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Formalized informal learning

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Formalized Informal learning – ICT and Learning for the 21st Century

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1 Introduction – research in a fluid environment

This paper presents findings from a large-scale longitudinal, qualitative study – Project ICT and Learning (PIL) – that engaged the participation of eight primary schools in Denmark, and was conducted between 2006 and 2008. The research design was based on action research, involving teachers and other relevant stakeholders, as well as participant observations in the classroom documented by thick descriptions, formal and informal interviews and focus group interviews. The aim of the study was to explore and identify relations between designs for teaching and learning and the students' learning of school subjects within defined learning goals and curricula, along with various implementations of ICT in the pedagogical everyday practice (Levinsen & Sørensen 2008). However, another research strand – the topic of this paper – emerged during the project's life cycle as a consequence of ongoing changes in society and technology. Thus, the first part of the paper is dedicated to the presentation of the gradual formulation and grounding of the research design for this new strand.

During the study, interactive whiteboards gradually came into use as a significant implementation of ICT while the students initiated the use of Web 2.0 resources in the school by simply using them. Occasional use of mobile phones initiated by the students was also observed. Gradually, the relation between the students' informal and the teachers' traditional approach to ICT emerged as an important theme, as it was observed how the students performed certain ICT-related activities at a higher level than the teachers and that the traditional teacher-student relation became challenged in both positive and negative ways; e.g. it was observed that in relation to the students' formal learning involving the use of Web 2.0, some school classes produced genuine trivia in terms of simple copy-paste solutions in fulfilling formal tasks, while other classes expanded beyond the defined learning goals of their grade levels. These phenomena were to a higher degree observed in relation to the introduction of Web 2.0 in the classroom than in relation to the traditional use of ICT in terms of applications and learning objects. These further raised questions such as: Does ICT or instances of ICT play a role in the observed changes in the classroom when Web 2.0 and occasionally mobile phones are used? If the answer is yes, then what kind of role is it? What can we learn from that? Do the students' informal strategies encompass qualities that may be useful for a school's general adjustment to the challenges of society's ever-increasing e-permeation?

As a consequence of these emerging phenomena, a new research strand emerged and the project had to formulate additional research questions and identify new empirical fields of attention for data collection, along with analytical categories. In order to achieve this, it became necessary to frame an understanding of the character of society's transition from industry toh network society, and grasp core concepts such as key competences and ICT-related competences or ICT literacy. In the beginning, it was perceived that this would entail an uncomplicated adjustment to the project; however, it soon turned out to be a bit more

complex. Therefore, the next section of the paper is dedicated to a discussion about the transition from industry to network society and related core concepts that helped ground the research questions for PIL's new research strand and the subsequent modifications of the project's research design.

2   From industry to network society

In his book, The Hypercomplex Society (1998), Qvortrup states that our society moves towards increasing hypercomplexity and that the industrial mode of production gradually has come to be replaced by the hypercomplex society's mode of production in which companies produce and process knowledge and offer network services as commodities. At the same time, the production units have come to be ad hoc – open and transparent project organisations that are made possible by the global digital network. According to Qvortrup the individual and organisational challenge is to deal with and reduce the hypercomplexity in adequate ways. The relations between globalisation, networked and ad hoc organisational forms and digitalisation are explored further by Manuel Castells in his acclaimed sociological study, The Information Age (2000). According to Castells, the industrial era of wireline networks saw the role of ICT as a tool in relation to production whereas ICT tools were allocated and delineated to definable locations. In the network society this view of ICT makes no sense because ICT has become ubiquitous and is just as integrated in such domains as politics, the military, economic power, society and citizenship, and interpersonal relations, as it is in activities of production (Ibid.).

With mobile and wireless technologies, multimodal digital media and Web 2.0 social software, ICT literally dissolves or penetrates physical structures and offers virtual environments that we can either choose to participate in or have forced upon us. In the same process, human interaction with ICT has expanded from being a mere interaction with tools to what has become an interaction as agency; users being actors, participants, producers and peers. Consequently, digitalisation has become a partly invisible but a constituting dimension in the world, and ICT must be understood as something that is interwoven in the social structure and culture (Ibid., p. 9). Table 1 outlines the most profound differences between the industrial and the network society's modes of production.

Table 1: Differences between the industry and network society modes of production

	The industrial mode of production	Network society's mode of production
World view	Predictable and stable	Uncertain and fluid
Commodity	Products	Services
Organisation	Linear and hierarchy	Flexible network
Core organisation	Companies	Ad hoc project organisations
Competition factors	Skills and values	Knowledge
Means of control	Rules to follow	Probability and choice
Strategy of action	Re-action	Pro-action and interaction
Role of ICT	Tool	Tool, Personal identity, social structure and culture
Role of ICT user	User of tools	User, actor, participant, producer, peer ...
Competencies	Generic (and self-programmable)	Self-programmable

The increasing e-permeation of all aspects of everyday life has radically changed the role and place of ICT in society from affecting limited parts of our lives, to profoundly impacting the way we live and how we

perceive the world and our mutual relations. Additionally, the transformation has impacted fundamental epistemological and ontological questions. In the industrial era, the basic conditions were perceived and treated as ontologically stable and predictable while universal and true knowledge was considered possible to achieve. In contrast, the basic ontological condition in the world of the network society is fluidity – that is, instability and unpredictability – while knowledge is equally subject to constant (re)construction and (re)negotiation. Accordingly, science and technology studies (STS) have increasingly developed towards constructivist and social constructivist positions (Latour & Wolgar 1986; Law 1999).

The fluid nature of the network society causes its mode of production to be highly dependent on the individual's ability to navigate in a fluid context. In contrast to Qvortrup who focuses on a system's (individuals and organisations) reaction towards a hypercomplex environment and how the system may reduce the hypercomplexity, Castells focuses on individuals' and organisations' ability to be proactive and think ahead when dealing with and performing in a complex and fluid environment (Castells 2000). According to the emerging demands of the global economy, Castells divides individuals as employees of the global economy into two dominant types: self-programmable and generic labour. Self-programmable labour aligns with the demands of the network society and is equipped with the competences for lifelong learning and the ability to retrain and adapt to new conditions and challenges. As such, the self-programmable individual reduces hypercomplexity through future-oriented performance of self-management and self-initiated learning. In contrast, generic labour aligns with the demands of the industrial society, needs instruction, and is both interchangeable and disposable. Thus, the generic individual reduces hypercomplexity through reactions oriented primarily towards the present and does not perform self-management or self-initiated learning. As the two types of labour are linked to employers' needs and visions about available employees and do not denote actual people, Castells argues that for a society to remain competitive in the global economy, the educational systems should devote particular efforts to the education of individuals who possess self-programmable rather than generic competences.

In the search of an approach to the emerging performances that were being observed in the PIL-study, the concept of self-programmable was deemed a useful theoretical tool, as it became apparent that there were some successful mixtures of students and teachers, curriculum and Web 2.0, which also seemed to bear similarities to self-programmable.

3   Understanding key competences

Key competences in the network society
Castells' theory has had a major impact on the international definitions of key competences for the network society that are used as guidelines for governmental decisions about education (OECD 2001; European Commission 2003; Rychen & Salganik 2003; G8 2006); e.g. the European Commission's Directorate-General for Education and Culture states:

> "… the fact that the world is e-permeated means that those who can understand and comfortably use e-facilities are significantly advantaged, in terms of educational success, employment prospects and other aspects of life" (Elearning Europa 2005)

The currently agreed upon list of key competences was developed in the period 1998-2003 when the OECD carried-out the project Definition and Selection of Competences (DeSeCo 2002). In Denmark, the key competences are included in the Danish government's educational strategy; this is the result of its own project – The National Account of Competences – which was realised in 2005 and which was based on DeSeCo. The DeSeCo key competences are listed below and divided by the author into general competences that are relevant for any agent in most social formations, and the competences that relate to the self-programmable individual, which are specifically relevant in the network society.

Table 2: DeSeCo key competences sorted in general and self-programmable competences

General key competences	Self-programmable competences
Literacy Social competence Communication competence Democratic competence Environmental competence Cultural competence Competence in health and body	Learning (to learn) competence Self-management competence Creativity and innovation competence

The DeSeCo self-programmable competences constitute a step towards the concretisation of PIL's new research strand. However, they do not specifically relate to ICT. One place to look for a relation between key competences and ICT rests in the body of studies regarding New Learners or Power Users. The terms refer to the members of the generation born into a world where ubiquitous ICT was already present, for whom the Internet, wireless and mobile solutions have become everyday phenomena. It is generally accepted that New Learners exhibit competences that cannot be reduced to basic device-operating skills and a number of studies show that students' use of the media is far more sophisticated and differentiated outside schools than in schools (Drotner 2001; Livingstone & Bowill 2001; Sørensen, Jessen & Olesen 2002; SAFT 2003; Stald 2009). They exhibit high-level informal IT-related competences, often surpassing their teachers with respect to both operational skills, as well as communication and networking competences.

The challenge of building key competences
Studies by Sørensen et al. (2004) and Malyn-Smith (2004) found that the informal play-related approach to acquiring key competences of the network society and ICT is a challenge to the educational system and schools' adaptation to the network society. It was found that the educational system perceives formal practice and informal learning strategies as contradictory. There have been indications of there being difficulties in accepting that for the first time in history, the system is forced to learn more from its surroundings and from its students rather than the other way around in order to adapt to the present and future e-permeated society.

In correspondence to the observations in the PIL-study, the studies of children's and young people's informal learning strategies towards ICT indicate that ICT may actually play a major role in schools' adaptation to the network society and in the development and building of network society key competences. Thus, in order to collect empirical data that may help to answer the challenges and questions, it became essential to formulate areas of awareness to guide the researchers' attention towards relevant observations. DeSeCo points this awareness towards three competences: creativity and innovation, learning (to learn) and self-management. The performance of the New Learners (Dede 2005) points towards observable actions related to ICT such as:

- Fluency in multiple media as well as in simulation-based virtual settings;
- Communal learning involving diverse, tacit, situated experience, with knowledge distributed across a community and a context as well as within an individual;
- A balance among experiential learning, guided mentoring, and collective reflection;
- Expressiveness through non-linear, associational webs of representations;
- Co-design of learning experiences personalised to individual needs and preferences;

DeSeCo's definitions and standards are limited in telling us about the desired destination and outcome of digital and key competence-building, while studies of the New Learners' performance and agency are

limited because they present a rather abstract and descriptive list of attributes related to self-programmable behaviour. Castells argued that society should devote particular efforts to the education of self-programmable individuals. But neither the definitions of key competences nor studies of the New Learners cue us towards what it takes to educate people to become self-programmable individuals. The basic challenge for the educational system is thereby twofold: 1) The actual making of digitally literate, key competent, self-programmable social actors; and 2) How to develop adequate designs for teaching and learning that allow informal learning strategies to unfold in a formalised context. Questions that seem obvious are never asked, for instance:

- What do self-programmable individuals do when they self-program?
- How do adults learn to become self-programmable, if they are not – e.g. teachers?
- How do we ensure that new generations grow up to be self-programmable rather than generic?
- What are the designs for teaching and learning that scaffold the building of the self-programmable individuals' competences?

In conclusion, we lack research and knowledge about what it means to teach and to learn to become a self-initiated lifelong learner or a self-programmable individual. We lack research that aims at describing the phenomenology of acquiring digital literacy and self-programmable. We also lack research related to the role technology has in these processes. Ultimately, we need to be able to identify and design relevant learning objectives and scaffolding. In this perspective, the emerging performance and use of ICT observed during the PIL-study provided the possibility for researchers to enter into this important research area and provide new knowledge. The first formulation of the research questions for the new strand in the PIL-study became:

> Do instances of key competence-building occur?
> > If so, which key competences are documented?
> Does ICT play a role in the building of key competences?
> > If so, what role does ICT play in competence-building and how is it enacted?

4 Future-Oriented Competence

The empirical challenge of PIL is to observe in a fluid field where also key concepts such as ICT-related competences and key competences are "essentially contested concepts" (Connolly 1993); that is, they are both ill-defined and subject to an ongoing negotiation of meaning. It is a challenge to observe competence-building as a process rather than the supposed or best practice outcomes of a competence-building process. The following section discusses the concepts of competence and competence-building and their possible phenomenological appearances in relation to the research questions of PIL's new research strand in order to encircle the phenomena for observation. As an outcome of this discussion, a new concept – Future-Oriented Competence – is suggested, which encompasses the current understanding of network society competences and offers a framework for the observation of learning activities?

Digital literacy

In the early era of everyday use of ICT, computer literacy was understood as the functional and basic skills required when undertaking particular operations. Additionally, users were subdivided according to Dreyfus & Dreyfus' Model of Skill Acquisition (1988): novices, competent users and experts. As search engines spread, search strategies and data management skills were added and later, the repertoire was supplemented with: ability to reflect upon, differentiate between and select among search results (Breivik 2005; Katz 2007). As digital media became increasingly complex, the user's cognitive ability to interpret representational forms and modes of interaction became important, and the term multimodal competence was introduced (Tyner 1998; Jewitt & Kress 2003; Erstad 2005).

As users of digital resources are no longer recipients but actors who consume, participate, produce, publish, collaborate and share information, the educational focus has changed from the transfer of best practices to an accommodation of general education or buildung for the network society. Buckingham (2003) claims that as part of their digital building, it is imperative that users-as-actors are able to meta-reflect on their interaction with other actors and on multimodal means of expression, while also understanding how agency and the virtual environment are intertwined, that they dialectically constitute and are constituted by one another. Martin (2006) expands on digital buildung – which he names digital literacy – to further encompass the lifelong ability to act in the fluid digital infrastructure of the 21st century and contends that digital literacy is fundamental for all citizens. Drawing on Bateson (1991), Martin argues that e-permeation demands that meta-reflection on one's personal digital development and learning must be part of digital literacy along with the ability to act and transfer knowledge to new contexts and deal with the yet unknown. Martin defines three stages or levels of engagement in the lifelong construction of digital literacy:

- Digital competence – the basic skills required for learning and undertaking particular operations through learning by doing;
- Corpus of digital uses – basic insight and agency that allow for critical reflection, transfer of knowledge and best practices between digital solutions in the digitalised environment;
- Digital transformation – ability to meta-reflect and change the basic premise for agency in the digitalised environment and enable creativity as an integrated part of the agency.

Martin's standpoint implies that the original ICT skills and competences are still relevant, but that their acquisition cannot be seen as a measurable threshold that one can pass. Acquisition must be seen as an ongoing and lifelong learning process. The competences are not successive, rather, they are interwoven and they flow together into the buildung process that Martin (2006) names digital transformation. People who master digital transformation as a self-initiated learning process align with Castells' self-programmable individual and the self-programmable key competences as defined by OECD (see Table 1). With Martin's definition, we get another step closer to unfolding what it means to be or become self-programmable and the kind of agency that self-programmable implies. Accordingly, we also get a step closer to operationalising what the researcher may guide his or her awareness towards when collecting data regarding the new research strand.

➢ In relation to data collection, this means that the observer must be sensitive towards situations where the actors display: computer literacy, the ability search for and process data, multimodal constructive and interpretive competences, and Martin's corpus of digital uses based on the transfer of knowledge and digital transformation.

Learning, proactivity and learning competences
According to Wenger (1998, p. 245) learning processes that are similar to acquiring digital transformation competences constitute a continuous negotiation and re-negotiation of meaning when coping with "...the interaction of the planned and the emergent". Thus, according to Wenger, learning is a dialectical process that oscillates between reflection and action; and following this, the self-programmable learner is expected to be able to evaluate his or her own learning process.

➢ In relation to data collection, this means that the observer must be sensitive towards situations where the actors encounter something unexpected or unknown and observe their agency and strategies over time in relation to acquiring an understanding of the new and to overcome obstacles.

To navigate between the planned and the emergent is, in the world of projects in fluid environments, called process management (Christensen & Kreiner 1991). According to Acroff (1976; Christiansen et al. 1999, p. 57) there are four types of strategies to apply when confronted with something unexpected. Acroff operates by distinguishing between what is a planning and a situated perspective, and by differentiating between what is a passive and an active behaviour. Passive behaviour matches inactive or reactive strategies of action, while an active behaviour is future-oriented and matches proactive and interactive strategies of action (see Table 3). In the large body of business research literature where these concepts are developed, active behaviours as a whole are named proactivity.

Table 3: Acroff's matrix of perspectives and behaviour

	Passive behaviour	Active behaviour
Planning Perspective	Inactive strategy Avoid changes until they are inevitable	Proactive strategy Looks ahead in order to spot trends and be prepared to meet challenges
Situated Perspective	Reactive strategy Tries to meet changes in ways that preserves the known situation	Interactive strategy Performs interventions in order to meet challenges

Wenger's concept of dealing with the planned or expected corresponds to Acroff's planning perspective. Moreover, Wenger's concept of dealing with the emergent or unexpected corresponds to Acroff's situated perspective. According to Wenger and Acroff, the self-programmable individual or the learner who masters digital transformation also masters the management of his or her learning process. These individuals are expected to make use of active behaviours or proactivity and perform learning process management (LPM); that is, to oscillate between the planning and the situated perspectives in order to perform process management.

> ➤ In relation to data collection, this means that the observer must be sensitive towards situations where the actors oscillate between the positions: being oriented towards the future and planning a head (reflection), and performing interventions in the present (action).

The self-programmable individual's performance or agency occurs over time and therefore the time dimension is important for observations. The proactive oscillation between action and reflection may appear similar to Donald Schön's Reflective Practitioner (2001), however, proactivity denotes a strategy that is always a conscious choice while reflection-in-action denotes an experience-based competence that has been built over years of practice. When competences have become tacit (Polanyi 1968) they may no longer be subject to conscious reflection. Thus, the reflective practitioner may both denote the virtuous expert and the unreflective practitioner characterised by routines. The so-called New Learners may be considered as reflective practitioners in both meanings of the concept. This may explain the observation mentioned above regarding the student-produced trivia; produced by students who are viewed by their teachers as New Learners. Based on this discussion, learners are subdivided into the following groups that correspond with Martin's three levels of digital literacy:

- Weak learner: a learner who displays basic difficulties regarding the oscillation pattern;
- Routine-based learner: prefers action to reflection and the situated perspective to the planning perspective;
- Self-programmable learner: oscillates rather effortlessly between reflection and action, as well as between the planning and situated perspectives.

> In relation to data collection, this means that the observer must be sensitive towards the differentiation of learners and signs of learners' progression over time between levels.

Informal strategies – bricoleur approach and play culture

As discussed earlier, the so-called New Learners and their informal learning strategies when dealing with ICT may function as inspiration for the observer. The New Learners' informal learning strategies are similar to the bricoleur-style's (Oblinger 2003; Malyn-Smith 2004; Sørensen et al. 2004; Dede 2005; Oblinger & Oblinger 2005; Levinsen 2006; Ryberg 2007; Sørensen, Audon & Levinsen 2010). According to Turkle and Papert (1990, p. 129) a bricoleur approaches challenges by connecting practice and concrete thinking in a process of arrangement and re-arrangement of materiality while constantly negotiating and re-negotiating meaning using either inner dialogue or shared negotiation. This process produces patterns of behaviour that are similar to the play patterns identified in studies of children's play culture – Construction Play and Role Play (Sørensen 1999; Jessen 2001; Trageton 2004) – and generates learning processes that may be described as assimilation and accommodation (Wakefield 2003).

However, recent studies document that no matter how competent the New Learners may appear to be in relation to new technologies, they do not possess the knowledge and the competences that are necessary to turn ICT into school-relevant perspectives and uses (Levinsen & Sørensen 2008; Gynther 2010; Sørensen, Audon & Levinsen 2010). Therefore the process of learning and knowledge-sharing between teachers and students and the subsequent implementation of ICT in everyday school practice are closely related and interdependent.

> In relation to data collection, this means that the observer must be sensitive towards play and bricoleur approaches that unfold in formal learning contexts as well as where teachers challenge students to reflect on their informal learning using formalised perspectives.

Self-directed skills of inquiry

The literature offers a large body of descriptions of the characteristics of informal learning strategies but only few texts address the unfolding of informal learning strategies in formalised primary school contexts. Literature on the formal use of informal strategies refers primarily to adult learners; in his paper on adults' self-directed learning, Malcolm Knowles (1975) offers a description of what self-directed learning may look like and what a teacher may facilitate when supporting self-directed learning. Knowles' theory addresses adults learning and he developed what he called the Andragogical Model that contrasts pedagogy, as he was convinced that adults learn differently than children. Knowles formulated assumptions about the adult self-directed learner (Knowles, Holten & Swanson 2005, p. 64) and argued that maturing means to become self-directed rather that dependent, and that one becomes able to draw on experience and becomes self-motivating rather than instructed. He also put forward that adults need to know why something is relevant, as a subject to learning.

Knowles' arguments for the difference between andragogy and pedagogy have been subject to debate (Davenport 1993; Jarvis 1977; Tennant 1996) and research has documented that children demonstrate the same need as adults in understanding why something is important in the learning, and that children are able to be self-directed and self-motivated (Gynther 2010; Sørensen, Audon & Levinsen 2010). However, as Knowles' description of the self-directed learner bears similarities to the bricoleur approach identified among young New Learners, it is argued that Knowles' theory may work as a useful tool in operationalising what the observer may look for. The learner, who masters what Knowles coins Self-Directed Skills of Inquiry (1975, p. 15), is able to identify, inquire and explore an unknown subject or topic and to reflect on and reduce the complexity of the gained information and transform it into knowledge that drives the learning process further. Knowles' distinction bears similarity to Vygotsky's (1978) pedagogic distinction between

the cognitive processes of externalisation and internalisation. As the present research addresses agency, neither Knowles' andragogic nor Vygotsky's pedagogic concepts are considered adequate.

In the following, the explorative activity is termed expansion, while the reflective and complexity-reducing activity is termed delimitation. As discussed above, only self-programmable learners may, in contrast to the routine-based and weak learners, be expected to perform self-directed learning and oscillate between expansion and delimitation.

> In relation to data collection, this means that the observer must be sensitive to the distinction between expansion and delimitation. Further, the observer must be sensitive to situations where oscillation between the two may occur or be absent.

Future-Oriented Competence
The DeSeCo key competences and New Learners' behaviour do not encompass the above-discussed qualities of the self-programmable individuals' performed agency in a field of tension between the expected and the emergent in an e-permeated and fluid environment. Accordingly, both the DeSeCo key competences and New Learners' behaviour are considered too narrow-scoped in this study. In order to integrate the previously discussed aspects of the network society competences and to cope with the "essentially contested" nature of concepts in the fluid conditions of the network society, the term Future-Oriented Competence is suggested as a temporal umbrella-concept and (Latour 1988, 1992) that encompasses the aspects discussed above: ICT-related competences, proactivity, future orientation and self-directed learning.
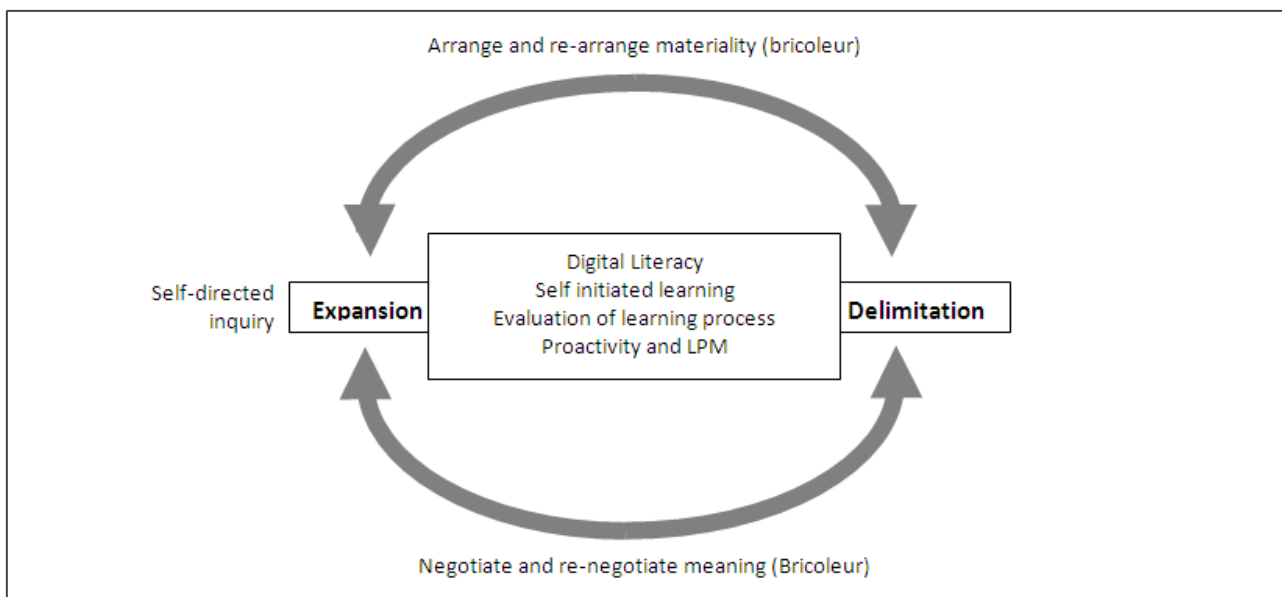
Figure 1: Model displaying the complexity of interrelation and interdependence between the dimensions of Future-Oriented Competence, when practiced in a field of tension between bricoleur activity and self-initiated inquiry

Stabilising Future-Oriented Competence encompasses the complexity of interrelatedness and interdependence as illustrated in the model above (Figure 1), in six dimensions. The four dimensions in the centre are formed by the direction of the self-directed inquiry-dimension towards either expansion or delimitation, while the bricoleur practice-dimension moves between arrangement and negotiation.

5 The case and research methodology

The previous section defined six dimensions of the Future-Oriented Competence that relate to areas of attention that may guide the observer's awareness towards relevant situations during learning activities. Based on the dimensions, the research questions for the new research strand in the PIL-study became:

Do instances of Future-Oriented Competence-building occur?
If so, which dimensions of Future-Oriented Competence are documented?
Does ICT play a role in the building of Future-Oriented Competence?
If so, what role does ICT play in competence-building and how is it enacted?

The next step in the development of a methodology was to formulate assumptions of how these situations may phenomenologically appear in practice. These assumptions are the precondition for collecting both the expected and the unexpected during observations. Table 4 shows the relation between relevant situations and the expected corresponding phenomena that may be interpreted as reifications of Future-Oriented Competence:

Table 4: The relation between the six dimensions of Future-Oriented Competence and the corresponding

Dimensions	Corresponding observable phenomena
• Digital literacy (Martin's three levels)	⇒ Do the actors search for and process data? ⇒ Do the actors understand and use multimodality in a constructive and interpretive way? ⇒ Do the actors display one or more of Martin's three stages of digital literacy?
• Learning competences and progression • Weak, routine-based and self-programming learners • Signs of progression over time between levels	⇒ (How) do the actors formulate requests for help or comments from the teacher? ⇒ What kind of support do the actors ask for? ⇒ What is the amount and nature of teacher attention the actors need in order to proceed? ⇒ Do the actors change strategies and complexity of approach over time?
• Informal strategies (bricoleur's style/play) vs. formal strategies (teacher-defined approaches)	⇒ Do the actors use play patterns as Construction Play and Role Play when exploring something new? ⇒ Do the actors arrange/re-arrange materiality (digital objects) while negotiating/re-negotiating meaning? ⇒ Do actors combine formal and informal approaches?
• Evaluation of one's learning process • Activity of oscillating between the planned and the emergent	⇒ Do the actors display awareness of discrepancies or alignment between the planned/expected and the emergent? ⇒ If so, do the actors express wonder, curiosity or frustration through words and/or body language? ⇒ Do the actors formulate and experiment with various strategies in terms of "What to do now"? "Do we need to know more"? "Are we on the right track"? ⇒ (How) do the actors negotiate meaning?

• Proactivity and learning process management (LPM) • Activity of oscillating between a future-oriented planning perspective and performing interventions in the situated perspective	⇒ Self-programmers are expected to formulate questions and to develop new strategies in terms of "What if …" scenarios ⇒ Self-programmers are expected to negotiate meaning based on gained knowledge and experience ⇒ Generics are expected to look for answers and to repeat a preferred strategy ⇒ Generics are expected to ask "What now?"
• Self-directed skills of inquiry • Activity of oscillating between expansion and delimitation	⇒ What do the actors look for and ask for when exploring? ⇒ (How) do the actors negotiate meaning? ⇒ What do the actors prioritise when reducing complexity? ⇒ Do the actors reconsider their assumptions? ⇒ Do the actors acquire knowledge about the topic or do they produce trivia?

After presenting the methodological framework of the new research strand, the case and PIL's research practice are briefly presented. The project was carried out from 2005 to 2007 in a suburb municipality of the Danish capital where primary schools demonstrated adjustments to meet the demands of the 21st century. The schools had been rebuilt to open-plan architecture in order to encourage flexible use of space and the schools had adopted flexible timetables that allow interdisciplinary activities over longer periods of time and across grades. When digital infrastructure, hardware and software were developed and implemented, the intention was to make digital resources accessible to the learners whenever needed throughout the day. These schools were therefore engaged in the process of becoming schools of the network society (Sørensen, Audon & Levinsen 2010).

The research was based on the participation of six primary schools in the municipality with 12 classes, ranging from grades 1 to 8. As PIL was a combined development- and research-project, the overall approach was action research. The teachers had formulated model-projects on how they wanted to experiment with combinations of designs for teaching and learning with ICT and accordingly, researchers and the teachers shared knowledge and discussed the actual practice in order to refine the model-projects into genuine educational practice. Data collection was based on anthropological methods such as participatory observation and informal interviews, semi-structured interviews and focus group interviews. Because of the main focus on ICT's learning potential in relation to specific school subjects, the classes were followed in Danish, foreign language teaching, maths and science. Depending on the teacher's model-project design, the observations followed subject-specific classes as well as interdisciplinary activities. The research visits were from one to four hours' duration, and each class was visited from one to four times, with a total of 38 visits. The use of digital resources ranged from teacher-controlled activities in computer rooms, through learner-centred project work, to the learners' self-initiated and ad hoc use of available ICT resources (Levinsen & Sørensen 2008). Collected research data included thick descriptions (Geertz 1973) and recordings of sound, video and stills. The learners' work and teachers' activity-plans were collected; this material has been analysed using methodology as described by Halkier (2008).

6   Findings
The empirics were analysed using the six dimensions (Table 4) as a tool for analysis. The analysis produced a series of indicators for the occurrence and emergence of Future-Oriented Competence in relation to ICT

during the observed learning activities. As the six dimensions appear interdependent and interrelated, the following examples were selected because each example accentuates one dimension.

Digital literacy (Martin's three levels)

When students work with different digital means of expression, they relate to ICT as complex information architecture and technology. They learn to install software and get to know about file types, formats, data transport and the size of data (bytes, megabytes) as well as the technical conditions for accessing the school's intranet from home. But apart from expanding their computer literacy (Martin's level 1) they also progress through Martin's levels 2 and 3.

In the second grade, two boys used MS Word to write a horror story in Danish, and they used CD-Ord, an application originally designed for dyslexics (Levinsen 2007), as it integrates sound with visualisations of words and lets young writers draw on their ability to listen and see when constructing words and spelling. During the process, the boys expanded their computer literacy as they searched for and downloaded horror-sounds for the story and finally they managed to change the path from the desktop to the memory stick, when they want to share the story. To begin with, they spoke sentences aloud and wrote afterwards, and only discussed single words on the screen. They gradually became able to cope with larger pieces of text and began discussing phrases as they pointed to the text on the screen. They gained experience in their use of keyboard, mouse and interface, and began using the spell-check in an integrated flow when writing, using the right-click functions and word suggestions from CD-Ord. They even managed to move larger pieces of text in order to improve the narrative quality. Throughout the process of writing and editing the text, they gradually built up a repertoire of digital uses for constructing and editing a text.

In language learning where the design for teaching and learning rests on storytelling and ICT, imagination is a necessary process driver. Independent of whether the teacher or the students defined the theme, we observed that students in all age groups formulated visions, pursued ideas and discussed the narrative structure of their storytelling. They produced sketches, storyboards, short lists and staging, and used a variety of digital tools together with digital cameras, mobile devices and internet resources to produce content. As the projects evolved, we observed that the students' digital competences expanded and most students consolidated a corpus of digital uses that allowed them to experiment with the storytelling, using bricoleur strategies. We even saw students progress to digital transformation and managed to redefine the premises for their stories, "kill their darlings" and start all over again with a new design, as well as students who redefined tools e.g. PowerPoint and PhotoStory, from being mere presentation tools to then become bricoleur's style sketching tools and storyboard tools.

Search strategies are central in digital literacy and depend on methodology, skills and imagination. A conscious and successful search depends on the ability to imagine the object of search and to ask questions in ways that exploit the potential of the search engines (Dervin 1992; Dervin & Frenette 2003). In a fifth-grade storyline project, two girls worked on a story in English about a mother who died in a car accident. They started a Google Image search for "dead people". At this point, they had no idea how to search or what they were actually looking for, and they used a trial-and-error strategy. Images from the tsunami in 2004 showed-up. "Uh, that's scary. Let's use our names instead," said Sara. Then the images became bimbo-like. "I sure don't wanna be like that!", and Sara searched for "Heidi". Then an image of a girl appeared: "… she looks like someone who lost her mother". They began realising that the Internet does not follow the same logic as their minds: on the Internet, Sara equals bimbo while Heidi equals the healthy girl from Switzerland. During the process, the girls progressed from unreflected trial-and-error to a reflected learning-by-doing strategy. Using Martin's terms, they progressed from simple digital competence to a corpus of digital uses for search engines. In their subsequent search for the father, they began negotiating what they were looking for before starting. "Let's find a father, he is a young man", said Heidi, and Sara wrote: "young man". This change in search strategy represents a change in the basic understanding of what

it means to search and accordingly, the two girls moved closer to exploiting the search engine in accordance to Martin's digital transformation.

Learning competences and progression
Weak learners and routine-based learners tend to approach lifelong learning in a generic manner, while self-programmable learners are by definition lifelong learners. Lifelong learning depends on the ability to motivate oneself for learning, but it is also a matter of establishing a habitus (Bourdieu 1990) for encountering obstacles or challenges with an inner drive even when it seems tedious. The network society's challenge is that it takes time to develop and establish a habitus. The following examples display how working with digital storytelling in role-play setups support the development of a self-programmable habitus while students move from weak to routine-based or even self-programmable learning competence.

In a cross-disciplinary role-play in English and maths, students of the fourth grade had become journalists who were responsible for their own research. They were assigned to an English-speaking location by the teacher, and provided coordinates in Google Earth. Students were to collect and select material about the locality. At the end of the day, students were to deliver oral reports and written English news-features to the editor of the newspaper (the teacher). The assignment also simulated travel to the locations, since students were to e.g. book hotels and flights and keep a fictitious travel budget. Frequently, we saw students expanding on the requirements of the role-play as they invented side-stories that required further research. They also generated more features for the newspaper, e.g. the story of why the statue of a lion appears on many pictures from Singapore, and the story of what the term "trouble" means to Northern Ireland. In the same project, two boys who are weak learners were assigned to explore London. They seemed bored and started to talk about computer games instead. When the teacher asked them how they would proceed, they insisted that the task was boring because they were only interested in beer and soccer. This was meant as a provocation, but the teacher chose to ignore their attempt to avoid doing school work. "Then, why don't you look for different pubs, beers and prices? And you could find the soccer clubs and famous players who play in London", the teacher suggested. The boys accepted the suggestion and they managed to write a feature in English about beer and soccer in London. During this process, the boys gradually displayed more sophisticated search strategies and they began negotiating meanings in relation to the feature. The teacher was experienced with student-centred pedagogy and gradually the boys changed their attitude from demanding instructions: "What should we do now?" to seeking advice and negotiating their own suggestions. In this example, the boys moved from weak learners towards routine-based learners. We also saw students who became so engaged with this way of working with digital tools and storytelling that they began to produce their own projects when they had finished the formal task. They planned and conducted productions about games (boys) or pets (girls) and they combined and challenged a multitude of tools and possibilities.

In these cases, the school's formal learning approach allowed space for the children's informal learning strategies, and the teachers actively created arenas where lifelong learning habitus could be develop.

Informal strategies (bricoleur/play)
Fourth-graders collected data about the weather over the period of a month to be used in building their own database in order to store data, compare data, and calculate changes over time. So as to become familiar with the database tool, two groups of students were asked by the teacher to collect data from two other groups: height, weight, shoe number and age, while names and addresses were put into the database's text fields. Most of the students followed instructions, while two girls insisted on finding the right pink colour for the background and changed the format of the shoe number input-field from numbers to numerals because they wanted to write "size 36 and size 37". During this process, they used a bricoleur approach and repeatedly arranged and re-arranged the appearance of their database while they discussed which attributes would be the most appropriate for their purpose. When they came to the part of the

exercise where they were supposed to compare results from the whole class, their informal approach turned-out to be fruitful. Suddenly, one of the girls exclaimed: "Oh, that's why – when we use word-numbers we cannot calculate and compare! That's why we have to use real numbers. But then we ought to have place for more than one shoe number". In this example, the girls demonstrated that they had grasped the conceptual difference between numerals and numbers and they indirectly used the concept of intervals. Following this, the girls continued developing and expanding their weather database using a bricoleur approach, and they produced rather sophisticated analyses compared to the learning objectives for the fourth grade.

Evaluation of one's learning process (reflection/action)

Seventh-graders were working with evolutionary theory that takes them from the time of the Big Bang to today. They had studied books and other theoretical sources and were assigned to produce a PhotoStory of their findings. They could use the Internet for further information but had to take digital photos. The teacher set a rule that a maximum of 12 photos could be used in the narrative and that only three could be derived from the Internet.

One group was waiting for a digital camera but used the waiting time to discuss narrative strategies and how to take the photos – motives and visual design. They wrote notes on paper and started searching for images of the Big Bang. One of the girls started using PowerPoint. "Why do you use PowerPoint" a boy asked, and the girl answered: "To get an overview of our narrative". Actually she was making a storyboard in PowerPoint and she typed on the first page: "Earth – sun system (as an orange)" and "cell lifecycle" on the second page. The storyboard inspired them to discuss whether Darwin's theory was important and whether Darwin is important. The girl suggested that they use an image of Darwin, because she found that the storyboard revealed a hole in the narrative. When they tried it out in the storyboard, they realised that the hole was not just about the order of the narrative, but that the hole was that they had not really understood what exactly the theory was about. After reflecting on this new challenge, they searched for additional information on the Internet and decided to act by redesigning the narrative framework and the list of images before they went out to take pictures.

Proactivity and learning process management (future perspective/situated perspective)

Eighth-graders were working on a cross-disciplinary theme that combines Nature and Science with Lego Mindstorms robots. The Mindstorms-part is about constructing and programming robots for the Robolab-competition. Students were divided into groups of four to six students. The groups were supplied with a construction set of bricks, wheels, cogwheels, axles and shafts, a programming brick that controls the robot, a remote control and three engines that drive the movements of the robot. The groups were provided with a task description, exercises, a robot manual and three laptops. In the physics room there was a copy of the track that the robot must be able to complete.

The robot programming software was installed on the laptops and after programming, the students had to upload their programming onto the programming brick and test the robot. In order to construct a functioning robot, the students had to plan and process-manage both research and testing. The groups agreed on a division of work among members. Some members experimented with the physical construction of the final robot whereas others experimented with programming and used "get-started-robots", while continuously negotiating how to proceed in the exploration and construction of a working robot. The construction-students found that if the robot was too delicate it became frail and fell apart when moving, and they additionally discovered that if it was too solid it became too heavy and could not move at all. They discussed ways to change the resistance and test how much weight the engines could work with, the difference between caterpillars and wheels, and they experimented with the construction in order make the robot more stable but lighter. The programming-students tested their "get started-robot" on the track and photo-documented the movements. They explored various solutions for programming movements and

used the manual to reflect on and plan new experiments. After ten minutes, a group of girls had managed to construct a robot that was able to run and turn on the track. They began using the remote control, but remote controls are not allowed in the Robolab-competition. The teacher explained that the remote control could work in another way if fastened to the robot. The remote control could then be programmed to make the robot change direction when colliding with something. Soon the programming-girls had found more information in the manual and began testing the remote control together with light-sensors.

When working with the robots, the students demonstrated a high level of complexity in their collaboration. They alternated between the future perspective of proactivity – "what if…" scenarios – and the situated perspective of testing the hypothesis in practice. They reflected on the results at the same time as they negotiated and evaluated the progression as part of managing the learning process.

Self-directed skills of inquiry competence (expansion/delimitation)
Expansion

Groups of two or three students in the first-grade measured a table with their thumbs, the classroom floor with their feet and the hall with a tape measure. They wrote their measurements into a group–post, in the class' database (MINIKORT®), which the teacher had prepared in advance. When all groups had finished their task, the teacher used the interactive whiteboard to display the database and showed various views to the class. The class was then asked to compare the sets of thumb-measurements and think about whether there was something to wonder about. Soon the students raised their hands and said that the groups had produced different results.

When the teacher asked if they could figure out why, they answered that thumbs had different sizes. When the teacher displayed the set of foot-measures, reactions were quick and students started to discuss one measurement that particularly stuck out. Then a boy said: "Oh, it's because I forgot to take my boots off – my boots are big so I counted less feet". In this way, the students used everyday language to formulate complex concepts such as accuracy and they concluded that feet and thumbs were inaccurate because they come in different sizes, while a tape measure is always the same. Because the tape measure ought to be precise, they concluded that the difference in measurements of the hall must have been due to sloppiness. In this case, the teacher facilitated and supported the students' process towards self-directed skills of inquiry.

In a fourth-grade class, students worked with surface measurement and drew their room and furniture on the interactive whiteboard. They visited IKEA's homepage, with its 3-D tool for arranging rooms with furniture. They did not know about volume as a geometric concept, as volume is not part of fourth-grade curriculum. However, they soon realised that some furniture filled the space in ways that could not be expressed only by surface measurements. They began discussing if it could be possible for a person to move about in the room when furnished in certain ways, and whether it would be possible to calculate – rather than actually putting real furniture into the real room – in order to answer those types of questions. Ultimately, the teacher had shown them how to calculate volume and in this way, the students managed to challenge and overpass the curriculum of their grade level. In this case, the students demonstrated that they mastered self-directed skills of inquiry and they expanded their understanding of abstract concepts by transforming "filling the space" into calculation of volume.

Delimitation

When using search engines, the big challenge is to distinguish between "finding something about X" and "finding something relevant and reliable about X". Critical source criticism and the ability to knowledgably select information are basic requirements in the network society.

A fifth-grade class was investigating Leonardo da Vinci and perspective in Renaissance painting. They Googled the Mona Lisa and the first image that showed up was Mr. Bean as Mona Lisa, followed by some apparently reliable links to reproductions, as well as some other manipulations where Mona Lisa is represented as smoking a cigarette, or has a moustache, or looks like Homer Simpson. These findings were used by the teacher on the interactive whiteboard to initiate a class discussion about findings which are reliable and valid Mona Lisa references, and which are not. However, the findings were also useful for a discussion regarding types of findings that are relevant for specific purposes. In some cases, Mr. Bean or Homer Simpson as Mona Lisa may be the relevant finding, and during the discussion, the class began constructing more robust, reflective and critical attitudes towards searching and selecting from the Internet.

The process of editing, remediating and producing a digital, multimodal presentation of a subject depends on the ability to critically select relevant material from sources. But it also depends on the ability to construct a communicative product which appears meaningful from the perspective of an audience. This is why the production of digital media products is categorised as delimitating, even though a media product may have the potential to function as a lever for expansion regarding the audience. We have observed that the production of all kinds of digital products meant for presentations implies activities such as remediation, inscription and decoding of representational signs and ordering of the media message and narrative. The majority of observed groups working with production discussed and experimented with content, narration, montage, means of expression and aesthetic design. They asked themselves questions such as whether they had gotten the content right, if they had missed information or had maybe not fully understood the subject. They reflected on how to remediate and integrate content derived from the sources in ways that may communicate to an audience. During these processes the students built up multimodal competences and the ability to delimitate and reduce complexity.

7 Discussion

The data analysis confirms that various ways of including ICT, digital media and e-learning into designs for teaching and learning may support the students' development and consolidation of Future-Oriented Competence. However, the relation is found not to be deterministic.

The positive effect is observed in relation to cases where the design for teaching and learning involves students' group work in problem-oriented narrative settings such as storyline and role-plays. However, it is not found in cases with traditional teacher-centred approaches involving ICT (Levinsen & Sørensen 2008). The effect is also found when the objective of the students' task reaches beyond the expansive exploration of a topic and also aims at the delimitative reduction of complexity in terms of: 1) remediation of material for a digital presentation; 2) production of empirical data in science that has to be documented and presented; and 3) when using process-oriented e-portfolios. Constructivist and social constructivist research have convincingly documented learning potential of these approaches and therefore it becomes relevant to ask:

Does it really make a difference that ICT is involved?

The answer is: Yes. Compared to using the above-mentioned approaches without ICT, we observed that even young students are able to work focused and independent for longer periods of time and that the teachers' interventions change from instructive guidance to constructive coaching. Moreover, we have made several observations where teachers had to remind students of the breaks, though they preferred to continue working. We also – as mentioned above – observed that students challenged and went beyond the official learning goals in language teaching, math and science. So the next logical question is:

What is it about ICT that makes a difference?

The ICT applications that support and inspire the acquisition of Future-Oriented Competence all share some important features. They are not necessarily designed for learning purposes and the interactivity is open-ended rather than pre-defined. They offer intuitive user interfaces and a WYSIWIG (What You See Is What You Get) mix of exploration tools and construction tools that are enhanced by easy access to internet resources and the transport of data between applications using copy-paste functionality. These applications allow for user-driven interaction and the manipulation of complex elements such as those offered by the WYSIWIG-principle. They also offer transparent relations between construction, editing, trial-runs, instant feedback, re-construction and re-editing. In short, what these applications invite is the continuing arrangement and re-arrangement of materiality in terms of digital representations, while the user or users negotiate and re-negotiate meaning in terms of inner or shared dialogues. In other words, these applications encourage users of ICT to draw on bricoleur strategies which the students already master in their informal, leisure-time explorations of ICT. Thus, when these applications are implemented in the above-mentioned designs for teaching and learning, students are allowed to expand on their formal student role with informal strategies and to exploit and develop these informal strategies while at the same time, work on the school assignment.

In conclusion, this is what we call *Formalized Informal Learning*. Variations of ICT that allow for bricoleur strategies to be coupled with designs for teaching and learning that invite self-directed inquiry, are genuinely supporting the building of Future-Oriented Competence. However, as research has also documented (Gynther 2010; Sørensen, Audon & Levinsen 2010), students' learning of the subject-matter and Future-Oriented Competence do not automatically result from this combination of pedagogy and ICT. There is a fair risk of producing digital trivia and therefore, having teachers as coaches and supervisors is equally important.

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