with a view to future research in the connection between digital learning materials and teaching patterns.

Resumen:

Existe una correlación estadística entre los tipos de métodos de enseñanza y los tipos de materiales de aprendizaje digitales utilizados en las escuelas públicas danesas. Especialmente cuando se trata de "materiales de presentación de aprendizaje", una categoría que subsume los libros de texto digitales y sistemas más grandes y los portales se caracterizan por un acoplamiento más flojo entre los sujetos y los cursos que la progresión lineal que caracteriza la estructura de capítulos de un libro de texto. Este es un hallazgo en un importante nuevo estudio llevado a cabo en 2012-2014 por Rambøll Management Consulting y Boston Consulting Group, dentro de un marco empírico y teórico desarrollado por Jeppe Bundsgaard y el autor. Esto se debe en parte a una revisión de la investigación internacional en el impacto de los materiales digitales para el aprendizaje, y en parte debido a un marco teórico con tipologías de patrones de enseñanza y material de aprendizaje digital. En este artículo se presentará la parte central del marco teórico, los resultados seleccionados, y termina con una crítica de los métodos utilizados en la recogida de datos empíricos con miras a futuras investigaciones en la conexión entre los materiales de aprendizaje digitales y los patrones de enseñanza.

1. Introduction

The aim of this article is to set focus on the relation between digital textbooks and other digital learning materials that have a didactic design and built-in goals, content, and methods on the one hand, and use of digital learning materials as part of an integrated teaching pattern on the other. Such a focus draws attention to the relationship between potential and actualisation, intentional and realized impacts. The background for this is a major review and subsequent theoretical development of a research design in order to analyse the impacts of digital learning materials.

It must be stressed here that Rambøll Management Consulting and Boston Consulting Group did not chart the real impact, but only the perceived impact. The study was undertaken using two extensive surveys, distributed through a representative sample of schools (477) with teachers (1450) and school heads (400) as respondents, and a qualitative follow-up with 194 detailed interviews with teachers from 31 schools.

The study presents three findings which are relevant in this context. Firstly, by far the main part of teaching with digital learning materials in Danish state schools is dissemination and exercise at 69 % (Rambøll & Boston, 2014, appendix 2: 5). Secondly, the majority of digital learning material used with a built-in educational design is directed towards transmission and training. Thirdly, there is a correlation between the types of learning materials and teaching patterns that teachers prefer (Rambøll & Boston, 2014, p. 26 ff.). However, there is little project-based teaching with digital learning materials that simulates practices in the real world (Rambøll & Boston, 2014, p. 24).

Overall, the study paints a picture showing that the most widespread teaching with digital learning materials is one which many observers will describe as traditional because it has a long analogous tradition prior to the introduction of ICT in Danish state schools. In other words, use of digital learning materials does not appear to alter the fact that teaching mainly aims to convey knowledge and train skills. There are not many signs that digital learning materials are used as a means to transform teaching toward more progressive patterns of teaching scaffolding pupils' skills in collaborating on real-life problem solving.

2. Research in digital learning materials and teaching patterns

The results of the study contrast with the enthusiastic approach to ICT in schools, which often characterises political discourse and the aspects of research in digital learning materials that focus primarily on opportunities ICT can provide.

ICT has great potential in relation to many of the process and structure elements that characterise good teaching and cooperation in, for example, portfolios, knowledge sharing, performance management, evaluation, and a clear structuring of activities. The problem is, however, that it is not possible to conclude from what one can do in theory and to transfer this to what can be done in practice. There is not a simple causal relationship between technological potential and didactic actualisation. This is confirmed by many international metastudies and analyses that point to the influence of the context for the effect of ICT in teaching (Hattie, 2009, p. 220 f.; Tulodziecki, 2010, p. 81 ff.).

Richard E. Mayer sums-up criticism of the enthusiastic approach to technology in teaching in the OECD report *Nature of learning* (Mayer 2010, p. 180 ff.). Mayer notes the many excessive claims about the potential of new technology in relation to transforming education and training, and how very few of these claims have been substantiated or tested systematically or scientifically (Lowe & Schnotz, 2008; Mayer, 2009; O'Neil & Perez, 2003/2006; PyllikZillig, Bodvarsson & Bruning, 2005; Reiser & Dempsy, 2007; Rouet, Levonen & Biardeau, 2001; Spector *et al*. 2008).

What counts as a systematic science is a lengthy. In this context it is suffice to note that the most enthusiastic technological research is often based on small qualitative studies where ICT has made a difference locally in special circumstances.

With this in mind one cannot simply generalise and give reasons for global effects. For the same reason ICT use is ranked low on John Hattie's overview of factors that influence pupils' learning. For example, computer-assisted learning is ranked number 71 with an effect below the average when compared with other types of effort (Hattie, 2009, p. 298). In other words, ICT *can* make a difference in teaching but rarely *does so* in practice.

International research in ICT and digital learning materials cannot only be used to criticise the technologically enthusiastic short-circuiting from technology to impact. It can also be used more constructively and inspire next practice. Instead of showing unique causalities, it points to correlations that create possible positive effects of an action. Thus, it is possible to highlight appropriate patterns in both the immediate learning environment and the school context.

In the learning environment it can be recommended to, for example, use computers as a supplement to teacher-led instruction, though not as a substitute for a teacher. It is also an advantage if there are several teaching strategies at work; if the pupils are to be included in their learning process; if they are willing to manage their learning process; if they work together rather than individually; if they have didactic practices in relation to working together; and if the teacher provides content-filled feedback instead of letting assignments, automatically corrected by the computer, replace interaction between the teacher and pupils (Hattie, 2009, p. 220.ff.).

Finally there is research providing information about the choice and use of digital learning materials, creating a greater awareness of probable links between types of digital

learning materials on the one hand, and types of effects in relation to teaching and learning on the other.

3. Know the impact of your digital learning materials

As the title of this section suggests, it is possible to twist Hattie's common theme in *Visible learning*. Teachers must be aware of their impact on their pupils' learning. Similarly, they should know the effect of their use of digital learning materials. This applies both in relation to pupils' learning and the teaching patterns affected by the digital learning materials. Formulated with four key 'wh-' questions in theory-based evaluation they should know which digital materials work, for whom, how, and under what circumstances.[i] By making the four key 'wh-' questions in theory-based evaluation the basis for a systematic use of digital learning materials, these materials can become a focal point for ongoing evaluation and help development of teaching. The starting point is the user's preconceived notion of the prototypical impact of learning materials. This is an idea that can be communicated on the basis of learning material research. Therefore, Jeppe Bundsgaard and the author have searched the Danish market for didactic digital learning materials and divided them into prototypes from the theories about learning and teaching which are reflected in their didactic design. Didactic digital learning material is computer-based learning material with a built-in educational design that has a prototypical effect because the design is based on a number of choices concerning objectives, content, expression and method.

The division into types is inspired by Koschman (1996) and Sawyer (2005), who distinguish between different paradigms in digital learning materials and educational trends. We use the term 'prototype' because it is not strictly a case here of paradigms as defined by Thomas Kuhn in *The Structure of Scientific Revolutions* (1962). Kuhn used the term in order to describe the disciplinary matrix that structures a normal science. As an alternative we use the term prototype from cognitive linguistics (Rosch 1978 & Lakoff 1987), which describes more loosely-structured domains with 'fuzzy' boundaries and grey areas (Hansen, 2011, p. 165 ff.). The point is that there is not a discussion about large incommensurable science paradigms, for example, the geocentric versus the heliocentric world picture, but about smaller educational trends that manifest themselves in artefacts such as different types of digital learning materials.

Thus, we distinguish between four prototypes, which are characterised by different perceptions of learning, knowledge and interactivity: "repetitive learning materials", "presentational learning materials", "scaffolding learning materials" and "practice scaffolding learning materials".

4. Repetitive Learning Materials

Repetitive digital learning materials can both have the form of training programs, learning apps, learning games and learning objects, where you have to solve a particular sequence of tasks. Common to them is that they are designed for repeatable training of simple routines, procedures and facts. It can be arithmetic, grammar, or clearly restricted subject-specific theory (for example photosynthesis or plate tectonics). The learning materials are based on the idea that the subjects and subject-specific domain can be divided

into smaller, clearly structured knowledge packages that make it possible to train them more or less independently of a greater understanding context.

Their self-instructional nature with automatically marked assignments suggests individual tasks where the machine initiates, the pupil responds and the machine gives feedback. The interactivity of the learning material resembles a familiar form of interaction in the classroom, termed I-R-F due to the action pattern of initiation, response and feedback.

The teacher, however, is replaced by a computer that assists the pupil. Hence the term ”computer assisted instructions” (CAI) and more generally what Koschmann describes as a CAI-paradigm (Koschman, 1996, p. 5 ff.).

The CAI-paradigm has been heavily criticised for being based on a behaviouristic view of learning and producing knowledge in an abstract, compressed and simplified form. A more nuanced criticism is required. Although the behavioristic learning theory has difficulty in explaining complex mental phenomena and interpretation, most learning processes contain a behavioural dimension. The learner must automate knowledge through repeated stimulus, response, and feedback.

The best repetitive learning materials can be used to support automation if they have sequenced tasks, a good design for interaction and are used to support what Hilbert Meyer has called intelligent training (Meyer, 2006, p. 100 ff.). Thus they can be used as supplying material in combination with digital textbooks.

On the one hand, they must be designed so that pupils have to be active, have time for the tasks, can choose the tempo, get private feedback, receive an immediate response and can take advantage of the machine's unlimited patience.

On the other hand, the teacher needs to design the teaching, so that training is not simply ‘more of the same’, but rather a strategy to create insight, overview and perspectives. Students should know why they are learning, and training must be varied with different types of content and challenges in order to increase learning outcome and transfer.

The problem with many repetitive learning materials is that they are filled with closed tasks, which inhibits the professional commitment and promotes a test-oriented education, which has a limited transfer effect where the learning outcomes are difficult to transfer to real-life problems, such as using one’s mathematical knowledge of equations to calculate gears on a bicycle, or the relationship between day and night charges for the bus or taxi.

In Denmark repetitive learning materials are distributed both as individual learning apps, and as complete packages or portals with many task modules or learning objects within the same genre, for example emat.dk, ElevLab, ABCity.dk and Matematikfessor. The majority consist of closed tasks for simple repetition, which can sometimes be difficult to determine at first sight if the tasks and portals are wrapped in superficial narratives and game logics. This applies, for example, to ABCity.dk, where one trains some of the more structuralist rules relating to beginner reading but the ’bitter pill’ is packed in a sugar-coating in the form of a ’Disneyfied’ universe with a narrative plot and a game logic that is built on the struggle between good and evil. Repetitive learning materials can also be found that are more suitable for intelligent training and repetition such as BigSeed, where one has to solve tasks in relation to mirroring and rotation. A common feature is, however, that they cannot stand alone, despite their self-instructional learning character. The user gets caught in a solution logic

where there is no didactic scaffolding or metacognition that can support the user when tasks become too difficult and when the acquired knowledge has to be related to a greater context of understanding.

5. Presentational Learning Materials

Presentational learning materials are transmission-oriented materials especially known as larger systems or portals that distribute knowledge within a discipline, a subject-specific domain or an interdisciplinary subject such as history, literature, or animals living in Denmark. An influential part of this category is digital textbooks which are characterized by their remediation of analogous features from the textbook. Thus they are defined by a linear progression and an interaction design grounded in a book metaphor. Another big part of presentational learning materials look like a digital version of a textbook, but differs while they are often characterized by a looser coupling between subjects and courses than the linear progression that characterises the chapter structure of a textbook.

Presentational learning materials are based on the instructional idea that skills and knowledge can be transferred and disseminated in a generalized form (Sawyer, 2006). This basic idea is often accompanied by a task-based approach in which students must process and assimilate the content communicated on the basis of activity suggestions.

Compared with the closed form of interactivity of the repetitive learning materials (stimulus-response-feedback), presentational learning materials have a higher degree of freedom and user control with a navigation structure, known from sites with tabs, drop-down menus and links. They support a flexible organization and implementation of training within the framework of a traditional lecture-based teaching. Teaching can be varied, as is known from the "flipped classroom" where the instruction takes place prior to teaching through video presentations. The basic axis is still the teacher's presentation and with pupils' ability to process information. Thus "flipped classroom" is not all that revolutionary, though it is sometimes presented as if it was.

Research on learning materials indicates that the learning effect is a variable that depends on several factors, for example, a) the degrees of conceptual abstraction, b) multi-modal correlation between particularly text and images, c) the progression of the task, d) the clearness of the instruction, and e) the appeal of the form and content, that is to say whether it is linked to the students, have an affective impact and encourages professional engagement (Brünken & Leutner, 2001, p. 357-366; Edling, 2006; Kay, 2006-2007, p. 412).

Presentational learning materials are typically produced for subject-specific teaching. It turns out, among other things, that they are marketed and sold with reference to particular contents and objectives in a curriculum.

The typical effect of presentational learning materials is that they support a subject-specific and lecture-based teaching and therefore promote subject-specific learning outcomes. On the other hand they rarely support innovative teaching, connecting the school to the outside world and promoting the pupils' development of general skills needed to succeed in the 21st century.

There are a number of extensive presentational and transmission-oriented learning materials in Denmark found as subject-specific portals, that is to say, platforms with many

texts, courses, tasks, and activities. Gyldendal's portal is, for example, built on courses with associated resources, while Clio Online's portal is built on activities with associated resources. Clio Online's portaler also has several automatically corrected tasks for repetitive training. Even though the presentational learning materials are transmission-oriented, these are also closely related to the repetitive materials.

6. Scaffolding Learning Materials

Scaffolding learning materials reminds of presentational learning materials, but they are built on a different axis than presentation-processing. The starting point is to better challenge the student and provide a scaffold for a process where the student works inquiry-based and experimentally with the subject-specific content. This can be done by incorporating simulations, interactive assistants, interactive dilemma questions or programming tools. The basic axis is challenge-inquiry.

The prototypical view of scaffolding learning materials is especially influenced by a tradition of developing visual programming languages such as Logo. This tradition goes back to Wally Feurzig in 1960 and has been continued by Seymour Papert and Mitch Resnick (Papert, 1980). They have been involved in designing and developing LEGO Mindstorm and Scratch, which allows the students right from primary school to program. Most recently, Douglas Rushkoff wrote a manifesto-like book that summarises the essence of this tradition in the book's title: *Program or Be Programmed: Ten Commands for a Digital Age* (2010). The point is that we become passive consumers if we only relate to the screen. The alternative is to use ICT to involve students in construction, programming and modelling.

Another example is digital learning materials with an I-D-R-F-structure (Wegerif, 2004:, p.182 ff.) that fundamentally change the I-R-F-structure, where 'D' stands for discussion or a similar dialogic phase scaffolded by the computer. This could be in the form of an interactive assistant, interactive dilemma game, or a sequence with explorative tasks. Thus, several producers on the Danish market have begun to incorporate digital tools for production and communication that can support an open and explorative process.

Scaffolding learning materials are based on cognitive, constructivistic learning theories that put the subject in the centre as the key actor and problematize the implicit transmission model for communication characteristic for presentational materials presented before. The point is that the subject itself must construct their knowledge through problem solving and interaction with the content, and it is this interaction, that is attempted to be scaffolded digitally. Therefore active acquisition of content is weighted rather than transmission, with the result that the interactivity of the learning materials has the form of structured dialogue and manipulation, and working with material, and processing substantial content (Bundsgaard & Hansen, 2013, p. 8 f.). Thus acquisition seems to offer another metaphor for learning than transmission.

Scaffolding engages pupils, assigns them a significant player role, supports the development of general cognitive skills and can gradually be taken down. A critical factor for scaffolding is that the scaffold can gradually be taken down. Roy Pea describes this feature as "fading" (Pea, 2004). Without fading scaffolding becomes prosthesis.

There has been a tendency in the past few years for some publishers to build in dialogic elements, simulations, process tools, and interactive assistants in learning materials

that are similar to the transmission-oriented. The consequence is a kind of didactical redesign of digital textbooks . This applies to, for example, iLitt.dk and iSkriv.dk, where the user is faced with challenges and has to cooperate with support from interactive assistants in order to obtain knowledge and complete tasks within a traditional literature analysis and a genre pedagogical universe. As digital learning materials can versioned and redesigned, and the dialogic and scaffolding elements can be in-built , the development of scaffolding end learning materials can take the form of a gradual transformation from transmission-oriented digital textbooks towards more scaffolding-end learning materials. This development adds to the difficulties that can occur with clear categorisations based on distinguishing features.

7. Practice Scaffolding Learning Materials

The last type of learning material is also scaffolding, but it differs in the higher amount of support for a practice community, such as a professional practice as a journalist, engineer or politician. The design for learning typically draws on different types of project-oriented teaching, such as inquiry-based science teaching, storyline education or entrepreneurship education.

Compared to more lecture-based teaching patterns (for example IRF and IDRF), the practice scaffolding learning material involves pupils as actors in real-life problems and solving these requires cooperation and practices specific progression. One of these could be, for example, the sequence of actions a journalist or engineer must perform in order to solve a problem professionally.

Practice scaffolding learning materials is typically based on social constructivistic learning theories that assign participation in learning communities and collaborative processes a key cognitive function. Therefore, the interactivity of this type of learning materials has the form of social interaction and negotiation, which is situated in a particular practice. ICT makes it possible to simulate a practice, set a frame for real-world problem solving and connect it to the world outside the school.

The practice scaffolding learning materials try to reduce complexity and provide tools that support process management in order to increase the efficiency of project-oriented teaching. Also, one should notice that research in practice scaffolding learning materials highlights other effects such as inner motivation, professional commitment and increased transfer (Shaffer, 2006 & Henderson, 2008). One explanation of these benefits is that practice scaffolding learning materials animates the use of composite skills to solve complex problems, which are particularly evident when comparing with repetitive learning materials where you train isolated skills and knowledge in relation to a narrow and restricted problem.

With John Hattie's distinction between surface knowledge and deep knowledge the effects of the scaffolding materials can be highlighted (Hattie, 2009, p. 28 f.). Scaffolding materials do not have a particularly positive effect on the level of surface knowledge, which are often tested in schools, but on the other hand it has a positive effect on the development of deep understanding which consists of skills and elaborated knowledge that is easier for pupils to remember.

The special prioritisation of deep knowledge in relation to reality-based problems is significant for the business model of this type of learning materials. In Denmark, it is typically corporations and other interested parties that finance practice scaffolding learning materials

because they have an obvious interest in raising the profile of their professions and professional communities of practice.

This applies to, for example, learning materials such as "Ekstra Bladet – Editors", "Future City", and "Filmlinjen.dk", which are characterised by their epistemic framing of journalists, engineers, and filmmakers in order to achieve a more in-depth learning.

8. A typology of didactic digital learning materials

In figure 1 four prototypes are represented making it possible to see the prototypical connection between the design of learning materials and the underlying perceptions behind them. At the bottom of the model a suggestion is made of how selected digital learning materials can be placed in the Danish market in the various categories. The cloud formations in the figure indicate that these are approximate measures as they are based on prototypical properties, and because manufacturers are continuously developing and modifying digital learning materials.

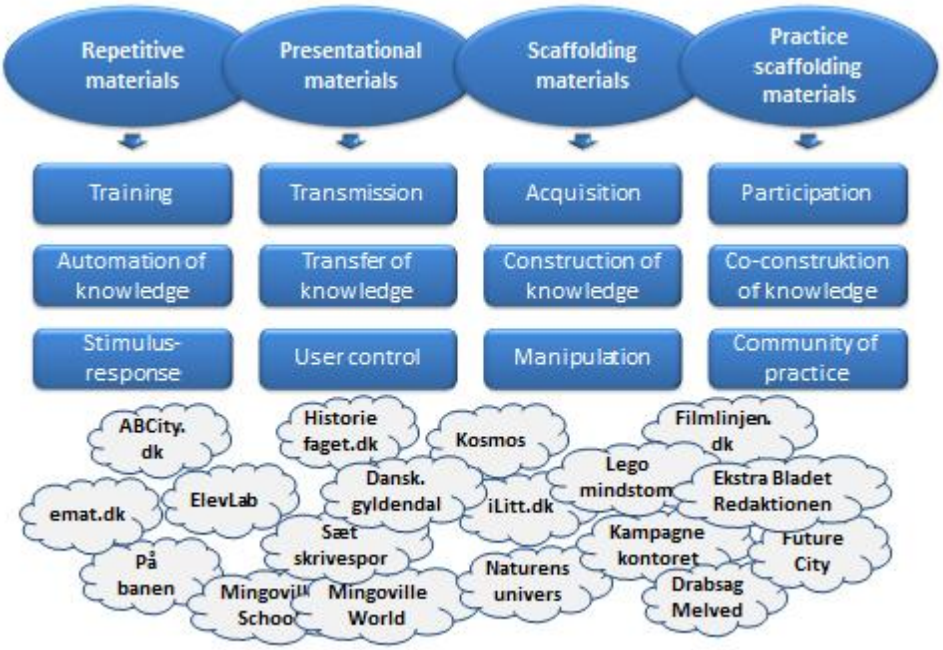

Figure 1. Didactic digital learning materials

9. Status and distribution

It was with the above review and typology as framework that Rambøll Management Consulting and Boston Consulting Group in 2012-2014 carried out an evaluation of digital learning materials. It is possible to state that it is not surprising that there is some consistency between the in-built didactic designs in teaching materials, and teachers' choice of types of teaching. On the other hand, it is surprising that training and communication takes up so much, both in the market for learning materials and in teaching.

The status is that the vast majority of digital learning materials are either repetitive or transmission-oriented. It can be explained by market logic. They are cheaper to program and produce and can easily be legitimised from a subject-based curriculum logic. They are located in the close continuation of the strong tradition of using books and one-off material in lecture-based teaching and repetitive training. Finally, they ensure the systematic activation of pupils who are framed by learning materials.

Conversely scaffolding and practice scaffolding learning materials are more expensive to program and produce because a more complex didactic design has to be built into them. They are legitimised from an external world logic that creates authenticity and realistic problem solving, but can be difficult to relate to cross-discipline curricula. They also relate to a tradition where teachers have produced their own materials. In addition, they also require that teachers work systematically with feedback and follow-up. Here it is possible to add that this is something teachers ought to always do, but this need becomes more apparent in connection with innovative types of teaching where there are not the same visible checks on understanding as with transmission-oriented teaching in the classroom, or training with automatically corrected assignments.

With this in mind it is possible to argue that teachers need a pedagogical terminology for dealing with digital learning materials and also need to get to know their prototypical impact. A vital point is that the effect depends on type, use, and context. There are important differences between, for example, presentational learning materials and remediation of the analogous textbook on the one hand, and scaffolding learning materials and didactical redesign of the textbook on the other hand. The aim is not to dismiss a particular type of digital learning material, but to draw a detailed picture of the possibilities and limitations of the different types. Training, transmission, acquisition and participation can be perceived as metaphors offering four different but valid perspectives on learning and understanding. As Lakoff and Johnson describe in *Philosophy in the flesh* (1999), complex phenomena require a combination of several metaphors in order to understand their composite character. The four learning metaphors are individually insufficient, and they contradict each other, but they can also be used together and supplement each other. A combination of learning materials and types of learning resource can be used to organise a varied education with changing roles and perspectives so pupils have both time and space for training, clear instruction, acquisition, and participation.

10. Methodological challenges and perspectives

A number of problems arose with both validity and reliability in connection with measuring the effect of digital learning materials made by consulting firms. Firstly, it is difficult to establish valid categories that are conceptually consistent, adequate in relation to the categorised phenomena – current digital learning materials and teaching patterns – and understood by respondents. In the study this problem was met in part by asking the respondents to provide specific product names of digital learning materials so categorisation could be carried out by consultants. In addition the many structured interviews were used to triangulate the provision of teaching patterns. The result was a relatively coarse description of how the teaching patterns described above could be correlated with the different types of digital learning materials. Moreover, a combination of questionnaires and interviews with teachers as respondents respectively informants has methodological limitations while they only provide access to impact experienced from a teacher's perspective. Therefore there are

limitations to the extent to which this sort of triangulation can be used to increase the validity in relation to the actual teaching patterns.

Secondly, it requires a lot of resources and domain specific knowledge to characterise and categorise digital learning materials and teaching patterns. Therefore the requirements for reliability and transparent data that allows others to verify the methods and results are often weakened. In the actual study this problem became overt in the scoring of the specific digital learning resources which is not based on an available codebook and score guide that clarifies the criteria for scoring, and thus may well be the subject for discussion. Furthermore, double scoring is apparently not used, either in development or use of the score guide. These two factors together - lack of explication and double scoring – are open to strong criticism, because they both weaken the validity of the scores and thus the credibility and reliability of the study. Therefore there is need for new and more methodologically-stringent studies.

The correlation between didactic designs of learning materials and teachers' use of teaching types opens a large, important area within learning material research, in which there is still little. Therefore Jeppe Bundsgaard and the author, together with a large research team, have developed new methodological approaches to this area where we tighten requirements for explication and validation for our data collection tools. This is done in connection with actual focus on school experiments in Denmark.[ii] Thus we use both score guides and double scoring of digital learning materials, scoring of pupil products, structured observations of several hundred lessons, and subsequent scoring of teaching patterns together with competence testing of pupils in conjunction with questionnaires and qualitative interviews in relation to several types of respondents: managers, supervisors, teachers and pupils. The result is extensive empirical data with a plurality of parallel primary analyses, however, this is necessary. It requires mixed methods, integration of data sets and interdisciplinary secondary analysis, based on primary analyses if we are to have any hope of reaching a deeper and more comprehensive understanding of the relationship between intentional and actualised teaching patterns.

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[i] Tilley & Pawson 1997.

[ii] See http://auuc.demonstrationsskoler.dk/ for a more elaborated presentation of interventions, methods and results within demonstration school projects in Denmark.